

Bhagawan Mahavira International Research Center Monograph Series

Scientific Perspectives of Jainism



: Editors :

Samani Chaitanya Prajna Narendra Bhandari Narayan Lal Kachhara

Excerpts from the Book

An implicit doctrine of evolution is found to be present in the Jain teaching if one reads the meaning of the concepts of parinitime, phanyative and yathā-paryatirt karana. The true guide of evolution is jiva, i.e., inner lifeconsciousness-wisdom, and NOT external selective factors, chance (i.e., spiritually unguided) mutations and 'struggle for continued evisitence' or 'survival of the fittest' – though all such factors must naturally play a role, but only secondary and superficially. How diversification and specialton take place on the various taxonomical levels can be explained by the law of karma, i.e. cause-and-effect according to Nature's laws and habits.

- Rudi Jansma, Chapter 16

From a Jain point of view it is unacceptable that IIIe, consciousness, intolligence and mind, energy and free will are products or emergent properties of physical matter alone. Nevertheless all these are substance (drawya). From a Jain and general oriental, or from an occult point of view, modern philosophy and science err when they sumise that IIIe and consciousness are later products of evolution. The pligrimage of each soul is a journey through the whole universe, in which all beings are interconnected and who have a common purpose. Jainsim is therefore teological a concept firmly shume by modern science.

- Rudi Jansma, Christopher Key Chapple et al., Chapter 25

According to their conception of Jains, a perfect soul has infinite knowledge, infinite intuition, infinite biss and infinite power. Although a perfect soul has many other characteristic, knowledge has been regarded as the main characteristic mowledge has been regarded as the main characteristic mowledge has been regarded as the main characteristic point of view its berificant to say that soul is knower and nothing else. He further stated that there is a difference between the knowledge with the wide is knower and nothing else. He further stated that there is perfect soul perceives and know he whole of reality and from the transcendental point of view he perceives and knows only the self.

- Surendra Singh Pokharana, Chapter 5

Physical, chemical, electrical, protein synthesis, DNA, spectrum of light rays, memory etc. are some characteristics exhibited by even non living materials. Science so far could not infuse sensory character into any non living substance and it is still beyond the reach of solentific techniques. Some viait characters of a living substance such as movement, respiration, sensitivity, growth, ergoduction, excretion, nutrition and responses have been recognized but sense of feeling, thinking process, memory impressions, consciousness, dream, purification of soul, doctrine of karma, rebirth, Darshama and finally Nivana do not form the subject matter of modern bioloav.

Scientific Perspectives of Jainism

Editors Samani Chaitanya Prajna Narendra Bhandari Narayan Lal Kachhara

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Scientific Perspectives of Jainism

Blessings



Jainology holds an important place in Indian philosophical studies. The study of Jainology can lead to multi-dimensional knowledge. c rya Tulsi and c rya Mahaprajna, the two great saints and philosophers of 20th and 21st century, have contributed profoundly in editing, translating and interpreting the Jain Agamas, which have been helpful in promoting the Jain Studies. To present Jainology in scientific perspectives is a very useful and timely task. Through this monograph entitled "Scientific Perspectives of Jainism" the readers will get an opportunity to acquire in-depth knowledge of Jainology in the light of theories of modern science Be the toil of the writers and editors come fruitful.

Kathamandu (Nepal) 24.04.2015

c rya Mahashraman

Prologue



In order to convert knowledge into wisdom, what is needed is blending of science with philosophy or rather with spirituality. The modern world today is stunned with the marvels of science and technology, but, at the same time, it is felt universally that there is limitation of scientific knowledge on one hand and the dangers of valueless technology on the other. Spirituality, philosophy and religion are those rich heritage of ancient wisdom, that can become complementary to science and technology, and thus not only the dead ends in the blind alleys where

science becomes stagnant could be opened, but also the destructive consequences of modern technology could be avoided through inculcation of spiritual and moral values resulting in humanising of modern global society.

In order to study and carry deep researches in the field of ancient wisdom what is needed first is to comprehend exactly what has been propounded therein and then by correlating it with the already accepted scientific concepts one may reveal something quite novel. This is, in fact, an innovative effort to bring about a happy blending of both -science and spirituality- or -science and philosophy-and thereby present before the world very valuable thoughts and practices for solving the burning problems of life on the global level.

Bhagaw n Mah v ra International Research Centre (BMIRC) established at the Jain Vishva Bharati Institute, Deemed University, Ladnun (Rajasthan), envisages a plan to encourage the scientists and scholars interested in the field to work together. The present monograph 'Scientific Perspectives of Jainism' is the outcome of three years efforts of the scientists and scholars doing work in this field.

What would be the highest goal of BMIRC

Although there are scores of subjects on which, painstaking research is undertaken and unexpected attainments could be made, yet the most noble and valuable contribution would be to discover those spiritual practices through which the ultimate transformation of consciousness, including neuro-scientific changes in attitudes and behaviours of human beings, can be brought about so as to translate the high principles of religion and practices in daily life of people at large. If this is achieved together with the scientific documentation showing statistically valuable efficacy of the spiritual practices, there is no reason why new avenues cannot be opened in evolving a new global world-order wherein non-violence, equality, justice, peace and bliss would prevail. Let us hope BMIRC would one day get success in attaining this highest goal.

Professor Muni Mahendra Kumar

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PALAIS DE LA PAIX 2517 KJ LA HAYE PAYS-BAS TÉLÉPHONE: +31 (0)70 302 23 23 TÉLÉGR.: INTERCOURT LAHAYE TÉLÉCOPIE: +31 (0)70 364 90 28 ADRESSE ÉLECTR.: mail@icjelj.org SITE INTERNET: www.icjelj.org



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Foreword

It is both pleasure and privilege to affix this foreword to this eminently readable monograph prepared by distinguished and illustrious authors namely Professor Samani Chaitanya Prajna, Professor Narendra Bhandari and Professor Narayan Lal Kachhara.

Jainism is one of the oldest, original, logical and scientific religions in the world, therefore, even now it is very relevant and useful to the society. Jainism has

moulded and influenced many societies predominantly because of its emphasis on non-violence.

Jain doctrine is pertinent when it advocates that the Universe uncreated, real, eternal and infinite with no beginning or end. Modern science has confirmed that the Universe has automatic working process and matter is never destroyed, it only undergoes changes to different states or modes. This is the law of nature. Jainism is fully logical and scientific and this statement can be proved from the following illustrations.

Jainism's theory of karma also finds support when we witness so much of disparity in society among living creatures. The doctrine of karma also does away with necessity of any outside agency, an invisible or pervading, omnipotent supreme being-creator, destroyer and preserver and dispenser of justice for punishing and rewarding the living beings. Scientists also do not feel any need of an unknown hand to interfere with automatic working of the universe. The law which regulates the doctrine of karma is based on the principle of cause and effect, the old saying "as you sow, so shall you reap" presents the whole doctrine in a nutshell.

The karma regulates genes and genes and karma both determine the life cycle and inheritance of living beings.



Genetic science says. "we are what we are because of our genes". Genes not only bear the genetic traits of their parents but also represent karma performed by an individual.

The researchers have arrived at a conclusion that karmas are the cause and genes are the effect. Karmas, direct, instruct and motivate genetic codes to function and mutate accordingly. In Jainism, every living being is responsible for its actions and thoughts and faces the consequences of his action in accordance with the basic law of Jainism.

The Jain philosophers and thinkers believe that plants, vegetables and all green vagetation's have life and this is incorporated in centuries old Jain scriptures. Eminent scientist, Sir Jagdish Chandra Bose established and scientifically proved in early 19th century that plants and vegetables have life like human beings.

Even small routine practices or rules which are observed by sections of Jains have scientific basis :

- a) drinking of distilled or boiled water
- b) not eating after sunset
- c) not eating green vegetables on some special occasions or *parvas*

Jainism also ordains its followers to drink water after proper distillation with the view to avoid killing of germs. Scientists have also found numerous tiny germs invisible to the naked eyes moving to and fro in water.

Having meals before sunset is scientific according to Jainism. Medical doctors have also confirmed it. Similarly the principles of psychology, sociology, anthropology, biology, chemistry, mathematics and other branches of similar type may also find support in Jainism.

The relevance of science, engineering, technology as well as scientific literacy is always used for the well-being of society from ages. In the present scenario it is more profound than ever before.

Elements of scientific research are found in ancient Jain philosophy. The study of astronomy (stars, planets, universe), physics (matter, atom, space, and motion and time) reveal that most of these scientific principles were laid down in old Jain scriptures.

Preservation of environment and ecology is intrinsic, inherent and innate in Jainism. It is inbuilt and integrated in every principle, tenet and concept of Jainism.

The present environment scenario is grim and dismal. The pollution level in the soil, water resources and air has already reached maximum permissible and tolerance limit and continues to increase unabated. Dangerous consequences have started manifesting in climate changes, melting of snow, shortage in crop yields, water scarcity, erratic rains, droughts, floods and diseases but the practices followed in Jainism has the potentiality of restoring the health of the environment.

It may be relevant to mention that consumption of per capita water is minimum among Jain *sadhus*, seers and monks and the consumption of per capita electricity is also negligible among them. Economic and rational use of otherwise scarce natural resources is the main, if not the only, solution of burning problems of environment and ecology. This solution is also based on Jainism's main principle of nonaccumulation (*Aparigraha*) of wealth and resources, or in other words to use things and resources which are absolutely necessary.

Albert Einstein in his article (Science and Religion) mentions 'science without religion is lame and religion without science is blind'. Jainism is the combination of both science and religion. All the living and non-living things in the Universe and the views about them are involved in Jainism. Einstein further says "I believe any human being who is cultured and who has religious outlook has the capacity of becoming free from the selfish motive".

The principles of Jainism are supported by modern science. Human welfare is hidden in every principle. They are proved in the laboratory of *kevala jñ na* - the supreme knowledge. They are proved by observation, logical thinking and illustrations. In this way Jainism has become a humanity centered religion. I firmly believe that synthesis of Jain philosophy and science will provide a valuable and rational framework that has tenets to transform the world into a better place to live.

The Jain Vishva Bharati University has been carrying on research activities on 'Jainism and Science' at its Bhagaw n Mahavira International Research Centre for Scientific Research and Innovative Studies in Social Sciences . In a unique experience Samanis, Scientists and Scholars are jointly carrying on research. The centre is involved in an endeavor to prepare a comprehensive document of Jain Philosophy that comprises all aspects of science including physics, chemistry, biology, astronomy, cosmology, geography and social and environmental sciences. The motivation for this project was to arrive at a rational, scientific basis of Jainism. This effort has culminated in this monograph which comprises scientific papers on several aspects. Chapters in this monograph cover aspects of Physics, Chemistry, Biology and Environment as also conceptual principles in Jainism like *Syadvad*, *Anek ntav d and Nayav da*, with their applications in logic, probability and statistics.

I congratulate Professor Samani Chaitanya Prajna, Professor Narendra Bhandari, and Professor Narayan Lal Kachhara for doing an outstanding work in preparing the monograph of a lasting value. I am happy that this important task has been undertaken by the country's leading experts and eminent scientists. The work is of a very high quality and is likely to have much greater impact on the scientific approach of Jainism. Aagams must be correctly translated, interpreted and scientifically evaluated, therefore it was imperative that task was assigned to such erudite experts and brilliant scientists.

I am clearly of the opinion that this synthesis of Jain Philosophy and Science will provide a valuable and rational framework that has the capacity and potentiality to transform the world into a better place to live. It will do so by guiding mankind towards its physical, psychological and spiritual well-being for peaceful and meaningful coexistence. Never was a time more appropriate than now, to inculcate the values enshrined in Jain Agams for betterment of humanity and its global environment.

I once again compliment the authors and wish them all the success in their endeavour and thank the editors for the privilege they give me to read this book, prior to its publication.

In my view this publication on Jainism would further enlighten the path of humanity.

Daber Bharden

Dalveer Bhandari (Judge, International Court of Justice)

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Preface

Jainism is one of the most ancient and profound faiths in the world which offers, besides a purpose to life and procedures for betterment of its quality in physical, mental and spiritual domains, solution to many a problems which beset the world today. This philosophy preached by Enlightened Tirthankaras, is compiled in short sutras in form of various scriptures called Aagams, written in ancient language of Prakrit. In the past few decades efforts have been made to translate and interpret the Aagams but still they are not easily accessible in modern languages. Therefore there is much need of carrying out further study and research to present Jain concepts with a scientific and logical foundation. The Jain Vishva Bharati Institute, Ladnun has established "Bhagawan Mahavira International Centre for Scientific Research and Social Innovative Studies", named after the last (24th) Tirthankara Mahavira, who preached Jainism about 2600 years ago.

Over the many millennia that have elapsed since the times of the first Tîrthankara, Rishabhadeva, and the last Tirthankara Mahavira, Jainism has been propagated through practice as well as preaching. However, the Aagams were compiled by learned saints many centuries after Mahavira's *nirvana*, based on their recollections. In view of the limitations in oral transmission of the Sutras from one generation to the next over many centuries, imperfections of human memory, subjective interpretations, besides the influence of other contemporary schools of philosophy, the Åagams need to be critically studied and properly interpreted. The Research Center has taken up this much needed initiative in this direction.

Jainism propounds that both the living and non living entities of the universe are governed by certain laws. The two visible components of the universe, living beings and material structures, continuously undergo extremely complex processes. Trillions upon trillions of atoms, molecules and their compounds, proteins, cells, neurons, tubules, tubulins etc., actively work in the conscious beings at every instant, are modified or die and are reborn, with a single purpose that we stay alive. Similarly trillions upon trillions of objects in the Universe are formed, destroyed and reformed every instant with a single purpose of providing continuity to Universe's existence. Living beings as well as the Universe, encompassing the smallest to the biggest entities, are thus huge workshops where none of the processes, be it in the human body or on the planet Earth, is independent, random or chaotic but operate in harmony and synergy, supporting each other, and with a purpose. This can only happen if every process follows certain laws. Thus living and non-living, both must be governed by universal and eternal laws. Science, as well as Jainism, as also many other philosophies, are basically attempts to understand these laws and thus have much in common. This book describes some of these laws and synthesizes science with Jainism. The monograph is an attempt to prepare a source book on these topics in scientific perspective. We hope that this book will serve as a useful collection of articles which will provide a starting point for serious discussion and research.

The book contains 29 articles on various topics by thirty three authors. The articles are grouped in six thematic sections. The first section is devoted to the theoretical foundations of Jainism. It contains several articles describing scope of various laws of nature, causative factors required for an event to occur, concepts of Syadvada, Nayavada and Anekantavada, which describe the multiple nature of dravyas and inherent uncertainties, limits of knowledge, theory of cognition etc. The article by Samani Chaitanya Prajna quotes the scriptures to show the depth of Jain thought covering a wide variety of topics e.g. dynamical properties of a paramanu, laws of motion, law of inertia, laws of aggregation and disintegration to esoteric topics in astronomy like Black holes, but deals with only one basic question in detail: what does it take for an event to occur in the universe? Is it only energy or matter which is necessary and sufficient for something to happen? and shows that coordination of five causative factors (Panch Samavaya) can only culminate into an event: the place and time have to be right; the nature (svabhava) of partaking entities has to be appropriate, a cause (karma or upadan) must exist and some catalytic or auxiliary agent (nimitta) must trigger the process to culminate it into an event. In addition effort (purushartha) and niyati (law of determinism) play a

role; nothing can happen without an effort or by itself. All these together, in cooperation, can only result in any phenomena involving living and non-living processes. The basic question whether randomness or destiny plays any role, though it may apparently appear to be so, is debated. The destiny is nothing but the state determined by the past accumulated karmas, the inherent cause. The multiple-faceted, multiplicity of the continuously changing nature of a substance is described by Anekantavada and manifestation of a particular mode depends on time, place and external conditions. Thus description of an object is constrained, not only by Anekantavada but also by Nayavada or perspectivism or point of view and Syadvada; the innate uncertainty, and free will, in case of living beings; indescribability being its one corner stone. These are the topics covered by Narendra Bhandari and S.S. Pokharna on Anekantavada and Syadvada. The former implies a continuing change of form of everything (paryaya) and the latter involves an amount of uncertainty in every description and, according to Jainism, in every law. Any formulation or description is therefore incomplete and provides severe limitation to knowledge. The authors go on to show that probability, statistics, wave particle duality or quantum mechanical behaviour are all implied in the seven modes of existence, i.e. Saptabhangi and this concept may find many applications in day to day problems and their resolution. This description leads to the proposition that everything, living and non-living, has an innate, unchanging "essence". In case of living entities, this essence is consciousness or soul, but in nonliving material things, it leads to a paradox. Such a paradox, defined as Theseus paradox, and other paradoxes can be explained on the basis of the seven modes of predication. Knowledge is the corner stone of Jain philosophy and two articles, by Viney Jain and Veersagar Jain, and by S.S Pokharna discusses the theory of cognition. Whereas Jain and Jain describe concepts of origin and development of knowledge, both in the Eastern and Western philosophies, within the framework of neuroscience, genetics and information theory, Pokharna discusses knowledge in the framework of General Systems Theory, neurophysiology, quantum physics and General Theory of Relativity and shows how conscious decision making is affected in the Orchestrated-Objective Reduction model of Penrose and Hameroff.

Jain and Jain also touches about *pramana* (or proof) and cognition in various types of species like plants and microorganisms. A short paper by B.R. Dugar supplements this discussion by describing the essential aspects of modern models of cognition, specifically the theory of Jean Piaget.

Karmavada is the basic law governing the living beings and several authoritative articles on the doctrine of karma, translation and pathways of individual karma into biological and neurological effects, genes, free will, rebirth and epigenetic factors etc. form the second section. Karma and soul are interdependent and mutually interactive and form the core of Jain philosophy and Jain practices, by which the former can be dissolved and the latter can be purified, leading to *moksha*, the state of infinite freedom, infinite bliss, infinite *jnana* and pure consciousness, which is the ultimate goal of all living beings. These three articles give a good idea of various aspects of cognition. The doctrine of karma and its modus operandi, i.e. molecular pathways through genes, and the way it influences destiny is discussed by N.L. Kachhara, S.R. Tater and Samani Unnat Prajna. They describe the types of karmas, their bonding and rise and also various types of bodies i.e. karman sharira, taijas sharira and the physical body and their interactions. Subhash Jain provides a complementary and logical approach for the way karma accumulates in different species and develops a semi quantitative model, for rebirth as different species. P.M. Agrawal, in a short paper, summarizes the views of George Wald, a Nobel laureate in chemistry, and some other scientists who come to the conclusion that science cannot explain every observation and invoke the existence of something beyond matter, we can call soul within the framework of Jain philosophy. The discussion continues in the next section where the behaviour of brain and mind are discussed in anatomical, neurological and physiological terms, in articles by Sanchetee, Mishra and Jansma, and in another article by Jansma, who provides a comparison between modern and Jain views. These twin articles provide physical as well as philosophical perspectives of brain function.

One of the major consequences of the *Karmavada* is development of Jain practices and their anatomical, physiological and psychological effects. Consciousness is the pillar of all Jain thought and some basic aspects of brain and mind are discussed in the context of consciousness. Meditation, breathing and Yoga form the main Jain practices to elevate the level of consciousness. Consciousness is currently a frontier area of research and much can be learnt by synthesizing the Jaina concepts with modern neurology, genetics and brain chemistry. Once these aspects are understood the techniques of Yoga and meditation, described by S.R. Tater and L.C. Jain, and by Sudhir V. Shah, can be used to improve upon human behaviour. These two articles provide a physical basis of these techniques and summarize their physiological effects.

Since Jainism is concerned with development of consciousness, much emphasis is laid on biological aspects and classification of living beings according to the number of sensory organs they possess. This classification is logical and is the subject matter of the next set of papers. G.C. Jain, S.L. Godawat and Suchita Jain discuss some of the biological aspects in organisms. Two serious discrepancies remain between Jainism and modern biology concerning the origin and evolution of life. The first arises from the fact that traditionally Jainism attributes different species to their karma in the previous birth and there is no mention of unidirectional upward evolution to higher species according to Darwinian evolution. There is clear observable evidence of Darwinian evolution in nature, i.e. interaction of living and non-living, in its vivid details, operating on the Earth, during its geological history, based on fossil records. Specifically, evolution and Neo-Darwinianism is discussed by Varsha Shah in a short paper. A unique Jain concept, at much controversy with the modern definition of life that earth, air, water, and fire considered to be non-living should be treated as living (sachitta) one sensed beings, under some conditions. Whereas existence of life, emotions and response to stimulation in vegetable kingdom has been accepted by scientific observations during the past century following the experiments performed by Jagadish Chandra Bose, after over two and a half millennia since it was propounded by Jain Tirthankara, problem of life in earth, air, water, and fire remains the bone of contention. This aspect is covered in some of the articles in this section. Ashok K. Jain and J.R. Jain make an attempt to explain life in one sensed Sammurchhan beings on the basis of peculiar molecular structures of air, water, etc.

that develop as receptacles of appropriate souls which populate the whole universe. This also forms the subject matter of another paper coauthored by J.R. Jain on cosmology, which can be taken as favouring the chemical origin of life, which is inconsistent with the Jain thought. The controversy can be resolved because what modern biologists may call as synthesis of life, Jains may explain as a soul descending from the cosmos in a molecular structure appropriate for a particular type of soul. In the following article on evolution and development of life Rudi Jansma provides some insight on the way the two concepts can be made compatible. Rajmal Jain provides a new insight about evolutionary chronology of species, based on fossil records and climatic cycles. There is much overlap between some aspects discussed in this section and articles presented in the next section, dealing with origin of life and time cycles, but this may well provide different perspectives by scholars with different expertise and may help initiate a healthy discussion.

Having discussed the basic Jain concepts in the four sections, summarized above, the last two sections deal with different aspects of Lokavada which includes physics, cosmology, geography, ecology and mathematics. Modern physics, which includes quantum physics, Relativity and particle physics etc., has brought in revolution in our concept of matter and the universe. According to modern science only laws of physics are universal and non-violable. It is therefore important to discuss various concepts of physics in relation to Jain philosophy. Laws of physics have been used to understand origin and evolution of the universe, the earth and time cycles. An attempt is made by Narendra Bhandari to compare some of these concepts with Jain doctrines. A good degree of agreement is found as depicted in a useful table where doctrine of karma (causality), anekantavada (complementarity), interdependence (entanglement) etc. are found to be common in Jain concepts and modern physics. Matter is one of the important constituents of the universe. The Jain concepts of matter, starting with paramanu, the indivisible particle, is compared with modern theories arrived at by dissecting matter to smaller and smaller units, as discussed by N.L. Kachhara and Rajmal Jain. Cosmology, planetary science, time cycles and geography are all considered together and elaborated in a series of Aagams related to Lokavada, although each of them has become a separate field in its own right. Modern cosmology, history of its development etc. are treated in separate articles before a comparison is made with Jain concepts. Serious disagreements are found between scientific observations and traditional interpretations of Aagams. An attempt has been made in some of the articles to reinterpret and synthesize them to obtains an agreement to the extent possible. this approach provides some logical foundation to Jain concepts, it Although remains largely speculative, preparing ground for further studies. Cosmology is the basis of Lokavada and is a very controversial topic. The basic disagreement is that Big Bang cosmology, having solid observational and theoretical basis, is at variance with the eternal universe, without origin or end, propounded by Jainism. In a series of three articles, S. Mohanty discusses scientific basis of conceptual development of Cosmology, R. Rangarajan summarizes the story of origin and evolution of our universe and Rajmal Jain, Jeo Raj Jain and Narendra Bhandari compares Jain cosmology with some modern concepts. The traditional idea of the structure of the Jain Lokakasha, depicted by a man standing with elbows stretched out is unstable, incompatible with basic forces of nature, as established by physics. Various possibilities are proposed so that some of the controversies can be reconciled. If our universe is a multiverse, with the proposed 11 dimensions, some concepts of the String theory may support Jain cosmology.

Time has been a very elusive and enigmatic concept. Is it only a parameter to define change or to determine rate of change or is a fundamental '*dravya*' constituting the *Loka* in Jainism? Time is only relative, as Theory of Relativity propounds or is there an absolute, Newtonian time, a concept long abandoned? A.R. Prasanna discusses some concepts of this enigmatic time and shows that it is simply a construct of mind. Jainism considers absolute time as a *dravya* which assists other *dravyas* to brings about change in them. It acts on souls and is the cause of the phenomena of birth and death; acting on matter it gives rise to phenomena of creation and destruction of matter forms. It acts on *akasha* and is responsible for the concept of sequential occurrence of events. Acting on *dharmastikaya* and *adharmastikaya*, time enables the phenomena of motion and inertia in objects.

Geography remains a serious point of contention. Since it is based on direct observations, there is no scope for a dispute, which normally arises from model based conclusions. There cannot be anything like Jain geography and an observation based geography. Both should be identical. It is here that traditional interpretation of Jain geography appears to be faulty. The traditional interpretation of Jain maps therefore requires rethinking. Taking cue from an earlier proposition by J.R. Jain, an attempt is made by J.R. Jain, Narendra Bhandari and J.K. Surana to reconcile Jain diagrams, what they call symbolic pictograms, with current observations. Jambudvipa, internal structure of Earth and many habitable planets are described in this article and are found to be consistent with some recent observations. These new results are quoted to support some of the Aagamic interpretations. A flat Earth, two sun and two moon appear as some of the controversial concepts which are challenged in this article emphasizing Bhoogol (used for geography) which literary implies that the earth is spherical, to show that the controversy is only in interpretation. This provides a new approach and calls for further study. Besides biology, much thought has been given to ecology and in many ways it is treated as a part of spirituality and therefore we include a few articles dealing with environment and ecology. The ecological aspects are discussed by Christopher K. Chapple, Rudi Jansma and T.M. Dak.

Mathematics is an integral part of Jain philosophy and Jains have contributed significantly to development of Mathematics although many such contributions are long forgotten and are wrongly attributed to European scholars who conceived them centuries later. Anupam Jain, R.S. Jain, and Samani Viney Prajna quote many Jain Aagams such as Bhagavati sutra, Trilokasara and Ganit Sarasangraha by Mahviracharya to provide documentary proofs about several concepts like arithmetical sequences and subsequences, various types of infinities, many geometrical formulae and other concepts, which were developed by Jain scholars during the first millennia of Christian era. Not only these concepts were developed, but they were applied to cosmology, astronomy and geography to calculate many parameters of the universe. In spite of all these significant developments, serious confusions have crept in the units of time and space used in Jain calculations.

Rajmal Jain and Anupam Jain make an attempt to rationalize these units to make them consistent with the units currently in use. In spite of this and many similar attempts made earlier, severe discrepancies remain which may be a subject matter for further research and study.

Thirty three experts from various fields including Samanis and Jain scholars, in addition to professional scientists, engineers, doctors, philosophers, and others who had interest in Jainism have contributed to this monograph. Although all the articles were reviewed and edited by the Editorial Board to avoid repetition and unsubstantiated opinions, some freedom of interpretation and conflicting opinions, as also speculation, were retained so as to initiate a healthy debate on various topics. Many articles may not be based on scientifically rigorous arguments and this is bound to happen in a heterogeneous group of contributors with their varying background. To avoid subjectivity, several authors were requested to write articles jointly so that their opinions are least subjective. Thus many articles are joint multi-authored articles. Since there are not many experts in both scientific study and Jain philosophy, who could synthesize them, some articles based only on scientific study (e.g. on cosmology, concept of time, brain function etc.), written by well known experts have been included, with the hope that these articles will provide current state of affairs as far as scientific study is concerned. Similarly some topics (e.g. doctrine of karma) are covered in multiple articles to provide different opinions by various experts. However, the opinions expressed in various articles are author's views and Editors do not take any responsibility for their correctness. In many cases it turns out to be matter of interpretation. Some authors complied to our request to include suggestions for further work, either as part of the text or as separate section, which will be useful for further work. We hope that this book will serve as a base line for undertaking research, study and interpretation and will follow with more monographs on specific topics.

A common thread in all these articles is to elaborate the Jain concepts in modern language, so that their salient features can be easily understood and to provide them a scientific and logical basis, which have so long been accepted only as a matter of faith. The above summary shows that several aspects of Jain sciences can be described in terms of modern concepts, which can be easily understood and appreciated. This of course is only a small beginning and we hope that this exercise will serve as a bench mark in Jainologial studies, although much more work remains to be done

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Samani Chaitanya Prajna Narendra Bhandari Narayan Lal Kachhara

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a slight disturbance (heating) or vibration (touch), the structures break down and the matter becomes *acitta* (life-less). This *sacitta* kind of RMSS form the infinite reservoir of Nigoda. More details are given in an accompanying article by Jain and Jain and the book by J.R. Jain.

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1. Jainistic Approach to the Laws of Nature

Samani Chaitanya Prajna

Abstract

According to Jainism, the Universeand all its constituents, living and nonliving, are governed by certain causative laws. The laws of nature as enunciated in the Jain canon Bhagavat (Pr krit: Bhagava) are enumerated in this article. Some basic questions related to origin of the Universeand why we exist, are discussed in the light of these laws. According to Jain philosophy, occurrence of any event in living and non-living system requires appropriate conditions of K la (time), Syabh va (nature of the substance), Karma (result of action, cause), Puru? rtha (selfeffort), and Niyati (determinism). All the five conditions apply directly or indirectly to all the systems living and non-living. These are necessary conditions for any occurrence. They apply to all the objects at all the times and everywhere. This is the reason they are known as causative laws of nature. However, the law of Purushartha applies only to the living systems. Besides these, certain amount of randomness also plays a role in some occurrences. There are some events which are not governed by any of the five causative laws. Looking at the five laws mentioned above it is clear that all the laws of nature are not determinate as is generally understood by the term 'Laws of Nature' in modern science.

Key words: Natural Laws, Param ?u, Fusion, Fission, Pañca Samav ya

Scriptures quoted: Bhagava, ?h ?am, Tattv rtha S tra, Uv sagadas o

1. Introduction

In the ancient times, philosophy, science and religion were all studied as one discipline. They were so finely interwoven with each other that it was difficult to understand one without the other. In order to understand spirituality or nonviolence one was bound to know entire biological world, various forms of life

and their fundamental nature. In determining rebirth or role of karmas leading to different realms of existence, one needs to know the evolution of life and process of death. Similarly, to live a good life one must know the way the nature works. Thus the ethical principles and practices prescribed in Jainism are not mere preaching but are directly or indirectly concerned with the laws of nature.

The laws of nature (Latin: lex naturalis) are the laws which are followed by nature, and therefore, the laws are considered universal; universal in the sense that they are applicable to everything, everywhere, in every condition and at all times. Thus they are invariant in space and time. This article deals with the laws of nature, which are followed by all kinds of existences—living and non-living—in the Universeand these have been described as metaphysical, ethical and logical truths, principles and rules respectively by the Jain seers, sages and philosophers.

The doctrine of the five causative laws is technically known as the principle of Pañca Samav ya i.e. the set of five factors. These factors together determine when and how an event would occur at individual as well as cosmic level. The thing worthy to note here is: sometime among the five factors one becomes dominant and other becomes secondary. Suppose there is a plant. The plant grows when it is properly sown and taken care of by the farmer. In spite of proper care if the seed of the plant is non-fertilized then it will not grow. The seed is fertilized yet the plant grows according to its potency. If the seed is of orange, the fruits of orange will grow and not of any other type. Furthermore, however one can put his best efforts to get fruits before the time but the plant takes time to produce oranges, so time also plays a crucial role in the growth of a plant. Lastly, how long the tree will survive depends on its life-span which is pre-fixed by the Life-span Determining Karma (yusya Karma). Thus, a phenomenon occurs with the support of all the five afore-said factors and not with the support of one or two of them.

2. Historical Surveys

In the west, the formulation of laws of nature dates back to an Ionian named Pythagoras (ca. 580 BCE - 490 BCE). The western concept of laws of nature, assumed to comprise of matter, space and time, emerged in the seventeenth century. The German astronomer Johannes Kepler (1571-1630) seems to have been the first to understand the term "law" in the sense of modern science, though he retained his animistic view of physical objects. Galileo (1564-1642) did not use the term "law" in his scientific works, it appeared later in the translation of his books. The person,

who first explicitly and rigorously formulated the concept of laws of nature, as we understand them today, was Rene Descartes (1596-1650).

Before the modern era the laws of nature were discussed by seers, sages and philosophers as metaphysical, ethical and logical rules. In the east, the discovery of laws of nature dates back to the 24^{th} T rtha?kara, Bhagaw n Mah v ra (599 BCE-527 BCE). Jainism, which propounds that natural laws govern all events in the universe, is based on five fundamental doctrines: Doctrine of Soul (*tmav da*), Doctrine of Karma (*Karmav da*), Doctrine of Action causing karmic bondage (*Kriy v da*), Doctrine of multiple natures of the constituents of the universe, i.e. j va and aj va (*Anek ntav da*), and Cosmology (*Lokav da*).

Bhagaw n Mah v ra was the first to explain the laws governing the universe, the living and non-living, and behaviour of a wide variety of objects, the smallest and the largest entities. For example, he propounded the four-parametric principle, involving *dravya* (substance), *k?etra* (space co-ordinates), *k la* (time co-ordinates) and *bh va* (mode or *pary ya*), which act together for an event to take place. He also described properties, function, structure, minimum and maximum speed of a Param nu and laws of their aggregation and disaggregation. Apart from the aforesaid principle, he talked of the intrinsic power of attraction of soul and matter, motion of planets, solar and lunar eclipses, conservation of quantity of matter and souls, cosmology, mass less particles, law of inertia, spherical shells surrounding the earth, black holes in the form of Tamask ya and Kri??ar j, etc. The observations and predictions of physical realities are astonishing and remarkable milestones in the history of human understanding of nature.

Mah v ra's realization that all souls, whether it is the soul of Kunthu, the smallest being, or the soul of the large-sized elephant, are identical in regard to their spiritual potentials, so there is no lower or higher beings among the living beings, implying that the Universeis not human-centered. It was really a milestone in our understanding of the cosmos. Since Mah v ra did not use the scientific methodology that is popular now, his theories did not need experimental verification but were accepted because he was omniscient. Also, the laws governing living beings and the physical laws governing the material universe, enunciated by him are similar in many respects. In many cases his insight leads to the conclusions which are surprisingly similar to what highly sophisticated scientific methods and techniques have shown recently.

Although the knowledge of Mah v ra was based on extra-sensory-perception (ESP) of the world, his predictions regarding a number of cosmological phenomena are accurate. He talked of the number of planets, stars, solar and lunar eclipse, and longest and shortest days and nights in a year. He defined Samaya, the smallest unit of mathematical time, to r?aprahelik , the biggest unit of mathematical time. In regard to the time, he not only mentioned mathematical time as Samaya and valik etc. but also symbolic time as Palyopama, S garopama, and K lacakra (one time-cycle) comprising Utsarpi? (the ascending time) and Avasarpi? (the descending time) sectors. By developing metaphysical and ethical principles Mah v ra not only focused on why nature behaves as it does, but also explained how it does. In short, what he said can be marked as the initiation of the modern scientific thoughts and principles.

In fact, Jain science can be taken as an endeavor marked by a strong interest in uncovering the nature and its laws to explain transcendental and empirical realities. Looking at the laws of nature discussed by Mah ν rait seems that we live in a highly orderly universe.

3. Some Basic Questions Regarding the Universe

There are some questions in regard to the Universewhich compel to think of some laws working behind the cosmic process. Now we look into three fundamental questions from Jain perspective:

Why the Universehas something rather than nothing?

Why do we exist?

Why the Universe follows a particular set of laws and not some different laws?

The answer to the first question is that there must be something pre-existent otherwise the world would have nothing. Nothing comes out of nothing as said in the famous saying ex nihilo nihil fit. If the Universeexists, it must have come out of something which was prior to it. In this regard the statement of Mah v ra is worth noting. He says, "If something is not prior and after, how it can exist in between?" It propounds the law of conservation. There is nothing new, only the restatement of what already exists. If there was nothing in the beginning then how the Universecame into existence, since nothing can come out of nothing. If something can come out of nothing then anything can come out of anything and there will be no need to look for any causal relation between two particular things.

Thus, the Jain model of Universeconsiders theological speculations in regard to the origin and fate of the Universeas full of contradictions and irrelevant to salvation, and such speculations must, therefore, be avoided. To say that God made the world is to face the fallacy regress *ad infinitum*. Like Ny ya-Vai e?ikas or later S nkhyas, to say that the material arose naturally is to fall into another fallacy. Then the whole Universemight have arisen naturally and there would be no need of intervention of God in such a naturally arising universe? If God is ever perfect and complete, how could the will to create, which is a sign of incompleteness, arose in him? If, on the other hand, he is not perfect, he would create the world in no better way than a potter could. "If out of love for living beings and their needs he made the world, why did he not make the creation wholly blissful, free from miseries and sorrows? These and other such questions arise which are difficult to resolve satisfactorily. According to Jainism, the world is uncreated. It existed before and will exist hereafter, forever. It is without beginning and is eternal.

According to Jain philosophy, the Universe comprises of five fundamental homogeneous entities technically called *Astik yas: Dharm stik ya* (the medium of motion), *Adharm stik ya* (the medium of rest), k *stik ya* (space), J v *stik ya* (soul) and *Pudgal stik ya* (matter and energy), besides *K la*. According to Jain philosophy and modern science, the quantity of matter and souls remain the same all the times and therefore, there is no question of emergence of any new param nu or living being who has no prior existence. The substance remains unchanged, only its form or mode changes with time. Thus, in Jain view, the world is eternal, perennial, indestructible, and permanent and has no end. There was no point of time when the world was not, is not and will not be there. It was, is and will always exist. Hence, Jains do not see any role or intervention of God, the Creator, in creation or regulating the universe.

The five fundamental entities mentioned above neither originate nor get destroyed. They are eternal and ever existent. The scripture *Sth n ?ga* (Pr krit: *?h ?am*) clearly states: *Param ?u* and soul, mobile and immobile living beings, animals and humans – all were, are and will always be there in the world. It happens that some species become extinct and some new ones emerge in the course of time in a particular region of space but there has never been a time when animals and humans have no existence in the universe. In this regard, the Jain concept of evolution is different from the Darwinian Theory of Evolution. Jains regard that a human may evolve to the higher or lower species depending on one's action, good

or bad. Life at various places in the Universemay evolve or devolve, depending on the local conditions. This becomes evident from the concept of 'aras' discussed under concept of time in Jain philosophy. If the initial conditions are bad, there is decline in quality of life and if the initial conditions are favorable, there is improvement in the quality of life with time.

Rene Descartes also accepted the importance of what we call "initial conditions." According to him, "The conditions describe the state of a system at the beginning of whatever interval of time over which one seeks to make predictions". In his view, "with a given set of initial conditions, the laws of nature determine how a system will evolve over time, but without a specific set of initial conditions, the evolution cannot be specified".

3.1 Why do we exist?

So far as the question of the purpose of humans on earth is concerned, science has no definite answer. But the Indian philosophy in general and the Jain philosophy in particular is very much clear about the purpose of human existence on the earth; the purpose of human life on the earth is to evolve spiritually and ultimately to elevate oneself to the state of purity or perfection.

3.2 How does the Universe work?

Several myths prevail in different cultures in regard to the creation of the universe. It is, in fact, the ignorance of the laws which led people in ancient times to invent gods to lord over every aspect of their life. "Since the connection of cause and effect in nature is invisible and not instantaneous, such gods apparently are attributed the role. In the east, the belief in super-natural powers or the trend of associating natural phenomena with various deities started to weaken with Mah v ra. In the west, it was Thales of Miletus (ca. 624 BCE-ca. 546 BCE) about 2,600 years ago, with whom the idea of gods began to change. Instead, the idea arose that nature followed consistent principles that could be deciphered and understood. "And thus began the long process of replacing the notion of the reign of gods with the concept of a Universethat is governed by laws of nature, and was created according to a blueprint we could someday learn to read.

Jainism is very firm in its assumption that the Universe is regulated by certain laws. After analyzing the nature of the micro and macro world, the Jain seers have identified some determinate and indeterminate laws governing the cosmic processes. In their view, since nature works according to certain laws, there is no need to invoke any creator God who sets things of the Universein motion and controls its destiny.

As far as the multiverse theory is concerned, the Jain view differs from modern science in its understanding of the universe. According to the Jain cosmology, the Universeis one and very vast. It is divided into three parts Upper (*rdhva*), Middle (*madhya*) and Lower (*adho*) Universe(*loka*). We, humans and animals, dwell in the middle part. Most of the lands of the middle part are unsuitable for habitation by humans. Only the central part of it which comprises of two and half islands: Jamb dv pa, Dh tak kha??a and half of the Pu karavaradv pa, technically known as Samaya-k?etra or M nu?ya-ksetra or Dh idv pa is suitable for human form of life. Thus, the human region is a tiny part of the grand cosmos (for detailed maps of these lands, see the articles on Jain Geology and Jain Cosmology in this volume).

Stephen Hawking and Leonard Mlodinov, in their book *The Grand Design*, have discussed the ways in which the quantum theory predicts "multiverse"- the idea that ours is just one of the many universes that appeared spontaneously out of nothing, each with different laws of nature. Concluding with a riveting assessment of M-Theory, an explanation of the laws governing our universe, they write that creation of multiverse does not require intervention of some Supernatural Being or God. Rather, these multiple universes arose naturally according to physical laws.

Thus, the atheist approach, the vastness of the Universeand different laws of nature discussed long ago by the Jain seers, are now being increasingly accepted by scientists. So far we have briefly presented the Jain view of the Universeand a few aspects of agreement with modern cosmology. More details, agreements and disagreements can be found in the articles by Rangarajan and others in this monograph.

4. Laws of Nature

Just as science leads to technology so does philosophical inquiry leads to ethical applications. Deeper is the metaphysical understanding, stronger is the ethical application. c rya Mah prajña said, "As one goes deep into reality, one loses one's own interest in the external world and as one loses one's own interest in the external world, one goes deep into the reality". Due to its deeper analysis of metaphysical realities, Jainism could evolve strong ethical principles and practices. Being emphatic on ethical issues, Jainism is recognized as an Ethical Realism. The ethical principles of Jainism are closely connected with the laws of nature. In the

search of laws of nature, thinkers have identified five causative factors, appropriate combinations of which control every process or event in the universe:

- ⊢ *K la* (Time)
- *Svabh va* (Nature of things)
- *Karma* (Principle of action and its consequences)
- + Puru? rtha (Self-exertion or effort)
- Niyati (Determinism/Destiny)

4.1 Time

In the four-parametric theory given by Mah v ra, four factors: the nature of substance, space, time and modes are considered important in explaining any phenomena. Like other factors time is not passive, it also affects cosmic processes. If the time is favourable, everything goes on smoothly. If the time is against then things would go wrong.

Metaphysically speaking, time is nothing but the change which takes place every moment in every object. The change of a single moment is subtle, inexplicable and invisible to common man. It can be experienced only by the extra-ordinary perception.

Samaya is the smallest indivisible unit of time. It is 'absolute' in the sense that the samaya is the same all the time and everywhere. Considering samaya as the smallest unit, other units of time have been fixed. The absolute, mathematical time starts with Samaya and ends with r?aprahelik , while the symbolic time units' starts with Palyopama and ends up with a time-cycle called one K lacakra or one set of Utsarpi? -Avasarpi? . Duration of one time-cycle (K lacakra) is 20 trillion S garas.

In the Indian tradition, whether it is Jain, Vedic or Buddhist, concept of time is regarded cyclic. But when time is analyzed in depth, it appears that time is both cyclic as well as linear. From the historical point of view time is cyclic, since the same era and events repeat after an interval. From metaphysical point of view time is linear. It is for two reasons: one, time has no expanse (dimension) in space, vertically or horizontally, and therefore, is called Anastik ya i.e. non-extended reality. It is a single unitary moment. The past moment is gone; the future moment is yet to come; only the present moment exists at all the times and therefore the past, present and future moments have no connection with each other. Each moment is separate and

independent of the other. Secondly, time is infinite. It flows continuously from the infinite past to infinite future. It means the moment which is passed is passed forever and will never return. Each moment is new. Hence, time is linear. Thus, Jain concept of time is cyclic as well as linear. Jains also believe in the eternity of time. As mentioned earlier, according to Jain philosophy, time did not begin with the creation of Big Bang as scientists postulate.

4.2 Nature of Things

The innate nature or natural qualities of an object also play an important role in occurrence of an event. Things work in a particular way because of innate nature of substance. It is the natural qualities of a seed due to which the plant produces particular type of fruits. Logic and effort made against the nature either fail or bring adverse results. A philosopher has rightly remarked, "svabh vet rkik h bhagn h" i.e. "The logicians fail before the nature".

4.3 Karma

The doctrine of karma deals with why and how every action affects the doer. The effect of any action depends on two things: 1. Intention or intensity of passions (*r ga* and dve?a: attachment and aversion) and the mode of the action. In what way and how long karmas affect a soul depends on the intention of the doer, while the type and quantity of karmas affect the soul, depending on the mode of the action. For example, one kills the other with extreme cruelty or bad intention. The karmas earned by the act of killing would affect the killer adversely for a longer time and with more intensity. Contrary to it, if a living being is killed by mistake or unintentionally, the effect of karmas will be mild and also for a short time. The theory of karma has been extensively dealt with in the vast literature known as Karmagrantha developed over the centuries in Jain tradition and is summarized in some accompanying articles which discuss the doctrine in context of modern biology and neuroscience (see accompanying papers by N.L. Kachhara, S. Tater, S. Jain, R. Jansma and others). To understand the core of spirituality in Jainism one need to know the theory of Karma.

4.4 Self-exertion

Without self-effort nothing is accomplished. To indicate the importance of self-exertion Mah v ra used five words: *utth na* (enthusiasm to do something), *bala* (force to execute the task), *v rya* (inner energy to achieve something), *purask ra* (efforts to materialize the goal) and *par krama* (action to accomplish something). To

achieve something one needs to make one or all five types of effort. Other factors may be dominant in some situations, but it does not mean that they become effective without putting any effort. For example, it is true that one who is born certainly dies. Death is inevitable with birth and therefore, is governed by the factor niyati, but how one dies depends on many other factors.

Being mainly a spiritual tradition, Jainism gives paramount importance to the law of self-exertion: free will, choice and action. According to it, the world consists of two realities: Living and non-living. In spite of being governed by the laws of nature, the living beings are different from non-living in many respects. The living beings have free will and choice of action which the non-livings do not have. By using the power of free will, choice etc. the living being can change the effect and duration of Karmas. The strong desires and rigorous practices to accomplish something special are the results of the free will of the living beings. Firm determination, commitment and resolution are also outcome of the free will, choice and action of the living beings. The fate of a living being is mainly governed by the law of self-exertion. In fact, karma is the result or reaction of the past action. The fate of living beings is governed mainly by the two factors: self-exertion and karma. Other factors are subordinates.

Without action karmic particles neither attach to the soul nor come into effect. The behavior of physical object is mainly governed by the laws of nature, while the behavior of a living being is mainly governed by his free will. In practical world even the non-living entities, especially matter, is affected by the will. For example, the bricks assembled by effort take the shape of house etc. Similarly, the oil is in seed but it comes out when the seed is crushed. Even the nature is directly or indirectly gets affected by human behavior. The world today is facing problems of global warming, ecological imbalance and environmental pollution mainly because of the consumerism and over-exploitation of the natural resources by humans.

Among the various causative factors the self-exertion or free will has its own importance. There are certain things, especially those which are amenable to change, can be changed or controlled by effort. Sometimes one can call it miracle or God's intervention. Jain view is that something appears as miracle till one does not know the concerning laws working behind it. There is no other way to achieve the goal than putting in efforts.

4.5 Determinism

Determinism is also an important factor in an occurrence. There are certain

things that are sure to happen and will necessarily follow. For example, one who takes birth necessarily dies. Everything that originates necessarily decays. There is no power which can hold or stop things decaying even for a single moment. Even cosmetic surgery cannot stop aging process of a human body. Similarly there are certain things which occur in a fixed pattern. For example, fertilization or non-fertilization of a seed is pre-fixed. To be eligible (*bhavya*) or not-eligible (*abhavya*) for liberation of a person is pre-fixed. There is no other law then destiny, which determines who will be liberated and who will not.

Sometimes in spite of putting all efforts, things do not occur in the way it is expected. Failure of efforts compels sometimes to believe in determinism as it is seen in the case of Ma?khal Go laka, a disciple of Mah v ra. Once Go laka was with Mah v ra and they were passing through a village named Siddh rtha. On his way, he saw a mustard plant and asked Mah v ra, whether the plant will grow or not? "The plant will grow and the souls of its seven flowers will be reborn as a plod with seven seeds", said Mah v ra. To falsify Mah v ra's prediction, Go laka uprooted the plant and threw it away. After an interval when he was returning with Mah v ra by the same route, Go laka found that the plants had grown. From that time, Go laka became a great exponent of determinism.

Mah v ra was not in favour of any absolutist approach to any of the laws of nature. His non-absolutist approach to the law of determinism becomes clear when he had dialogue with aka? Ia, a strict follower of determinism. He was of the firm belief that everything which occurs in the Universe predestined. Once Mah v ra asked him, "suppose all the pitchers, prepared by you, are destroyed by someone then what would you do with him? aka? Ia replied that he would beat up the person. "What is the fault of the person if the destruction of the pitchers is predestined? aka? Ia realized the limitation of the law of determinism and became a true follower of Mah v ra. Thus, the law of determinism has also its limit. It does not work anywhere and everywhere. There are other laws too which are simultaneously working in the universe.

5. Limitations of the Laws

If Universeis governed by the laws of nature, three questions arise:

- 1. What is the origin of the laws?
- 2. Are there any exceptions to the laws, i.e. miracles or supernatural phenomena?
- 3. Is there only one set of laws applicable everywhere?

These questions have been addressed differently by different scientists, philosophers and theologians. The answer to the first question in Jain perspective is that the laws are eternal since the Universeis eternal. If the Universewith all its complicated processes exists, it must be governed by some laws and the laws must be eternal. Hence, there is no question of the origin of laws; the laws are always there as part of the nature.

So far as the second question is concerned, apart from the aforesaid five factors the principle of uncertainty also works. There are certain things which cannot be predicted with accuracy beforehand. For example, the time between minimum and maximum time limit of a *param* ?*u* for coming from non-vibration to vibration state is uncertain and therefore, unpredictable. Mah v ra was asked about the minimum and maximum time a *param* ?*u* takes to come into motion. He said, "A *param* ?*u* takes minimum one moment (*samaya*) and maximum innumerable moments (*asa?khya samayas*) to come into motion". But he did not quantify the time it takes since it is unpredictable. A *param* ?*u* may get into motion even after two or three moments or more.

What follows from the above discussion is that Jainism posits two types of laws: Determinate/certain and Indeterminate/Uncertain. So, to say that all the laws of nature are fixed and determinate is not absolutely true. There are certain events which occur in a particular way are certain, but there are some events which are subject to indeterminacy or uncertainty. Even the omniscient cannot predict precisely about them.

The opinions of the western philosophers and scientists in regard to the second question have been sharply divided. Plato and Aristotle, the most influential ancient Greek philosophers, think that there can be no exception to the laws. As far as the biblical view is concerned, the Christians firmly believe that God has not only created the laws but can be appealed by prayers to make exceptions to heal terminally ill, to bring premature end to droughts etc. In opposition to Descartes' view, almost all Christian thinkers maintain that God must be able to suspend the laws to accomplish miracles. Even a rational scientist like Newton believed in miracles of sorts.

In Newton's view, the orbit of the planets would be unstable because the gravitational attraction of one planet towards another would disturb the orbits which would grow with time and result in the planets either falling into the sun or

being flung out of the solar system. God must keep on resetting the orbits or "wind the celestial watch, lest it runs down.". However, like the Jains denying the intervention of divine power and accepting the laws, Pierre-Simon marquis de Laplace (1749-1827) argued, "The perturbations would be periodic, that is, marked by repeated cycles, rather than being cumulative. The solar system would thus reset itself and there would be no need for divine intervention to explain why it had survived to the present day". Scientific determinism, formulated by Laplace, is now the accepted position. Given the state of the Universeat one time, a complete set of laws fully determines both the future and the past, excludes the possibility of miracles or an active role for God.

Recent studies apparently seem to suggest that it is our physical brain, which acts according to the laws, that determines our actions and not some agency like' soul' which is not governed by these laws. Yet the outcome is determined in such a complicated way and with large number of variables so as to make it impossible to predict human behaviour. It is impractical to formulate the underlying physical laws of human behavior. In such a situation, the psychologists adopt an 'effective theory' to explain human behavior.

In physics, an effective theory is a framework created to model certain observed phenomena without describing in detail the underlying processes. In the case of humans, since we cannot solve the equations that determine our behavior, we use the effective theory that people have free will. This effective theory is only moderately successful in predicting human behavior because decisions of a human being are often not rational. Sometimes they are emotional or are based on a defective analysis of the consequences of the choice.

6. Why this set of laws and not some other? why are the laws of nature so constant?

In answer to the question, why this set of laws and not others, it can be said that in Jain view, Time, Nature of Things etc. are only the laws which apply to all the systems and operate all the times. Their application can vary depending on the individual, geographical, temporal and situational conditions and, quality. To understand the application one needs to understand the Jain geographical concepts. In Jain view, the Universe(*Loka*) is very vast. It is divided into three parts: upper, middle and lower. The human beings live in the middle part. The application of the laws in human sphere is not the same. For example, the application of the law

of time differs in Bharata and in Airavata, in comparison to Mah videha of Jamb dv pa which is in the middle of the middle universe. In Mah videha the time always remains equivalent to fourth r (era). There is no ascending and descending order of time. Contrary to it, in Bharata and Airavata there are both ascending and descending orders of time having six types of r s.

7. Exceptions to the Laws

The laws of nature under discussion are universal. They are the principles which govern all the phenomena. Hence, in normal conditions there is no exception to these laws. Apart from these laws some randomness takes place and for that Jain philosophers have no answers. They call it wonder (*acher / carya*). Such wonders happen once in hundreds or thousands of years. In the long history of Jainism we find ten such wonders. They are, for example, a woman named Malli Kumari, becoming the 19th T rtha?kara or the birth of Rishabha in the third *r* to liberate and become T rtha?kara . Thus, in understanding and explaining any phenomena, whether it is a real object or laws, the Jain approach has always been non-absolutist.

All the natural laws can be broadly divided into two categories: 1) Metaphysical and 2) Rational. The metaphysical laws can again be divided into two categories: Determinate and indeterminate. The determinate metaphysical laws work all the times and everywhere. They are universal and eternal. The indeterminate laws vary from person to person since they are governed by the karmic laws, freedom of will, choice and action along with specific innate potentials of an object. The rational laws work mainly in the past and present times. If the initial conditions change, the consequences will automatically change. Many theories or laws based on scientific observations and experiments become outdated with new research, as more observations are made. With the invention of new theories the limitation of the existing theories becomes clear.

Many scientists presume that a law of nature is based on an observed regularity and can be used for predictions that go beyond the immediate situation upon which it is based. But, according to philosophers, all generalizations cannot be thought of as laws of nature. Some generalizations may be falsified in future and therefore, cannot be considered as laws. c rya Mah prajña endorses this opinion when he writes that all generalizations, especially rational ones, are not universal, since they may change in future. Philosophers are unanimous that most of the laws of nature exist as part of a larger, interconnected system of laws. The Jain canons

c r ?*ga* and *Da avaik lika* support it. Scientific laws of nature are usually formulated in mathematical terms. They can be either exact or approximate, but they have been observed to hold without exception if not universally, at least under a stipulated set of conditions. For example, Einstein felt an urgent need to modify Newton's laws when the objects were moving close to the speed of light. Yet Newton's laws are considered to be valid laws, for conditions encountered in everyday world, in which the speeds are far below the speed of light. We conclude by stating that the laws, discovered by omniscient or the universal observer are eternal while the laws, discovered by the logicians or philosophers, may be subject to change in future.

8. Conclusion

In concluding remarks, it can be said that to know the reality, whether it is law of nature or any phenomena, one needs to observe the reality as such without any pre-supposition or bias. The truth itself reflects in unbound pure consciousness. The omniscient, yogis, seers, sages, and saint-philosophers use this technique to observe the realities: empirical and transcendental. As a result, they could discover some laws applicable under all conditions and everywhere. They have not only created this new knowledge but on the basis of this knowledge they have also evolved such ethical principles and practices which are equally universal and are necessary to create a harmonious and peaceful world-order. Clearly, one presupposition of this article is that the Universeis not of our making. It is selfmade, ever existent and regulated by its own laws. The Universeis eternal and not a construct of mind or consciousness or any Supreme Being. It works in a particular way as explained in this paper. *Given the sheer size of the universe, the human effect on it is infinitesimal.*

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- 20. Ibid 1.191-199, p 35-...esa ?am poggale t tam a?antam s sayam. ...esa ?am j vet tam a?antam s sayam samayam bhuv ti vattavvam siy.
- 21. Ibid 1.133-138 pp 27-28-...atthittam atthitte pari?amai natthittam natthitte pari?amai....
- 22. Ibid 2.45 p.87– na kay i na bhavissai bhavinsu ya, bhavati ya, bhavissai ya dhuve niyae s sae akkhae avvae ava?hie, nice, natthi pu?a se ante.
- 23. *?h ?am* (VS 2033), ed. c rya Mah prajñ , Jain Vishva Bharati, Ladnun, 2.1, p.35. Jadatthi ?am loge tam savvam dupao ram, tam jah j vacceve aj vacceva. Tasaccev th varacceva....
- 24. c rya Mah prajña, *Jaina Dar ana Manana Aur M m ms* (1995), Adarsh Sahitya Sangh Prakashan, Churu, pp 233-250.
- 25. The Grand Design, p.26
- 26. *Bhagava* 1.20, pp 36– Savve te uppa??an ?a-dansa?adhar , arah ji? keval bhavitt t ao pacch sijjhanti, bujjhanti, muccanti parinivvayanti savvadukkh ?amantam karensu v , karenti, karssantiv .
- 27. The Grand Design, p.17
- 28. Bhagava 11.110; 20.62-63
- 29. Ibid 2.122, 123 p.113-Goyam !Addh ijjadiv , do ya samudd , esa ?am evaie samayakhetteti pavuccati.
- 30. *The Grand Design*, pp 8-9
- 31. c r ?gabh ?yam, ed. c rya Mah prajña, Jain Vishva Bharati, Ladnun, 1st edn. 1994, p.169.
 Yath yath sam y ti samvittau tattvamuttamam, Tath tath na rocante vi?ay ? sulabh ? api
 - Taul taul natocante vi/ay / sulabil / api
 - Yath yath na rocante vi?ay ? sulabh ? api,

Tath tath sam y ti samvittau tattvamuttamam

32. *Sanmati Prakara?a* of Siddhasena Divakar (1st edn. 2008), Tr. Dhirajalala Dahyalala Mehata, Surat: Jaina Dharma Prasarana Trust, 3.53–

k losah vaniyai, puvvakayam purisak ra neganta/

Micchattam te ceva uvvam, sam sao hoti sammattam//

33. Ibid 11. 128-se ?am samayatthay e valiyatthay ej vaussappi?itthay e....; (ii) 6.132-134 pp 257-260-

...visams garovamakod kodiok loosappini ussapini ya.

- 34. c rya Tuls , *Illuminator of Jain Tenets*, 2.1, p.1–....opac rikam dravyamasau.
- 35. *That Which Is (Tattv rtha S tra)* (1994), tr. Nathmal Tatia, London: Harper Collins Publishers, 5.39, p.14–so'?antasamaya?.
- 36. Stephen Hawking and Mlodinow Leonard (2010), *The Grand Design*, New York: Bantam Books, p. 51.
- 37. Bhagava 1.174-Goyam !a?hakammapaga?iopa??att o....
- Ibid 1.146 p 28–evam sati atthi utth nei v , kammei v , balei v , V riye v , purisakk ra-parakkamei v .
- 39. Sanmati Prakara?a of Siddhasena Divakar (1st edn. 2008) 3.43– duviho dhammav o, aheuv o ya heuv o ya/ tattha ya aheuv o, bhaviy bhaviy dao bh v //

40. Bhagava 15.75 p.669-

tae?am tassa Gosalassa Ma?khaliputtassa te satta tile

ganama?assa ayameyaruve ajjhatthie cintae patthie manogae sa?

kappe samuppajjith - evam khalu savva j v vi

pau??aparih ram pariharanti-'esa?am Goyam !

Gos lassa Ma?khaliputtassa pautte',

esa ?am Goyam !Gos lassa Ma?khaliputtassa mama, antyao yaeavakkamane pa??atte.

- 41. Uv sagadas o7.25-27
- 42. Ibid 5.169–param ?upoggale ...jaha??e?am egam samayam, ukkose?am asnkhejjamk lam evamj vaanantapadesio.
- 43. The Grand Design, p. 30
- 44. Ibid, p. 30
- 45. Bhagava 2.125-se sam sao pañcavihe pa??atte, tam jah davvao, khettao, k lao, bh vao, gu?ao.
- 46. ?h ?am 10.160, p. 947-dasa accher ya pa??att ...itthitittham... ka?hassa....
- 47. *Ac r ?gabh ?yam* 1.39 p. 47– ?eva sayam logam abbh ikkhejj , ?eva att ?am abbh ikkhejj , je loyam abbh ikkh i, se att ?am abbh ikkhai, je att ?am abbh ikkhai, se loyam abbh ikkhai. (ii) Tattv rthas tra 5.21 p.131–Parasparopagrahoj v n m.....

2. Sy dv da and Anek ntav da in the Modern Scientific Context

Narendra Bhandari and Surendra Singh Pokharna

Abstract

Anekantavada, the Jain doctrine describing the real nature of all objects (*dravyas*) in the Universe, states that everything, living and non-living, has an infinite number of modes (*pary ya*) which coexist but are manifested under different conditions at different times. Thus the nature is multifaceted and multilayered. One may observe a thing or situation from a particular perspective at a particular time but that does not describe it completely; each view only explains one aspect of it. Some of these descriptions may prima facie be mutually inconsistent or even contradictory, but different views are complementary and, all together, give a more wholesome understanding of the true nature of the object.

Syadvada emphasizes that every statement is only partly true and must be qualified by its context or perspective. One may visualize a given thing or situation from any one of the standpoints (*Nayas*). Since no description is complete or wholly true, it must be qualified by the statement that " in regard to same contexte (syat) it is like this". The only statement one can, therefore, make with certainty is that no description is certain or complete. *Sy dv da* thus defines the limits of knowledge and can be called the principle of contextual perspective. In this article we show that the doctrine of *Syadvada* can be compared with the Gödel's Incompleteness Theorems which postulate that knowledge about the nature of reality has severe limitations. It is discussed in relation to human understanding which is neither deterministic, nor random but is non-computable as proposed by Penrose.

Jainism postulates that there are three types of knowledge: Known, Unknown and Unknowable. Whereas 'unknown' can be converted into 'known' by study of an object, unknowable can never be known, at least by sensory organs or mind, and can only be experienced by consciousness. Combinations of these three aspects of knowledge about an object, i.e. the 'known', 'unknown' and 'unknowable' give rise to seven (and only seven) states of predication termed as *Saptabha?g*. The modern concepts of statistics and probability are incorporated in these seven possibilities.

The concepts of *Sy dv da* and *Anekantavada* have enormous scientific importance, specifically in relation to the principle of complementarity, quantum mechanics, wave-particle duality, logic, probability and statistics which are discussed in this article.

In addition *Anekantavada* has found practical applications in personal, family and social relations and has led to the concepts of tolerance, compromise, forgiveness, and mutual respect for each other's views and is essential for harmonious living.

Key Words: *Anekantavada, Syadvada*, indescribability, Wave-Particle duality, *Saptabha?g*, *Naya*, Probability, Statistics, Paradoxes

Scriptures Quoted: Bhagavat, Samayasara, ptam m ms

1. Introduction

The conceptual origins of *Anekantavada* can be traced back to the fundamental Jain doctrine that everything in the Universe, except soul (*atma*) and *parama?u*, is an aggregate (*skandha*), consisting of two or more constituents. Two things can combine in multiple ways and can exhibit multiple properties, at different times, under different conditions, leading to multiple modes. Only soul can be in a pure state and therefore it can exist in this state forever, but when the soul becomes impure by combining with karma particles, it becomes *jiva* (living being) and *jiva* can take many forms, depending on the state of karmas.

Every object possesses many properties which coexist, without interfering with each other, and only a few manifest at some time and others remain latent till the right conditions arise. It is therefore not possible to know all the aspects of its nature. This theory of multiplicity of nature of an object has been called anekantavad, and it has been variously described as multifacetedness, multidimensionality, relativism, non-equivocality, pluralism, contextuality, non-one sidedness, non-absolutism etc. Acarya Amritchandra (~10th century CE) described *Anekantavada* in the following way.

"Any real object in the world is existent (*sat*) as well as non-existent (*asat*), one and many, eternal (*nitya*) and non-eternal (*anitya*), describable (*abhilapya*) and

indescribable (*anabhilapya*), neither this nor that, but both, i.e. this as well as that, in terms of its nature, time, space, material and mode (*svabh va*, *kala*, *k?etra*, *dravya* and *bhava*)".

The principles of *Anekantavada* and *Syadvada* have found practical applications in almost all spheres of life such as personal, family, social and political (national and international) relations and led to the concepts of mutual respect, compromise, tolerance and forgiveness for each other's views and is essential for coexistence and harmonious living. These aspects have been discussed by Acarya Mah prajña (2010), Mookerjee (1994), Samani Shashi Pragya (2014) and others in numerous books and articles. Here, we mainly discuss the concepts of Jain philosophy in relation to the principles of knowledge, complementarity, quantum mechanics, wave-particle duality, probability and statistics. The social aspects are mentioned only briefly.

1.1 Historical Background

The concept of multiplicity of modes is the foundation of Jainism and is probably as old as Jainism itself. It developed into a full grown theory of Anekanta over time and occupied the central place in Jain philosophy. Several other concepts, e.g. Syadvada "conditional description", Nayavada "specific viewpoints", *Saptabha?g* (seven modes of existence) etc. arose from it as a result of the teachings of Mahav raz (599-527 BCE), the 24th Jain T rtha?kara.Vibhajyavada is perhaps the earliest phase of the Anekanta doctrine and is mentioned in S trakrita?ga (1.14.22) where Mah v ra instructs his monks that, since they have taken the vow of truthfulness, they should not explain anything without qualifying it with the word "syat" (in some context), otherwise the statement will become false. Everything must be explained by resorting to Syadavada, or by division of issues (vibhajjav yam ca viy garejj). Later on Nayavada (the contextual view point) was developed and concepts of Saptabha?g and Syadvada are found in Bhagavat Sutra (XII. 10.211-226). Although these concepts were integrated into the well developed theory of Anekantavada much later, they formed the subject-matter of Asti-Nasti Pravada, containing teachings of the T rtha?karas prior to Mahav ra, which had long been forgotten and lost.

The earliest reference to Syadvada occurs is the writings of Bhadrabahu. It is not clear if it was Bhadrabahu I (433-357 BCE) or Bhadrabahu II, who lived around 375 CE. Syadvada is also mentioned in the Ny yavatara of Siddhasena Divakara

(about 480-550 CE). A little later Samantabhadra (about 600 CE) gives a full exposition of the seven parts of *Syadvada* or *Saptabha?g* in his treatise ptam mams .It is clear from ptam m ms that *Syadvada* was well developed by the sixth century CE. It is the subject matter of Syadvadamañjar written by Mallisena (1292 CE). Vimala Dasa's Saptabha?gitara?gi?i and other commentaries throw light on the importance these ideas received during the medieval period of Indian logic; For over a millennia, the Jain logic based on Anekantavada, *Syadvada* and *Saptabha?g* provided the foundation of Indian logic, though remained in isolation, till scholars like J.B.S Haldane (1957) and P.C. Mahalanobis (1954,1957) realized their importance in terms of theory of statistics and probability and D.S. Kothari (1985) found its predictions in context of wave-particle duality similar to the solutions given by the quantum theory. G.N. Ramachandran (1980, 1982, 1983), in a series of papers used Syad Nyaya System (SNS) for developing computer logic and worked out a new formulation of Sentennial Logic and its isomorphism with Boolean Algebra. Some of these aspects have been discussed by Jain (2007, 2011).

2. Limits of Knowledge: The Jain View of Unknowability

The main question is whether everything can be known about everything or knowledge has any limitations. Science divides knowledge in two parts: known and unknown. As an object or phenomena is studied, unknown becomes known, and eventually, everything becomes known and nothing remains unknown. In contrast Jainism postulates that the knowledge is of three types: Known, Unknown and Unknowable, as schematically shown in Fig. 1. Whereas unknown can be converted into known, unknowable can never be known, by sensory organs or mind, and can only be experienced by consciousness. The perception of sensory organs (and mind) have limitations, because they are not perfect and always in a state of learning and improvement, but this is only a trivial reason. The main reason is that everything does not manifest all its aspects (modes) at once, but they are manfested as and when conditions become appropriate, depending on context, cause, interaction with environment, time and place, etc. as discused in an accomanying article (Samani Chaitanya Prajna, 2017).

It has been realised, in view of recent developments in modern scientific logic that knowledge has severe limitations. To illustrate the point, we cite two examples here. Because of the finite velocity of light, we are able to observe only



Fig. 1. Science view of knowledge having two components, known and unknown, represented by a liner relation (left). Any object lies somewhere on this line. This view is compared with the Jain view of complete knowledge of any object which has three components, known, unknown and unknowable (right). Any object is located somewhere in this triangle. The knowledge of a kevali (omniscient) lies at the left bottom corner of this triangle, where everything is known, and nothing is unknown or unknowable about the object. (Avyakta) represents unknowable or indescribable aspect of the knowledge.

the part of the universe, defined by the distance light has travelled over the age of the universe. The velocity of light is about $3x10^8$ meters per second and the Universe about 13.4 billion years $(4.2x10^{17} \text{ seconds})$ old. Light from beyond $\sim 1.3x10^{23}$ km can not reach us and we are not able to observe what lies beyond the visible Universeoutside a distance of $1.3x10^{23}$ km. If the Universe is infinitely large, then much of it lies beyond this limit and we see only a small part of it. We take the second example of our brain. As we learn about our brain, this information itself evolves the brain and we will never be able to know the state of the brain completely; we can only know its previous state before we examined it. Such a case has given rise to Cantors paradox of infinite sets, in which a set cannot contain all the sets (including itself). We consider two other simple cases here: an electron and water. An electron, for example, has mass, charge, spin, magnetic moment etc. but by observing these properties we can never find out that electron sometimes

3. A brief introduction to these scientists is as follows: J.B.S. Haldane, a British biologist, originally at University college, London, settled in India, made important contributions to genetics and origin and evolutionary theories of life. G.N. Ramachandran, a molecular biophysicist is credited with the discovery of triple helical structure of collagen and many proteins. Roger Penrose, a famous cosmologist is known for his contributions to General Relativity, quantum mechanics and neurophysiology. Kurt Godel is known as a brilliant mathematician. P.C. Mahalanobis, a famous statistician was founder of Indian Statistical Institute. D.S. Kothari was a theoretical physicist of repute and educationist. and was Head of the physics Department at Delhi University. He served as Adviser to the Minister of Defence and Chairman of the University Grants Commission.

behaves like a wave. Similarly water has molecular structure, certain chemical composition and its boiling point, freezing point etc. are well defined. However, it also has other properties because of which it is so critical for life processes. Simultaneously it has interesting effects on the human body under different circumstances. Hot water makes one feel good in winter but cold water gives good feeling in summer. One can never quantify or write down all the properties and effects of water; some properties, like how much thirst it will quench, will always remain subjective, hidden and come into play at appropriate time. Thus it should be realized that whenever one is describing properties of electron or water, then due to limitation of language in expressing knowledge and their context, it is not possible to describe all its aspects.

3. Modern View of Knowledge

We now discuss the work of a few scientists³ in context of the Jain principles cited above. According to Heisenberg's Uncertainty principle the measurement of energy and time can not be made with precision and there will always be some uncertainty delta, defined by (DE x Dt = h/2) where h is Planck's constant. The laws of physics do not work below a scale shorter than Planck length= \ddot{O} (h_c/2 c³) =1.6 x 10⁻³⁵ meters and Planck time= \ddot{O} (h_c/2 c⁵)=5.4x10⁻⁴⁴ seconds.

As discussed below, in Godel's Incompleteness Theorems, any methodology to understand reality has limitations (See Pokharna, 1977) where these theorems are discussed in light of *Syadvada* and *Anekantavada*). In fact there is much in common between Incompleteness theorems developed during the past century and *Syadvada*, propounded at least 2600 years ago. In view of such limitations, any decision must be based on the multidimensional aspects of nature and latent, not yet manifested, aspects; otherwise it will lead to erroneous outcome.

3.1 Knowledge and Gödel's Incompleteness Theorems

We generally have the impression that mathematical representation, e.g. formulae describing various scientific facts make our knowledge more precise and accurate. This may be true, but precision and accuracy is obtained at the cost of completeness. Formulation of any observation makes knowledge incomplete as its aspects which can not be formulated are lost. Kurt Gödel has shown that mathematical representation of any physical reality limits and actually reduces our knowledge of that reality. Complete knowledge must necessarily have its foundation in an unexpressed, unmanifested field of intelligence. Similarly, we do

not know what an electron really is: a particle or a wave or something else which sometimes manifests as one and sometimes as the other.When electron is observed by a particle detector, it materialises and the other aspect, which was coexisting with it, is lost for ever. It also happens the other way round, i.e. when it is observed as a wave. Thus observation also leads to loss of information.

The two theorems proposed by Gödel are:

- 1. If the system is consistent, it cannot be complete, and
- 2. The consistency of the axioms cannot be proven within the system.

These are briefly explained below.

3.2 Gödel's first Incompleteness Theorem

This theorem states that the truth of a formalism (which describes any phenomenon) cannot be proved. Thus no finite expression of mathematical knowledge can ever provide a basis for comprehensive knowledge even of elementary properties e.g. of the counting numbers. If one starts with a collection C of symbolic mathematical (or any other) axioms which is specifiable by a finite number of mechanical rules, and if C is consistent, then there will be a true statement about the counting numbers which cannot be proved from the axiom C, using the standard rules of mathematical logic. The proof of this theorem shows that from C one can construct a sentence S in simple mathematical language of elementary number theory whose meaning is: "This sentence is not provable from C". Once S is constructed it follows easily that S must be true but not provable from C. Thus on the basis of any finitely specifiable collection of axioms C, one cannot prove all true propositions about the counting numbers.

3.3. Gödel's Second Incompleteness Theorem

A formal language (mathematical or any other), if consistent, cannot define its own truth i.e. the definition of truth for a theory must be of a higher order than the theory itself. We can say that the consistency of any specifiable collection of axioms can never be established on the basis of mathematical arguments which can be justified by these axioms. Thus to establish the validity of any single mathematical system one must necessarily utilize a more comprehensive system; to validate the latter system one has to investigate an even more comprehensive system.

These two theorems clearly show a need for a concept of consciousness

which may provide a better description of reality. It is consistent with the Taoist maxim that truth can never be written down or expressed in words and whatever can be expressed is not the truth, at least not the complete truth.

4. Anekantavada: Theory of Multiple Manifestations of Reality

All living beings and non-living things are interconnected (or entangled) with each other in a highly dynamic way, according to the Jain theory of mutual dependence, aptly described by the aphorism "*Parasparopagraho j vanam*". The Universeis made of different parts which are influencing each other through complex interactions. Thus in a brain, various thoughts interact among themselves and one or a few thoughts dominate at any given instant. After some time, some other thoughts dominate one's mind. So decision taken on the basis of the first set of thoughts may not be meaningful at a later time. Hence, consistent with the concept of *Syadvada*, a certain decision taken on the basis of an instantaneous impulse considering only the present state may not be a correct decision. A correct decision should take into consideration all possibilities including those, presently hidden and indescribable, which may manifest in future. Such a balanced decision will be more lasting and fruitful. In this context, simulation studies which consider some probable scenarios are desirable.

In Jain view of *Anekanta*, reality is varied and variegated and encompasses all aspects of life. There can be multiple ways, views and approaches to comprehend reality. Each view is incomplete in itself but different views complement each other and, together, they give a more wholesome understanding of reality. However, it is not possible to describe anything completely, because number of modes in which a given "thing" can exist are many, very large or even can be infinite.

4.1 Nayavada

Anekantavada has essentially evolved from Nayavada which can be defined as perspective from different stand points. It is based on the fact that all objects in the Universe possess a large number of modes of existence (*paryaya*). One may visualize a given thing or situation from any one of these stand points or modes (nayas). There are several nayas such as *sa?graha naya* (holistic view), *vyavah ra naya* (practical view), ni caya naya (definate view), rijus tra naya (current view), naigam naya (teleological view), *abda naya* (synonymous view), *samabhir ?ha naya* (etymological view), and *evambh ta naya* (pragmatic view). To these *nayas* can be added the philosophical view, scientific view etc. Each of these views holds good only in a limited context, i.e. these views are valid only under certain conditions and do not describe a particular thing or situation in totality or in an absolute sense.

In view of the above discussion, Anekanta has been variously interpreted as the theory of many-foldedness, multi-facetedness, multi-layered, multi-sidedness, multi-perspective view, contextuality, pluralism, co-existentialism, nonabsolutism, non-equivocality and relativism. S. Mookerji (1994) calls it the theory of non-one sidedness, implying the many sided nature of reality. We prefer to call it theory of multiple manifestations. In the physical world, as in the philosophical domain, things or ideas have plurality of attributes, with some in agreement, some indifferent and some apparently contradictory or conflicting with others. Anekantavada successfully takes a synergetic view, and assimilates them and establishes harmony amongst the various views. Considering them together in totality, gives us a more complete description of the true aspect of reality. Thus, according to Anekanta, each standpoint should be considered only as partial truth that holds good in relation to a particular context. Thus, different contexts or perspectives depend upon or are related to physical as well as the mental frames of reference of the knower (or observer) and hence Anekantavada has also been termed as Relativism. Because of the usage of the term "relativity", Anekanta is sometimes, and erroneously, compared to Einstein's theory of relativity. Hence we think it necessary to clarify that such a comparison is not appropriate, and the similarity is only valid to a limted extent.

4.2 Comparison with Theory of Relativity

In the Special Theory of Relativity (STR) the parameters of motion of an object (velocity, time, spatial dimensions) depend on the frames of reference of the observer and the object, their motion (or acceleration) relative to each other. If one is looking for similarity between the special theory and *Anekantavada*, it can be said that knowledge about an object depends on the perspective of the observer, i.e. his frame of mind. To extend the analogy further, as envisaged in STR, time and space (and motion) are not absolute, so also in *Anekanta*, description of the nature of a thing is not absolute but relative. Thus as far as the question of similarity between *Syadvada* and Special theory of relativity is concerned, we can say that the perceived knowledge of an object depends on the mental frame of reference (or perspective of the observer), just as the perceived motion of an object in STR depends on

dynamical frame of reference of the observer. For this reason, in Jain philosophy *Anekantavada* is termed as relativism. We feel that only to this notional extent, anekantavad and Relativity have a common approach. In essence, their subject matter and domains are very different and no further similarity is warranted.

4.3 Inherent Uncertainty in a Description

It is clear from the above discussion that when any of the naya propositions or standpoints are stated categorically with certainty, i.e. "this is it" and is claimed to be absolutely true, actually the statements turn out to be false. Sometimes *Anekantavada* is contrasted with *Ek ntav da* (monism), the latter standing for a particular or definite and categorically well defined philosophical position. Such an emphatic assertion, as discussed above, would not only be incomplete but also incorrect. To describe it differently, *Anekanta* always denies universality of a law. Thus there is always an uncertainty or incompleteness and absence of universality in every proposition.

Anekantavada can be practically demonstrated through a Buddhist parable as follows. A Buddhist monk in China was approached by the king who lamented that the Buddhist philosophy is very complicated and asked the monk to express its essence in a simple way. The monk sought a day's time to explain it. The monk fixed mirrors at various angles on all the sides of a hall, its floor and ceiling and installed Buddha's statue in the centre. The mirrors reflected infinite views of the Buddha. He invited the king to see for himself and explained "The essence of Buddhism is that the whole Universe represents multiple reflections of the self (Buddha mind)". This anecdote amply demonstrates the philosophy of anekanta. One gets infinite views of the same reality, depending on how the observer perceives it and not all the views can be seen simultaneously, at a given instant of time. This is the essence of Anekanta.

4.4 Anekantavada and the Physical Reality

Anekanta is not merely a philosophical doctrine but is deeply rooted in physical reality, giving a correct description of nature of things. Science, in comparison, gives only a partial description of objects depending on what is being observed and the technique employed for the observation. Yet, to understand the principle of *Anekantavada* scientifically, we take recourse to quantum physics. As already mentioned above, it has been shown experimentally that a photon or

electron (or any elementary particle) sometimes behaves as a solid material particle, like a grain of sand, and sometimes as a wave, similar to the ripples that are created on the surface of water in a pond when a stone is thrown on it. They manifest as a particle or a wave depending on the experiment one sets up, or essentially what an observer wants to observe. Each experiment, thus, gives only a partial view and all views taken together take us nearer to the real nature of the "particle".

4.4.1 Gross (Macro) and Subatomic (Micro) Worlds

Physics divides the Universe into two parts, the gross (macro) and subtle (micro). The macro world (galaxies, planets, rocks, dust and the objects that can be seen with unaided eyes) are governed by laws of classical physics. Micro-world (atoms, elementary particles etc. that cannot be seen without employing a magnifying device, such as an electron microscope) are governed by the laws of quantum mechanics. The laws of classical and quantum mechanics are quite different. We note that the gross matter has only a limited number of properties. For example, things we see around in daily life exhibit only a few properties like weight, volume, shape and colour. Even though the gross matter is made of protons, neutrons, electrons etc., their existence cannot be perceived directly. As we closely examine these subtle entities of matter constituting the micro-world, they exhibit additional properties, such as electric charge, magnetic moment, wave-particle duality etc. The essence of this discussion is that in the domain of elementary particles, as one goes to finer and finer constituents of matter (from atoms, to protons, to quarks, and so on), it exhibits increasingly newer and more complex properties or attributes (quantum states). It is difficult to perceive all of these attributes in gross matter, although they coexist in it all the time. It is not possible to comprehend or quantify all these states at all times, because they manifest differently at different times under different situations. This is the true nature of reality. According to Jain concept of matter, as we go down in size, param ?u, the smallest particle of matter (which is not the same as "atom" in modern physics), may have infinite attributes that are impossible to comprehend. This is neither a limitation of the instruments (or the technique employed for measurement) nor a limitation of the experimental prowess or analytical ability of the observer (consciousness), but is due to the inherent nature of things which

^{5.} This principle of contextual uncertainty has nothing in common with the Heisenberg's Principle of Uncertainty in physics and should not be confused with it.

^{6.} tksl nkfu; e dkfu"ksk djrkg\$vk\$jfuikr: i lsfl) g\$mlsL; kr-dgkx; kg& og oLrpdksl ki{kfl) djrkg&

prevents them to exhibit all their properties simultaneously at any given instant of time. Understanding the true nature of an entity requires consideration of all of its attributes that represent the manifold aspects of its existence (*paryayas*) for a complete description.

4.5 Anekantavada and the Principle of Complementarity

Scientifically, the closest approach to understand *Anekantavada* is by the "principle of complementarity", which is also the cornerstone of modern physics. Complementarity is quite a revolutionary and significant concept in quantum physics. Neils Bohr, who propounded the basic principles of quantum mechanics, had difficulty in explaining the behaviour of certain particles in the micro-world, particularly the observed phenomenon of particle-wave duality.

The phenomenon of particle-wave duality apparently seemed contradictory to common sense since it was presumed that a photon or an electron should be a solid material particle and cannot be a wave which is just a vibration. Certainly it cannot be both. Bohr explained this seemingly contradictory behaviour by stating that particle and wave are two complementary, albeit contradictory, aspects of their true nature. He used the Chinese concept of Yin and Yang, which have opposite characteristics (colour, orientation, eyes etc. of the fishes) but coexist and both are required for the sake of completeness. Anekantavada goes a step further and states that it is not just the duality (such as particle and wave nature of the elementary particles) which needs to be explained but many (aneka) or even infinite modes of behaviour that are manifested when one goes to more subtle, smaller constituents of matter, ultimately to the level of indivisible param ?u. To illustrate this point, Kothari (1985) considered a particle in a box and divided the box in two compartments A and B. If one then asks the question "In which box the particle could be", one gets a number of answers. We will take up this example later on in context of Saptabha?gi.

Anekanta not only accommodates but takes a synergetic view between seemingly contradictory propositions in several aspects of daily life, philosophy, micro-world, mental perception as also in the spiritual domain. It also leads to the concept of *avyaktavya* or inexpressibility of certain states. Science has progressed on the assumption that everything is logical and expressible and does not permit inexpressibility of any characteristics. In contrast *Anekanta* emphasizes that some of the aspects can, however, be indescribable or inexpressible. Questions which



Fig. 2 Particle in a box

cannot be answered unambiguously, either in the affirmative or negative, such as the existence of soul, can be dealt within the framework of inexpressibility. In essence, Anekanta is a multi-view perception which does not arise due to limitations of consciousness to perceive all the aspects of the physical world completely, but represents the true behaviour of things.

Anekantavada has many consequences for its practical application and we discuss two of them, Syadvada and Saptabha? gi here.

5. Syadvada and Contextual Relevance

Syadvada is based on the concept that nature is a multi-layered system and is a consequence of the fact that part of the truth (property) invariably remains latent and thus indescribable. In other words, one can state that all aspects of reality are contextual and there is no unique, absolute, complete truth although some element of truth exists in every proposition of reality. One may be closer to the truth when one qualifies a particular perspective by saying that perhaps this perspective too may be correct. It does not mean any doubt, confusion, ambiguity, or uncertainty but makes our understanding as wholesome and certain as it can be. Since all propositions are contextual, the only statement one can make with certainty is that no proposition is absolutely certain. This is the way one can define *Syadvada* or the Jain Principle of contextual uncertainty.⁵ We would like to emphasise that it is not *San ayavada* or doctrine of confusion or doubt but is a doctrine of truth.

Syadvada proves the relativity of predication. This is best illustrated by the Jain parable of an elephant and the six blind men, each of whom look at different parts of the elephant, i.e. legs, trunk, tail, ears, body, and tusk and describes it differently, i.e. as a pillar, branch of a tree, rope, hand fan, wall and solid pipe, respectively. The problem was resolved when a wise man explained to them that the elephant has all these features and they all are partially right and none is completely correct. We conclude this discussion by defining what exactly *syat* means. The one

which always contradicts a universal law and applicable in all circumstances is called syat⁶. This rule is infallible, it is claimed, although such a statement contradicts the rule itself.

6. Saptabhang: Seven Modes of Predication

Saptabha?gi, literally meaning seven modes of existence, is a practical application of Syadvada which states that every "thing", living or non-living, can exhibit seven modes of manifestation These seven modes of *Saptabha?gi* are :

The dialectic of sevenfold predication (Saptabha?gi)

- (1) May be, it is;
- (2) may be, it is not;
- (3) may be it is and it is not;
- (4) may be it is indescribable;
- (5) may be it is and yet is indescribable;
- (6) may be it is not and it is also indescribable;
- (7) may be it is and it is not and it is also indescribable.

6.1 Saptabhangi and Wave-Particle Duality

The existence of these seven states of elementary particles can be demonstrated by the phenomenon of particle-wave duality exhibited by an elementary particle (say an electron) at a particular instant. Both Saptabha?gi and quantum mechanics are characterized by seven possibilities, viz. It is a particle; it is a wave; it is a particle and yet it is not just a particle (indeterminable); it is a wave and yet it is not just a wave (indeterminable); it is neither a particle nor a wave; it is both, a particle and wave; and its state is indeterminate. This has been succinctly explained by Dr. D.S. Kothari in terms of quantum mechanics in his essay on "Complementarity principle and Eastern philosophy" through the example of a particle in a box which is divided into two compartments (A and B) by a partition with a hole in it. In accordance with the particle-wave duality, the particle can either be in compartment A, or in compartment B, in A and still not only in A, in B and still not only in B, neither in A nor in B but somewhere else (outside the box), in A as well as in B and in an indeterminate state (avaktavya). The same scenario emerges from quantum mechanical considerations, as has been shown mathematically by considering wave functions that describe the behaviour of the particle.

Again, for an electron behaving as wave as well as particle, one can think of the following seven possibilities:

- 1. May be Electron is a wave.
- 2. May be Electron is not a wave (but a particle).
- 3. May be Electron is both a wave and a particle.
- 4. May be Electron is indeterminate.
- 5. May be Electron is some times a wave but its real nature is indeterminate.
- 6. May be Electron is sometimes a particle and its real nature is indeterminate.
- 7. May be Electron is both, a wave and a particle and its real nature is indeterminate.

Thus *Saptabha?gi* introduces the concept of indescribability (*avyaktavya*) which states that some of these seven states are indeterminate. This concept of *avyaktavya* is scientifically somewhat intriguing as it means an indeterminate, indescribable or unmanifested state. If we further extend this approach, following Haldane, Mahalanobis and Ramachandran we find that *Syadvada* can have applications in probability, statistics and logic, briefly discussed below.

7. Syadvada and Probability

Since for every object seven states are probable, each state has a finite probability of existence. Thus the concept of probability is ingrained in *Saptabha?g*. According to the modern experiments, an electron may exist in any form but it materialises as an electron ($P_{electron}=1$) when one observes it by a particle detector. Again it is detected as a wave ($p_{wave}=1$) only when one sets up an experiment to observe it as a wave. Probability (p) is inherent in the concept of *Saptabha?gi*, even while not considering indescribability. When we assert that a thing exist (p=1) as well as it does not exist (p=0), it is automatically implied that it has a value in between (p= 0 to 1). In fact if we include indescribability, then p belongs to a three valued (dimensional) system and value of p can be anything. Mahalanobis (1957) mentions that "There are certain ideas in Indian-Jaina logic called *Syadvada* which seem to have close relevance to the concept of probability, and supply a convenient backgroundon the foundations of statistics " and makes several points which may be summarised as follows.

1. The seven categories, defined by *Saptabha?gi*, are necessary and also sufficient and exhaust all the possibilities of knowledge. "... the fourth category out of the seven categories, is a synthesis of three basic modes of "it is" (assertion), "it is not" (negation) and inexpressible or indefinite, or "indeterminate" (which itself is resolvable into either "it is" or "it is not") and provides the logical foundation of the modern concept of probability". *Syadvada* differs from the probability theory in one respect; in the modern probability theory, the sum of all probabilities is unity whereas in case of *Syadavada*, which is more general, some indeterminism, which is inbuilt in nature, always remains.

2. "A real is a particular which possesses a generic attribute". This is very close to the concept of an individual in relation to the population to which it belongs. The Jain view, in fact denies the possibility of making any prediction about a single and unique individual which would be also true in modern statistical theory.

3. There is an emphasis in Jain philosophy on the relatedness of things and on the multiform aspects of reals which appear to be similar to the basic ideas underlying the concepts of association, correlation and concomitant variation in modern statistics. Mahalanobis brings in stochastic processes also when he writes "The Jain view of "origination, persistence and cessation" as the fundamental characteristics of all that is real necessarily leads to a view of reality as something relatively permanent and yet relatively changing which has a flavour of statistical reasoning. "A real changes every moment and at the same time continues" is a view which is somewhat sympathetic to the underlying idea of stochastic processes". In *Syadvada*, the qualification "*syat*" that is "may be" or "perhaps" must be attached to every predication without any exception. Hence all such predications are similar to the concept of "uncertain inference" in modern statistical theory.

8. Syadvada and Logic

Logic does not have just two answers to a problem, Yes and No, as can be illustrated by several paradoxes. As we shall see below, some answers can be yes and no, both, some answers can be contradictory and some answers can be Indeterminate. This is what exactly *Syadvada* predicts.

According to the western thinking, the knowledge can be of two types, known and unknown. As we study more, unknown is converted in to known and eventually everything becomes known. The Indian thinking does not subscribe to

this logic. According to Jain philosophy the knowledge is of three types, known, unknown and unknowable (scientifically by sensory organs). Thus there is clear limitation of knowability. Though the unknowable can be experienced, it cannot be described. Language is incapable of describing it and this knowledge is beyond logic.

9. Haldane's Approach to link *Syadvada* with Mathematics and Psychological Decision Making

Haldane (1957) has given a new dimension to *Syadvada*. Starting with a simple equation, if x^2 - 3x+ 2= 0, then x=1 or 2, one cannot say that the probability that x=1 is greater than, less than or equal to the probability that x = 2. More data are required to decide their relative importance. Further if $x^3 - x^2 + x - 1 = 0$, then there are three solutions: x = 1 or $x = \pm A$

The last two solutions $\pm \dot{A}$ are indeterminate and were inexpressible till complex numbers were discovered.

Further the equation $(x^2-x) \cos x = 0$ (modulo 2) gives seven (and only seven) solutions:

0, 1,v [0 or 1], [0 or v], [1 or v], [0 or 1 or v] where v stands for *avyaktavya* $\sqrt[1]{v=vO}$; Dr¹/₂ or indescribable. This equation correctly describes *Saptabha?gi*.

Application of *Syadvada* in psychological decision making is illustrated by a simple experiment in which sensitivity of a person's eye is examined for increasing illumination levels. Seven possibilities, similar to the seven predications of *Saptabha?gi* emerge, as follows: When the illumination is much below or above the threshold sensitivity, the answer is clear no or yes. but as the illumination level approaches the threshold, either he sees it but is not sure (indeterminate), or does not see it but is not sure; now he sees it and now he does not; is not sure whether he sees it or not (indeterminate) and he sees it and also does not see it and is unsure.

This example can be extended to other sense organs (ears, taste etc.). Numerous examples can be given, which will illustrate that every moment in real life, whether we are seeking a goal or result of an action, we always live by *Saptabha?gi* and have seven possible outcomes; either we will achieve the anticipated result or not or we may achieve some unpredictable result or combinations thereof.

10. *Syadvada* and *Anekantavada* in Interacting Systems, Networking and Systems Theory

Syadvada and Anekantavada can also be better understood in modern terminology, using concepts of interactions, networking and systems theory. Interaction has a profound implication in science as also in Jainism and implies relationship between two or more than two entities in nature. The bodies in questions can be physical or biological or their combinations. Movement of Earth around the Sun by gravitational interaction is one such relation, which is dynamic. The other relation could be between a biological system and its physical or biological environment. If we increase the number of such bodies in each of these examples, then we have more complex systems and instead of two body problem we have to consider many body problem and essentially we have a number of parameters which have dynamic values. We have therefore to consider the whole system, made of many subsystems (parts), which interact with each other and at the same time provide feedback to the system. A typical family, e.g. with two parents and two children, each member having multiple talents, views, perspectives and relational attributes towards each other, can well illustrate the importance of Anekantavada as the relationship is multi-layered, multidimensional and dynamic and changes every moment. Certainty as well as indeterminacy or uncertainty is a part of every decision making process and one must resort to Saptabha?gi for correct appraisal of the situation. Syadvada and Saptabha?gi thus play important roles in any decision making or making a choice between various options.

11. Psychological Decision Making and Quantum Physics

We now show that decision making involves the uncertainty defined by *Syadvada* i.e. one has to choose between various possibilities defined by *Saptabha?gi*. For this purpose, we first briefly review the present understanding of consciousness, brain and reduction process, leading to decisions, mainly based on the work of Penrose (1999), P.M.Agarwal and R.C. Sharda (2012), and Penrose and Hameroff (2014).

We begin with a brief outline of brain function (see e.g. accompanying article by Sanchetee et al., 2016). There are over a 100 billion neurons in the brain which receive and process electrical and chemical nerve signals. The connection between neurons is made via synapses. The decision is not made at neuron level and is not a classical phenomena because it is not a binary choice between yes and no (see the accompanying paper by Pokharna for details). This unpredictability of decision must therefore be attributed to quantum mechnical phenomena. Neurons can not be involved in decision making because they are too big, 0.4 to 100 microns wide and upto several meteres in length. Inside neurons there is a "cytoskeleton", the structure that holds cells together, whose "microtubules" (hollow protein cylinders, about 25-nanometers in diameter) control the function of synapses. Penrose suggests that 'consciousness' is a manifestation of the quantum cytoskeletal state and its interplay between quantum and classical levels of activity. We must point out here that, according to Jainism, consciousness is a characteristic of the soul only and not of metter a non-material. It is neither a material product nor a material phenomena. What Penrose calls as a decision taken by consciousness is actually, according to us, a voluntary decision, what we colloquially call as conscious decision making. We now discuss the way a voluntary decision may be taken by brain from multiple choices available. This is termed as subjective reduction.

Subjective reduction is made according to the Copenhagen interpretation of quantum phenomena. Suppose the system is in a state consisting of "superposition" of many possible states and when a subjective decision is made, the system reduces (or "collapses") to a specific state as per the subject's choice, that is if the subject wants the system to behave like a wave then it will act as a wave, but if the subject wants the systems to behave as a particle then experimental setup can be adjusted accordingly, such that it will act as a particle. Circumstances offer multiple options for taking any decision and there are always choices available through what is known as free will.

At the same time, it may be noted that the brain and its memory repository, which is believed to be holographic in nature, are not localized, i.e. are non-local. When an object is under observation, its sense of colour, shape and motion, for example, and their corresponding "locations" in the visual cortex are situated in different regions and are sensed at the same time (known as the 'binding problem'). How does one, then, have a feeling of simultaneity in these three different observations? Also it is not known, how the processes occurring in the subconscious mind are different from those taking place in the conscious mind.

We now discuss the role of quantum physics in decision making process. In general, quantum systems may be existing in many possible states, but when we try to perform a measurement, it shows only one of these possible states.
Quantitatively, one can only give probability of finding a quantum system in a given state. Hence there is an inbuilt uncertainty in description of any quantum system.

In order to explain the complex behaviour of brain and its constituents like neurons and synapses, along with the experimental observations in psychology and neurophysiology, like discreteness in behaviour of consciousness, time delays in stimuli and action taken (in advance of stimuli), free will, binding problem, working of subconscious mind etc., Penrose and Hameroff (2014), have made an attempt to explain "consciousness" by combining neurophysiology with quantum physics and general theory of relativity. Entanglement is another property of quantum physics which can explain the strong interconnectedness, and a consequence of association of large parts of neurons and synapses that is not reducible into the properties or individual neurons and synapses. As mentioned above, neurons contain some finer structures known as microtubules which in turn consist of thousands of very small constituents known as tubulins. The tubulins consist of two parts which are 8x4 and 8x5 nanometers in size and behave like a quantum physical system. Millions of such tubulins, spread among thousands of neurons, can collectively oscillate and can produce a large quantum mechanical state, essentially a quantum superposition state. Such oscillations are made possible through gap junctions among synapses and neurotransmitters. Actually one can have a superposition of several such states, which can be described by Schrödinger wave equation. They then argue that this superposition state is unstable and reduces to one of the possible constituent states. This reduction has been called Orchestrated Objective Reduction (Orch OR). The word orchestra is being used as thousands of tubulins are participating in this process like an orchestra. The reduction of superposition state takes place due to extremely small gravitational self energy difference between two states of group of tubulins. The time when this reduction takes place is governed by the Heisenberg's Uncertainty principle. After the objective reduction, one is left with just one classical state of the brain. They call this process of Objective Reduction in which transition takes place from quantum physical reality to classical reality as "conscious decision making". Models are then

⁷ Many paradoxes can be formulated if two contrary statements are made e.g. 1."The following sentence is true."2. "The previous sentence is false.".

^{8 &}quot;There is only one barber in town who shaves all those, and only those men in town who do not shave themselves." Then "Who shaves the barber?" According to the statement above, he can either shave himself, or go to the barber (which happens to be himself). However, neither of these possibilities are valid: they both result in the barber shaving himself, but he cannot do this because he shaves only those men "who do not shave themselves".

developed to link it with neural correlate of consciousness like 40-80 Hz gamma waves found in EEG patterns (see the accompanying article by S.V. Shah). They believe that the majority of activities taking place at subconscious level are quantum mechanical in nature.

They proceed further by using quantum gravity, combining quantum physics with General Theory of Relativity to derive a model of conscious decision making process. There is a speculation that information can be stored in spin foams of quantum gravity, at Planck's lengths that is around 10⁻³⁴m (which is 20 orders less than the size of a proton). Thus according to Penrose and Hameroff, space-time geometry can store information and that can play an important role in determining major operations of the neurons and hence of our brain, including the Orch OR. Penrose (1999) had earlier speculated the possibility of Objective Reduction at Planck level. He extended General Theory of Relativity to Plank level and argued that a particle at certain location will have some space-time curvature and the same particle in some other location will have opposite space-time curvature. Hence a superposition of the two will form a quantum superposition state. This will be like a bubble with opposite curvatures and will remain unstable, till the energy corresponding to the two states exceeds certain threshold of energy and time, governed by the Uncertainty principle. Beyond this, an Objective Reduction of the quantum state will take place and only single state will be obtained. Some of these arguments are still in a preliminary state of investigation. However, the model implies that uncertainty in our determinism exist at the very finest level.

Thus, according to Penrose, the human understanding is neither deterministic nor random but is non-computable, and contradicts the concept used in artificial intelligence that human understanding is completely computable. To summarise, the Penrose model presupposes that space-time geometry can have information in spin foams at Planck level when we consider quantum gravity. Reduction of quantum superposition at this level is governed by the energy difference between two quantum states of a particle. A similar Objective Reduction occurs at brain level through "tubulins", the quantum systems operating within neurons through microtubules. Both have inbuilt uncertainties in them based on the perspective, and is in conformity with the concepts of Syadvada.

12. Saptabhangi and Logic

G.N. Ramachandran (1981,1982a) and Jain (2007) have developed logic systems based on *Saptabha?gi*, which can be used in computer applications. Jain

(2007) has shown that the proposition with two assertions:

It exists (A) and it is indescribable (v) leads to four logic states: It is true (T) if affirmed A is consistent with not affirmed v; It is false (F) if v is affirmed and A is not; It is doubtful (D) if both A and v are affirmed; It is empty or null (X) if both are not affirmed.

Ramachandran has shown that Saptabha?gi can be reduced to a vectormatrix description of binary logic, based on which computer logic can be developed. Classical logic permits only binary propositions i.e. true or false. However, there exist certain propositions with variable answers representing partial knowledge. Furthermore, since fuzzy logic is a form of many-valued logic and deals with reasoning that is approximate rather than fixed and exact, it can be developed from the concept of *Saptabha?gi*, There is a certain amount of vagueness in fuzzy logic as compared to the binary logic. Fuzzy logic variables may thus have a truth value that ranges in degree between 0 and 1 and has been developed as an infinite-valued logic. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false and has been applied to many fields, from control theory to artificial intelligence. Both degrees of truth and probabilities range between 0 and 1 and hence may apparently be similar but Fuzzy logic and probability address different forms of uncertainty.

13. Resolution of Paradoxes

Many paradoxes can be resolved using the criteria given by *Saptabha?gi*, but not in terms of binary logic of yes and no. Ramachandran, (1981; 1982 a,b.) has formulated the logic using Boolean algebra and has shown that a solution to various paradoxes can be found within the framework of *Saptabha?gi*. We illustrate this concept with a few paradoxes here which were known to the Greek philosophers and bear their names.

- 1. Cretan Liars paradox
- 2. Double statement paradox
- 3. Barber of Seville Paradox
- 4. Cantors paradox of infinite sets
- 5. Theseus paradox of ships and question of identity

We illustrate the concept in the case of Cretan Liars paradox : "A man says that he always tells a lie. What he said is true or false?" One cannot answer it without contradicting the man's statement. It is illustrated in the following example, where one starts with "x is not true" and one concludes that "x is true"

Suppose: 1. If x = "x is not true". Then:

- 2. x is true if and only if "x is not true" is true. And:
- 3. x is true if and only if x is not true.
- 4. Therefore: x= "x is true" (QED)

By using options given by *Saptabha?gi*, it can be said that either it can be true or it can be false or it can be indeterminate and other combinations thereof given by the seven possibilities described above. The Double statement paradox⁷ or Barber of Seville Paradox⁸ can also be resolved in a similar manner. Cantor's paradox of infinite sets is similar to Gödel's incompleteness theorem that there is no set which can contain all the sets including itself, implying that nothing can contain everything.

13.1 Theseus Paradox and Question of Identity

If each part of a ship (A) is removed and replaced, one by one, till all the parts are replaced, will it remain the same ship (A) or it becomes a different ship? This is a question of identity known after Theseus as recorded by Plutarch in life of Theseus from the first century CE. Obviously it is difficult to answer this question either in the affirmative or negative. The paradox was extended further by Thomas Hobbes who proposed that if each removed part is reassembled in to a new ship (B), the ship B is the same as A or different?, again with divided opinions. Much before Theseus, the problem was resolved by Mah v ra in context of rebirth by propounding the role of soul, which is the 'essence' of a living being, and does not get destroyed at the time of death and provides the continuity fom one birth to another. During a discourse on rebirth according to Buddhism," Is the person who is reborn the same as the one who has just died or different?" asked the king. Nagasena replied that he is neither the same nor is he different. Just as the last flame of a lamp, burning all through the night, is neither the same as the first flame nor different". The answer to these puzzles can be found within the framework of Saptabha?gi. The ship, the newly born, and the flame, all are the same, different, same as well as different, neither the same nor different, indeterminate and combinations thereof. It depends on the perspective as to what is being considered as the identity, material or its use.

In effect, it is cessation of one and creation of another, while the essence remains the same.

14. Application of *Anekantavada* to Harmonious Living in Personal, Family, Social, National and International Domains

Life consists of a series of decisions. One has to make a decision every moment, during contemplation, planning and execution. Even when one is not taking a decision, it is a result of a decision "of not taking a decision". Actually, one cannot live without taking a decision. Every decision involves choice. Normally choice can be either yes or no; This concept is fallacious. A particular choice will lead to the desired result or not is hard to visualise a priori, because in reality, every decision involves seven choices. 1.It will work; 2. it will not work; 3.It may work beyond our expectations, but we cannot predict it now (indeterminate); 4.It may work below our expectations but is unpredictable (indeterminate); 5. It may work but in effect it will not give the desired result; 6. It may not work but in effect it may appear to work if it gives the desired result; 7.It may lead to some altogether unpredictable result. Such a situation exists in all domains, in personal, social, management etc. These aspects have been discussed in many books and articles (e.g. see Mah prajña, 2010); Samani Shashi Pragya, 2014) and will not be discussed here. In the modern context of information technology we, however, need a decision support system (DSS) which will go beyond yes and no i.e. asti, followed by counter choice (*n sti* or alternative). These two options do not lead to correct decision and for the modern life style, encompassing all its aspects, a proper Decision Support System can be developed for arriving at correct decision within the framework of Syadvada and Anekantavada (Pokharna, 2013a,b).

15. Comparison with Other Doctrines

The Universe consists of an infinite variety of things. Three different doctrines have been propounded in various oriental thoughts: *Advaitavada* (non-duality or monism), *Dvaitavada* (dualism) and *Anekantavada* (infinite possibilities) to understand their origin and nature. The first proposition, *Advaitavada*, is that everything we see around has emerged from 'one' (*eka*) and they all have a single core tattva. Thus *Advaitavada* (literally meaning "not two") implies that everything is a manifestation of " one". If in the beginning there was only "one", logically "many" (*aneka*) cannot originate from "one" because, according to causality, for anything to materialize requires a cause. Without a cause " one " would exist as it is, remaining unchanged for ever. Existence of a cause requires something other than

the "one" (i.e. at least "two"). Causality requires existence of at least two entities to interact with each other and give rise to "many". Many coming out of "one", without a cause, violates the principle of causality and therefore this proposition rejects "*Advaitavada*" (non-duality) and necessitates the concept of "*Dvait v da*". In the latter case, everything emerges from the interaction of *puru?a* and *prakriti. Anekant vada* goes a step beyond this. It emphasizes that the " one " has infinite attributes and thus one and many become the same. Thus *Anekanta* offers a true and complete description of the physical reality. In a nutshell, *Anekantavada* emphasizes that this is true (but only partially) and that also is true. Contrasting it with the upanishadic concept of *neti* wherein the Upanishads look at the existence of God in every conceivable manner or object and mention it in the negative "*Neti*, *Neti*", implying (that God is) neither this, nor that. In fact, none of the visible objects is God. In contrast, *Anekantavada* asserts it in the affirmative "This is true and that also is true".

16. Concluding Remarks

In this paper we have brought out the scientific importance and merits of *Syadvada* and shown that *Syadvada* can be used to define the limits of knowledge and finds applications in quantum mechanics, logic, probability theory and statistics. *Anekantavada* helps us understand the true nature of soul as well as matter and *Saptabha?gi* represents various choices available to us in life and options from which decisions have to be made.

The principle of *Anekantavada* is generally considered as a philosophical concept, having many applications in social domain. Thus, besides explaining the true nature of "things", conceding that all views have some element of truth, as explained in this article, *Anekantavada* has been widely and successfully applied in day to day life for understanding and harmonizing diverse, often contradictory, personal, domestic and societal issues, as also philosophical and spiritual views, to reduce conflicts between different cultures, faiths, religions and social matters. It has been shown that this single concept can lead to harmony in day to day life, between groups of people and between nations and promote coexistence. Thus, the unique concept of *Anekantavada*, can bring harmony in various spheres of life and reduce conflicts. Much has been said and written in the praise of *Anekantavada*. Understanding of *Anekanta* is essential for attaining correct perspective in life as well as the correct world view or *samyak dar ana*, essential for attaining enlightenment.

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Viney Jain and Veersagar Jain

Abstract

Various concepts of origin and development of knowledge are discussed in this paper. We start with discussing the Jain theories of knowledge as understood from descriptions in different scriptures and commentaries. The second part attempts to deal with some crucial aspects of western theories of cognition. This is a multi-disciplinary field involving physics, neurosciences, genetics, evolutionary biology, linguistics, information and computer sciences, artificial intelligence besides psychology and sociology and is developing very fast. In the last section, important problems and questions, which remain to be resolved are outlined. Attempt is made to identify important concepts and approaches of Jain and modern theories of knowledge, which could be fruitfully integrated and investigated in future.

Key Words: Knowledge, *Le y*, *Jñ na*, *Dhy na*, *Ny ya*, *Pram ?a*, Grounded Cognition, *Dhy na*, *Ny ya*, *Pram na*

Scriptures Quoted: Ny yad pik ; Pariks mukham; Nand S tra; Tattv rthas tra; Pravacans ra

1. Introduction

Answers to questions concerning the origin, the nature and processes of acquiring knowledge about the Universe and the Self have been sought for thousands of years in all civilizations. How do we know what we know and whether what we know corresponds to reality? Answers to these complex questions are difficult since the phenomena like thoughts, emotions, tendencies to act, which underlie knowledge and its applications in regulating behavior, are not directly observable. Great rishis, saints, philosophers, scientists, scholars and

educationists engaged in this quest all over the world have explored several aspects and expounded divergent views.

In ancient India, Bhagw n Mah v ra (599 BCE–527 BCE), who, according to Jain tradition, was the 24^{th} and the last T rtha?kara of the present era, preached that knowledge is an inherent attribute of tman (soul) and perfect true knowledge of the Universeand the Self can be gained by purification of the soul. In contrast, Charvak, one of the earliest philosophers of materialism and founder of Lok yata philosophy (6thcentury BCE), declared that sensory perception is the only source of valid knowledge - only what is perceptible by the senses is true.

In ancient Greek philosophy, which provided the foundation of the western civilization, several views about knowledge were discussed. Plato developed a tripartite model for the structure and function of the soul distinguishing between the elements of cognition, emotion, and conation. Aristotle, on the other hand, seems to disagree and questions the subdivision of the soul: in what sense we are to speak of parts of the soul, or how many we are to distinguish, for in a sense there is an infinity of parts. Parmenides (510-440 BCE) believed that knowledge comes only through reason (rationalism), since sensory experience cannot be trusted. Protogoras (490-420 BCE) declared that Truth depends on the perceiver since perception varies from person to person because each perceiver has different experiences. Socrates (469 BCE-399 BCE) taught that the goal of life was to gain knowledge and understanding essences (concepts) constituted knowledge. Epicurus (341–270 B.C.E.), like Charvak, preached that the goal of human life was pleasure and absence of physical pain. He based these ideas on an empiricist theory of knowledge originating from physical sensations, together with the perception of pleasure and pain.

In modern times, advances in science and technology have greatly influenced the development of theories of cognition, which now employ concepts and approaches from many disciplines including physics, neurosciences, genetics, evolutionary biology, linguistics, information and computer sciences, artificial intelligence besides psychology and sociology. It is a fast developing and rapidly changing discipline. The fundamental philosophical problems, however, remain unresolved, much the same as in antiquity.

It appears to be worthwhile to examine whether some of the unique concepts of Jain epistemology, when developed further in conjunction with the modern cognitive sciences would be useful in providing new insights and open new

avenues for further progress to understand the complex nature of cognition

The present paper is divided into 3 parts. The first part describes the salient features of Jain theories of knowledge as understood from descriptions in different scriptures and commentaries written by various c ryas and scholars. This is not a simple task since there are many versions and interpretations in the existing literature, which is vast, representing developments over more than two millennia.

The second part attempts to deal with some crucial aspects of modern theories of cognition developed mainly in Europe and America. Since this is a fast developing multi-disciplinary field only a few selected aspects, which the authors feel are relevant from the present perspective are presented.

In the third section, important problems and questions, which remain to be resolved will be outlined. Attempt will be made to identify important concepts and approaches of Jain and modern theories of knowledge, which we believe could be fruitfully investigated in future research.

2. Major Concepts in Jain Epistemology

Theories of knowledge in Jainism are based on its beliefs about the structures and functions of the living beings (*j va*). The structural organization of a worldly living-being (*sansar jiva*) consists of the soul (tman/j va), a non-material entity, blended with a subtle material karmic-body (*k rma?a ar ra*) and a visible gross physical body (aud rika ar ra). The karmic-body is constituted by the various karmic particles (assumed to belong to a special category of matter) and associated radiant (energy) body (*tejas- ar ra*). The karmic-body encodes the past actions and experiences of the living-being. Evolution of knowledge and behavior depends on the manifold dynamic interactions between the various components of the livingbeing, the embodied soul. These interactions are mediated through *Le y* radiations which encode information about the states of the subtle karmic-body and the gross physical body (expressed in the form of feelings, thoughts and actions). In simple words, *Le y* provides the link between the powers of the soul, the karmic-body and the physical body.

The gross physical body perishes (dies) after a limited life-span determined mainly by the *yu?ya* karma. The karmic-body enveloping the soul transmigrates to a different life-form (*Gati*) and a different physical body (rebirth). *Le y* at the moment of death is instrumental in determining the life-form of rebirth. This cycle of death and rebirth of the physical body, influenced by the karma-dynamics and

the karmic-load, continues till the soul is purified and becomes liberated (*Mukta*) by eliminating the bonding with karmas and becomes free from the karmic-body (karmic-load = 0). In this long journey towards liberation, evolution of knowledge plays a central role.

2.1 Different States of Embodied Consciousness in Different Forms of Living-Beings

Jains believe that consciousness (*Caitanya*) is the most important natural characteristic of the soul (*j va*). The function of consciousness is to enlighten the Self and the Universe (non-self).

Knowledge (cognition), feelings (emotions) and conduct (conation) are the three interrelated aspects in the expression of consciousness. Manifested functions (*upayoga*) indifferent states of consciousness are distinguished as '*dar ana*' (awareness/perception/attitude) and ' $j\tilde{n}$ na' (knowledge or comprehension). The distinction between *dar ana* and $j\tilde{n}$ na is subtle; *dar ana* being indeterminate while *jñana* is determinate knowledge (see Tatia, 1951 for more information).

The worldly living-beings (*sansar j va*), such as humans, animals, insects, plants and microorganisms, represent different states and levels of embodied consciousness, where the states of *tman* (Soul) are contaminated by bonding to the karmic-particles corresponding to the inherited past karmas of the living-being. The karmic-body restricts and distorts the attributes of the pure consciousness and thereby its capacity for knowing the true nature of reality is reduced in proportion to the size and types of the bonded karmic-particles (karmic load). The inherent capacities of knowledge also depend crucially on the life-forms and the structures of the physical bodies. Since the living-beings have diverse structures of physical bodies and also differ in their burdens of karmic loads at given times, their potentials for perception and knowing the reality vary accordingly. Human beings are supposed to have the highest potential for transcending the constraints of the body and acquiring perfect knowledge.

Jain scriptures and Jain saints have discussed in great detail the origin, functions and regulations of instincts, emotions and passions in relation to acquisition of knowledge within the framework of the doctrine of karma (for detailed discussions on the Karma doctrine, see Chapters 6 & 7). The dynamics of karmic bondage involving the influx, bond formation and dissolution or efflux of

the various types of karmas, profoundly influences the state of consciousness and its associated capacities and qualities of cognition of reality. The falsity, flaws and errors in knowledge (*Mithy jñ na*) are consequences due to the presence of affective states and intensities of attachments, aversions, passions, feelings and desires arising from the activation of the Deluding-karma (*Mohan ya-karma*) in particular.



Fig.1: Emergence of V tar gat and Perfect Knowledge by Spiritual Practices

2.2 Emergence of Knowledge is a Consequence of Spiritual Purification

According to Jain philosophy perfect and complete knowledge (*Kevala jñana* or omniscience) of all the substances in the Universe in their infinite manifestations, modes and attributes emerges only after purification of the soul by eliminating its karmic load of psychical nature (*Ghati Karmas*). Thus, growth of knowledge is directly linked to the development of spirituality.

The importance of right perception and right knowledge leading to right conduct (*Samyak-darsana, Samyak-jñ na* and *Samyak-c ritra*) for the spiritual development viz. purification of the soul by eliminating the karmic bondage of psychical nature has been clearly brought out in the ancient scriptures. With the enhancement of processes of purification of the soul by spiritual practices such as non-violence (conduct avoiding hurt/harm to another living-being) and virtuous meditations (*Samayik, Dharma-Dhyan* and *Shukla-Dhyan*), its inherent attributes

begin to be expressed. Finally as the state of *Vitaragata* (equanimity /detachment / objectivity) is achieved, perfect knowledge of the Self and the Universe, called *Kevala jn na* (omniscience) emerges. It should be noted that *V tar gat*, a passionless state of consciousness, free of any attachments, aversions and desires, is an essential prerequisite for acquiring true knowledge of reality.

Achieving a state of true *Vitaragata* is very difficult (almost an impossible task) even for spiritually advanced beings (saints, rishis and munis). Several spiritual practices have been recommended in Jain scriptures to facilitate progress towards this goal. Practice like *K yotsarga* (abandonment of the identification of the Self with the body) and meditationz (*Shukla Dhyan*) on the true nature of the Self (tman), have been found to be very effective in eliminating the attachments and aversions, transcending the bodily restraints and progressing towards the states of *V tar gat* and Perfect Knowledge.

This is depicted schematically in Fig. 1, which shows that Right-Perception, Right Knowledge and Right-Conduct are highly inter-connected and integrated in both top-down and top-up ways. This implies that the practice of Right-Conduct, based on Right-Perception and Right-Knowledge greatly enhances *V tar gat* and emergence of perfect knowledge. Conversely, in the absence or deficiency of Right Conduct, Right Knowledge cannot advance beyond a point, since the processes of spiritual purification become constrained under these conditions.

In simple words, ethical and moral conduct, based on objectivity and equanimity, are essential for gaining true and perfect knowledge.

In Sum: Emergence of Right and Perfect Knowledge of reality in a living being (embodied consciousness), depends on the purification of the consciousness. It is a dynamic process involving interactions between the states of the karmic-body, the associated gross physical body and the spiritual energy of consciousness (self-effort, *puru*? *rtha*).

Right Attitude (perception) directs the self-effort towards Right Knowledge and practice of Right Conduct. This integrated dynamic process leads ultimately to purification of the consciousness and a detached, passionless, conscious state of *Vitaragata* (equanimity/detachment/objectivity), is attained.

Progress on this path to achieve V tar gat, difficult as it is, can be facilitated by ethical conduct, self-restraint and spiritual practices. The equanimous and non-attached state of *Vitaragata* leads to perfect knowledge of reality.

These insights from Jain Philosophy have important implications for the practice of ethical and moral conduct for growth of knowledge in an individual and for improving social interactions, peace, wellness and sustained development in knowledge based societies. In depth studies of the correlations, interactions and integration between attitude, knowledge and moral conduct (important aspects of spirituality) should be, therefore, undertaken.

2.2.1 Categories of Knowledge

From the practical point of view, attaining complete *Vitaragata* and perfect knowledge, though possible, is very difficult to realize for lay persons. Progress in this direction can be made gradually by gaining partial true knowledge through biophysical, psychological and spiritual processes leading to the development of various categories and stages of knowledge.

Knowledge can be gained with the help of senses (indriyan) or without them. Two different pathways namely, (1) direct (*pratyak?a*) and (2) indirect (*parok?a*) have been recognized in Jain scriptures. Five different kinds of knowledge (*jnana*) acquired via sense organs and the mind or without them have been described. These are: (1) *Mati*, (2) *Sruti*, (3) *Avadhi*, (4) *Manahparyaya* and (5) *Kevala jñ na*. The fivefold categorization of knowledge has been described in gams and also in subsequent texts and commentaries written by Jain logical thinkers, though there are differences in interpretations (for detailed discussion see Tatia, 1994 ; Shastri, 2000).

Mati-jñana (Sensuous Cognition) also called *abhinibodhika* (Perceptual Cognition) is the knowledge of substances/objects existing at a given time and it is acquired with the help of senses and the mind. The following four major stages in the development of *Mati-jñana* have been distinguished.

- (i) *Avagraha* (Perception/awareness): In this stage, which lasts for a very short time, only the general features are perceived by the sense-organs, the distinguishing characteristics remain unknown. It is indeterminate intuitional cognition of the objects by senses.
- (ii) *Ih* (Speculation): In this stage, attempts are made to search for the distinct properties of the object to ascertain its true nature. It may last for a relatively long time but not longer than a muharta (48 minutes).
- (iii) *Ap ya* or *Av ya* (Perceptual Judgment): This is the stage of determinate cognition, which occurs after exclusion of non-existent features of the object. In this stage, the object is recognized clearly and precisely.

(iv) *Dh ra?* (Retention): In this stage, the perceptual judgment is consolidated into a lasting impression, which can be retained for a long time. It includes emergence of a mental trace (*samskara*), recollection of it at a later time without any lapse of the cognition.

Shruti-jñana is the knowledge based on testimony and is derived via signs and symbols such as gestures and spoken or written words (scriptures/texts). *Shruti-jñana* can deal with objects existing any where, not only in the present but also in the past and future.

Mati- and *Shruti-jñana* are the types of knowledge acquired with the help of senses, and are normally used by all living beings in their day to day lives. Sensory perception and cognition are also the major topics of studies by modern scientific disciplines.

The remaining three kinds of knowledge viz. *Avadhi-, Manahparyaya-,* and *Keval-jñana* emerge directly, independent of the senses and the mind, and belong to the category of extra-sensory or transcendental direct knowledge (*P ram rthika Pratyak?a*). *Avadhi-* and *Mana?paryaya-jñana* are imperfect (*vikala*) whereas Keval-jñana is perfect (akala) infinite pure knowledge, unobstructed and unbounded by space and time. *Kevala-jñana* emerges after the tman (consciousness) has achieved a non-attached and passionless conscious state of complete *Vitaragata* or supreme equanimity and objectivity.

Avadhi-jñana (clairvoyance) is cognition of all types of concrete objects irrespective of time and space but with some limitations which depend on its level determined by the dissolution of karmas and state of spiritual purification. It is of two types: (1) *Bhava-Pratyaya* that is innate or inborn, for example T rtha?karas and the heavenly and hellish beings are born with it and (2) *Gu?a-Pratyaya*, that is acquired through spiritual practices of self-purification and is subject to changes in its capacity in accordance with the degree of self-purification achieved.

Mana?paryaya-jñana (Mind-Reading/Telepathy) is the direct knowledge of contents of other minds. This ability is a very sophisticated kind of cognition that evolves clearly in individuals at very advanced stages on the path of spiritual purification.

Kevala-jñ na, the perfect and infinite knowledge (omniscience) encompassing every substance (*dravya*) with all its qualities and modes (*pary ya*) and happenings in the Universe emerges after complete annihilation of all the

destructive (*Gh ti*) karmas, which have been obstructing the complete expression of the attributes of the soul. The *mohan ya-karma* (delusion), the underlying cause of all desires and passions, attachments and aversions, is destroyed first to attain the state of *V tar gat*. *Kevala-jñana* then leads to liberation and a state of eternal bliss (*Mok?a*). The concept of omniscience is central to Jainism since the ancient and most valued scriptures called gama are believed to be scripts of percepts and preaching of T rtha?kara Mahavira after he gained omniscience and are therefore considered to describe the true reality.



Fig. 2: Categories and sub-categories of Valid Knowledge (Pramana)

The nature of the omniscient state of consciousness and the plausibility of its real existence have been matters of considerable debate among the different schools of Indian philosophy (for a comparative description, the reader is referred to an account given by Shastri, 1990). Omniscience can be understood on the basis of the Jain belief that everything in the Universe is interconnected and influences every other thing in space and time. Therefore, in principle, if one substance is known completely in all its forms and modes, it would imply that everything can be known. In other words, if one knows the Self, one knows all (Tatia, 1951).

2.3 Methods to Distinguish True from False Knowledge

Mati-, *Shrut-* and *Avadhi-jñana* could be error prone and lead to false, wrong or invalid knowledge (*mithy tva*), therefore, instruments and processes to

distinguish between true and false knowledge (erroneous cognitions) need to be established. *Ny ya* doctrine describes the way this can be accomplished. Jain *Ny ya* was mainly developed by Jain logicians and saints (Samantbhadra, Akalanka, and others) from basic concepts already mentioned in Agams.

2.3.1 The System of Ny ya

"*Ny ya* is a system by which we can properly and thoroughly know the exact nature of a substance. The method employed by *Ny ya* consists of: (a) *Anvik?* (observation), (b) *Yukti* (logic), (c) *Parik?* (examination or verification) and (d) *Samik?* (constructive criticism).

Ny ya is a combination of *Prama?a* (valid proof) and naya (limited perspective or partial view point). Etymologically *Prama?a* is derived from the root M, to measure, signifying an instrument of measurement. It is a cognitive procedure of acquiring valid and accurate knowledge of reality, which is free from all types of blemishes (doubt, vagueness) and which ascertains objects with all their multiple forms, attributes and characteristics as they exist in nature. *Naya* is partial valid knowledge, it is concerned with one aspect or mode of an object as viewed from one particular frame of reference (standpoint). A *naya* expresses a partial view from the stand-point of a knowing agent (jn t), not excluding other views. Therefore, to gain a holistic valid knowledge of a substance, *Prama?a* and *naya*, both are required.

2.3.1.1 Pramana (Valid Knowledge)

Prama?a is the knowledge possessed by a person with right attitude (*samyag dri??i*). Persons with perverted attitudes (*mithy dri??i*) cannot have right knowledge (*samayak-jn na*). Jains classify *Prama?a* in two categories viz. (1) *pratayk?a* (direct) and (2) *parok?a* (indirect), which have been further divided into various subcategories as shown in Fig. 2.

2.3.1.2 Direct Knowledge (Pratyaksha Pram na) and its Subdivisions

Direct Knowledge knows the objects in a lucid manner on its own, without the help of other types of knowledge. It is further classified into two types: (1) Transcendental (*p ram rthika pratyak?a*), that which occurs directly in consciousness, independent of sense organs or any other medium (intuition) and (2) Empirical (*s mvy vah rika pratyak?a*) that which occurs via sense organs and the mind. Strictly speaking empirical knowledge occurring through sense organs should be classified in the indirect category but due to weightage given to common

usage of the term in other systems of Indian philosophies, it is usually included in the direct category.

Transcendental direct knowledge is further subdivided into two types (i) Incomplete (*vikala*), pertains only to a class of objects within certain limitations of space, time, substance and modes and (ii) complete (*sakal*), which includes all types of objects and substances (with and without form) with no limitations.

2.3.1.3 Indirect Knowledge (paroksha pram na) and its Subdivisions

Five components in the formation of indirect knowledge have been described namely:

1) Memory (*smriti*) is cognition or knowledge based on awakening (remembrance) of impressions of a previous direct experience. It plays important part in inference and behavioral changes.

2) Recognition (*pratyabhijñ na*) arises from memory and perception by noticing similarities and differences with an object known previously. It is cognition by comparison.

3) Logic (*tarka*) is the knowledge of an inseparable universal connection (*vy pti*) between the object of cognition (*s dhya*) and another object (*s dhana*) known by observation or otherwise. *Sadhya* is called the major term; it means that which is to be proved. *Sadhana*, called the middle term; it is the means by which *s dhya* is proved.

For example, fire and smoke have an inseparable relationship; where there is fire, smoke invariably also exists (*vy pti*). *Tarka* or the knowledge of *vy pti*, also called *avin bh va* or concomitance, is the basis of inference.

4) Inference (*anum na*) is the knowledge of *s dhya* (major term) arising from s dhana (middle term). *Anum na* is of two types: (i) *Sv rth num na* is the inference for the sake of self; it is based on the valid knowledge arising in one's own mind by repeate observations of facts and (ii) *Par rth num na* is inference for the sake of others. Based on *Sv rth num na*, it is used to convince others. For *Par rth num na*, syllogism (deductive arguments), consisting of assertion, reason, example, application and conclusion is employed, whereas for *Sv rth num na*, syllogism is not required.

5) Scriptural Knowledge (gama) is the knowledge derived from scriptures based on the words (sermons) of an *pta*, who is all knowing (*sarvajña*, an

omniscient being), who is completely free from all attachments and aversions (*veetaragi*), and who preaches for the welfare and benefit (*hita?kara*) of all living-beings.

2.3.1.4 *Naya*: Relative Knowledge from a Particular Stand-Point or Frame of Reference

Every object has infinite attributes and modes. To know or describe all of them at the same time is not possible. Cognition or describing knowledge of a part of an object, its attribute or mode without ignoring or discarding the existence of other parts of the object is called *Naya*. Knowledge of the other parts becomes secondary, is kept in the background but never ignored. *Naya* reveals only a partial knowledge of reality from a relevant perspective characterized by the choice of focus of the knowing agent (jn t). It does not rule out other perspectives. Thus, avoiding dogmatism, philosophical basis of pluralism is provided by the *naya* doctrine.

There can be infinite number of *nayas* based on infinite attributes of a substance. However, for the sake of simplicity, they have been grouped into two major categories called (i) *Ni caya naya* or the Transcendental Standpoint and (ii) the *Vyavah ra naya* or the Pragmatic Standpoint.

The Transcendental stand-point keeps the commonality, universal and the generic aspects in view, while the pragmatic standpoint looks at the differential, specific and practical aspects. In other words, the transcendental stand-point describes the inherent nature of a substance while the pragmatic standpoint views its different modes attributes in association with and relative to other substances/objects.

The doctrine of *Naya* expresses only relative truth from one point of view, which is not sufficient to comprehend the complex reality in totality. Any proposition or assertion is valid only in the context of certain conditions or presuppositions. Complete truth can be derived by integration of all standpoints. The *naya* doctrine thus serves to emphasize the importance of context and to recognize at the same time, the multifaceted aspects and view-points (*Anek ntv da*) from which the reality needs to be apprehended and described (discussed in detail in Chapter 2).

3. Selected Aspects of Modern Theories of Cognition

Today, cognition science has become a subject of intense multi-disciplinary research (Thagaard, 2005). An overview of modern theories of cognition is

presented in Chapter 4. Interesting developments relating to applications of quantum mechanical effects, concepts and formalism in biology have been mentioned in Chapter 5. Concepts like discreet energy levels, superposition, coherence and entanglement have been shown to be applicable also at the macroscopic levels and are being used to formulate models of consciousness, cognition, memory and information processing (Jibu et al., 1996).

In this Chapter, we shall highlight only a few selected aspects relevant to Jain epistemology. Before, we attempt to discuss the various view-points, it will be appropriate to clarify the meaning of the concept of cognition. The English word cognition is derived from the Latin cognoscere; from co- + gnoscere to come to know, or the act or process of knowing. From the common sense view, the term cognition can, therefore, involve all processes by which knowledge can be acquired. The experts, however, assign different meanings to cognition depending upon the perspectives they prefer. Since majority of researchers are concerned with human cognition, they define cognition from the human perspective. A generally acceptable answer from the researchers in the field of cognitive sciences is, therefore, not available.

Definitions of cognition vary. Broad definitions of cognition encompass all processes underlying the acquisition, retention, and use of information from the environment and thus would include perceptual processes, memory, learning, intelligence, judgement, decision making and problem solving (Godfrey-Smith, 2001). From the perspective of evolutionary biology and psychology, the function of cognition is to enable the agent to deal with environmental complexity. Cognition is a tool, a collection of capacities which, in combination, allow organisms to synthesize information from diverse sensory and memory sources to act appropriately in response to environmental challenges (Godfrey-Smith, 2001).

Recent years have witnessed remarkable changes in cognitive sciences. Traditional theories of cognition, focusing on the mind as distinct from the body, developed under the influence of Cartesian dictum "I think, therefore I am." Majority of these theories are anthropocentric and based on the hypothesis that the powers of mind of abstract thinking" reasoning could be derived from the rule based manipulations of symbolic representations of the sensory data. The basic assumption underlying such an information processing approach (developed mainly during the last 5-6 decades of the 20th century), is that mental processes can be described in terms of certain representational (symbolic) structures and their

transformations by operations following rules or algorithms, analogous to computer programs (Thagard, 2005). Despite some success in explaining certain psychological phenomena, it is now increasingly realized that purely computational-representational abstract formulation without any considerations of the necessary hardware in terms of biological structures and mechanisms is insufficient to understand all aspects of cognition. It needs to be complemented and integrated with the biological and psycho-social approaches. This is reflected, for example, in the developing theories of embodied cognition and grounded cognition".

Theory of embodied cognition, takes into account the physical body of an organism as a key constituent of the cognitive system. The interdependent bodily structures and states can influence the processes of cognition in several ways (Varela et al., 1991). Exploring the nature of embodiment, the precise role of the body and the constraints it imposes on cognition have become topics of intense research in recent years (Wilson, 2002; Anderson, 2003; Leitan & Chaffey, 2014). The sensory and motor activities of the entire body (including the neural and non-neural systems), which underlie the perceptual and action systems, interact with the environment to determine the types and forms of cognitive processes.

Going further, recent theories of grounded cognition propose that cognition is grounded in perception, bodily states, situations and action in interplay with the internal and external environments. Concepts underlying knowledge are often understood via metaphors, are therefore, not simply representations of abstract symbols. From this perspective, concepts are generated from sensory-motor patterns and modal simulations of situation specific actions that allow the organism to dynamically interact with the physical world. Empirical evidence supporting that mental simulations (for example imagery) of specific situations and contexts as the processes involved in cognition has been presented (Barsalou, 2008, Borghi and Pecher, 2011).

Possibly, there may be several pathways to process information and to control behavior; a neuronal system incorporating the brain employed by humans being the one which has been studied the most.

These developments are leading to novel insights in the nature of cognition with new theories and their modifications being proposed almost every day. In the light of the recent advances, the present paper focuses on three fundamental issues

concerning cognition, which are of interest in the context of Jain epistemology and have been persistent topics of debate among philosophers, scholars and scientists representing various views and approaches to cognition.

- (1) The foremost important question concerns the origin and development of knowledge. Do the living beings come into existence like a blank slate (the Empiricist' view) or like a scripted slate, with some fundamental innate cognitive structures and/or innate processes already built in (the Nativist's view)? Does all knowledge develop solely as a product of learning by experience through multiple interactions of the living-being with the environment?
- (2) The second vital issue, which is confronted universally, concerns the interactions between the affective states (emotions, feelings, passions, moods) and processes involved in cognition.
- (3) The third controversial issue concerns nature and processes of cognition in the non-human life-forms. Do animals, insects, plants and microbes, have the capacity for cognition or are they simply reflex machines?

3.1 Acquired vs Innate Knowledge (Blank Slate vs Scripted Slate)

The development of the modern theories of cognition in the western world, starting from ancient Greeks to the present day, can be best described by the debates between the "nativists" and "empiricists".

The concepts of innate (not acquired) traits or knowledge structures, that are supposed to be present already at the time an organism comes into existence, have played important roles in the development of cognitive sciences since they are often invoked to explain a broad array of psychological phenomena, which otherwise are difficult to be understood.

The notion of innateness was first introduced by the ancient Greek philosopher Plato (428 – 348 BCE). Plato argued that roots of knowledge lie in reason rather than in perception since perceptions of the physical world yielded only opinions relative to the perceiver. Plato establishes requirements for true knowledge: it must be (1) infallible, and (2) real (of what is), and (3) the truths can be discovered using a priori reasoning and insight by the triggering of concepts that are innate.

It should be mentioned in this context that Plato believed in reincarnation

and he supported the view that prior to coming into the body, the soul dwelt in pure, complete knowledge. Between incarnations the soul dwells in the region of Forms (a Form is a perfect idea, which exists independently of particular things), carrying this knowledge into the next rebirth. Overcome by bodily senses and desires, the soul loses its knowledge of the Forms, however, because worldly objects resemble the Forms of which they are copies, experiencing them reactivates the innate knowledge of Forms. According to Plato, ethical conduct must be founded on knowledge of eternal values which are not subject to the shifting and changing impressions of senses or of subjective opinion.

Subsequently, several different versions and interpretations of the concept of innateness have been proposed by philosophers, scholars and scientists. Nativists believe that human beings possess innate, domain-specific mental structure, not merely for low-level perceptual processes but also for various "higher" cognitive tasks.

The concept of innateness has, however, remained rather vague, and has been strongly contested by the empiricists, who believe that all knowledge can be derived from experiences based on sensory perceptions and as such the notion of innate knowledge structures is unnecessary. The famous English philosopher John Locke (1632-1704), for example, says . "There are no innate ideas; mind is a blank slate, a tabula rasa, which is shaped by experience; sensations and reflections and Knowledge is determined only by experience derived from sense perception" (An Essay Concerning Human Understanding). On the other hand, Gottfried Wilhelm Leibniz (1646-1716), the German mathematician and philosopher disagrees with Locke about the nature of the mind and the possibility of innate ideas. He believes that while we are not aware of all our ideas at any time, certain innate ideas or truths are in our minds as dispositions or tendencies (New Essays on Human Understanding).

These debates between the "nativists" and "empiricists". have been going on from ancient times, with no satisfactory resolution to the present day. With the modern scientific and technological advances in genetics, neurosciences, information sciences, including computers and artificial intelligence, new perspectives of innateness in cognition are emerging. Recent advances have been described in the series of books (3 Volumes) entitled "The Innate Mind". edited by Carruthers, Laurence, and Stich, published by Oxford University. In this paper we intend to briefly discuss some of these approaches.

The case for innateness got substantially strengthened when Noam Chomsky (1959) argued that our knowledge of language, or more accurately, grammar is innate. Chomsky's central argument, called 'the poverty of stimulus (POS)' is based on the observation that children master linguistic grammar accurately at an early age from very poor information inputs. It was argued that the knowledge of grammar is not derived solely from the child's experience of the external world and that the initial language acquisition involved ."innate, domain specific information". Domain-specific mechanisms are devoted to special functions or special tasks and can be thought of as mental organs or modules. This was developed further by Fodor (1983) in his book entitled "Modularity of Mind". Fodor presents a model for perception and cognition based on 3 basic components viz. (a) The transducers, whose function is to translate the physical stimulations into neural signals. (b) The input systems, responsible for basic cognitive activities such as language and vision, are modular and function to interpret transduced information, and (c) The central system, responsible for more complex cognitive activities such as analogical reasoning, which is not modular.

Fodor listed several features of the modular systems, however, it is not mandatory that a module shows all the features. The major features of the modular systems have been identified as:

domain specificity, • innateness, • informational encapsulation, • fastness,
hardwired (neurally specific), • autonomous, • not assembled.

'Domain-specificity' is the most important feature characterizing a module; it signifies that a cognitive system responds only to stimuli of a particular class. The requirement of 'information encapsulation' means that the processes inside a module are not subject to cognitive influences (beliefs, presumptions or desires) from outside the module. This is somewhat similar to identification and localization by functional neuroimaging techniques (using f MRI and PET) of innate brain structures or neural networks that perform specific functions.

More recently Spelke (1994) extended the nativist view of development to other domains beyond language, claiming that "core knowledge" of physics, psychology, number, and geometry is innate. Thus, in this view sophisticated early knowledge about the fundamental properties of the world gained without much experience (POS) indicates innateness.

3.1.1 Genetic Determination, Invariance and Innate Traits

Innate traits are considered to be genetically determined, domain specific computational modules, invariant to changes in the environment of development. Recent researches have, however, shown that environmental interactions profoundly influence and regulate gene expressions epigenetically by modifying the chromatin structure both at the DNA and histone levels. Thus, it is now believed that both the genetic and environmental (including local, physical, social) factors would be involved, though in varying degrees, in causation of the biological traits, implying the impossibility of only genetic determination of innate traits.

To overcome this difficulty, it has been proposed that innate traits are developmentally invariant, that means 'a phenotypic trait is innate for a given genotype if and only if that phenotype will emerge in all ranges of developmental environments'.

3.2 Role of Affective States in Cognition: Innateness as the Product of Internal Causes

It has been generally appreciated since ancient times, both by the eastern and western philosophers and scholars, that emotional states can color the acquisition of true knowledge of reality. However, in the majority of empirical and theoretical studies in cognitive sciences, the roles of intrinsic states and factors such as basic needs, emotions and feelings, in knowledge acquisition has been largely overlooked. The focus has been more on external/environmental factors such as sensory stimulus. In the past, the prevailing view has been that affect and cognition are separate and independent states, localized in specific regions of the brain. During recent decades this approach has gradually changed. With advances in our understanding of the brain structure and function and connectivity of neural networks, the present view recognizes that affective and cognitive systems strongly interact and jointly influence the processes involved in acquisition of knowledge and behavior (Phelps, 2006; Pessoa, 2008).

Recent empirical studies have clearly established that emotions significantly influence the perceptions; acquisition of knowledge, decision-making and behavior (Schwartz and Clore, 2007; Pfister and Bohm, 2008). It is also being increasingly realized that living beings could be born with innate multi-component affective systems which function to shape their evolutionarily adaptive responses involving the cognitive, experiential, behavioral, and physiological reactions to changes in the

environment. The precise nature of the innate endowment, however, remains elusive. In this context it would be also relevant to ask the question whether pure cognition states without any perturbation by affective states can be acquired by humans.

3.2.1 How Affective States and Factors Influence Cognitive States?

Studies to comprehend the relationship between affective and cognitive states, elucidation of innate factors that influence the activation of knowledge structures and cognitive capacities, the distinctive roles of feelings and emotional dispositions determined by our innate affective endowment, have now acquired the focus of current research.

In English, the word affect signifies a change or an influence. In the context of psychology "affect" refers to feelings or emotions which can induce changes in the internal state of the body resulting in painful or pleasurable experiences (Barrett and Barr, 2009). Emotions may cause subtle perturbations in the homeostasis of the internal milieu of the body, which can eventually be reflected in measurable physiological changes such as alterations in the respiratory and heart rates, increase in blood pressure and blood flow, perspiration and skin conductance, facial expressions and behaviors.

Affective states constitute essential components of the mental state. Recent researches have highlighted the necessity of understanding the complex and manifold cognition-emotion interactions (see, for example, Cognition and Emotion Reviews of Current Research and Theories, edited by Jan De Houwer and Dirk Hermans, 2010).

Empirical studies have demonstrated that angry emotions (the most common emotions in the modern society) may hinder objectivity and rationality leading to distortions in perception, attention, judgment, decision-making and behavior (Lerner and Tiedens, 2006).

Similarly in visual tasks, anxious emotional states, characterized by high physiological arousal as well as negative valence, have been observed to reduce perceptual attention and decrease the accuracy of detecting visual targets (Cacioppo et al., 1996). Increase in anxiety is also associated with an enhanced focus on the local features of visual stimuli, and reduced attention to their global context. Notably, recent studies have pointed out that the relationship between anxiety and attention is more complex and highlighted that considerations of the intensity of

emotions (arousal) and valence (negative or positive) as well as individual differences in anxiety, are of vital importance for a complete understanding of how emotional distracters affect attention (Sussman et al., 2013).

It has been proposed that emotions can color cognition by influencing (a) stages of information processing and (b) judgment and decision-making processes (Clore and Palmer, 2009). Emotions may interact with four basic constituents of information processing: (1) attention; (2) priming of concepts and knowledge structures; (3) computational capacity; and (4) reflective processes. Attentional effects involve biases in the selection of information that is preferentially processed. Priming effects are observed when certain concepts or knowledge structures are more strongly activated than others in memory systems. Computational capacity refers to the cognitive resources available to process particular information. Reflective processes are the ways in which information is used strategically to orient further deliberative processing (Blanchette and Richards, 2010).

The deficits in the social information processing induced by the innate affective endowment may underlie the unpleasant and undesirable consequences such as aggression and violence. The mechanisms involved in the intra- and interindividual variability observed in the emotional and behavioral responses, generally as a personality trait/disposition in the context of a specific situation, remain yet to be elucidated and form important topics for future research.

3.3 Cognition in Non-Human Life-Forms

Voltaire, the great enlightenment writer and philosopher, once said, "Nobody thinks of giving an immortal soul to a flea." Now, nearly 300 years later, the mass of accumulated scientific evidence suggests we may have to." - Robert Lanza, M.D., author of "Biocentrism" How Life and Consciousness Are the Keys to Understanding the True Nature of the Universe".

Western religion and philosophy, in contrast to Eastern Philosophy, traditionally considered humans as radically different from other species, because humans, created in the image of God, were supposed to have a mind and a soul. The famous Greek philosopher Aristotle, considered by some as the father of biological sciences, distinguished living-beings in three types. Plants, devoid of movement from one location to another, yet demonstrating the basic capacities of metabolism, growth, reproduction and decay, (supposed to be important intrinsic properties of all living beings), were classified as the lowest type (level 1) among the living

organisms. Animals having the abilities also to move and to perceive were classified at the level 2, whereas humans were the highest level 3 in the hierarchy because of their additional and unique capacity for cognition. This classification was accepted widely and influenced the beliefs and thinking of majority of the Western scholars.

Thanks to modern advances in molecular biology and genetics, it is now generally accepted that all terrestrial life-forms from micro-organisms to humans follow fundamentally a similar pattern of metabolism (transformations of information stored in DNA and metabolic energy derived from nutrients in interactions with the environment) responsible for maintenance, growth, development and reproduction during their life-cycle. The questions of complex capacities and abilities for cognition, feelings and awareness in various non-human species, however, have remained controversial. Answers to these questions are of vital importance, not only for ethics and morality, but also have many practical implications for treatment of animals in scientific research, agriculture, nutrition and medicine. We briefly review the changing thinking among scientists.

3.3.1 Cognition in Animals

For a long time in the past, animals have been viewed as simple systems that merely responded to various stimuli in evolutionarily pre-programmed, invariant ways. The French mathematician and philosopher René Descartes (1596-1650), often called the father of modern philosophy, introduced the idea of duality of mind and body, and believed that all animals were machines, simple reflex devices that couldn't even think because they did not have language. Contrary to this view, Herbert Spencer (1820-1903), the eminent English biologist, sociologist and philosopher, claimed that man's mind had evolved from the simple automatic responses of lower animals to the process of reasoning in the thinking man. Shortly afterwards, Charles Darwin (1809-1882), the founder of theory of evolution by natural selection, stated that "the difference in mind between man and the higher animals, great as it is, certainly is one of degree and not of kind" (Darwin 1872). This view was based partly on the available anecdotal evidence on behavior of animals and the emerging conviction in the principle of continuity across species during the physical and mental evolution. The view that animals can think, albeit without language, gained ground.

Towards the end of the 19th century, the British psychologist Lloyd Morgan (1852-1936) stipulated that no higher mental abilities are required to be attributed to

an animal if mechanistic explanations suffice. This principle of parsimony, which became known as Morgan's canon, wielded enormous influence in the subsequent studies of animal behavior. It also helped in the growth of the behaviorist movement of experimentalists, mainly in North America in the 20th century. The behaviorists (like Pavlov, Thorndike, Watson, Skinner) dismissed the notion of animal cognition and preferred to confine their efforts to study the relationships between observable stimuli (environmental inputs) and observable responses (outputs). The behaviorists treated the organism as a black box without any references to the inner structure, physiology and mental (cognitive) processes of the organism. This approach led to the development of important concepts of reinforcement and operant conditioning for successfully explaining animal learning behavior. Behaviorism, became very popular among psychologists for a few decades, however, lost influence around the middle of the 20th century. The behaviorist approach, based entirely on experiments performed in the laboratory, faced severe limitations in extending to more complex situations like the natural environment and failed to explain the inter-species differences.

Studies by ethologists, Tinbergen and Lorenz, who observed animal behaviors in natural environments, gradually gathered attention and finally the scenario changed with the publication of the book entitled The Question of Animal Awareness: Evolutionary Continuity of Mental Experience in 1976 by Donald Griffin, a hardcore physiologist. Citing more recent experimental evidence on animal communication, Griffin (2001) argued against the assumption that the mental life of animals is qualitatively different than of humans and linked cognition with the concept of consciousness. More recent studies have provided ample evidence on similarities in emotional and cognitive behaviors (including purposiveness, imitation and empathy) between various animal species from fishes and birds to monkeys and humans, supporting Darwin's ideas on the evolutionary continuity between animals and humans (F.B.M. de Waal, 2009; Shettleworth, 2010; Cocchi et al., 2013). Interestingly, these views are also in agreement with the essence of Jain philosophy on the unity in diversity of all life-forms.

3.3.2 Cognition in Plants

All living-beings are embedded within a physical environment that shapes their organization and behavior. Sensing of the abiotic and biotic environment is physically mediated through the senses of touch, hearing, seeing, feeling, or smelling. The neurobiological apparatus translates sensory information first into

electrical impulses and only thereafter into biological information inducing organismal actions. Human perception of the outside world relies on so-called 'neural code,' which links together sensory signals and neural responses. Similarly, in plants, numerous parameters of the physical environment monitored by specialized cells and the sensory information obtained from the environment is translated into motoric responses.

Over a century ago, Jagadish Chandra Bose (1858- 1937), the Indian biophysicist par excellence, using a set of sensitive instruments and techniques designed by him, produced evidence that plants possess the equivalent of a well-defined nervous system (Bose, 1926). Plants have receptors for stimuli, conductors (nerves), which electrically code and propagate the stimulus, and effectors, or terminal motor organs. He stated "...these trees have a life like ours...they eat and grow...face poverty, sorrows and suffering. This poverty may...induce them to steal and rob...they also help each other, develop friendships, sacrifice their lives for their children..." (cited in A. Nandy, 1995).

Bose's novel ideas met with hostile resistance from some of the established scientists, who doubted his results and competence. Subsequent research has, however, completely validated the truth in observations, conclusions and theories propounded by Bose based on his experimental work (Shepard, 2012) and this has given birth to a new discipline of "Plant Neurobiology".

Today, Plants are regarded as knowledge-accumulating systems, organisms that recognize their kin, forage using trial-and-error strategies rivaling those of certain animals, make choices and anticipate the future, modifying their behaviors according to their past experiences (Attenborough, 1995).

Recent researches (Galis et al., 2009) have shown that plants actively experience environment and can both store and retrieve memories. Plants possess molecular mechanisms that allow them to memorize previous stress events and generate memory imprints ranging from minutes or hours to days or weeks (by changing the concentration of small molecules and proteins), or even next generations of siblings (by genetic and epigenetic modifications).

Bose had demonstrated the fundamental importance of electrical signaling in plants (Shepard, 2005, 1999), and measured electro-mechanical oscillations, which are of great interest today. Plants lack specialized neuronal cells, yet information flows by electrical and chemical means through different levels of their

structural organization. The primary network in plants is a signal transduction network involving cytoplasmic calcium, which acts as a ubiquitous cellular second messenger.



Fig. 3. A simple schematic model depicting the dynamics of acquisition and application of knowledge by a living-being. Color of *Le* y correlates with the intensity of emotions and feelings (*Kashaya*), behavioral traits, karma dynamics and spiritual purity as shown in Table 1 (modified from Jain, 2012).

Table 1: Correlations of Leshya color with Kashaya, Karma dynamics, Behavior, Cognition capacity and Spiritual Purity (I: Influx and D: Dissolution)

S. No.	Leshya color	Kashaya intensity	Karma dynamics	Behavioral dispositions	Cognition capacity	Spiritual Purity index (Gunsthan)
1	Krsna (Black)	++++++	I >>> D	Violent, Cruel, Impulsive	+	1-4
2	Nila (Blue)	+++++	I >> D	Greedy, Lazy, Deceitful	++	1-4
3	Kapot (Gray)	++++	I > D	Jealous, Angry, Arrogant	+++	1-4
4	Taijas (Red)	+++	D > I	Upright, Kind, Simple	++++	1-7
5	Padam (Yellow)	++	D >> I	Forgiving, Self-Sacrifice	+++++	1-7
6	Shukla (White)	+	D >>> I	Non-Violent Equanimous	+++++	1-13
7	Aleshi	0		Ayog Kewali	00	14

Recent researches have provided ample evidence confirming the observations and conclusions of J. C. Bose. It may be stated that in complexity of signaling networks and problem solving within their own environmental context, plants and animals are fundamentally similar (Trewavas, 2009; Garzon and Keijzer, 2011).

3.3.3 Cognition in Microorganisms

It is noteworthy that results of recent researches have confirmed that even single celled prokaryotic (such as E.coli) and eukaryotic (such as slime molds) organisms demonstrate complex communication capabilities, can sense their environments and intelligently adapt their movements and behavior using simple mechanisms for learning and memory (Berg, 2000; Garcia, 2011) This evidence suggests that minimal elements of cognition, using relatively simple two component signal transduction (TCSD) mechanisms, can be detected even in simple organisms without the aid of a nervous system (Van Duijn et al., 2006). Formation of bacterial colonies is based on sophisticated communication and cooperation between cells, which seems to suggest that the origin and the beginning of evolution of cognition lie in bacterial systems (Lyon, 2006; Jacob et al., 2006). The studies of cognition in simpler living beings are thus providing new insights to cognitive sciences.

4. Future Directions of Research

4.1. Integrating Concepts from Jain Epistemology and Modern Cognitive Sciences

Summarizing the above discussion on the present theories of cognition, following statements can be made.

The traditional approaches of information processing based on representations of sensory inputs by symbols and their manipulations, have been found to be inadequate. The modern trends support the ideas of "Embodied Cognition", which propose that the internal and external bodily states profoundly influence the cognitive processes. Theories of "Grounded Cognition" further suggest that cognitive processes emerge from manifold dynamic interactions of internal bodily states, the environment, situated action and simulations in modality-specific systems.

A consensus among the majority of researchers seems to be emerging that a

certain minimum degree of innateness is necessary for the learning mechanisms based on the interactions with the environment to operate. However, there is no clarity about the nature of the innate structures.

There is also ample evidence that affective and cognitive states closely interact. Under given circumstances the nature and intensities of emotions can profoundly influence information processing at several different levels, causing errors in cognition of reality and leading to wrong judgement, decision making, action and conduct.

The present experimental evidence supports the view that all life-forms, from bacteria to humans, represent cognitive systems differing only in degree. This has led to a major shift from human-centric to bio-centric approach, in agreement with the continuity of evolution from simpler forms to more complex forms. Studies on simple organisms have made it abundantly clear that cognition is a biologic function and the nervous system (including the brain) is not essential for cognition. The existence of alternate instruments of information processing and cognition have been demonstrated in microorganisms and plants.

It is noteworthy, however, that many basic questions concerning the nature, acquisition (learning), development and functions of knowledge have not been satisfactorily answered and many controversies are yet to be resolved. The physico-chemical, psycho-biological and psycho-social mechanisms that may underlie the interactions between emotions, acquisitions (learning) and functions of knowledge yet remain to be elucidated. Presently, little is known with certainty about the instincts, the innate affective endowments and development of personality traits, which manifest vast individual differences between and within species of living-beings.

"Consciousness (awareness/intentions) can affect the physiology of the body" is known for a long time, yet how consciousness interacts with the physical body remains largely unknown.

Modern theories of cognition have also not been able to provide adequate explanations of certain psychological phenomena and behaviors such as extrasensory perceptions (ESP), "Intent or Free Will" and "Altruistic" behaviors observed in humans and non-human life-forms.

In the following, we briefly outline an approach that might be useful in future studies on some of the important issues.

4.1.1. A Simple Conceptual Model for the Evolution and Expression of Knowledge

A simple conceptual model, integrating concepts from Jain epistemology and theories of Embodied and Grounded-Cognition is proposed. The model can be useful in explanation of hitherto understood psychological phenomena such as extra-sensory perceptions and free-will. Aspects of the model are experimentally verifiable. Briefly the conceptual model is based on the following assumptions:

A Living-being represents a dynamic developmental system involving interactions between consciousness, karmic body, physical body and environment. The complex dynamic processes in the living being comprise interactions between two major sub-systems: (1) The Psychic-System (P-system) pertaining to the states of consciousness and (2) The Body-System (B-system) pertaining to states of the physical body. The P-system is embedded in the B-system and knowledge emerges through interactions between the two systems in response to stimuli from the external and/or internal environments.

(1) The P-system, embedded in the B-system, is subtle (*s k*?*ma*) and invisible psychical system that involves consciousness and the karmic-body as the major interacting components. The karmic-body is composed of subtle material particles, we may call them karmons, that encode and temporarily store information about the past actions and experiences. The information is expressed when the karmic particles get activated. *Citta* is a dynamic construct where energy vibrations from consciousness (termed *puru*? *rth* or self-effort/free will) interact with the radiations from the activated karma particals. The intensities and frequency distributions (spectrum) of thus modulated radiations characterize the intents (*bh va*) and behavioral dispositions. The radiation spectrum is related to the innate knowledge and influences the potential developmental trajectories of the living being. The radiation spectrum over a time interval, on translation into corresponding colors, termed *le y*, facilitates communication between the P- and B-system (for a detailed discussion of *le y*, see Jain, 2012).

(2) The B-system is gross (*sth la*) visible system of the physical body (*aud rika ar ra*). It is composed of several interacting sub-systems of sensors, effectors and regulators made up of bio-molecular structures such as chromatin (DNA + histones), proteins, lipids, metabolome, membranes, microtubules etc. organized in organelles (such as mitochondria, ribosomes), cells, tissues, modules and organs

designed for specific functions.

The important functional characteristics of the two systems are:

- (a) In the P-system, the karmic-body, blended with consciousness, entails the long term memory of the past actions and could be considered innate in the presently existing form of the living being. Activation of the karmic-body occurs by intrinsic factors pertaining to Karma-dynamics, developmental and environmental agents and gives rise to the emotions and passions (*Kashaya*) that significantly affect behavior by influencing the capacity to acquire valid knowledge of reality.
- (b) In the B-system, information encoded in the chromatin, comprising DNA and the enveloping proteins (histones), plays a major role in determining the structure and function of the gross physical body.
- (c) The physico-chemical and psycho-social environment, interacting with the sensors can modify the genetic information encoded in chromatin thereby affecting gene expression and behavior by epigenetic mechanisms (see Fig. 2). The epigenetic changes brought out by structural modifications in the chromatin (DNA + protein) can modify information processing, provide short term memory and influence behavior over a life-time that could underlie learning.

The subtle P-system is embedded in the gross B-system. The communication and interactions between the two systems is mediated by *Le y* as shown schematically in Fig. 3. *Le y* radiations provide the crucial link between the state of the *Citta* and the activities of the physical body (mind- body interactions). The power of soul which remains unobstructed by the karmic body interacts with the karma induced *kashaya* to influence the expressions of consciousness, which manifest as *bh va* (feelings, emotions, passions, desires). *Le y* represents stream of bh va during a given period of time.

Spiritual practices such as austerities and meditation, in particular *Le y* - meditation, an important component of Preksha-meditation, can lead to changes in *Le y*, transformation of consciousness and modification of behavior (Tulsi, 1994). Neuroimaging techniques have demonstrated significant structural and functional changes in the human brain by meditation. In recent studies, alterations in gene expression have also been observed after practice of *Vipassana* (mindfull) meditation (Kallman et al., 2014). It may, therefore, be expected that spiritual
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practices would bring about profound changes in gene expression by altering the epigenome. Thus, it would be possible to experimentally verify some of the predictions of the proposed conceptual model.

Preliminary studies on practitioners of transcendental meditation (TM) have suggested that practice of meditation could also change the pattern of biophoton emission (Van Wijk et al., 2006). Biophotons are ultra-violet low frequency coherent light photons (in the range 100-1000 nm) emitted at very low intensities (ultraweak) by all living systems from bacteria to humans. Biophoton emission (BPE) depends on cellular functions. Biophotons have been shown to effectively transfer information within and between organisms (Fels, 2009; Sun et al., 2010). Interestingly, results of recent experiments to study visual imagery of white light in human volunteers suggest that BPE could also influence cognitive processes (Dotta et al., 2012). It is pertinent to note in this context that *Leshya*-meditation, a Jain practice involving white light imagery, is stated to transform malevolent *le y* (black, blue and grey) into benign ones (red, yellow and white). It has also been conjectured that BPE could provide novel quantum mechanical entanglement pathways for the non-localized and spontaneous information transfer (for example in parapsychological phenomena such as telepathy/clairvoyance) between living beings.

These findings are of great importance for studies aimed at experimental verification of the model proposed in Fig. 3. In the first phase, effects of *leshya* meditation on epigenomic alterations, specific gene expressions, imaging of biophoton emissions and behavioral dispositions could be investigated as indicated as schematically indicated in Fig. 4.



Fig. 4: Possible Effects of Meditation on *Leshya* Transmutation, Epigenome, Gene Expression and Behavioral Dispositions

In conclusion, it may be stated that a comprehensive research program to investigate the possibility of combining some of the concepts of Jain epistemology with modern neuroscience and theories of cognition could open new avenues of understanding the age old question of how do we know what we know and what can we know.

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4. Modern Theories of Cognition

B.R. Dugar

Abstract

Cognition is an important branch of study since the human cognitive capacity involves a person's experience with environment, determines his all-round development and helps in development of his system of thinking. The prominent disciplines in this field are Artificial Intelligence (AI), artificial life (A-life), psychology, linguistics, computational neuroscience, and philosophy- especially the philosophy of mind and language. Some relevant subfields include robotics, whether classical, situated or evolutionary; study of enactive vision, where the organism's own movements (of eyes and/or body) provide crucial information about his behaviour and response; the psychology of human-computer interaction, including various aspects of virtual reality such as *avatars*; and computational theories of literature, art, music, and scientific discoveries. Non-human minds are studied by computational ethology and neuroethology, and by A-life. Piaget, a well-known cognitive scientist has explored new avenues in the field. This paper seeks to describe different aspects of various theories of cognition.

Key Words: Cognition, biological equilibrium, consciousness, stimuli, psychoneural phenomena.

1. Introduction

Cognition is the act of knowing or the process involved in knowing. When we 'know' something, it means that we are not only aware or conscious of it, but that we can, in a way, make some sort of judgment about it. Cognition is therefore a broad term that covers a complicated mental process involving such functions as perception, learning, memory, and problem solving.

The nature of cognition, or how we know, has been the subject of

investigation since the time of the ancient Greeks. It has been studied by philosophers as well as scientists. Around 1970, a new field of investigation called cognitive psychology began to emerge. Many of its practitioners study the brain and compare it to a computer in terms of its information storage and retrieval functions. However, most people who study cognition recognize that they are not focusing on how the brain, as an organ, works, but are more concerned with the way the mind works. While there are several competing theories, all try to explain how the mind works or how we know; one idea common to most of them is that the mind builds concepts- which are like large symbolic groupings, patterns, or categories-that represent actual things in the real world. When it encounters a new object or event, it compares them with the concepts it has already built and stored.

2. Development of Modern Theory

The theory of cognitive development proposed by Jean Piaget during 1930's through the 1970's explains how people's ability to understand the world grows and changes, and it is this changing cognitive capacity that creates some interesting circumstances. Piaget called the study of the way individuals learn to know as "genetic epistemology." The use of the word "genetic" simply refers to "origins" or "beginnings". Epistemology is the study of knowledge. Piaget studied the origins in an individual's ability to know by observing how infants, children, and adolescents understand the world. According to Piaget, children take an active part in their own development. The acquisition of understanding comes from interactions with the world around them. All experiences are understood according to the level of thinking that individuals use. The very act of acquiring new information, however, also changes the way one understand the world.

Information gathering process through experiences is called adaptation. Often, this process is little more than using what one already knows. For example, a toddler who knows how to use a cup, may be trying to drink from a slightly largerthan-normal cup. The child must adapt to the larger container. This is a relatively simple task and requires only the application of what the child already knows. Still, the behaviour is new and does cause the child to grow and change slightly. Such adaptation is called 'assimilation'. On the other hand, the same child may be attempting to eat with a spoon. Because toddlers usually eat with their fingers, the changes required now are significant and call for new abilities. More challenging the task, much greater is the growth. Such adaptation is called 'accommodation'.

Piaget believed that such changes occur because of an innate drive to maintain equilibrium. Biologically speaking, human bodies maintain relatively constant temperature, weight, oxygen, hydration levels and so on. This type of equilibrium is called homeostasis and is described as a dynamic balance. The input of food, energy, and air matches the output and maintains the status quo. If a person gets out of balance (for example, if one holds his breath too long or has not eaten for a long time) he or she is in disequilibrium and is motivated to re-establish the balance. Similarly, Piaget believed that the human cognitive capacity maintains a balance between a person's experience with the environment and his system of thinking. If the experience requires only application of the knowledge one already possesses, such as drinking from a glass, one does not need to change significantly; one adapts with little cognitive growth because one's abilities can handle the challenge. If a person does not have the necessary skills (as when trying to eat with unfamiliar gadgets such as chopsticks) he or she is in disequilibrium; abilities and experiences do not balance. In order to regain their balance, one must change the way one views the world.

Piaget called the ways we view the world 'cognitive structures'. He believed that we all follow the same general pattern in acquisition of new and advanced structures. He described the pattern of growth as a series of stages throughout life. Cognitive growth within a stage is slow. Generally, it involves application of the understood concepts to new situations (assimilation). Piaget described these types of changes as quantitative in nature. That is, the number of things an individual can do or understand using a particular concept, will grow, but the concept itself does not change significantly. The change from one stage to another is qualitative. It involves new concepts and ways of viewing the world (accommodation). This period of change is relatively rapid. Once the new stage is reached, however, change will be fairly slow while the new concepts are applied to various aspects of life.

Piaget believed that this process of growth and change was attributable to both nature and nurture. The child's drive to experience the world in an active fashion and to maintain equilibrium is biological (nature), whereas the impact and changes caused by the experiences provided by the world is environmental (nurture).

3. Cognition as Awareness

When we seek the simplest possible cognitive position, we are not seeking

the origin of knowledge. It is generally accepted that inquiry into origins is beyond the business of science. But we may ask, what are the facts about knowledge which involves the latter in its most elementary form? We obtain knowledge in its simplest form when we go back to the most elementary description of consciousness which we possess. It is simply that of awareness, or of simple apprehension. We may neglect for the moment the fact that awareness has in it a voluntary and a feeling element, and concentrate our attention on the fact that it has a cognitive element. Both Locke and Kant agree that all knowledge begins with experience, and from this there is no dissent on the part of any philosopher. What then is the simplest form of experience, or the ultimate datum from which knowledge starts? Do we have any state of mind which may, for this purpose, be regarded as 'ultimate', which, though itself unexplained, may afford the explanation of everything else?

Here, if anywhere, we have an act of knowledge seemingly concerned with the present reality, and with that alone. It is to be remarked again, by way of caution, that we isolate, for the purpose of study, the act of knowledge from the other elements in the complex state of consciousness which we call awareness. When we speak of knowing, of willing, or of doing, we abstract these from the normal state of consciousness which usually involves all three. Pure thought, pure feeling, pure will, are abstractions and not names of any concrete reality. Awareness is a state of consciousness which possesses all the elements of experience. Here we concentrate attention on the cognitive aspect of awareness. We may, from this point of view, name it apprehension, which is the simplest and the most ultimate of all cognitive acts. At the same time, it is contended that even the simplest state of consciousness has a cognitive aspect. The consciousness of the present is itself an act of knowledge. If, at this stage we may use language more applicable to a subsequent stage of the argument, a state of consciousness is the state of any conscious subject, and it has an object. But, one may ask, can every conscious state be described as knowledge? Would not this be a contradiction of the statement that knowledge, feeling, and volition are not to be derived from each other, that they are primary and underivable? It may be granted that each of these aspects of intelligence has peculiarities inseparable from its very existence, which must be described from attributes peculiar to itself. On the other hand, it may be justly contended that every state of feeling has its cognitive aspect, every state of knowledge has its feeling tone, and that volition has its emotional and cognitive aspect. Still we may focus our attention on the cognitive aspect which is present in every mental state. Awareness

is mainly cognitive, even if it also be volitional and emotional. This awareness, at its simplest, implies the consciousness of a content present to us, and an assurance that we are so far in possession of knowledge of it. It seems to be the simplest of all the acts of knowledge, and cannot be derived from anything simpler.

We are aware that the last statement is deeply contentious, and one which is attacked fiercely and from different standpoints. Idealism contends that the simplest act of knowledge is constituted by thought-relation, and we cannot have an act of knowledge which does not involve relations constituted by thought. Empiricists, on the other hand, tend to isolate sensations, and to make these the sole foundation of possible knowledge. We do not have space here to fully argue this question, but it may be said that even Idealism must have some data from which to start. Something must be given if thought is ever to make a start. And the common starting point of all the subsequent explanations of experience is just this position of awareness. Awareness may be so interpreted as to involve the whole outcome of completed experience. It may, indeed, be truly said of it that it is the awareness of a subject, and this is sufficient to justify all the claims of idealism. On the other hand, empiricism may contend that the first thing is the sensation, and that the awareness is second and that is the effect of the sensation. But it seems more consistent with the fact of experience, and with the whole analysis of the case, to take awareness as the first thing we meet with; it seems to be the ultimate fact beyond which we cannot go, itself unexplained, yet the explanation of everything else. From this primary and underived fact we may explain all the phenomena, whether these take the form of the ordered world of knowledge known as science, on the one hand, or all the facts which are formed into the ordered knowledge which we call by the name of Logic, Psychology, or Metaphysics, on the other. Awareness is the pre-condition of all the systems, and it is well to take it as the starting-point of any theory of knowledge.

Cognitive science is the interdisciplinary study of mind, in which the concepts and methods of artificial intelligence (AI) are central. The most prominent disciplines within the field are AI, artificial life (A-life), psychology, linguistics, computational neuroscience, and philosophy- especially the philosophy of mind and language. Cognitive anthropology is included too, though it often goes unseen under the label of evolutionary psychology. The many relevant subfields include robotics, whether classical, situated, or evolutionary; studies of enactive vision, where the organism's own movements (of eyes and/or body) provide crucial information for acting in the world; the psychology of human-computer

interaction, including various aspects of virtual reality such as avatars; and computational theories of literature, art, music, and scientific discovery. Nonhuman minds are studied by computational ethology and neuroethology, and by A-life.

4. Cognitive Science: A Modern Perspective

Cognitive science includes cognitive psychology and involves the study of language, memory, perception, problem solving, and creative thinking. What is more, most research has focused on individual human adult cognition. However, other aspects of mind are studied too: motivation, emotion, choice [1], development, psychopathology, interpersonal phenomena, motor control, and animal psychology. Consider emotion, for example. The role of emotion in problem solving, attitude formation, and neurosis were topics of research in AI and computational psychology in the early 1960s. But the problems were too difficult, and were largely dropped. Interest revived later, partly because of neuroscientific work on emotional intelligence and partly because of advances in the computational theory of scheduling in multi-goal systems [2]. Interdisciplinary conferences on the psychology, neuroscience, computer modelling, and philosophy of emotion blossomed at the turn of the century, when the topic became a prominent aspect of research. Whether the focus of attention is on development or psychopathology, emotion or motor control, the prime interest for cognitive science is in the abstractly defined computational functions that generate the concerned behaviour. But the neural mechanisms that implement them are also often studied. Despite the functionalist doctrine of multiple reliability, many cognitive scientists want to know how psychological functions are actually implemented in the brain. When functionalism began in the 1960s, little attention was paid to the nervous system by philosophers or AI scientists. Since the 1980s, that has been less true.

Indeed, neuroscience as such has become increasingly concerned with computational questions. On the one hand, there are theories of specific neural circuits doing closely specified things. For instance, cells in the retina and/or visual cortex that compute particular visual features, such as light gradients or surface textures; or cells in the female cricket's brain that enable her to discriminate the song of male crickets of the same species, and to move accordingly. On the other hand, there are broad-brush theories about the computational functions carried out by large areas of the brain, where the focus is less on specific individual cells than on

general neuroanatomy- different cell types, locations, and connections of the neurons.

4.1 Context of Cognitive Theory

Piaget's theory continues to have an immense impact on social science in general and on child development and education in particular. At the time his work was translated into English, the field of child psychology was mostly concerned with either Freudian concepts (Sigmund Freud's psychoanalytic theory) or behaviourism (mostly from B.F. Skinner and other learning theorists). Unlike the psychoanalytical methods or laboratory experiments used by proponents of those approaches, Piaget primarily used an observational strategy in collecting data. Occasionally he would ask questions or pose problems, but even then he allowed the child's behaviour to guide his explorations. This approach led to many new and startling conclusions about how children think. His theories resulted from this technique of gathering data and are remarkably useful.

4.2 Developmental Issues in Cognition Science

Most cognitive scientists study already established phenomena, although many include learning in their subject matter. And some do this because they believe that adult psychology cannot be properly understood without knowing how it developed. In short, they see the mind as an epigenetic system, deeply informed by its developmental history. Epigenesis was stressed long ago by Conrad Waddington in biology and Jean Piaget in psychology. It is self-organized development, grounded in innate predispositions in continual dialectic interaction with the internal and external environment. For example, there are inborn dispositions to attend to broadly face- like stimuli, or to human speech-sounds. Once the attention is caught, learning can help develop the infant's pattern recognition and discriminatory powers. In some cases, such as face recognition, the neural mechanisms relevant at different stages have been largely identified. An epigenetic view is not strictly environmentalist, or strictly nativist either. Rather, it stresses the dialectical interplay between the two. Late twentieth-century work in developmental neuroscience and developmental psychology has therefore led to a radical re-conceptualization of nativism [3]. Some philosophers of biology have defined new accounts of self-organization and dynamical development accordingly.

4.3 Cognitive Science is Computational

Cognitive science employs computational models of mind in two senses. First, the substantive concepts in its theories are computational. The mind is seen as some sort of computational system and mental structure and mental processes are described accordingly [4]. Whereas many psychologists use computers to express their theories, especially to analyse their experimental data, only cognitive scientists import computational ideas into their theories. Some work in cognitive science (in AI and psychology, not only in philosophy) employs computational concepts and insights, but with insufficient detail to allow programs to be written. When programming is possible, it provides several advantages. Even program failures can be scientifically illuminating, pointing out lacunae or mistakes in the theory, or fundamental limitations of the methodology used.

4.4 Cognition: Some Philosophical Problems

Many philosophical disputes arise within cognitive science. One dispute concerns the relative merits of the two AI approaches: classical (symbolic) AI and connectionism, or neural networks. The latter is broadly inspired by the basic structure of the brain. There are several types of neural networks, but the one most widely used within cognitive science- and the one of greatest interest to philosophers- is parallel distributed processing, or PDP. Some researchers champion only one of these AI approaches, whereas others admit both, because of their complementary strengths and weaknesses. Symbolic AI is better for modelling behaviours that involve hierarchical structure, advance planning, deliberation, and/or strict sequential order. The conscious, deliberative aspects of the mind are best suited to this approach. Connectionism, by contrast, is better for modelling the tacit learning and knowledge involved in pattern recognition, including the fuzzy family resemblances between instances of one and the same concept. It does not follow that all unconscious mental processes are best modelled by PDP systems. Some psycho - neural theories of action errors, including various clinical syndromes, employ hybrid (mixed) models in which the hierarchical aspects represent both conscious and unconscious processing.

4.5 Opposition to Orthodox Cognitive Science

A sixth controversy-or rather, batch of controversies- arises from the recent work that opposes orthodox (neo-Cartesian) cognitive science [5]. This involves both empirical theory/modelling and philosophical discussion. In general, it draws on the traditions of phenomenological philosophy and/or autopoietic biology, rather than Cartesianism. It rejects both symbolic and connectionist AI, and the concept of representation. It highlights embodied systems (not abstract simulations), embedded in their environment and responding directly to it. Examples include situated robotics in AI, dynamical systems theory, ecological psychology, and A-life studies of evolution and co-evolution. Philosophies inspired by these empirical researches include the theory of extended mind [6]. This starts from the position that minds must necessarily be embodied and that memory storage lies largely outside the skull and goes on to argue that an individual person's mind is extended over the surrounding cultural artefacts: language, customs, and material objects- from palaces to pencils. The claim is that mind is not merely deeply influenced by these things, but it is largely constituted by them. Philosophical questions associated with A-life include whether evolution is a necessary characteristic of life, and whether the concept of autopoiesis captures the essence of life [7]. If living things are defined as autopoietic systems- whose physical unity, boundaries, and self-maintenance are attained by self-organized metabolic processes- then questions about the origins of life take on a different colour, as do questions about the possibility of strong A-life (life in computer memory)- so called by analogy to strong AI. Philosophers of A-life consider not only the nature of life as such, but how and why it is related to mind. Must all minds be evolved, for example? Autopoietic theorists define all life as involving cognition, while insisting that only linguistic life (i.e. adult humans) involves representations. But questions remain about whether, and if so why, life really is essential for mind? By the same token, questions remain about whether the study of A-life is essentially unrelated to cognitive science or is fundamental to it?

5. Cognitive Science and Culture

Culture directed research in cognitive science raises philosophical questions too. One concerns the nature of group mind, or as it is more commonly called, distributed cognition [8]. Can one identify aspects of cognition that cannot be attributed to any single individual, but only to a team of encultured persons acting in concert- and if so, can one model such phenomena in computers? Two more such questions concern the evolution of information-processing mechanisms that underlie important cultural phenomena- religion or aesthetic appreciation, for example-and the evolution of culture as such.

6. Perception and Cognition

For Piaget, learning played an important part not only in the elaboration of intellectual structures but also in the field of perception. It is this that distinguishes his view from that of the Gestalt psychologists. For the latter, the perceptual constancies of shape and size belong directly to the perceived objects and are independent of age and ability. For Piaget, however, perception of figures is built up as a result of a series of random eye and other muscular movements, which are gradually corrected. A young child does not attribute a constant size or even identity to the objects around him. Piaget believed that the logical forms of activity that emerge in child behaviour, namely classifying, relating, and so forth, arise as a result of his trial-and-error activities. Piaget's views on perception have certain philosophical implications. Previously, as he points out, philosophers have assumed a definite psychology of perception in their epistemologies. A good example of this is John Locke's sensationalism, in which it is assumed (1) that empirical facts are passively given in perception and (2) that they correspond to a certain range of linguistic expressions that designate them. For Piaget, however, even the notion of an object, one of the simplest forms of perceptual invariants, requires a definite learning process. Before the child is able to use linguistic expressions to refer unequivocally to definite objects, he must first have developed concrete classificatory and relational activities. Even the simple statement, "This is green," implies the acquisition of such skills and hence cannot be regarded as a reference to a simple perceptual datum. When we talk intelligently of green, this presupposes that we have learned to classify objects according to their colour and to differentiate one colour from another.

7. Conclusion

There is no doubt that cognition has become increasingly concerned with human behaviour. On one hand, there are theories of specific neural circuits doing closely specified things and on the other, there are broad-brush theories about the computational functions carried out by large areas of the brain, where the focus is less on specific individual cells than on general neuroanatomy.

The theories of cognition are pertinent and significant in mapping of the human behaviour and a lot can be done for better understanding of the human psyche through these theories. Cognition in Jainism assumes consciousness (chetana) and awareness (darshana) as inseparable entities that are inevitable and the most elementary forms in any given state of knowledge as discussed in this article.

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5. Jain Concepts of Knowledge in Context of General Systems Theory and Physics

Surendra Singh Pokharna

Abstract

This paper summarizes limitations of scientific methodology and the concept of knowledge used to study living systems including human systems. It includes limitations caused by the Gödel's Incompleteness theorems and conservations laws defined for isolated closed systems. Hence General Systems Theory should be used to understand these systems. It is argued that the concept of Jainism that knowledge is structured in the consciousness needs to be examined in the modern context. The scientific knowledge appears to be a subset of a much wider concept of knowledge. Some examples are given which show that the concept of knowledge of consciousness has deeper meaning and should be pursued scientifically. The first idea is concerned with Shatavadhanies, who demonstrate highly evolved mental faculties through which one can perform and recall hundreds of activities simultaneously in a sequence or randomly without making any written notes. The second example is concerned with the remarkable memory of Swami Vivekananda. The third example provides a table which indirectly indicates that ancient Jain Acharyas had estimated the size of the smallest particles of matter which are statistically significant and comparable to the sizes of the elementary particles of matter measured recently using scientific techniques.

Research on consciousness may provide new frontiers of knowledge, not yet recognized in the modern science. Some recent studies to understand consciousness using quantum physics, general theory of relativity, finer structures of neurons like microtubules and tubulins is also discussed. Finally it is proposed that the process of enlightenment as described in Jainism to achieve the highest state of soul may be accompanied by a reduction in rate of entropy increase and a decrease in resource consumption at every stage. Key Words: General Systems theory, *Shatavadhan*, Quantum mechanics, Neurophysiology, Conservation laws, Consciousness, Orch-OR

1. Introduction

Science and technology and their applications in economic developments and commercialization have revolutionized the world in such a way that everything appears to have changed in the past century. Developments in the field of space technology, atomic energy, electronics, biotechnology, modern agriculture, telecommunication, and manufacturing industries are some of the examples of these changes. These changes have also played a key role in making the world truly global. However, they have also resulted in an increase in population, depletion of natural resources, damage to the environment, increase in terrorism, threats of nuclear wars and so on. All these consequences have resulted in a large increase in entropy at different levels in different fields (Pokharna, 2012). In addition, because of these changes and domination of science and technology in all walks of life, an impression has been created that scientific knowledge is supreme and anything else, which does not fall in this domain, is not relevant. But the modern science and technology are just two hundred years old and there was a concept of knowledge and technology even before the modern science came into the existence.

Actually one finds that scientific methods developed to study the physical systems are not adequate when biological and human systems are also included (John Gigch, 1978; Bertalanffy, 1976), because all living systems are essentially irreversible in nature, that is they grow and decay and they are open systems compared to the physical systems which, at some scale, become closed systems. Furthermore, in living systems, there are micro controls in the form of thought processes which cannot be easily adjusted in any planned "scientific experiment". Also they have a capability of infinite amplification because of the thought processes, which makes it difficult to study them in a strictly scientific way. Any experimentation is difficult in case of human systems (Goldsmith 1990; Jones 1990), as they have memory, free will, creativity, tendency to interact strongly with other fellow beings and the environment. So the biological and social systems cannot be strictly subjected to the process of measurement and hence they are not exactly describable in the strict terminology of the physical sciences. Expressed in a different way, it is now felt that the standard concepts used in any scientific study like compartmentalization, reductionism, causality, mechanism, induction,

empiricism and passivism etc. (Goldsmith, 1990, Jones 1990) cannot be used to study biological and social systems. Not only this, but the basic parameters used in science like energy, mass, linear momentum and angular momentum which are defined for closed isolated physical systems, may not be the best choice for describing biological and social systems (Penrose, 1990; John Gigch, 1978; Pokharna, 2012). The final blow to limitations of scientific methodology has been given by Gödel's Incompleteness theorems (Penrose, 1990) which have virtually shaken the foundation of modern science. Hence, a totally new perspective and concepts are required to handle the modern problems of the society.

It is observed that most of the development in science and technology and their economic exploitations have resulted in a large increase in the entropy at all levels starting from the human brain to the whole biosphere. The General Systems Theory (GST) can be used for better understanding of the whole problem because, by its intrinsic nature, GST can give a better picture of the interconnectedness of various components of the Human-Earth-atmosphere-Universesystem. It is eventually a problem of order versus disorder (Pokharna, 2010, 2012) at all levels and so when we talk of development and evolution, we should talk about the development of order and evolution of order for complete understanding of the term development. These concepts will have significant impact on most burring problems of the modern life. The concept of "order" as defined in the case of General Systems Theory needs to be closely examined in view of irreversibility of the biological and human systems. Therefore it appears that the Jain concept of evolution of consciousness might be closely related to some kind of knowledge and order at different levels.

In the recent past, extensive work has been done to understand the concept of consciousness through psychology, philosophy, neurophysiology, medical science, artificial intelligence, mathematics, computer science, quantum physics and general theory of relativity (Appendix 1) etc. The work of Penrose and Hameroff (2014) about finer structure of neurons in terms of microtubules and tubulins, which may be controlled by quantum gravity are discussed. We also discuss the possibility of information being present at Planck's level in space-time geometry, which may imply soul like concepts mentioned in Jainism.

2. Science, Technology, Economic Development and Entropy

The consequences of a unidirectional concept of economic development and its amplification due to science and technology, have damaged the environment

and is degrading the life support system irreparably. Actually economic development is required for smooth running of a society and everybody wants it. However, with advancements of science and technology, industrial revolution has taken place in the world and economic activities have started concentrating at a few places and in a few cities. These activities started polluting the natural resources in a highly damaging way. The process of pollution of the environment can be traced to the increased industrial activities and increase in population (due to decrease in death rates etc.). Due to congestion of the cities, there results a cut throat competition among people for survival. The old value system based on simplicity, honesty and sincerity started getting replaced by complexity, consumerism, dishonesty, and unwanted domination of certain groups and countries over others. It has also resulted in large scale corruption in many places in the world. The emphasis on economic development has become so much so that all other types of developments have been set aside. Thus people, specially women, in many countries who used to work towards spiritual development, religious activities and family welfare, have started working for only economic development. Also indices based on economic growth have become prime so the impact of economic devlopment on environment is generally ignored.

Effectively one can say that the ultimate consequence of these activities is a large increase in the entropy (disorder) of the environment and the society. Some examples where one finds entropy increase in one way or the other are:

- (a) Mixing of hydrocarbons like petrol and diesel (vapors) with air and water etc. which were otherwise distinctly separate.
- (b) Spread of industrial chemicals and other pollutants in rivers and ponds and flow of millions of tons of fertile soil in the sea every year.
- (c) Adulteration of food and medicines and many industrial products.
- (d) Spread of electromagnetic pollution in atmosphere due to large increase in use of mobile phones, internet and other electronic gadgets.
- (e) Decrease in orderliness in music and increase in noise.
- (f) Overlapping of social roles of men and women, which were quite distinct in the past resulting in a change from complementarity to competition.
- (g) Increase in corruption and black money due to which unaccounted money is diverted from main economy to areas and accounts which are not counted in GDP, and so on.

Creation of the so called non-biological ordered systems (say concrete jungles, industries, machines etc.) in the name of economic development has basically led to increase of entropy in the biosphere. Such ordered systems can be called as "Non-biological ordered material systems" generating large entropy in the atmosphere. To understand the root cause of these problems, one has to closely examine the basic laws of science and find out whether such an analysis can provide better alternatives and new directions of development.

3. Limitation of the Scientific Methodology

In scientific experiments, one measures a small set of parameters and then correlates them to get some relations, which lead to some rules and laws. For example in Newton's laws of motion, one defines mass and acceleration of a particle and then a relation is developed between the two. However, let us look at a little more complex system where problems arise and where interaction with other parameters can be seen more clearly. For example, when high yielding crop varieties were introduced in the country, the experiments were conducted in small plots by selecting those varieties to confirm the claims of higher yields. These practices were then adopted for large areas, as happened in Punjab and other parts of the country. Now over the years, this has ultimately resulted into degradation of soil on a large scale and depletion of the ground water. This has happened because while conducting the experiments (laboratory scale), such long term consequences were not considered. It means some parameters like extra use of water and increased use of fertilizer and pesticides in the future were not taken into account. These factors become important in long run when large scale extension is made. Another example is use of mobile telephone. In this case one can receive signals from a large distance through electromagnetic waves and communicate with others through emails and telephones etc. However, while using these appliances, their effect on human body and mind and memory is not studied. A common complaint is that use of mobiles reduces one's memory. Here again some parameters were not taken into account while conducting an "experiment". These new factors come into picture later and virtually become uncontrollable when there is a large scale generalization of the "experimental observations" and an uncontrollable expansion of the "experimental observations in the interests of the public". There is a need to closely examine these "benefits of science" as well as their harmful consequences on the society in general.

3.1 Limitations of Scientific Methodology due to Conservations Laws

Any phenomenon is called scientific if it can be verified in a laboratory under a given set of controlled conditions and is reproducible at any point of time and at any place. This condition is called space-time invariance. In addition, we define conservation laws in physics which are foundation of all scientific measurements. Thus we have conservation laws for energy, linear momentum, angular momentum etc. These conservation laws are defined for isolated closed systems, approximating natural systems. Thus energy is a parameter of a closed isolated system which does not change over time. But in nature, we can never have a completely closed isolated system. Similarly linear momentum is a property of a closed isolated system which remains invariant with any spatial displacement and so on. Hence mere definitions of conservation laws are not perfect because they compartmentalize the world. The interaction among various sub-systems is then studied by considering the nature and magnitude of the interaction among them.

3.2 Gödel's Incompleteness Theorems

The most attractive aspect of scientific knowledge is its mathematical basis. We generally feel that a mathematical representation of various scientific facts makes our knowledge more precise and accurate. However, from the following theorems which have been put forward by Kurtz Gödel, we find that any mathematical representation of any physical reality limits our knowledge of that reality. Not only so, but the theorems also imply that none of the descriptions or representations can express the reality of nature completely with perfection. Complete knowledge must necessarily have its foundation in an unexpressed, unmanifest field of intelligence. For detailing these theorems, we refer to the accompanying article by Bhandari and Pokharna on *Syadvad* and *Anekantavad*).

3.3 Physical Systems versus Living Systems and the General Systems Theory

For biological systems which strongly interact with each other, interactions can be more important than the behaviour of the individual sub systems. In fact these individual qualities are constantly changing with time due to interactions at different levels. Thus, for example, one cannot label a person as good or bad, because he may be bad or good from another point of view. In addition, he or she may just change in short period of time due to interaction with other persons or

some situation. Also all living beings evolve essentially irreversibly, that is, they grow and decay and they are also open systems compared to the physical systems (which are treated as closed systems, with some approximation). They constantly interact with the environment. For example human beings take oxygen from the atmosphere and release carbon di-oxide. Also experimentation is not possible in case of human systems because, human systems have memory, free will, creativity, tendency to interact strongly with other fellow beings and the environment. Furthermore, as already mentioned, there are micro controls in the form of thought processes which cannot be easily adjusted in any planned "scientific experiment". Also these are goal directed systems. Hence biological (and social) systems cannot be subjected to the strict process of physical measurement and they are not exactly describable in the terminology of the physical sciences. Therefore such systems are studied in a different way by using statistical procedures. In such methods only some rough trends or patterns can be established. To handle the above problems, we look for a General Systems Theory (GST, John Gigch, 1978) which has been developed to handle complex systems and their properties. Different sets of rules are there to describe and understand such systems. According to this theory all systems are characterized by transfer of information. Here knowledge and order (entropy) are more important compared to any other attribute, such as energy. Hence, under this discipline, physical sciences are categorized as hard systems and sociology, religion, psychology, biology etc. are classified as soft systems. Thus religion and science can be put together in this formalism.

3.4 Human Understanding is neither Deterministic nor Random but is Non-computational

Another interesting consequence of scientifie advancements quantum biology is /and a proposal that human understanding is neither deterministic nor random but is non-computable, and contradicts the concept used in artificial intelligence that human understanding is completely computable. It presupposes that space-time geometry can have information in spin foams at Planck level when we consider quantum gravity (Hameroff and Penrose, 2014; Penrose, 1990). Reduction of quantum superposition at this level is governed by this information, which we cannot consciously control. A similar Objective Reduction (OR) occurs at brain level through "tubulins", the quantum systems operating within neurons through microtubulins.(see section 8,9,10 of Appendix 1 for details).

3.5 Process of Measurement in Quantum Mechanics takes away Information

As is well known, all quantum mechanical systems have several Eigen states and at the time of observation, the system collapses into one of the Eigen state. The probability of finding any of the Eigen state is determined by the Schrodinger equation. Since the process of measurement results into just one Eigen state only, information about other Eigen states is lost due to the process of measurement. Hence, it is impossible to get complete information about a quantum mechanical system by any formulation of wave function or measurement. In view of the loss of information, wave function is now termed as a "wave function of ignorance". Here again we see limitations of scientific knowledge.

4. Scientific Knowledge: a Subset of Total Knowledge which might be Structured in the Consciousness

The above discussion shows that knowledge is probably structured in the consciousness. Even the scientific knowledge is based on interpretation of experiments which are ultimately interpreted by the human consciousness. With the advent of science and technology, misunderstanding and misconception have developed among the masses that the scientific knowledge is the only ultimate knowledge in the world. Not only this, it also presumed that the knowledge which is experimentally verifiable and repeatable at any place and at any time alone is the actual knowledge. This is far from the truth. The fact is that the metholdology of science is a recent phenomenon and has developed over the last few centuries whereas the concept of knowledge existed for several millennia. Vedas, Upanishads, Puranas, Agamas, Mahabharata and Ramayana, etc. have lot of knowledge about various aspects of life and the universe. Take, for example, the technology of gold manufacturing or architecture of temples etc in ancient India. People working in the field of art, culture and sports have several different types of skills and knowledge, which need not have only scientific content. They involved knowledge, which has much wider scope than the scientific knowledge. Actually recent developments in computer science and neurobiology clearly show that the so called knowledge is nothing but information organized in some way (Goldsmith 1990) and information, in turn, is just organization of data in some fashion. It is also realized that human consciousness (and also animal consciousness) is capable of organizing data and generate information leading to knowledge in some way. Thus,

the scientific knowledge is only a subset of total knowledge, which exists in the human consciousness.

5. Consciousness and its Evolution - a Fundamental Element of Total Systems Approach

Philosophically, several Indian schools of thought talk of consciousness and its evolution. They basically assume that knowledge is structured in the consciousness. For example in Jainism, a pure soul has infinite knowledge (intelligence), infinite intuition (awareness), infinite bliss and infinite power (energy). Although perfect soul has sevral other characteristics but the knowledge has been regarded as the chief among them. It is stated in Jainism that although from empirical point of view there is a difference between soul and knowledge, yet from the transcendental point of view it is sufficient to say that soul is the knower. Essentially, there is no difference between the knower and his knowledge. It is further argued that this infinite knowledge gets restricted due to attachment of karma particles with the soul.(see Kachhara 2014 for details) These karmas have been attached with the soul since eternity. They can be slowly removed through spiritual practices, which may take several births. A state of highest orderliness is defined as a pure soul, towards which, everyone must try to evolve. The path of evolution of soul in Jainism is described through fourteen stages, through which one has to pass through before getting liberated. It may be noted that this concept is compatible with GST, where definite goals are defined and every part of the system has to strive to attain that goal. Here the goal is to get moksha i.e. the pure state of the soul.

Order (reduction of entropy) seems to be the most critical factor in the process of development, specifically the order in the brain. It influences all other types of orders. Secondly knowledge is another crucial concept associated with the brain and mind and ultimately linked to consciousness. It is therefore important to understand the concept of knowledge along with order associated with the brain, mind and consciousness. The concept of consciousness is described in biology, psychology, neurobiology and quantum mechanics. In addition, several experimental studies have been carried out to recognize various states of consciousness like sleeping, waking and dreaming states. A fourth state of consciousness is well established now (meditation). Further studies are required in this direction since Indian yogis and rishies talk of several higher stages of consciousness.

In the Indian context, the evolution of consciousness is closely related to the practices which are carried out while living with nature, so they help in preserving the environment (see Maharishi Aurbindo, 2011). This must be recognized as a superior approach compared to exploitation of the environment caused by uncontrolled materialistic developments. Such ideas of spiritual evolution should also be examined while considering economical development.

6. Shatavadhan and Extra-ordinary Memory

It appears that continuous dedication and spiritual practices, lead to higher states of consciousness, and in many cases, it is accompanied by an improvement of memory, say in capture, storage and recalling of objects, activities and events, etc.

As an example, we mention Swami Vivekanand, which had a highly evolved state of consciousness and he could recall almost anything from eleven volumes of Encyclopaedia Britannica, which he scanned through only once (The Life of Swami Vivekanand, 1989).

Another example is that at *shatavadhan*. *Shatavadhan* (*Shat* = 100 + *Avadhan* = focused attention) is the power to remember 100 different activities, some occurring simultaneously and some serially, in a single session. A *shatavadhani* can remember 100 different things in different orders, spoken by 100 different persons. This is possible only when one is able to have total control of the mind, organized memory and experiences the power of soul, cultivated over years of self- control, because a normal human being hardly utilizes 2 to 4% of his total mental potential. A common person can hear and remember serially 3 or 4 events at a time. Anyone with good intellect can extend this number to about 10. However, taking this number to 100 is beyond the powers of most of the people. In Jain tradition Shrimad Rajchandra, Guru of Mahatma Gandhi (Kalarthy, 2004) had this power.

Presently, Muni Ajeet Chand Sagarji, a *Mahasatavdhani*, disciple of Acarya Naya Chandji, demonstrated his mental powers in Ahmedabad (2008) and Mumbai (2012). He recalled and answered questions in the same sequence, reverse sequence and random order, in which they were asked, after four hours with 100 percent accuracy. Muni Ajeet Chand Sagarji later repeated the performance with about 500 avadhans in the presence of around 5000 persons at Sardar Vallabh Bhai Patel stadium in the National Sports Club of India in Mumbai from around 08:30 am to 04:00 pm in the evening. When asked about the way this memorising capability was attained, the muni said that it was cultivated by over 12 years of restricted '*maun*' (in

which he had only limited conversation with his Guru and others meditation, and by following Jain practices of penance and self discipline. Appendix 2 gives wide varieties of 108 questions asked by the audience to Muni Shri Ajeet Chandji in Ahmedabad and subsequently answered by him in different orders.

7. Size of the Smallest Particles of Matter

We mention another example, taken from ancient Jain scripture, a table for measuemant of length from Tiloypa??atti (Jain, 1975). It starts from the smallest particle of matter and goes up to one Yojan (a commonly used unit of length in ancient India). It indicates that ancient Jain acharyas developed a table for measurement of length in octal system in 20 steps and the size of the smallest particle of matter that is *avsannasannaskandha* was estimated to be around 2.9 X 10^{-11} cm. This value lies between the size of an atom (10^{-8} cm) and the size of a nucleus (10^{-13} cm). (see table VIII in chapter 29).

The fact that this value was derived thousands of years ago through realization of higher level of consciousness, when modern tools of science were not available, is worth examining. An Acarya who is having this capability must have his brain in a highly ordered state.

8. Consciousness and Soul

Scientific developments in this field can be categorized according to different disciplines. For example, in the field of brain sciences, discoveries of neurons and synapses and their interactions in cortex and thalamus regions have indicated that consciousness (physiological, in particular) presumably has strong connections with the processes going on in these regions and flow of information through electrochemical impulses. It is inferred that coherent waves having frequency of 40-80 Hz (cycles per second) known as Gamma waves found in the EEG (Electroencephalogram) patterns of the brain are strongly correlated with the level of consciousness. When awareness or consciousness is at higher level as during yoga and meditation, for example, then there is more coherence in these waves. It is also found that hundreds of neurons combine through synapses and axons to form hyper neurons or Hebbian networks and these play important role in conscious decisions. (Hameroff, 2011)

Several approaches are being developed in the field of artificial intelligence, computer science, neurophysiology, psychology, philosophy and robotics to understand consciousness. It may be noted that some western scholars use the term

consciousness for soul also. Hence the meaning should be kept in mind while looking at the context.

8.1 Binding Problem and Consciousness

The memory of the brain is holographic in nature that is, it is not localized but is non-local. There is another area, where non-locality can play an important role; it is binding of sense of colour, shape and motion of objects whose corresponding "regions" in the visual cortex are located in different regions and are processed at different times, and all this information is synthesized to provide a 'wholesome' picture. This is called the 'binding problem'.

8.2 Application of Quantum Physics, General Theory of Relativity and Neurophysiology to Understand Consciousness

The possibility of using quantum physics for understanding consciousness was motivated from the discovery of wave-particle duality of elementary particles like light photons and electrons. In addition, there is an inbuilt uncertainty of the outcome which is determined by the experimental set up, but the choice, in turn, is determined by the state of human consciousness. In general quantum systems can exist in many possible states (known as Eigen states), but when we try to perform a measurement then it shows only one of these possible Eigen states. Quantitatively, one can give only probability of finding a quantum system in a given state. This is similar to uncertainty in our thinking process, which is ultimately related to our consciousness. (Appendix 1 describes several models developed in these areas).

We have mentioned above that human memory is holographic in nature and is non-local, a property similar to that of a quantum mechanical system in which a wave function is always non-local. In addition, in quantum physics we also have a property called entanglement, according to which two parts of a quantum system (e.g. spins of a two electron system) are strongly interrelated. Entanglement can explain the strong interconnectedness, which is a result of association of large parts of neurons and synapses in brain and which is not reducible to the properties of individual neurons and synapses (Binding problem for example).

The processes occurring in the subconscious mind could be different from those taking place in the conscious mind. It is speculated that quantum mechanical processes involving quantum computers are going on in sub-conscious mind (Hameroff, 2011). Memory is stored in the form of "state of a person in certain space at a given time". With each new input, system state changes to new space-time

coordinates. It explains holographic memory and the space time geometry which can lie outside the brain also (see James Culbertson: psycho-space, Appendix 1). In addition, there can be some kind of telepathy and clairvoyance at certain level in the mind, which might have connections with advanced and retarded propagation of waves as per Klein Gordon equations (Appendix 1).

It may be mentioned that quantum physics is now extensively used to understand many phenomena of conscious decision making which cannot be explained by ordinary computer models and neurophysiology. They try to explain several properties of consciousness, psychological phenomena, parapsychological phenomena etc. Even possibility of backward propagation of signal in negative time direction is explained, which may enable one to see the future. Some of these phenomena involving parapsychology are similar to those described in Jainism.

8.3 Concept of Objective Reduction and Theory of Consciousness at Planck's Level

The theory of Objective Reduction was developed by Roger Penrose (1989) by unifying General Theory of Relativity (GTR) and Quantum Theory . He has defined space-time curvature, to the Planck scale (10^{-33} cm in length and 10^{-43} seconds in time), which is the smallest and basic level of the universe. As we go down from atomic scale, eventually we reach the basic level of reality that is Planck scale geometry with coarseness, irregularities, and is probably carrying information as well. Descriptions of Planck scale geometry include string theory and Loop Quantum Gravity. String theory model, in which Planck scale strings vibrate at specific frequencies correlating with fundamental particles, has some problems, lacks background geometry, for example, in which the strings vibrate. In the other approach of Loop Quantum Gravity, which depicts that space-time geometry is quantized into volume pixels that is, Planck scale polygons whose lengths vary with average value of 10^{-33} cm. Planck volumes evolve and change with time, conveying information as a 3-dimensonal and time of 10^{-43} seconds spider web of spin known as spin foams.

A particle in one state or location would have a specific curvature in spacetime geometry, and the same particle in another location would have curvature in the opposite direction, extending downward to the Planck scale. Superposition of both locations can be seen as simultaneous curvatures in opposite directions, and hence, according to Penrose, a separation, bubble, or blister in the very fabric of reality. Penrose has suggested that such space-time separations are unstable and will reduce, or collapse to one particular state or location at a particular time due to an objective threshold, intrinsic to the fine structure of the universe, like infinitesimally tiny soap bubbles bursting one facet or another, shaping and creating a new reality. Penrose also suggests that each OR (Objective Reduction), or self-collapse, essentially results in a moment of conscious experience. This is in direct contradiction to the Copenhagen interpretation in which consciousness lies outside the scope of science, externally causing reduction by observation. In Penrose' concept of OR, consciousness is reduction of a particular type. Thus OR is the only scientific world view incorporating consciousness into the universe. Penrose OR differs in another important way from Copenhagen interprepation in which particular classical states are selected randomly from among superpositioned possibilities. The selections in OR are not random, but influenced by information embedded in fundamental space-time geometry and graviton like energy threshold. Penrose suggests another possibility which avoids the need for multiple universes. Values for physical constants defining our Universe may be encoded in the fine structure of the Universe itself, along with mathematical truth, Platonic values, and precursors of mass, spin, charge, and consciousness. The roots of consciousness may thus extend to the most basic level of the universe. Hence a term "Quantum Soul" has been coined by Deepak Chopra and Stuart Hameroff (2011). This concept supports the concept of soul in Jainism where soul (tman) is assumed to be a fundamental constituent of the Universe and different from matter.

8.4 Penrose and Hameroff Model of Consciousness

Penrose and Hameroff have developed a model of consciousness using Quantum gravity with neurophysiology to explain consciousness at brain level. They feel that physiologically consciousness must be a quantum phenomenon because neurons are too big to account for consciousness. Inside neurons there is a "cytoskeleton", the structure that holds cells together, and whose "microtubules" control the function of synapses. They believe that consciousness is a manifestation of the quantum cytoskeletal state and its interplay between quantum and classical levels of activity. According to the "Orchestrated objective reduction" ("Orch OR"), consciousness depends on quantum computations in structures called microtubules inside brain neurons. Microtubules are cylindrical polymers of the protein "tubulin," and major components of the cell cytoskeleton which selfassembles to configure intracellular architecture, create and regulate synapses, and

communicate between membrane structures and genes in the cell nucleus. In addition to bone-like support, microtubules and other cytoskeletal components seem to act as the cell's nervous system, its "on-board computer," continually reshaping and differentiating. Actually these microtubules consist of millions of smaller structures called tubulins, which behave like quantum mechanical systems and they are the candidates for quantum equivalent of binary digits ("0" and "1") used in ordinary computers. These are called qubits.

According to Hameroff and Chopra (2006) "Recent evidence suggests that Planck scale information may repeat at increasing scales in space-time geometry, reaching the scale of biological systems, that is at neural level. The British-German GEO 600 gravity wave detector near Hanover, Germany has consistently recorded fractal-like noise which apparently emanates from Planck scale fluctuations, repeating after every few orders of magnitude in size and frequency from Planck length and time (10⁻³³ cm; 10⁻⁴³ s) to bio-molecular size and time (10⁻⁸ cm; 10⁻² s, Hogan 2008; Chown 2009). At some point (or actually at some complex edge, or surface) in this hierarchy of scale, the microscopic quantum world makes transitions to the classical world. If this transition is due to OR, consciousness occurs as a process on this edge between quantum and classical worlds" (Hameroff and Chopra, 2006). The author feels that these various levels may be better described through the General Systems Theory.

9. Is Knowledge Structured in the Consciousness: Quantum Information and Brain

It is argued that quantum computers like processes are possible in the human brain even at biological temperature. It is claimed that human subconscious mind works on the basis of quantum computers (assuming tubulin's groups acting as a cellular automata), and so its activities are hidden from us. When the Orch OR takes place, one enters into classical world.

Till recently, capacity of human brain was assumed to possess 10^{17} bits states per second. It was based on the assumption that there are 10^{11} neurons in the brain, and on the average there are 10^3 synapses per neuron and again there are around 10^3 operations per synapse per second. And these are treated as classical bits. However, with the new discovery of tubulins which individually and collectively, being entangled, behave as quantum systems, the human capacity estimate has gone up to 10^{27} quantum bits of information. Now let us look at the following numbers:

- 1. Number (estimated) of neurons in the human brain: 10^{11}
- 2. Number of synapses per neuron in the human brain: 10^3
- 3. Number of operation per synapses in one second: 10^3
- 4. Number of bit states per second in the human brain: 10^{17}
- 5. Number of tubulins per neuron : 10^7
- 6. Number of oscillation per microtubule : 10^8
- 7. Nanosecond switching in microtubule automata per neuron per second : $10^{\mbox{\tiny 16}}$
- 8. Hence for a human brain, number of bits offered per second: 10^{27}

This may be compared with performance of the best supercomputer in the world that is A 1 exaFLOPS (EFLOPS) computer system, which is capable of performing one quintillion (10¹⁸) floating-point operations per second. However, in case of brain, these bit states are not classical bits but quantum bits (qubits) and they operate as a parallel computer. This will ultimately lead to almost infinite information, as per the latest developments in the field of quantum computers and quantum information. This means that a human brain essentially can possess almost infinite knowledge.

The above discussion thus shows that the concept of infinite knowledge possessed by a pure soul (*keval Jnani*) in Jain philosophy is practically possible.

10. Quantum Entanglement, Quantum Information and Metaphysical Phenomena: Some Speculations

Quantum entanglement is an important property of a quantum mechanical system. As per Einstein, Podolsky and Rosen (EPR) paradox, if there are two coupled electrons moving away from each other and are with net spin zero then if spin of one electron is measured and is found to be +1/2 in certain direction then the other electron will automatically take a -1/2 spin value, if measured at some other time. This may be true at any spatial separation of the two entangled electrons but experimentally it has been confirmed up to a distance of 149 kilometers. It means that the other electron knows (even at a great distance from the first electron) that measurement has taken place on the first electron. To explain such experiments, it is now suggested that quantum information can propagate backward in time. Such properties are also found in some experiments in psychology and they indicate that

processes can take place in brain which imply backward propagation of information in time (Hameroff 2011).

10.1 Extra Sensory Perception

Many cases of Extra Sensory Perception or premonition have been reported by different persons from time to time and it is subject of many global studies. However, they are subjective and are not reproducible phenomena or experiences and do not meet the primary criterian of scientific study. Therefore, they have not been taken seriously. These phenomena require an approach different from the method of modern science to understand and they may be governed by some other rules, which could be different from those of the scientific logic. They might involve advanced waves of Klein Gordon equations and can be understood within the feamework of discussion given above.

10.2 Classical Information, Quantum Information versus *Paroksa Jñana* (*Apar Vidhy*) and *Pratyksa Jñana* (*Par Vidhy*)

It is now well established that classical information is very different from quantum information. The classical information flows only in positive time direction, whereas quantum information can flow in both, positive as well as negative directions. It means backward propagation of quantum information is possible. It also has properties of entanglement that is information at two different spatial and temporal levels can be strongly correlated with each other as in EPR paradox. Due to this, qubits situated at different places can have strong connectivity resulting in huge capacity to process information and at very high speed. Finally, for a quantum system in a superposition state, if a measurement is carried out to know the state of the system then, only partial information is obtained (available in the Eigen state into which a superposition state has reduced due to measurement process) whereas some information is lost which was available in the other Eigen states. As quantum systems are extremely sensitive systems, they are easily disturbed by the so called "decoherent factors" or noise. Hence it is difficult to access this quantum information.

In Indian philosophy, two types of knowledge are discussed, apar vidy (known as *Parok?a Jñ na* or ordinary knowledge) and *par vidy* (known as *Pratyak?a Jñ na* or superior knowledge). It appears that *apar vidy* may be the classical information and the *para vidhya* may be the quantum information. The recent arguments that subconscious mind works on the basis of quantum information

(working as a quantum computer), is in agreement with the ancient scriptures that actual knowledge is hidden from us and is much more than what appears at the observable level. As mentioned above, one gets classical information from quantum information through the process of Objective Reduction, hence the ultimate source of information or knowledge could be para vidhya.

10.3 Concept of Rebirth and Karma Theory

Theory of karmas (Kachhara 2014) can now be understood since information stored in the space-time geometry of a person may have records of all the past lives and can influence the working of brain at very micro-level. Similarly the deeds of the present life are also stored as some information in its space-time geometry, which may influence the next births and so on.

India has great spiritual traditions and our rishis, munis and acharyas have discussed the ancient lietrature in great detail and have practically experienced several dimensions of reality, not yet explored by the modern scientific methods. Once the mechanism of information flow between human brain and the space-time geometry is understood properly, it may become possible to discuss the theory of karma in a more rational way.

10.4 Full Awakening of Cetan

There is lot of emphasis in Jainism for fully awakened state of *cetan* (awareness) in which the soul has active information/knowledge at one's command. The current models of brain and consciousness clearly explain this property in terms of larger and larger connectivity among a very large number of neurons and synapses (and hence tubulins) with minimum noise level (or decoherence). Probably in a fully awakened state, total quantum information also becomes available.

$11.\,Current\,Models\,of\,Consciousness\,and\,Concept\,of\,Soul\,in\,Jainism$

In view of these observations, the theory of knowledge through consciousness as described in various schools of Indian philosophy seems to be promising. In particular, the Jains have defined knowledge as an essence of soul. According to their conception, a perfect soul has infinite knowledge, infinite intuition, infinite bliss and infinite power. Although a perfect soul has many other characteristics, knowledge has been regarded as the main characteristic of soul. Kundakunda has stated that although from the empirical point of view there is a difference between soul and knowledge yet from the transcendental point of view it is sufficient to say that soul is knower and nothing else. He further stated that there is no difference between the knower and his knowledge. From empirical point of view an omniscient (*Keval* i.e. perfect soul) perceives and knows the whole of reality and from the transcendental point of view he perceives and knows only the self. There are five types of knowledge viz. *Shruta jñ na*, *Mati jñ na*, *Avadhi jñana* (clairvoyance), *Manhaparyaya jñana* (mind reading) and *Kevala jñ na*. The third and fourth are extra sensory perceptions. When a person becomes a *kevali*, omniscient, all other four types of knowledge disappear and he acquires absolute knowledge through which he perceives all characteristics of all systems in the Universe, in past, present and future; nothing is unknown to him.

12. Spiritual Processes and Entropy Production in the Biosphere

From the above analysis, we find that Jain acharyas and other Rishis and Munis have a spiritually ordered mind and if we look at their behavior and daily practices then we find that they consume minimum resources and hence generate minimum entropy in the environment. As they go to higher and higher stages of evolution of consciousness, their resources consumption go on reducing. It appears that as the number of persons carrying out these practices increase, the average overall rate of entropy production in the biosphere decreases. In addition, this may be accompanied by the appearance of a new kind of order which is described above and could be linked with an orderly state of consciousness. Therefore there is a need to investigate different stages of human consciousness which can be in highly ordered states as mentioned in the above sections.

13. Discussion and Conclusions

This paper examines the current problems facing the society and reasons of their occurrence. It is argued that modern science, technology and their economic exploitation are the main causes of these problems and result in an overall increase in the entropy of the biosphere. There are stringent limitations of the modern science and true nature of reality can never be understood through purely scientific approaches. The General Systems Theory is a better alternative to search for new ways for improved understanding of reality. This approach implies that Jain concept of spiritual evolution based on 'knowledge' and 'order' as criteria is promising and should be examined further. The concept of consciousness as discussed in the modern science using quantum physics, General Theory of Relativity and neurophysiology are discussed in some details. It is suggested that concept of quantum information possessed through tubulins in the brain could imply that knowledge is structured in the consciousness. Hence for spiritual evolution, the decoherence should decrease so that more and more information or knowledge can be realized. This will imply that spiritual processes are accompanied by decrease in rate of entropy production at all levels.

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Appendix 1: Models of Consciousness

With permission we summerize here various models of consciousness developed using quantum physics, Theory of Relativity and neurophysiology as described by AntonellaVannini in (Syntropy 2007, pp. 130-146).

1. Lotka's Hypothesis of Mind-Brain Relation Using Quantum Physics

Alfed Lotka proposed in 1924 (when the quantum physics was just born) that mind controls the brain by modulating quantum jumps that would otherwise lead to a completely random existence. The nature of quantum jumps and their characteristics were not known at that time.

2. Niels Bohr Model: Consciousness Creates Reality through the Collapse of Wave Function

The Copenhagen interpretation proposed by Niels Bohr and Werner Heisenberg, suggested a direct link between consciousness and Quantum Mechanics. This interpretation attributes an explicit role to Consciousness, through

the act of measurement and observation, forcing the wave function to collapse into a particle and determining in this way reality itself. According to Bohr and Heisenberg consciousness would be an imminent property of reality which exists before the creation of reality. (This idea is close to Jainism which also believes in soul which is pure consciousness, an entity different from matter.)

3. Luigi Fantappiè: Advanced Waves and Syntropy

Fantappiè starts from the d'Alembert operator which in Klein-Gordon's relativistic generalization of Schrödinger's wave equation has two wave solutions: retarded waves which diverge from the past to the future and anticipated waves which diverge from the future to the past, and which for us, moving forward in time, correspond to converging waves, attractors/absorbers (http://www.sintropia.it/english/2007-eng-1-3.pdf). Studying the mathematical properties of these waves Fantappiè discovered that the diverging waves are governed by the law of entropy, whereas the converging waves are governed by a symmetrical law, which concentrates energy, produces differentiation, structures and order, and which Fantappiè named syntropy. Fantappiè recognized the properties of the law of syntropy in the living systems, and concluded that living systems are a consequence of anticipated waves. Starting from the mathematical properties of the laws of syntropy and entropy, Fantappiè arrived at the formulation of a model of consciousness based on the following elements:

- a. Free will: which is generally considered as a fundamental element of consciousness and is seen as the consequence of a permanent state of choice between information coming from the past and emotions coming from the future.
- b. Feeling of life: another basic component of consciousness is, according to Fantappiè, a direct consequence of waves moving backward in time, from the future to the past. This is equivalent to anticipation or prediction.

Fantappiè says that when physical senses vanish, as in deep meditation, people experience states of consciousness which coexisted in the past, present and future. The coexistence of past, present and future would be a direct consequence of the coexistence [materialization] of advancing and retarding waves. This idea can justify the capability of a keval Jnani in Jainism who can perceive past, present and future at once. It is a super-sensuous state.

Non local memory: Fantappiè suggests the existence of non-local correlations in the universe, as a consequence of advancing waves. For example, in living systems, memory could be a manifestation of non local links with past events which according to Klein-Gordon's equation are still existing (see also Wolman, B. B.(1977)).

4. David Bohm: Implicate and Explicate Order

Bohm introduced the concepts of implicate and explicate orders. In the implicate order there is no difference between mind and matter, while in the explicate order mind and matter are separated. When we deal with quantum mechanics the implicate order prevails, but when we deal with classical physics, that is the macroscopic laws, the explicate order prevails. According to Bohm, consciousness coincides with the implicate order. In the implicate order particles take form, through collapse of the wave function, and the implicate order coincides. According to Bohm each material particle contains a rudimentary form of consciousness. The process of information constitutes a bridge between mental and material properties of particles. At the smallest level of matter i.e. the quantum mechanical level, the mental and physical processes would coincide.

5. Evan Walker's Synaptic Tunneling Model

Evan Walker (1970) argued that electrons between adjacent neurons can create a virtual neural network which can actually overlap the real neural network. It is this virtual nervous system that can produce conscious decisions and govern the behavior of the real nervous system. The real nervous system operates through synaptic messages whereas the virtual one operates by means of quantum effects of tunneling of electrons (similar to Josephson junction in superconductors) through barriers which are forbidden by classical physics. It was therefore argued that although the brain works on the basis of classical physics, consciousness works on the basis of quantum physics.

6. Exploring the use of Bose-Einstein Condensation in Biological System to Understand Consciousness

Bose-Einstein condensation is a phenomenon predicted for a group of identical atoms having an integral value of spin (known as Bosons) which condense into one single state when the temperature decreases. Here the wave function of all the atoms overlaps and the whole group acts as one single unit where the identities of individual atoms disappear and they all merge into a small space. They have lowest possible energy state known "zero point energy" arising due to Heisenberg's uncertainty principle. In this situation, the whole is more than the individual parts, effectively losing the individual identities.

HerbertFrohlich (1986) suggested that biological systems can behave like Bose Einstein condensates due to the presence of the so called Biological oscillators which are there in a non-equilibrium state at constant temperature (due to the presence of external source of energy like Sun light). Such biological oscillators are present in all living matter due to the presence of water and bio molecules which have dipoles. These biological oscillators, like a laser, can amplify signals and encode information, generated by some external stimuli.

7. Umezawa and Ricciardi: Quantum Field Theory (QFT) and Quantum Brain Dynamics (QBD)

In 1967 Luigi Maria Ricciardi and Horoomi Umezawa suggested a model of consciousness based on Quantum Field Theory (QFT). This model starts with the work of Froehlich on Bose-Einstein condensates. The functions of the brain are seen as a consequence of collective quantum order states. For example, memory is associated to "vacuum states". In QFT vacuum states are the lowest level of energy in which, by definition, no particle is present. The stability of vacuum states make them ideal as a unit of memory. Umezawa and Ricciardi underlined that one of the properties of vacuum states is that of developing correlations and order which can extend to macroscopic level, producing fields which can affect the neural system. According to Umezawa, consciousness would be the result of the sum of quantum processes, while the neural systems would be limited to the transmission of macroscopic signals. (This model is somewhat like the Jain concept of soul and karmas. Thus when all karmas disappear, a pure vacuum state comes which has all knowledge like memory of a ground state. Excitations are just like karmas.)

8. Nick Herbert: Pervasive Consciousness

According to Herbert, consciousness is a basic force of the Universe and pervades all nature,. Herbert reaches this conclusion after analyzing the probability principle, the existence of matter (objects are formed only when they are observed) and interconnection (entanglement). These three principles are directly linked to the fundamental characteristics of consciousness: free will, ambiguity and interconnection. (Existence of such an entity is similar to the idea of consciousness in Jainism.)

9. James Culbertson: Psycho-Space

According to Culbertson, memory which is at the basis of consciousness is a consequence of the change of state of matter in time. In other words, memory is equivalent to different modifications in states of matter in time. From this point of view memory is not formed by data stored in the brain, but by links between different states of space-time, and consciousness would therefore be located outside the brain, in space-time coordinates. In order to describe this concept Culbertson coined the term psycho-space. All objects of nature change their state in time. Therefore, all objects of nature could be endowed with consciousness.

10. Karl Pribram: Holonomic Model of Mind

Karl Pribram suggested a holographic hypothesis of memory and mind. A hologram is a 3D photography produced with laser. In order to produce a hologram, the object is first illuminated with a laser light, then a second laser light creates interference pattern with the first one and the interference pattern is stored on the photographic film. When the film is developed, the interference pattern is revealed, but when this pattern is illuminated with a laser light, the original 3D object appears. When the holographic film is split in half and then Illuminated with a laser light, each part shows the original 3D image. Even when the film is divided in minuscule fragments, each fragment will contain the original 3D image. Differently from classical photography, each part of a holographic film contains all the information. According to Pribram, memory is not stored in a specific location of the brain, but works as a hologram. Only the interference among waves is stored. According to this view each information is transformed by the brain in a wave, and all the waves interfere giving place to holograms.

Appendix 2: Typical Types of Question asked in Shatavadhan

Types of one hundred and eight questions answered in the same sequence by Shri Ajeet Chandra Sagarji, disciple of Acarya Shri Naya Chand Sagarji, did 200 items simultaneously in Mumbai on March 4, 2012, but here only a list of 108 items is given). Recently, on November 16, 2014, he successfully performed 500 avadhans in Mumbai.

1 to 10	One Line sentences may be in questioners form
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- 11-20 Words of Wisdom in a sentence of 5 to 7 words
- 21 First line of a Sanskrit verse

22 to 30	Synonym or Antonym in Gujarati
31	Second line of the same Sanskrit verse
32 to 40	Idioms
41	Third line of Sanskrit verse
42 to 50	Any first line of the same Sanskrit verse
52 to 60	Names of any priest, religious book or religious place
61	A mathematical puzzle
62 to 70	Name of any philosopher, scientist or patriotic person
71	First part of 16 Blocks - A mathematical miracle
72 to 80	See and Remember (Darshan-Avadhan)
81	Second part 16 Blocks - A mathematical miracle
82 to 90	See and Remember (Darshan-Avadhan)
919	Blocks-Mathematical miracle
92 to 99	Mathematical calculation with 8 persons
100	Day of the Birthday
101-104	A line from Religious, cultural or patriotic song
105 to 108	Verse from Jain gamas

6. Karma, Living Systems, Genes and Human Performance

N. L. Kachhara, S. R. Tater and Samani Unnat Prajna

Abstract

Karma is the central principle of Jain philosophy. It is records of actions performed in the past. This information is stored and carried forward to next life thus providing continuity to lives of a soul. Karma becomes the source information for structure and performance of the physical body. Jain philosophy describes two types of karma, *bh va* karma (psychic states) which makes up the impurity of the soul and *dravya* karma (karmic particles), which is a physical structure made up of subtle matter. Karmas bond due to activities and passions of the soul and are defined by four properties: numerical strength, type or nature, duration and intensity of bond. There are mainly eight types of karmas, which are classified in two groups: psychical and biological karmas; both have specific roles in the constitution and performance of the body.

Bonding, rise and shedding of karma are continuous processes; the rise occurs by causes, some being main and some are auxiliary types. A study of rise (fruition) of karma explains the basis of the processes taking place in the body and have been studied scientifically. The working of different types of karma in the life of a being is discussed in this article.

The body system comprising of soul, subtle karma and fiery bodies, and the gross material body is described and interactions between the three component units is discussed. The interaction is supposed to take place through radiations known as *adhyavas* y and *le* y. The relationship between karma and gross body is discussed in detail. The inter-connection between all types of bodies is also examined.

It is shown that there is a similarity between the roles of karma and genes. Genes, being structures of atoms and molecules, are supposed to be devoid of

natural intelligence. The karmas are postulated to be the source of intelligent actions of genes and many of their functions. The overall performance of the being is determined not only by karma and genes but also by external factors constituting the environment.

Key Words: Karma, Bh va Karma, Dravya Karma, Nokarma, Gh ti Karma, Agh ti Karma

Scriptures Quoted: Tattv rtha Sutra, Gommatas ra Karmak ??a, Bhagava,

1. Introduction

All Indian philosophies subscribe to rebirth and believe that the records of actions performed in the life are maintained in some form and that these records become a cause for consequences in the future life. Such records are known as karma (*Samsk ra*). The soul is immortal and is embodied due to his karma, which are the cause of cycle of rebirths. All births of a soul are not temporally independent but are linked through karma records. The powers and abilities the soul enjoys in a particular life depend on his performance in the previous births. Therefore, the state of a soul in this life is a logical outcome of his previous performances.

According to Jaina philosophy the soul is one of the six 'reals' that constitute this universe. The other important reality is matter, both subtle and gross. A reality or substance has three properties: (1) it undergoes transformation and changes its form. Each form is called a pary ya. (2) it has the property of destruction, that is one form is destroyed as the other originates and (3) in the process of transformation and destruction the intrinsic nature of the reality i.e. its essence is preserved; its basic characteristic is permanent and is not altered [1]. Such properties are easily evident in physical matter. For example, when a substance changes its form from solid to liquid and to gas, the chemical composition does not change. So is the case with the soul. The soul leaves one body on "death" and enters another body according to well-defined rules of karma. Here "death" only implies that the soul leaves the present mode; the soul, in fact, does not die. The soul is immortal and only changes its form when it leaves one body and enters another. In this process the karmas, which are impressions of the actions performed by the soul, are carried forward to the next body and continuity in mundane existence of the soul is maintained.

In modern times *pudgala* (matter) has received more attention of scholars and scientists and the body as a physical entity has been studied in detail. These studies

try to explain all processes and phenomena in the body on physical grounds neglecting the existence of *j* va (soul). Because impure *pudgala* (*skandha*) is also possessed of powers and is capable of self organization in a limited way, some success has been achieved in explaining the body processes and its functioning by physical laws. But there are many deeper aspects of the body that defy pure physical basis and no satisfactory answers are found. Jain philosophy asserts that it is combination of soul (*tma*) and *pudgala* that is working in the body and anyone of them alone cannot completely explain the structure and functioning of the life unit.

j va being non-physical is not amenable to direct physical analysis. The connection between *j* va and the material body is also not direct but is made through the karma body. Jain philosophy describes in detail this karma body, its formation, functions and its role in the formation and functioning of the material body. This knowledge can help in a big way in decoding the mysteries of the material body and its functioning. We briefly survey in this paper the scope and potential of interaction between the karma body and material body and try to understand the combination of *j* va and *pudgala* in a scientific way.

2. Bh va Karma and Dravya Karma

There are two types of karma: *bh va* karma and *dravya* karma [2]. *Bh va* karma is the impurity of the soul or impure consciousness and is non-physical. These karmas are impressions of the thoughts and actions of the soul and exist as some kind of virtual structures in the soul. The impression is memory of the action and so the soul knows all the actions performed by him in the past, including all previous lives. The information stored in the memory relates to worldly activities and is hindrance in self-realization. This is why it is called impurity that hides the real nature of the soul. *bh va* karmas are the cause of future modes of the soul.

Bh va karmas have physical counterpart as *dravya* karma constituted by subtle matter called karma *varga?* . The *dravya* karmas form a body known as karmic body. Thus *dravya* karmas are physical records of past activities of the soul. There is perfect balance between *bh va* karma and *dravya* karma and this balance is dynamic in the sense that a change in one makes a corresponding change in the other automatically, satisfying the principle of parallelism between *bh va* karma and *dravya* karma. It is because of dravya karma that the non-physical soul is able to perform physical acts. If all *dravya* karmas were removed by some process, which also means elimination of all soul impurities, the soul would be rendered incapable of performing any physical act. So a mundane soul has necessarily to be impure and

these impurities impose limits on manifestation of natural powers of the soul. More the impurities, more are the karmas, and lesser is the power of the soul which is manifested. So, we are all imperfect souls, our imperfection is a direct function of the amount and type of karma.

3. Bonding of Karma

A living being is engaged in some kind of activity of its body, speech or mind or some combination of them. These actions and accompanying passions (*kas yas*) induce vibrations in the soul (*bh va* karma). The karma body also vibrates on account of the principle of parallelism that holds between the *bh va* karma and karma body [3]. The vibrating karma body attracts karma *varga*? from the surroundings by the principle of resonance. The incoming karma *varga*? bond with the existing karma and become part of karma body. This karma carries the impression of the source action. The process of bonding takes place both in the soul and karma body simultaneously. Passion is the binding force between incoming *varga*? and the existing karma. If the passion were absent or not operative at any instant, the incoming *varga*? shall not bond with the karma and will exit back to cosmos. The karmas bond all over the karma body, *tm prade as*, that occupies the space of the physical body. In terms of physical body it means that karmas bond uniformly with each cell of the body. So each cell contains the same amount of karma at any instant.

3.1 Karmic Bonds

There are four properties of karma bonds [4]. These properties describe the way in which the karma system works.

1. Numerical Strength of Bond (*Prade a bandh*): Numerable, innumerable or infinite number of karma *varga?*, depending on the strength of the action, may bond on each *pradesa* of karma body, and on each soul *prade a*, (and so on each cell) uniformly.

2. Nature of Karmic Bond (*Prakriti bandh*): There are eight main types of karmas; their nature is defined by the particular property of the soul they obscure [5].

1. Intelligence (or Knowledge) obscuring (*jñ navar? ya*) karma. A pure soul has perfect knowledge; karma obscures and limits the pure and perfect intelligence/knowledge of soul.

- 2. Awareness obscuring (*Dar an var? ya*) karma: This karma restricts the self-awareness and perception ability of soul.
- 3. Feeling producing (*Vedan ya*) karma: A pure soul enjoys infinite bliss. This karma obscures the bliss property and produces the feelings of pleasure and pain, depending on the situation.
- 4. Deluding (*Mohan ya*) karma: A pure soul experiences the absolute truth. The deluding karma hinders the perception of truth. This happens in two ways; firstly the perception and comprehension is obscured so that the truth is not apparent, and secondly the equanimity of conduct is obstructed.
- 5. Age determining (*yu?ya*) karma: A pure soul is ageless, it is never embodied. The age determining karma determines the age i.e. the life span, in a particular realm viz., animal, human, infernal or heavenly mode.
- 6. Form producing or (*N* ma) karma. This karma decides the form of existence, species, in a particular realm and the structure, personality, outward appearance etc. of the being. The concept is very general and refers to all kinds of forms including all animals, plants, humans, infernal beings and heavenly beings.
- 7. Status determining (*Gotra*) karma: This karma refers to the quality of performance (conduct) in a given mode, including effects of inheritance (genetic) one gets from the parents.
- 8. Vitality (or Will Power)-obstructing (*Antar ya*) karma. This karma produces obstruction in the expression of vitality of the soul and causes hindrance in the soul's activities.

3. Duration of Bond (*Sthiti bandh*). The karma remains bound to the karma body for certain duration of time. This duration is determined by passions active in the soul and consists of two parts, passive and active duration. In the passive period called *ab dh k la* the karma exercises no effect on the soul. In the active or experience period, the karma manifests itself and the soul experiences the prescribed effect of the karma.

4. Intensity of Bond (*Anubh ga bandh*). What shall be the intensity of good or bad experience when the karma becomes active? This depends on the intensity of the bond which has already been pre-decided at the time of bondage of karma. The

intensity of bond is determined by the total amount and quality of passions present in the soul. The strength of bond is the real power of karma. The other three properties are of marginal value if the strength the of bond is weak in which case intensity of experience by the soul shall be mild on rise of karma. This implies that the passions are the controlling factors (forces?) in the experiences which the soul undergoes.

The karmas are divided in two groups, *gh* ti and *agh* ti, depending on their influence on soul [6]. The former drastically alters and harms the basic nature of the soul; the latter does not do so. The karmas are the forces that support the bodies of living beings and this provides another basis of defining karmas. The *agh* ti karmas determine the biological structure of the organism and its functions and the *gh* ti karmas determine its psychical performance. So the two groups are:

- 1. Psychical (*gh ti*) Karma: These karmas affect the psyche and inhibit and destroy the fundamental nature of the soul. The intelligence obscuring, awareness obscuring, deluding and vitality-obstructing karmas belong to this group. These karmas limit manifestation of the psychical powers of the soul and are the cause of our imperfection.
- 2. Biological (*agh ti*) Karma: These karmas concern with he physical body and do not cause any harm to the fundamental character of soul. This group includes feeling producing karma, form producing karma, status determining karma and age determining karma. These karmas keep the soul embodied but allow manifestation of natural psychical powers of the soul when the psychical karmas have been eliminated.

The psychical karmas may destroy or obscure or defile the fundamental nature of soul fully or partially. It may be mentioned that the fundamental quality of soul is never fully obscured. If that were the case, the soul would lose its basic character and became as good as an inanimate object.

The effects of psychical karmas can be briefly summarized as follows [7].

- 1. Generate attachment and aversion qualities like anger, ego, illusion and greed.
- 2. Generate desires, drives, instincts and needs like hunger, sleep, defense (fear), and mating (sex).
- 3. Determine the level of intelligence, knowledge, wisdom, perception, will power, and determination.

- 4. Determine faith, philosophical and spiritual qualities.
- 5. Determine personal and social conduct and behavior.

Biological karmas have a wide variety of functions ranging from the type of realm of birth to the minutest details of the body. These karmas can produce all possible types of bodies of all species, all possible variations in bodies of a given species, all different features like outer appearance, deficiencies, voice etc., autonomic and physiological functions, and structural quality of the body. The feeling producing karma may operate at mental or body level to produce mental or body oriented pleasure or pain. The age determining karmas have a temporal character and may be connected with the *pr* ?*a* body.

We explain the function of biological karma with an example. Suppose the age determining karma decides that next birth of *j* va shall be as an animal with a particular life span. The form producing karma shall determine the type of species in the animal kingdom and the shape, size, appearance, structural details, colour, smell, voice, full development, etc. of the body. If the next birth is as a dog then the breed, exact shape and size, look, colour, overall appearance etc. are determined by form producing karma. Whether the dog would live in forest, street, or as a pet would be determined by status determining karma. Irrespective of the location the experience of pain and pleasure shall be decided by feeling producing karma. It may be noted that the age determining karma bonds only once for a lifetime, for one birth, whereas the other three karmas bond for several lives. Therefore the type of species, status and experience of pain and pleasure in the next birth depends not only on the karma accrued in this life but also on karmas accrued in all the previous lives.

The eight main types of karmas are further divided into sub-types; the total number of sub-types is 148 [8]. Each of the sub-type of karmas can vary in grades, giving a large range of karmas which become the basis of differentiation between individuals and diverse types of living beings. The difference in karma makes each individual a unique personality that has no parallel in the past, present and future.

3.2 Rise of Karma

The bondage of karma and rise of karma is a continuing process. Some activity of mind, body and speech is generally taking place every moment., resulting in continuous accumulation of karma. The rise of karma takes place in two ways (1) rise of karma on maturity of the duration of the bond period, and (2) rise of

karma before the maturity period on the initiative of the soul [9]. The rise in the first case is called 'udaya' or 'the rise'. The rise of the second type, called fruition or vipaka, due to puru?arth relates to the exercise of free will of the soul. In the first case of udaya, the soul experiences the consequences of the rise spontaneously without invitation. The second case is a voluntary action of the soul and the experiences are made due to self-initiative. All karmas cannot be aroused prematurely. It is only those karmas which have become capable of being aroused prematurely can be subjected to premature rising. The criterion for this capability is determined by the varieties of prematurely arising karmic type, karmic duration, karmic intensity and karmic units.

Fruition and rise of karma is responsible for the worldly life and therefore its study is of much practical importance, particularly from the scientific point of view. Life flourishes because of fruition of karma and, to study life, we must know why and how karmas get fruition.

Nimitta or auxiliary cause plays an important role in fruition of karma. Let us elaborate this a little more. A cause is that which affects the action; action does not take place without a cause. There are two types of causes for any action to take place [10].

- 1. The Main ($Up \ d \ na$) Cause: It is the cause that transforms into action. This is also called the substantive cause.
- 2. The Auxiliary or Catalytic (*Nimitta*) Cause: It helps the action to take place and motivates the main cause. During action the auxiliary cause does not transform into the main cause and is therefore not destroyed. However the auxiliary cause influences the main cause.

Auxiliary causes are of two types:

(1) Karma is the main auxiliary cause.

(2) *Nokarma* is the supportive auxiliary cause responsible for rise of karma. This again is of two sub-types [11].

- a. Bonded *nokarma*: related to the fiery body and the gross material body.
- b Non-bonded *nokarma*: External factors like family members, contacts, wealth, property, society, geological, climatic and environmental conditions etc.

j va and karma have the mutual relationship of being the main cause as well as the auxiliary cause i.e. the soul transforms by its own cause as well as by the effect

of karma and karma changes by its own cause as well as due to actions of the soul.

Generally, fruition of karma takes place on meeting a *nimitta*. If karma is strong, *nimitta* presents itself automatically. Only in case of *nik can* karma, its rise is independent of *nimitta* and it rises irrespective of *nimitta*. *Puru? rtha* is supposed to enable the soul to fight the karma. This is generally attained by changing the *nimitta*, which, in turn, alters the fruition of karma.

Bondage of karma is important from the spiritual point of view whereas the fruition of karma is important from the scientific point of view. Fruition can take place due to self-initiative by the soul or on soul meeting an auxiliary cause, *nimitta*. There can be one or more *nimittas* at a time. *Nimitta* can be internal i.e. the impurity of the soul itself, or external, living or non-living, with which the *j va* interacts. Thus fruition of karma may take place due to one or more causes, both internal and external. Also, one or more types, generally up to all eight types of karmas, can fructify at a time.

Fruition of karma is associated with mental, verbal or physical activity; one or more activities may take place at a time. These activities, known as yoga in Jainism, are also accompanied by passions. Mental activities exist as thought process, memory recall and interaction with the brain. Verbal action may be spoken words, murmuring or even mental recitation or speech in some form. The physical action can be motor actions or physical movement of limbs and body parts and other biological processes taking place in the body. The activities of fiery body also constitute physical actions.

Fruition of karma takes place in four ways (a) fruition in space (*k*?*etra-vip* k) (b) fruition in j va (*jiva-vipaki*) (c) fruition in particular realm of existence (*bh* va*vip* k) and (d) fruition in body (*pudgala-vip* k) [12].

Fruition in space (k?etra): Truly speaking, all fruition takes place in space but some karma subtypes are specially placed in this category. The *Anupurvi nama* karmas are of this type; they get fruition during migration of soul from the present life to the next life. Presumably fruition of these karmas provides the necessary force for *j va* to move from the present location to the next destined location.

Fruition in *J* va: The *j* va-vip k karma subtypes fructify in the soul directly i.e. fruition first takes place in the *bh* va-karma and are simultaneously followed by fruition of *dravya* karma. *J* va-vip k karmas are of 78 subtypes.

Fruition in a particular realm of existence: The age determining karma belongs to this category. These subtypes get fruition in the next birth.

Fruition in Body: These karmas consist of subtypes of body forming karma; their fruition takes place directly in the body. This fruition determines the structural and functional aspects of the body. Gomma as ra Karmaka??a mentions 62 subtypes in this category. *Vedan ya* karmas are both *j va-vip k* and *pudgala-vip k* types.

The above division of karmas is of special significance. It shows that fruition of all *gh* ti karma directly takes place in the soul and influences its natural powers and performance. Further, fruition of some other karmas like status determining karma, feeling producing karma and some form producing karmas also directly affect the soul. The *pudgala-vip* k form producing karmas which fructify directly in the body are very likely related to biophoton emission, as shown below, discovered by scientific studies; both of these are concerned with processes taking place in the body.

Fruition of karma physically means irradiation of karma body that may exist as some kind of field. Karmas of different types give different kinds of radiations? which interact with the gross body. An entity known as dravya manah or conscious mind, counterpart of bh va manah, exist in all human beings and influences all activities. Conscious mind controls thinking, speaking and physical actions, both biological and motor actions, according to beliefs, norms, procedures and habits stored in the memory. The conscious mind, in turn, is influenced by fruition of karmas. When sleep karmas are on the rise, the working of conscious mind is suspended temporarily. So in the sleep state the mental and some physical activities loose regulation and may take place in an arbitrary manner, escaping the paradigm of accepted beliefs and norms. This happens in dreams in which *j* va experiences unthought of sequences of events without conscious effort. These experiences may consist of non-sensible events, uncensored reflections of the unconscious mind (karmic body) or desires stored in the memory, current tasks being attempted in the conscious mind or even problems the *j* va has been trying to solve. The activities of *j* va in the dream state can be mental or physical or both. Mental activities take place in the form of perception of events as described here. Physical activities may consist of some processes like weeping, laughing, uttering words and sentences, walking, and doing some acts unconsciously, biological processes like anger and other emotions, seminal discharge etc.

In the waking state, the conscious mind controls the mental and physical activities and these activities are organized in a meaningful and purposeful way. This is achieved by choice and selection of *nimitta*, both internal and external. It means that the conscious mind has regulatory function in fruition of karma; the fruition of karma is not entirely arbitrary. Of course, the *nik cita* karma has no control of the conscious mind and the *j va* has to experience their consequences. *Upa ama* is an important method of controlling fruition of karma; by this way the *j va* changes the choice of *nimitta* and temporarily postpones the fruition of karma and selection of *nimitta* are mutually dependent and one leads to the other; which one occurs first depends on the circumstances. Sometimes fruition of karma leads to choice of *nimitta* and mutually influence each other.

The following are the possible effects of rise of different karmas [13].

- 1. *Jñ n var? ya* karma: The soul fails to know, in spite of its curiosity, the subject of relevance. His sensual perception is veiled.
- 2. *Dar an var? ya* karma: The soul fails to be fully aware, in spite of being alert, of the subject in sight. Either his sensual perceptions are blocked or he goes in sleep state.
- 3. *S* t *Vedan ya* karma: The soul experiences pleasure in the form of words, sight, smell, taste or touch of liking or favourable mental, verbal or body conditions.

As t Vedan ya karma: The soul experiences pain. This could be in the form of unpleasing words, sight, smell, taste or touch or adverse mental, verbal or body conditions.

- 4. *Mohan ya* karma. The soul experiences perverse state and its character deteriorates, suffering from lack of righteousness, perverseness, or both, and attack of passions and quasi-passions.
- 5. *yu?ya* karma. The soul incarnates in a particular form. These forms could be as infernal beings, heavenly beings, animals or human beings.
- 6. *ubha n ma* karma. The soul experiences higher physical and verbal conditions. He may have superior speech, looks, smell, taste, touch, movements, position, beauty, fame, physical strength, courage, valour, and melodious, impressive, effective and mentally pleasing voice.

A *ubha n ma* karma. The soul experiences lower physical and verbal conditions. He may have inferior speech, looks, smell, taste, touch, movements, position, and loss of beauty, fame, physical strength, courage and valour, and harsh, unimpressive, ineffective and mentally displeasing voice.

7. High *gotra* karma. The soul experiences states of elevated class, family status, power, position, industrious working, scholarly achievements, gains and prosperity.

Low *gotra* karma. The soul experiences lower states of class, family status, power and position, loses capability of working hard, scholarly performance and prosperity, and suffers losses.

8. *Antar ya karma.* The powers of soul are obstructed. Acts of charity, gains, enjoyment, pleasure and spiritual initiatives can not be carried out.

3.3 Working of Karma

For any worldly activity subsidence-cum-annihilation (*k?hayopa?ama*) of psychical karma and rise of biological karma is essential. Either the soul enjoys favourable conditions when the subsidence-cum-annihilation of psychical karma and rise of auspicious biological karma takes place or faces adverse conditions when the psychical karma and inauspicious biological karma arise. For any event in life to occur, proper combination of subsidence-cum-annihilation of all the four psychical karmas is required.

We illustrate the working of karma with the help of an example. Suppose one is enjoying music. At this moment biological karmas are on rise. The age determining karma is on rise so that one is alive to listen to music. The form producing karmas are on rise so that the body is properly functioning, ears are receiving sound and brain is transforming the sound signals into suitable input so that the music can be understood. The rise of feeling producing karma is producing good feeling and the rise of status determining karma is enabling one to have a sense of good performance, a feeling of having access to good music. The psychical karmas are in the state of subsidence-cum-annihilation. The ocular and non-ocular awareness obscuring karmas are being annihilated so that one is aware of the music and annihilation of empirical and articulate knowledge obscuring karma enables him to cognize the music. The deluding karma may have either subsidence or annihilation, normally the former. The wrong belief deluding karma having subsidence is active so that one perceives the music as a source of sensual enjoyment. The ego passion having subsidence is active and allows the soul to have a feeling of possessing this good music album. Indulgence quasi-passion karma allows development of liking for the music. The enjoyment and re-enjoyment karmas have annihilation so that there is no obstruction in enjoyment. In this example the soul is the enjoyer and is the main cause (*up d na*) for the act. Karma body, fiery body and the physical body are the principal auxiliary cause as these help the soul to enjoy. The music system and favorable environment are the other auxiliary causes that make listening to music possible.

We find that all the eight types of karma are in operation to enable us to physically exist, work coherently in a meaningful manner and perform the act of our choice. One may similarly try to explain other activities of life with the karma principle.

Another important aspect of the doctrine of karma is that while the existing karmas are annihilated or subsided, new karmas of similar type may bond. The soul in any activity is agitating and the karma body is vibrating. The vibrating karma body attracts karma varga? of the kind which are active and bonds with new karmas due to active passions. On analyzing our experience, we find that we pay maximum attention to our feelings, good or bad. Our next attention goes to our perception of the experience, our desires, our emotions, our liking and disliking and satisfaction of our desires (ego). Therefore the highest amount of karma we bond with is feeling producing karma [14]. Next higher in order is deluding karma. In practice seven types of karmas bond at a time, the age determining karma bonds only once in a life time and has the least proportion out of the eight karmas. The net gain of karma in the karma body may be positive or negative depending on the amount of karma being bond and that being annihilated. It is because of this reason that the soul is normally not able to get rid of karma. For reducing the karma balance the soul has to stop inflow of karma. To achieve this, the soul must control his passions, which in the above example means giving up the feeling of ego and liking. For example, the soul has to stop enjoying music; he should consider music as any other sound and take no interest in it thinking that this is the cause of endless migration in the world. He has to develop a feeling of detachment to worldly pleasures which do look attractive for the time being but ultimately bring sorrow and misery in the long run. This amounts to renunciation which in fact is the way to achieve the state of permanent bliss, a state of inner realization.

4. The Living System

A living being commonly has three bodies - physical (*aud rika*) body, fiery (*taijasa*) body and karma body. The physical body is visible but the other two bodies, fiery and karma bodies are invisible. The karma body is the repository of karma. The fiery body comprised of fiery varga? is supposed to be electric body. The fiery body has two important functions to perform: (1) Management of the body systems, and (2) To support and provide control on the physical body [15]. The karma body and the fiery body, both, are always attached to the soul. This union is maintained till the soul attains the state of emancipation. The liberation of the soul is, in fact, shedding these two bodies and to become absolutely free of them. Kirlian photography has shown that a luminous body leaves the physical body at the time of death, implying the existence of some kind of subtle body.

A simple model of living system is shown in figure 1 [16]. The system consists of three bodies, the karma body, the fiery body and the physical body. The soul pervades the entire space of the body, it manifests in all the three bodies. Karma body is closest to soul and consciousness and powers of the soul are first manifested in it. Fiery body acts as a link between the karma body and the gross body, which converts these powers into physical actions and interacts with the environment. Thus by means of this system of interfacing bodies, the soul interacts with the environment and vice versa. The environmental effects are first communicated to the gross body and they reach the soul via the fiery body and the karma body.

The *bh va* karma comprises of psychical *bh va* karma and biological *bh va* karma. Some of the *bh va* karmas which are in fruition (or rise) are active at every instant. The active psychical *bh va* karmas (mental states) are supposed to constitute the *bh va* manah or the psychical mind. The agitations or vibrations in the psychical mind due to passions are called *adhyavas ya*, which bear the characteristics of the karma active at that instant [17]. The vibrations in the soul due to rise of biological *bh va* karma are also named as *adhyavas ya* but these are of a different kind. *Adhyavas ya* continuously changes with time and *nimitta* plays an important role in this change as mentioned above. Good or bad *nimitta* produces good or bad *adhyavas ya* respectively. The *adhyavas ya* vibrations in the soul induce similar vibrations in the karma body as the principle of parallelism holds good. The events in the soul and karma body take place simultaneously. The rising psychical *adhyavas ya* and biological *adhyavas ya* must operate in different ways.



Figure 1 The Living system showing interaction of soul (j va) with various bodies, i.e. karma, *taijas* and physical bodies and *citta* via *adhy* vas ya and *le* y.

The psychical adhyavas ya interact with the fiery body and produces another kind of vibrations called lesva. The biological adhyavas ya are supposed to interact directly with the body cells, most probably with DNA and its structural proteins, and regulate (and control) the gene functions, the biochemical activities, autonomic functions and other body related functions. The le y represent our bh va or emotions, thoughts and attitude. Some of the adhyavas ya bypass the fiery body and directly interact with the brain. This interaction produces physical imprint of our past memories and impressions in the brain, which is chitta in the physical form. The adhyavas ya themselves are subtle chitta and comprise of the following four aspects of our personality (1) Non-righteousness or perversity (mithy tva) (2) Nonrestraint (avirati), (3) Non-vigilance (pram da) and (4) Passions (ka? ya). The nonrighteousness distorts the vision so that we are not able to see the things in the right perspective. The non- restraint character develops desires in us which produce greed and greed based habits etc. The non-vigilance aspect of the citta develops attachment or delusion. All these are our internal creations and have no relationship with the physical body or brain. These characteristics originate from adhyavas ya or karma. functions and other body related functions. The le y represent our bh va or emotions, thoughts and attitude. Some of the adhyavas ya bypass the fiery body and directly interact with the brain. This interaction produces physical imprint of our past memories and impressions in the brain, which is chitta in the physical form.

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Adhyavas ya are present in all living organisms. The mind is developed only in human beings and other five -sensed beings. The *adhyavas ya* perform the functions of mind in rest of the living organisms, which do not have mind. *Adhyavas ya* are the means of harvesting the intelligence of the soul. The *adhyvas ya* may be pure or impure. Because of *adhyavas ya* the organisms without mind (or brain) can also have bondage of karma. This happens in plants and in organisms having one, two, three or four senses.

Let y provide connection between the subtle body and the physical body [18]. They work in both directions. They pick up signals from the karma body and transmit them to the mind and the physical body. On the other hand, whatever is performed through activities of mind, speech and body is communicated by le yto the karma body.

The *lesya* are of two kinds - *dravya* (physical) lesya and *bh* va (non-physical) *le* y. The physical *le* y are radiations and the *bh* va lesya is the perverted state of the soul. The physical *le* y in the form of radiations have colors which form the basis of there classification. There are six kinds of *le* y. (1) *Krisna le* y - is dull blackish in color (2) *N la le* y - having dark blue color (3) *K pota le* y - has grey, pigeon like color. (4) *Tejo Lesya* - is bright red. (5) *Padma Lesya* -having bright yellow color. (6) *ukla Le* y - bright whitish color. Each kind of *le* y represents some specific qualities of the organism corresponding to the state of the soul or active *bh* va karma. The first three types are the malevolent *le* y s and indicate negative qualities of the being.

Le y change with time and only one *le* y is present at any particular time. Human beings and animals can have all the six *le* y *s*. Hellish beings have only malevolent *lesya* and higher celestial beings have only benevolent *le* y. *le* y *s* are influenced by colors. Colors have a profound effect on our feelings and thoughts. Psychologists assess the characteristics of a person based on his liking for color.

In the human body system the *le y s* are supposed to interact with the endocrine glands and influence the secretion of hormones. The hormones mix with the blood and reach the nervous system and the brain which influence and control our, emotions, thoughts, attitude, speech, conduct and behavior on the physical plane. Thus the active psychical karma through *lesya* and hormones determine our psychical personality and traits. The endocrine glands are seen to provide a system that establishes link between the subtle body and the physical body. These glands convert the information from the karma body, in radiation form, into chemicals which finally control the body and the brain.

We can speculate on the working of the body system now. The karman *varga*? is attracted from cosmos by resonance and convert into karma by bonding with the karma body. Karma exists in this form for a certain period determined by the bonding conditions and, on maturity, is emitted as radiations known as *adhyavas ya*. These karma radiations interact with the fiery body to produce *le y* radiations. As karmas are distinguished by their frequency, the *le y s* also exist in a range of frequency. This justifies classification of *le y s* by colour. *Le y s* with different frequencies interact with DNA, which also possesses vibrational character and work as holographic computers. The fiery body is also formed by fiery *varga*? as a bioplasma body that emits radiations to perform the management and control functions. One form of this radiation is *le y*.

From the foregoing discussion, we note the following important roles of karma.

- 1. Karmas store and preserve the information of all the activities of the soul.
- 2. Karmas are the means of communicating the intelligence of the soul to mind and body. Matter has some self organizing power, such as formation of crystals and some simple molecular structures, but the intelligent functions involving genetic, cellular, biological and physiological behaviour, observed in the body are due to karma.
- 3. Karmas provide the psycho-physical force for operation of body and mind.

- 4. The karma body functions through radiations which interact with the body, mind and fiery body.
- 5. The functions of biological and psychical karmas differ widely. The biological karmas determine, and are essential for, the physical existence; the psychical karmas determine the psychical activity of the soul.

4.1 Relationship between Karma (in Fruition) and Body

The crucial question is how karma in fruition and body are related? This is a subject of research but some speculations, based on available evidence, can be made. The following appear to be the primary ways in which karma interacts with the body.

- 1. Bio-photons [19, 20]: It has been found in laboratory experiments that all living systems emit a weak flux of some light photons which provide energy for chemical reactions {photochemical} in cells and regulate the biochemistry and biology of life. The source of this light is said to be a coherent photon field whose source is not known. The biophoton emission is indicative of an endogenous, innate, electromagnetic field pervading the entire organism. Biophoton emission is thus seen as a crucial evidence of a physical basis of life. According to Jain philosophy n ma karma is responsible for the structure, design, development, maintenance and several other activities of the body. Thus a relationship between biophoton emission and *n* makarma and other non-obstructing karmas can be proposed for further verification. These karmas may be connected with the functioning of DNA which is supposed to be the basis of life. It is possible that this connection is made through the fiery body so that the energy of this body is used in affecting various processes in the gross body.
- 2. Conscious Mind: Psychologists believe in the existence of conscious mind which is different from the brain. Some scientists are of the view that brain itself acts as conscious mind. The brain receives and sends signals to every part of the body and thereby controls the activities taking place in the body. In our model given above the conscious mind (*dravya manah*) is formed by fruition of obstructing karmas and is connected to brain for it's functioning. Therefore it is envisaged that obstructing karmas play an important role in controlling the activities and functioning of the body system.

We now briefly present possible roles of different karmas in the body systems.

- 1. *Jñ n vara?iya* and *Dar an vara? ya* Karmas: These two types of karmas are responsible for cognition activity. As this activity is assigned to the brain and the nervous system in medical science, these two karmas are supposed to be related to functioning of the brain and the nervous system through the conscious mind.
- 2. *Mohan ya* Karma: Perception is considered as a mental activity in medical science. Therefore perception deluding karma determining our belief system should be related to functioning of the brain. Emotions are closely related to the secretion of hormones by the endocrine glands. Hence the conduct deluding karma determining our desires and emotions must be related to the functioning of the endocrine gland system. The pituitary and pineal glands and hypothalamus located in the brain are found to control the functioning of other glands in the body. So the perception deluding karma , through its influence on the brain, is also expected to be responsible for our emotions and desires.
- 3. *Antar ya* Karma: Our willingness and/or resistance to perform an act is assumed to be governed by the conscious mind. *Antar ya* karma is related to mind states like mood, disinterest, grief, worry etc. and unhealthy body conditions. The *antar ya* karma therefore is expected to influence the functioning of the brain.

It may be noted that the above four obstructing karmas operate through conscious mind. When these karmas are eliminated in the omniscient state the conscious mind becomes redundant. In this state the psychical mind as also the unconscious mind ceas to exist but the *dravya manah* or the conscious mind physically exists but it is rendered non-functional as the *j* vano longer needs it. The perception and cognition is made directly by *jiva*, and the conscious mind and the brain have no role in it.

4. *Vedan ya* Karma: Production of pain is seen to be related to the state of tissues in the body and experience of pleasure has some connection with secretion of hormones. The state of tissue is connected to the local chemical activity and performance of the genes. So it can be speculated that *vedan ya* karma influences functioning of the genes, local chemical

activity and secretion of hormones by endocrine glands. As secretion of hormones also depends on the state of conscious mind, *vedan ya* karma and conscious mind together must produce pain and pleasure that the *j v*a experiences.

- 5. *N ma* Karma: Biological science has shown that the genes carry the code according to which the design, construction, structure, growth and development of the body takes place. *N ma* karma therefore provides the essential instructions for these functions. Different subtypes of *n ma* karma describe in detail how the architecture of the body is determined, and the various parts, organs and organ-systems are built to develop the body structure in a systematic and pre-determined way. This karma also decides the growth, maintenance and activities of the body.
- 6. *Gotra* Karma: The quality of performance of the body system is also ascribed to the behaviour of genes. The *gotra* karma, therefore, must play an important role in the performance of genes. The way in which the gene code works and controls the anatomical and physiological functions, performance of the body parts and functioning of the living system is therefore also dependent on *gotra* karma besides *n ma* karma.
- 7. *yu?ya* Karma: The *n ma* karma is believed to have a master code for design, construction and activities of all kinds of species found in loka (universe). The *yu?ya* karma seems to tap a specific code from this pool and proceeds with design and construction of one particular form according to *yu?ya* karma bond in the previous life. Another important aspect of life which is particularly emphasized in eastern philosophy is *pr ?a.* Also, blood is supposed to be life line of a living system. Is *yu?ya* karma related to the production and circulation of blood and role of *pr na* in the body ? *Pr ? y ma* has been found to increase the blood circulation in the body suggesting a relation between *pr ?a* and blood supply. On death *pr ?a* leaves the body and the production of blood stops.

Besides creation of structure and maintenance of bodies, the system also has mechanism for defense of the body against deseases, possible dangers from environment, bacteria, virus, and other harmful organisms as well as internal malfunctioning and disorders of the system. The body has inbuilt self-healing mechanisms to cure and protect itself from these dangers and survive against all odds to the best possible extent. The body is a wonderful system that creates structures, maintains and protects the system with minimum inputs in the most efficient and optimum manner and in a very versatile way, in the sense that it can cope up with highly diverse situations. The body has several levels of operations which are chosen according to the internal conditions, environment and available resources. The structure of the body depends on the development of consciousness and the activities of consciousness are a function of the structure of the body, particularly the brain. This is because the soul and body are intimately connected and there are two way interactions. So versatile is the design of the human body that it is impossible for human mind to design and build even a small part of the system; the entire system is well beyond the comprehension of human mind.

4.2 Connections between various Bodies

How are the subtle bodies and the gross body connected to each other physically? Without any connection, they are not likely to hold together. According to Gommatsara Karmakanda, the body (*sarira*) type form-producing karma has the following types of bonds:

- (a) Gross-gross body bond meaning that parts of the gross body bond together.
- (b) Gross-fiery body bond meaning that these two bodies bond together.
- (c) Gross-karma body bond meaning that these bodies have bonds between them.
- (d) Gross-fiery-karma body bond meaning that these three bodies are also bound together.

Similarly there is bonding between parts of the fiery body and between fiery and karma bodies. The karma body and fiery body are made up of *karman varga*? and taijasa *varga*? respectively and are of electric nature, or some kind of electric fields. The two bodies therefore are supposed to have an affinity or some kind of electrical attraction. A third unit of conscious mind (*dravya manah*) made up of *mano varga*? comes into existence in five sense beings. This *varga*? is also of similar kind and hence the three units combine together to form a subtle combination unit. The three kinds of *varga*? perform different kinds of functions according to their specific properties but are spatially not separated since they occupy the same space as the space of the gross body and the soul. The working of the conscious mind is different from that of other two subtle bodies in the sense that it is dependent on the structure of the gross body. Mind works in conjunction with the brain and the

nervous system and, in the absence or malfunctioning of this system, the mind, in spite of having the potential, cannot deliver the output. This is not the case with karma body and fiery body as these are unaffected by the structure of the gross body.

Besides having mutual connections, these three units are also connected to the gross body due to interaction and interchange of varga? . In the beginning of life cycle, the fiery body is the first to make contact with the fertilized egg, that is, the fertilized egg is infused with the pr ?a (energy) from the fiery body because of the yusya karma of the soul taking birth. The n ma karma then decides the structure and further growth of the body. All the karmas are supposed to be transferred to the gene structure of the egg cell by the process called *pary pti*. The subtle energy of taijas body known as pr ?a is the essential ingredient for structure and functioning of the gross body and there is intimate connection between the taijas body and the gross body. Pr ?a flows to the gross body and it is distributed to various parts through *pr* ?*a* channels known as *n* ?*is*. In this manner the gross body is energized for its functioning. The karma body, on the other hand, is intimately connected to the soul but is also linked to the fiery body. Thus the soul has primary connection with the karma body and secondary connection with the fiery body. The karma body is connected to the gross body through fiery body and also through the conscious mind as shown below.

The conscious mind is a derivative of *gh ti* karma and it functions in conjunction with the brain and the nervous system as mentioned above. So the conscious mind is intimately connected to the gross body on one hand and to the karma body on the other hand. Thus the fiery body, conscious mind and the gross body are connected to karma body in various ways. Connection of these three units with the soul is made through the karma body.

There are two ways in which the fiery body establishes connection with the developed gross body. One way was described above. The other way develops due to electrical activity in the gross body. The gross body has centers of intense electrical activity like brain, nervous system, endocrine glands, joints, extremity parts like finger toes and some other centers recognized in acupressure and acupuncture systems. These centers induce high electrical activity in the fiery body, leading to formation of local vortices called chakras in yoga system. These chakras become channels of *pr* ?*a* energy transfer between fiery body and the gross body; they also provide additional coupling between the two bodies. The major chakras

are located in the brain and on spinal cord matching with the position of the endocrine glands. The rate of energy transfer in these channels is a function of pr na potential that can be increased by pr? y ma techniques. The conscious mind becomes a catalyst in this activity and, by focusing attention on a particular center, the rate of energy generation at that center can be increased manifold. The increased rate of energy transfer enhances the metabolic activity, improves the health of the gross body and enables the various body systems to function efficiently. The location of chakras shift in space as the body grows and develops. At the time of conception no chakra exists, the chakras come in to existence as the body parts are formed. The enhanced potential and increased activity in the fiery body also influences the karma body which undergoes transformation and ultimately affects the soul. The vortex formation in the fiery body may also extend to the karma body and the conscious mind fields because of the spatial relationship and it results in a kind of coupling between these units. All units of the system are therefore interconnected and mutually influence each other. The activities of the gross body, fiery body (pr ?a) and the conscious mind influence the soul in some way. It can be seen that meditation focusing attention on the chakras and pr? y ma practices are potent means of influencing the karma body.

At the time of death *yu?ya* karma is completely exhausted and the connection between the fiery body and the gross body is snapped. The brain stops working and loses connection with the conscious mind. The connection between the conscious mind and the fiery body is also snapped as this needs a working brain. So when the soul leaves the body, the conscious mind does not accompany it and only the karma body and the fiery body transfer to the new body. Therefore, the conscious memories are not carried forward to new life. However the information in the karma body, and the unconscious mind, is carried forward. In the absence of gross body the chakras do not exist in the transition period between the two lives and these are formed again in the new body according to its structure.

It is interesting to know as to what happens when the soul transfers from one body to another in its life time, a feat that can be performed by some yogis having that kind of power. In this case the *yusya* karma is in balance and the connection between the brain and the conscious mind is not snapped. Therefore the conscious mind is also transferred to the new body along with the karma and fiery bodies. How the conscious mind works in the new body depends on its structure. Suppose a human soul transfers to another (dead) human body, then a proper brain structure is available. The fiery body and the karma body get connected to the new gross body and the conscious mind functions according to the available brain structure. On the other hand, if a human soul transfers to an animal body say a lion (dead) the karma body and the fiery body get connected to the new gross body as before but the conscious mind suffers limitations of the brain structure available in the lion's body. Although the soul continues to feel existence of human form through the conscious mind, the functioning of the mind is impaired. The soul now thinks as a human being (purely mental activity) but can only perform physical activities of a lion compatible with the available body and brain structures. The behavior of this lion will, of course, be different from normal lions and will have many thinking attributes of a human being.

This is only a broad analysis of the possible connections among the bodies and a great deal of thinking and research is required to explore the wonders of the body system scientifically.

5. Karma and Genes

Once chief disciple Indrabhuti Gautama asked Mah vira: "*kammao ?an bhante j ve no akkammao vibhattibh vam pari?amai*". There is dissimilarity in the whole world, some possess less knowledge and the others possess more. What is the reason for this? Mah v ra replied, "Karma is the cause of this dissimilarity." If today a biologist is asked this question, he will say that genes are responsible for all

dissimilarities [21]. The characteristics of genes and chromosomes determine the human personality. According to genetics, every gene contains six million orders and as per doctrine of karma infinite instructions are written on each karma pradesa [22]. Thus the function of biological karma resembles the function of genes. Rather the concept of karma goes one step further in the sense that, apart from transporting the hereditary influences over many generations of both the parents, it also takes into account the effect of individual's performances in the previous births.

Every cell of a multi-cellular organism contains the same blue print but in different types of cells, e.g. skin cell, nerve cell, bone marrow cell, etc., genes operate in different ways according to the body requirement. These genes are supposed to be directed by the rising biological karmas. In every cell similar type of genes exist, but some genes remain inert and some are active for a certain time. This process is very complex. It is believed that in developed complex beings up to 2-15 per cent genes remain active at a time [23]. In reality the karma decides which genes become

active and which remain inactive. The control is exercised through hormones, vitamins, minerals, chemicals and immune system. It is believed that the genes are controlled by the environment around it, cell nutrition wrapped around the genes, and the temperature. Thus, genes are said to be the deciding factors for various characteristics of a living organism and these are controlled by some known or unknown causes which are in fact karmas of an individual.

According to the modern anatomy, all creatures have originated from the same building block of life [24]. It is only due to mutation of the genetic codes that different types of species, right from amoeba to man, take birth. According to c rya Mah prajña "the theory of *sa? krama?a*," i.e. theory of transformation of karma, is somewhat similar to the theory of mutation of genes, though they differ widely in scope.

Every human embryo contains 23 chromosomes of father and 23 chromosomes of mother. The biologists guess that due to the interaction of all these chromosomes- 16, 77, 216 kinds of similarities are expected [25]. Today, through the genetic mapping, all the genes which control the various states of our traits have

been discovered. We have also discovered all the sequences of genome and new knowledge about the genes are being discovered everyday.

A group of researchers led by Paul Thomson of the University of California at Los Angles has given evidence that intelligence is largely determined before birth [26]. Still the puzzle regarding all the traits of human beings has not been fully resolved by science. On the other hand, the Jaina karma theory determines not only the characteristics of the body of various organisms but also all their behavioral characteristics e.g. intelligence, happiness, sorrow, perception, age and performance.

It is certain that mental as well as intellectual merits of genes are necessarily affected by a man's pre-birth internal state, nature, and also by the after-birth outer environment such as air, temperature, light, moisture, nutrition, etc., i.e. nurture. If the two identical twins are kept separately in different outer environmental conditions, their body structure, their personality and mental characteristics will differ from each other, despite the fact that both have the same genome structure and similar development of the embryo in similar internal environment. These factors clearly indicate towards karma-the controlling factors and existence of soul [27].

One important thing is that the rise of karma takes place according to an auxiliary cause. Let the pain-causing karma rise at the same time in two different persons, if one person listens to religious sermons and devotional songs and the other is kept in a closed room doing nothing, then the rise of pain causing karma will cause more pain to the second person in comparison to the first person [28]. In another example, if two children are born to a mother, one in some cold country and the other in some hot country, the former will be comparatively fairer than the other child. If some person begins to live in a cold country, his complexion will become fair. Thus, we see that the personality of an individual depends not only on karma but also on heredity, environment, and geographical location and ecological conditions i.e. *nokarma* (epigenetic factors).

5.1 Karmic Expression: An Analogical Analysis

Karma is a set of codes which design the state of a being. The soul imbibes the karma and the karma responds to the soul. There must be a process or method by which this physical karmic code expresses it self? What is the process of karmic expression for execution? This remains an important and challenging point for further study and research.

The challenging task of unveiling the tacit knowledge of the process of existential karmic particles becoming karmic expression is attempted here. Existential reality which is a static force (in the state of *anudaya* / non-fruition) becomes a dynamic force usually supported by a mediator. The *dravya*, *k?etra*, *k la*, *bh va* and *bhava* (DKKBB) are five components which aid in the karmic expression. DKKBB can be analogues to an enzyme which serves to bring about the whole chemical reaction, enzymes work as a mediator. The DKKBB though plays the role of an enzyme, it is not a chemical reaction. It could be a dynamic interaction depending upon temperature, weather, geographical conditions, life style and other factors.

5.2 Karmic Decoding

Karma has to be decoded to express. Decoding, in semiotics, is the process of interpreting a message sent by an addresser to an addressee. The complementary process - creating a message for transmission to an addressee - is called encoding.

Although the addresser may have a clearly defined intention when encoding and may wish to manipulate the audience into accepting the preferred meaning, the reality is not that of textual determinism. What is decoded does not follow inevitably from an interpretation of the message. Not infrequently, the addressees find different levels of meaning. Umberto Eco called this mismatch between the intended meaning and interpreted meaning 'aberrant decoding'.

In regards to karma, the encoded message decodes depending on the activity of a person (*nimitta*). The person's own psychological state can make a difference. This apparent relativity of communication between the karma and the bearer of the karma may result from the fact that they are of a different social class or because they have different training or ability, because they have different world views or ideologies, or because they are from different cultures. David Morley argues that the outcome of decoding will be influenced by pragmatic issues, i.e. whether:

+ The addressee has the ability to comprehend the message in its entirety:

The soul too when stressed out loses the opportunity to enjoy the *s tavedan ya* karma i.e. happiness.

+ The message is relevant to the addressee:

Soul or consciousness is in the mode of receiving it such as when one is fasting; the person is in the mode of receiving *as tavedany a* karma.

+ The addressee is enjoying the experience of receiving the message:

When the deluding karma is intense, the consciousness is stupefied, and enjoys the delusion. In such a stage the karma is fully forceful.

+ The addressee accepts or rejects the addresser's values:

Consciousness rejects or sends a contradictory wave of energy when karma sends a message. For example, when *mohan ya* karma pollutes the mind, the consciousness makes an effort to defy it by meditating.

Further, Umberto Eco [29] distinguishes between closed texts which predispose a dominant interpretation and more open texts which have latent meanings or be encoded in a way that encourages the possibility of alternative interpretations.

This physical law fits well into the spiritual laws also. There are karmas which are unamendable like closed text which cannot be manipulated or amended; these are *nicachit* karmas while the non-*nicachit* karma are like open texts which can be regulated by the addressee. The message decoded will make a difference depending on the addressee which is the soul or the body and the mediator i.e.

DKKBB. The soul by its will power can defy the message or augment it. The fervour created in two persons varies according to the mode in which the message is received. One takes it easy and is stress-free while the other is burdened and intensifies the experience. Here the claim is not that taking it easy is a good act or not taking it easy is negative. Here the simple attempt is only to reflect the difference created by the addressee. Hence the Jain theory of karma is not deterministic in approach but depends on the choice made by the self.

Further, the karmic language seems to be like Sanskrit and Latin, which does not carry any syntax, rather than like English, since it is a coded message. The reasoning behind delegating it as coded language is its message pattern. Though karma is highly structured, the message is not explicit. Similar situation may apply to the karma theory; if a person has to suffer *vedaniya* karma, the person can have some desease (e.g. thyroid or diabetes).

5.3 Karmic Phenomenon of Epistasis and Pleiotropy

The karmic expression can be divided into two platforms physical and psychical. Depending on the target, the karma is titled as gh ti and agh ti. The gh ti karmas are those which are directly targeted to the soul hence are psychical in nature while the *agh ti* karmas are those which target at the physical level. Though this categorization dissolves at times or gets blurred, yet it is helpful in understanding the two categories of karma. For example, the *jn n var*? *ya* karma impacts the cognitive ability which can also be visible at the physical level of impaired brain efficiency. Here the the effect on brain efficiency is an indirect consequence or, in other words, is a side effect. The *jn n var? ya* karma's key role is not brain impairment but rather cognitive impairment. To bring about this change, at times, appropriate physical conditions are required, which is assisted by the n ma karma. Here we find that multiple karmas work together to lead ultimately to the consequences one has to face for his actions. Hence the process of epistasis operates here. Epistasis is a phenomenon about the effect of one gene being dependent on the presence of one or more 'modifier genes' (genetic background) [30]. A similar kind of function is observed in karma as well. Any karma to act at physical level will need the assistance of *n* makarma.

Although the *vedan ya* and *mohan ya* karmas are distinctly different, they need to work with *n* ma karma. Taking another example, we see that when one is angry and the body is trembling with anger, the anger could be an expression of

mohan ya karma while the body, which is related to *n ma* karma, is targeted by it. Here we see the intertwined nexus of performance of different karmas which is a phenomenon of Epistasis.

Pleiotropy [31] is another phenomenon which has a parallel in medical science and karma theory; it describes the genetic effect of a single gene on multiple phenotypic traits. The underlying mechanism is that the gene codes for a product that is, for example, used by various cells, or has a signaling function on various targets. Similar functionality could be observed in karma as well. The *n* ma karma undertakes different types of roles to regulate the skin color, height, body size etc. Further, if we analyze this phenomenon from a different perspective, vedan ya karma can manifest as thyroid or heart disease, depending on the readiness of the body. The karmas manifest at a particular location; if one has malfunctioning pancreas, the person can be hit with diabetes or he can suffer from thyroid, if that is easier to target. Or, it could be a genetic message about the malfunctioning state of the pancreas or thyroid which inflicts the deasease. The genes work as DKKBB to regulate the expression of karma. Further, depending on the kind of epistasis support of *n* ma karma, the vedan ya karma manifest. This analogy expresses not only the web of connections of different karmas but also the idea that even though karmas are simplistically similar, they may express very differently. Hence the manifestation of karmas is not deterministic in nature.

5.4 Karmic Expression

The interface between matter and soul is not understood, yet it is visible. Here we present three hypotheses to explain this invisible-visible functionality of karmas. The possible postulates are:

- 1. The Secret theory
- 2. Mediator theory- the karmic fruition is mediated by certain DKKBB (*nimitta*) which could be either internal or external or both.
 - a. External a person is sick during cold weather.
 - b. Internal lack of immunity and hence the disease.
- 3. Epistemic transfer transfer of message.

The karmic consequences arise by the efforts of the soul. The karmic 'energy', while ready to express, needs a receiver and a mode of communication or expression. A similar claim that our genes govern us, and there is a process of gene

expressions, is based on scientific study. The genetic message is communicated to the body or person who acts as a receiver and leads to a chain of reactions. The genes carry the message in chemical language. Genes replicate to produce RNA. The RNA serves as a messenger /mRNA to produce certain kinds of proteins. Many biological activities are carried out by proteins. The accurate synthesis of proteins thus is critical to the proper functioning of cells and organisms. Depending on the protein synthesis, one can define one's state of being and health. For example, dopamine secretion is related to happiness.

5.4.1 The Secret Theory

As the famous physicist Feynman has said, "physics just describes what we see, so quit trying to understand why things look the way they do and just describe what is there". In other words, physical science is a description of what we observe and not "why" [32]. Therefore, when a process is not understood but explains the outcome, it can used as a 'secret theory', a term used when we do not know the functionality, possibly when manifestation of energy is subtle and invisible. The unanswered question of how karma really brings about a diseased state or depression is beyond the realm of sensory perception and hence there is a need to explore the subject using a different, empirical approach.

We may consider that the karmic particles have certain coded message built in their structure. The karmic message is not uncertain in terms of its content and time of manifestation i.e. what the karma's consequences will be and when it will be executed. All we know is that it depends on DKKBB. Taking cue from quantum physics and analogy with the particle-wave duality, we wonder if it is possible to imagine that the karmic particles are in wave form during their dormancy and transform into particle form when they are ready to manifest. It may be noted that the wave and particle forms are not actual forms but properties of the light photons. Quantum analogy implies that one observes what one is looking for; wave and particle are mere mathematical tools [33].

5.4.2 It is like a karmic design

"When one has a new thought, it is a new quantum state. With each thought a new qwiff (quantum wave function) is generated that begins interacting throughout the universe. The new thought continues to interact with the universe and with other qwiffs in the universe, that are similar to it, until a new entangled and common qwiff "coheres" and becomes the next instant's reality. This is the essence and the heart of the Secret [34]" theory.
Is it possible that the karmic message goes all over into the space which intensifies it and manifests it? We may mention here that Acharya Mahaprajna has discussed the energy generated inside us and that obtained from the outside environment. The imbalance which exists between the inside and outside is equilibriated soon. It is something like homeostasis, where we tend to reach the point of equilibrium set by the karma. Depending on the energy we take from outside, we have the health or disease status accordingly. When the *asata-vedaniya* karma generates its vibrations, the energy one pulls from the environment synchronizes with it, and the person accordingly becomes sick. Conversely, when karma and environment are in disequilibrium, either influences the other. When the environment triggers the karma, *udirana* takes place; when the karma triggers the environment in the body, its effects are manifested.

5.5 Mediated and Non-mediated Expression Theory

There are two types of karmic expressions, mediated and non-mediated. The mediated can be internal or external. Mediated karma is manifested at specific targets, be it body, mind or environment and is mediated by genes or body.

Non-meditated karmas do not need any intermediate source as in the case of n ma or gotra karma. A person receives recognition on fruition of auspicious karmas. It is not about karma expressing at physical level but it is a virtual expression. Mystifying is the fact that karma travelling in space manifest in a specific way.

The dormancy, excitement and fall are basic nature of karmic complex molecules. The Bohr model of electron can be used to understand the functionality of karma. In a specific atom, the lowest energy level an electron can occupy is called the ground state. The higher orbitals represent higher excitation states. The higher the excitation state, more the energy the electron possesses. When an electron absorbs energy, it jumps to a higher orbital. An electron in an excited state can release energy and 'fall' to a lower state. When it does, the electron releases a photon of electromagnetic energy. The energy contained in that photon corresponds to the energy difference between the two states the electron moves between. When the electron returns to the ground state, it can no longer release energy, but can absorb quanta of energy and move up to excitation states (higher orbitals).

The idea of excitation, release of energy and fall off to lower state could be used as an analogy to explain karma. The karma being in the dormant state is like

the atom in a ground state. Once the karma is ready to express, the message is released in the form of specific energy. Once the message is communicated, it is executed. Followed by this the karmic particles are shed off and no longer remain attached to the soul.

5.5.1 Epistemic Transfer

Epistemic transfer is used here to depict the idea of a message being transferred to an entity which could be a person or object, to execute it. The message need not be direct in terms of target or the message.

Here, we give an illustration of a kind of chain reactions termed as "semetic interaction" (Hoffmeyer 1995). A well-described case is exhibited by caterpillars munching upon the leaves of corn seedlings (Hoffman 1992; Krampen 1992). The munching process evokes an interpreter to be formed in the damaged leave cells in the form of a (unknown) molecular message that is carried around to all the leaves. Healthy leaves understand the message as an instruction to produce a certain volatile substance (a terpenoid) which is then emitted to the air. Wind will carry the terpenoid away and eventually it will be absorbed by certain wasps where it may then eventually provoke the formation of an interpreter in the form of muscular contractions destined to bring the wasp to the emitter of the volatile substance. When the wasp arrives there, it senses the presence of the caterpillar and its body is induced to perform the chain of movements necessary for injecting its eggs into it. Upon hatching, the wasp larvae eventually eat and kill the caterpillar.

Seen from what actually happens is that the wasp and the corn seedling have a common, if opposite, interest in the caterpillar and that they find a productive way to cooperate to further their interest by entering a shared dimension of the semoisphere (Hoffmeyer 1996; Hoffmeyer forthcoming). Most interestingly however, wasps are not attracted by the terpenoid the first time they come upon it but have to learn how to interpret the substance. Or to state this differently, a regularity of nature, i.e. the corn seedling's emission of a certain terpenoid when attacked by caterpillars, has become a signal leading the wasp to the caterpillar. Semitic interactions depend on the capacity for associative learning, which is typical to living systems [35].

In this example we find the chain reaction bringing about the desired result. The encoded message, when decoded, produces a chemical which reaches the destination like the wasp. In case of the leaf, we are familiar with the idea of smell as it is within our range of sensory faculties, which is used to send a new message. But in case of Karma which sends a message might not belong to our range of capability. The karmic message is communicated in a language not decipherable by a common man, yet it is received and acts like n ma karma related to appreciation and nonappreciation of our actions.

6. Conclusions

Karmas are cause of the mundane existence of soul. *Bh va* karmas are impurities of the soul and *dravya* karmas constituted by *karman varga?* form a subtle body. Karmas bond to the soul due to its activities, yoga, and passions, *ka? yas*, and impose restrictions on the manifestation of natural powers of the soul. Psychical (*gh ti*) karmas and biological (*agh ti*) karmas have specified roles in the functioning of the soul and the body. The body system functions due to rise or fruition of biological karmas and subsidence-cum-annihilation of psychical karmas.

The body system consists of karma body, fiery body and gross body and the

soul in impure state. Interaction between the three bodies takes place through radiations called *adhyavas ya* and *le y*. The relationship between the three bodies, conscious mind and soul is discussed in this article and it is shown that the whole system works as a unit. To analyze working of any one of the components, consideration of its relationship with other components is essential. Explanation of working of any one component, say gross body, without taking into account the other components of the system is incomplete. The eight main types of karmas have specific roles in the body system.

The role of biological karma and genes is compared and it is shown that genes themselves, without karma, may not be able to provide explanation of all the processes taking place in the body. It is inferred that karmas control the genes. The overall performance of the organism is determined not only by internal factors like karma and genes but also by external factors, *nokarma*, prevailing in the environment.

The question of karmic expression is implicit in the belief system but not yet understood. There are many scientific innovations which can assist us explore the karmic functionality in similar terms like epistasis and pleiotropy which are accepted but have not yet received specific mention in Jain terminology. The three postulates presented: Secret theory, mediated and non-mediated theory and

epistemic transfer are attempts to help explore the karmic expression and its interaction with the being and the world around. These tools may enable better comprehension of complex karmic philosophy.

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Suggested Research Problems

- 1. Study of relationship between various types of karma and biological functions of the body and psychological performance of humans. This shall need study of Jain literature in respect of role of karmas, human biology and psychology.
- 2. Study of relationship between functions of bio photons and role of biological karmas.
- 3. Study comparison of functioning of cell and DNA, role of epigenetic effects and role of karmas

7. Doctrine of Karma, Free Will and Rebirth: A Logical Approach

Subhash Jain

Abstract

It is the law of nature that every deed (karma) has consequences and the doer of the deed has to bear them. In other words, the law of karma is based on the laws of nature; hence, no one can violate it. Many individuals are skeptical of the law of karma as its different interpretations are alleged to be suffering from inconsistencies and controversies. Due to inconsistencies in the karma doctrine, some western scholars have dubbed the karma doctrine as a 'convenient fiction' (Deutsch 1965). Though there exists a wealth of literature on the karma doctrine, there are still many unresolved questions, such as free will and rebirth, that lack logical answers. This paper fulfills the need for a logical and coherent interpretation of the karma doctrine that would provide logical answers to the unresolved questions related to the karma doctrine and the critical issues of free will and rebirth.

Key Words: Karma, rebirth, Nokarma, Metaphysical karmic model

Scriptures Quoted: Gomma's ra J vak ??a, Tattv rtha S tra, ?a'kha?? gama, Dhaval ?ik .

1.1 Presuppositions

The laws in most branches of knowledge are based on presuppositions that are considered to be true, or else the laws would be meaningless. This is also true of the karma doctrine. Because the karma doctrine is related to living beings, its presuppositions are brought to light in the answer to the question, "What is the structure of living beings?" The answer to this question provides the necessary presuppositions for the metaphysical model of the karma doctrine.

1.1.1 Substance

All living beings have a body. Everyone, including secularists, spiritualists, and scientists, agrees that the bodies of living beings are made of living matter. But are living beings made of matter (*pudgala*) only, or is there another substance in addition to matter? The answer to this question has crucial implications to the karma doctrine. Before finding the answer to this question, we will define the term substance (*dravya*). The term substance in Jainism carries a specific connotation. Substance is that (i) which exists, (ii) which has properties (*gu?a*) and modes (*pary ya*), and (iii) which is characterized by simultaneous origination (*utp da*) of new modes, destruction (*vyaya*) of old modes and permanence (*dhrauvya*) of intrinsic properties.

Let us examine how these definitions of substance are applicable to matter. One of the characteristics of matter is that it can neither be created nor destroyed. Logically, something which exists cannot become non-existent, and that which is non-existent cannot come into existence. In other words, matter is eternal and the total amount of matter in the universe is conserved; it has a capacity by which it always exists. All substances that constitute the universe always exist; hence, they are eternal.

Substance serves as a substratum for different properties that have various states or modes. Matter possesses countless properties, but four intrinsic properties which can be recognized with our senses are touch, taste, smell, and color. These properties are always present in matter, but the modes of these properties change constantly, some at imperceptible rates and others at noticeable rates.

Substance is characterized by simultaneous origination (*utp da*), destruction (*vyaya*) and permanence (*dhrauvya*). All the entities that surround us are different modes of matter and all of them are undergoing changes. In other words, matter has a capacity by which it is always changing. But matter during modification remains matter; it does not lose its intrinsic properties and does not become non-matter. Permanence signifies persistence of the intrinsic properties and change refers to the destruction of the old modes and the origination of the new modes.

1.1.2 Emergent Properties

Since our bodies are made of living matter, they have the four physical properties of touch, taste, smell, and color of matter. But the living matter of our bodies has additional properties, such as biological and mental properties, termed

by scientists as emergent properties (Kim 2006; Baker et al 2011). Why are there emergent properties in living matter? Are we able to introduce these emergent properties of living matter in nonliving matter? Is there a need of a substance whose association introduces the emergent properties of living matter into nonliving matter? If so, what is the nature of the other substance? If it is not matter, it is nonphysical. It, then, cannot be recognized by our senses and cannot be subjected to experiments; hence, it does not fall within the domain of conventional science. The existence of a nonphysical substance can be inferred only by logical reasoning and indirect empirical evidence. This mental process is likely to initiate skepticism, but we can minimize or even circumvent skepticism by making use of careful logical reasoning.

If we presume that living beings are composed of matter only, as some scientists do, the answer to our question, then, is that life is a mere accidental combination of appropriate chemical elements. In this view, nonliving matter under proper conditions transforms into living matter which has the ability to metabolize, grow, and reproduce. The main constituents of the living matter are nucleic acids, proteins, carbohydrates, and lipids, which scientists are now able to synthesize from nonliving chemicals. DNA (Deoxyribonucleic acid), stores genetic data as sequences of nucleotides, that determine many characteristics which constitute the living matter. These constituents cannot be considered living matter, as they cannot grow or reproduce by themselves. Scientists are able to introduce some of the biological emergent properties in only living cells, but not in test tubes. This piece of information implies that there exists a substance in living cells which does not exist in the material environment of test tubes. Only time will tell whether scientists are able to transform nonliving constituents into living constituents in test tubes and identify the 'essential' substance in living cells.

As living beings we also have mental emergent properties such as capabilities of knowing, feeling, and willing; in other words we have consciousness. Can consciousness be explained in physical terms? So far it has not been possible to introduce mental emergent properties in living cells. Some scientists and philosophers consider consciousness as one of the characteristics of mind, but they are divided in two groups on the issue of ontology of mind: property dualist and substance dualist (Kim, 2006). Property dualists consider mind a part of the body; hence, it is made of living matter. Substance dualists believe that mind is made of a nonphysical substance.

Several sources of empirical evidence support the existence of the nonphysical mind. One main source is the studies related to remembrance of past lives. The most comprehensive study has been done by the American psychologist Ian Stevenson of the University of Virginia, who spent over 40 years studying children who have spoken about past lives (Stevenson, 2001). In each case Stevenson methodically documented the children's statements. Then he identified the deceased person with whom the child allegedly identified, and verified the facts of the deceased person's life that matched the child's memory. From his studies, published from 1960 to 2003, he concluded that the phenomenon of rebirth is the best explanation for the child's memories. The mountain of evidence accumulated on this subject has permitted some scientists to conclude that rebirth is a legitimate phenomenon.

1.1.3 Premises

It seems reasonable to conclude that the following questions are unsolvable by experimental science. Why does DNA work only in living cells, not in test tubes? No doubt the brain is the main instrument for perception, judgment, memory, etc., but who feels the emotions of love, fear, etc.? Few thousand cases of persons who have given account of their previous lives have been reported, but who remembers the events of the past life? Until or unless the scientists are able to provide answers to these questions and are able to introduce the emergent properties of living matter into nonliving matter, we will have to work on the following premises:

- 1. Consciousness is not a property of matter.
- 2. Living beings are not made of only matter.
- 3. A nonphysical substance that has properties different from those of matter is one of the constituents of living beings. The nonphysical substance is termed "soul."
- 4. We have a physical mind, referred to hereinafter as simply "mind."

It should be pointed out that matter has the intrinsic properties of touch, taste, smell, and color, which the soul does not have, and the soul has the intrinsic property of consciousness, which the matter does not have. Every substance during modification keeps its intrinsic properties and does not transform into another substance. Matter does not transform into soul and soul does not transform into matter. Matter always remains matter and soul always remains soul.

1.2 Matter and Soul

The karma doctrine deals with living beings which are composed of matter and soul. Both matter and soul have properties. The knowledge of their properties, which is essential for comprehending the metaphysical model of the karma doctrine, is summarized here. For our discussion, matter, soul and their properties are each divided into two categories: living and nonliving matter; pure and mundane soul; and intrinsic and extrinsic properties.

Matter that has association with soul is termed living matter; otherwise, it is nonliving matter. Bodies of living beings, as they have association with soul, are made of living matter. The remaining matter in the universe does not have any association with soul; hence, it is nonliving matter. Similarly, a soul that has association with matter is termed mundane soul; otherwise, it is a pure soul. Souls of living beings are considered mundane souls, as they have association with matter. A mundane soul always has been in a state of transmigration in the past and remains in a state of transmigration until it liberates itself from association with matter and transforms into a pure soul. The purpose of human life is to achieve liberation by transforming the imperfect mundane soul into a perfect pure soul.

Living matter and mundane soul have properties in addition to intrinsic properties (to be discussed later) that are termed extrinsic properties. A substance can exist without extrinsic properties. The difference between intrinsic and extrinsic properties of a substance is that the substance cannot exist without the former, but can exist without the latter.

1.2.1 Properties of Matter

It is easy to identify the intrinsic and extrinsic properties of matter as they are recognized by our senses. As stated earlier, matter possesses four intrinsic properties of touch, taste, smell, and color. The living matter of living beings also possesses four fundamental capabilities of physical senses (indriya), physical action (bala), respiration (sv socchav sa) that is required to metabolize, and age (yu), as every living being has a certain life span. In Jainism these four capabilities are known as vitalities (pr na). As these four capabilities of senses, physical action, respiration, and age are intrinsically absent in nonliving matter, they are the fundamental extrinsic properties of matter. Not all living beings have the same capabilities of physical senses and actions, because they have different number of physical senses and means of physical action. There are five types of sense organs

(skin, tongue, nose, eye, and ear) and three types of means of physical action (body, speech, and mind). Hence there are altogether ten secondary extrinsic properties of matter: five extrinsic properties of senses; three extrinsic properties of physical action; and one extrinsic property each of respiration and age. We can recognize all these ten extrinsic properties with our senses.

Not all living beings have all ten extrinsic properties, but all of them do have at least four extrinsic properties, namely touch, physical action of body, respiration, and age. Living beings can be classified according to the number of their senses that range from one to five. Only five-sensed living beings have a mind. Living beings like humans, cows, lions, birds, and fish have all five senses and all ten extrinsic properties. Living beings like reptiles, bees, and flies do not have the sense of hearing and thus have only four senses and they do not have mind; therefore they have only eight extrinsic properties, lacking both mind and a sense of hearing. Living beings like bugs, ants, and spiders do not have the senses of hearing and vision and have only three senses; therefore, they have only seven extrinsic properties. Living beings like worms, shells, and leeches have only two senses of touch and taste; therefore, they have six extrinsic properties. Living beings like plants have only one sense of touch and one type of physical action of body; therefore, they have the minimum extrinsic properties of four. It should be pointed out that senses have a hierarchy, starting from touch, then taste, smell, vision, and finally hearing. Similarly, the means of physical actions also have a hierarchy, starting from body, then speech and finally mind.

1.2.2 Properties of Soul

Recognizing the properties of soul is not as easy as that of matter. It was straightforward to identify the properties of matter as they could be perceived through our senses. The soul is non-physical and imperceptible to our senses, so we must resort to logical reasoning to infer the properties of a soul.

We know at least one characteristic of the soul, namely, consciousness. According to psychologists, consciousness has three faculties: cognition, affection, and conation. Cognition includes the abilities of perception and knowledge. Affection refers to the emotions such as love, attachment, fear, aversion, and the like. Conation includes the ability to make decisions and various tendencies to construct and learn that engage living beings into physical actions. The three faculties of consciousness can be demonstrated with an illustration. Consider that

you are strolling in the woods and a wild dog runs towards you; feeling threatened, you climb a nearby tree. Your perception and knowledge of the dog are the aspects of cognition. Your feeling of fear and desire not to get injured are the aspects of affection. Your decision to climb the tree, as well as your physical action of actually climbing the tree, are the aspects of conation.

All three aspects of consciousness are essential for the performance of a deed. You might not have performed the deed of climbing the tree unless you had perception and knowledge of the dog. Cognition is necessary for the performance of the deed, but it is not a sufficient condition. The presence of cognition does not ensure the performance of the deed. Even with the presence of cognition, a deed cannot be performed in the absence of affection. You might not have climbed the tree without experiencing fear and desire not to get injured. Even with the presence

of both cognition and affection, a deed cannot be performed in the absence of conation. Even with the knowledge of the dog and the feeling of fear, you could not have climbed the tree without the resolution and physical effort. The physical action of climbing the tree is due to the extrinsic properties of living matter.

A mundane soul has many properties, but the properties that are essential for the three faculties of consciousness are considered herein. Two properties of the mundane soul can be recognized with cognition: perception, that is, first contact, or indistinct awareness, or simple cognition without interpretation; and knowledge, that is, comprehending the details of what has been perceived. Cognition includes both perception and knowledge.

The third property of the mundane soul concerns the faculty of conation and is related to willpower, which a person can use to control desires. Will power is not physical power, as a physically weak person could be equally or more capable of controlling desires than a physically strong person. Willpower is a metaphysical effort whose nature is different than that of physical effort. If willpower is not power resulting from matter, then it has to be power from the soul. Will power, or metaphysical effort, is spiritual power or effort. It manifests as resolution, decisiveness, and determination and is also related to self control. This property of the mundane soul is termed "*v rya*." The resolution of climbing the tree in the above illustration is due to *v rya*.

Another property of the mundane soul concerns the faculty of affection that deals with its capabilities of emotions and feelings. Due to sentimental capabilities,

the mundane being develops desires for all the things concerned with the body and remains engrossed in attachment to worldly objects and gratification of senses. Desires lead to attachment and aversion (r ga-dve?a) and that in turn create 'ka? ya' such as anger, pride, deceit, and greed. The embodied mundane being has a misperception that its body, instead of its soul, is relevant to happiness. The property of misperception-cum-*kas ya* is termed *moha* (delusion).

It is shown later that a mundane soul loses the property of *moha* when it reaches the pinnacle of its "spiritual advancement" and transforms into a pure soul. The state devoid of *moha* of the soul is termed bliss and is related to its self-contained nature. It is not easy to recognize bliss as hardly any of us experience it in our lives. Although *moha* is considered antithetical to bliss, these two are not mutually independent properties and they never occur together. Bliss and *moha* are the purified (*svabh va*) and defiled (*vibh va*) states of the same property of the soul, respectively. *Moha*, which can be called as spiritual unrest (*a nti*), is an extrinsic property of the soul, because, as mentioned above, the pure soul exists without *moha*. The soul at any time can be either in the bliss state or the *moha* state. In other words, the duration of bliss increases as the duration of *moha* decreases. The duration of bliss and *moha* depend on the karmic load, as explained in the ensuing section.

The five properties of a mundane soul briefly discussed above are perception, knowledge, *virya, moha*, and bliss. We can infer the properties of a pure soul from the properties of the mundane soul. Because consciousness is the property of a soul, it is logical to assume that a soul must have the faculty of cognition; consequently a pure soul has the properties of perception and knowledge. Moreover a pure soul being a perfect soul must have perfect perception and perfect knowledge. A person uses willpower to control desires. A person with temporary willpower has too many desires as he or she is unable to control his or her desires. A person needs an everlasting *virya* as it has no desire. A pure soul is devoid of *moha*, and, therefore, has the property of bliss. In summary, a pure soul has perfect perception, perfect knowledge, everlasting *virya* and everlasting bliss.

The four properties of perception, knowledge, *virya*, and bliss are the properties of the mundane soul as well as the pure soul. These properties are then the intrinsic properties of a soul as it cannot exist without them. The property of *moha* is an extrinsic property of the mundane soul, as the pure soul exists without this property.

The presuppositions for the metaphysical model of the karma doctrine are the following:

- 1. Living beings are composed of two substances: matter and soul.
- 2. Matter has four intrinsic properties of touch, taste, smell, and color.
- 3. Living matter has up to ten extrinsic properties, namely: capabilities of touch, taste, smell, vision, and hearing; capabilities of actions of body, speech, and mind; capability of respiration; and capability of age.
- 4. A soul has four intrinsic properties of perception, knowledge, *virya*, and bliss and one extrinsic property of *moha*.

1.3 Deeds and Consequences

The karma doctrine is a law of cause and effect, which implies that every deed has consequences. A deed is the cause and its consequences are the effect. The deed is an intentional, voluntary action and includes both the physical action of mind, speech and body, termed yoga and the spiritual action that includes intention, motivation, desire, etc, steered by attachment/aversion, termed *kas ya*. In short, a deed is an activity performed by yoga-plus-kas ya.

It should be pointed out, as explained below, that all consequences of a deed are not governed by the karma doctrine. The answer to the question "What type of consequences of a deed are governed by the karma doctrine?" is not easily available in scriptures. Most people know either the wrong or incomplete answer to this question, which can become a source of controversy and inconsistency in the karma doctrine. The correct and complete answer to this question can be found by analyzing the characteristics of the karma doctrine.

1.3.1 Characteristics of the Karma Doctrine

For the law of karma to be meaningful, it should be valid everywhere and all the time (Jain, 2010), i.e. it must be universal and eternal. The law of karma will become meaningless if it is not applicable at all places and times. Therefore, the consequences of a deed that are governed by the law of karma should depend only on the deed, not on the time and place of the deed. It implies that the consequences of a deed that change with time and place of the deed are not governed by the law of karma.

1.3.2 Consequences

There are, therefore, two types of consequences of deeds. One type of consequences of deeds, termed invisible consequences, depends only on deeds;

such consequences are universal and governed by the law of karma. The other type of consequences of deeds, termed visible consequences, depends not only on deeds, but also on other factors such as the time and place of the deed; these consequences are nonuniversal and governed by man-made laws/or chance, not by the law of karma. This finding can be used to formulate a rule for determining the law-of-karma-governed consequences of deeds. The rule is that only those consequences of deeds that do not change with time and place of deeds are governed by the law of karma.

1.3.3 Invisible Consequences

Invisible consequences of deeds affect only that particular living being who performed those deeds; they cannot affect any other living being. The karma doctrine will become meaningless if invisible consequences affect living beings other than whosoever performed those deeds. Living beings are composed of a mundane soul and a body. Invisible consequences of deeds are such that they affect living beings through the manifestation of the intrinsic and extrinsic properties of the mundane soul and body. The properties of the mundane soul and body are universal and the invisible consequences of deeds that affect these attributes are, therefore, universal.

It seems logical to assume that invisible consequences affect the living being in the future after carrying out the deed. If the invisible consequences affect the living beings in the future, it is possible that a living being is not able to experience the invisible consequences of deeds carried out a few moments prior to its death. This inference implies that some invisible consequences of past deeds are experienced in the next life. There is a need to identify a carrier that conveys the instructions of the invisible consequences of past deeds to the next life.

1.3.3.1 Carrier of Invisible Consequences of Deeds

The soul of a living being is a mundane soul as it has an association with the body which is made of matter. The mundane soul leaves the body at the time of death. The transmigrating mundane soul has association with matter, but we are unable to identify it with our senses and available scientific tools. It implies that matter associated with the transmigrating mundane soul must be subtle matter. What could be the purpose of association of subtle matter with the soul? We can get some clue from the genome which delivers genetic instructions used in the development and function of living beings. The main role of DNA structure is the long-term storage of information needed to construct components of the body cells.

If the DNA structure in association with the soul have such powers, it seems logical to infer that subtle matter in association with the mundane soul is the carrier of the invisible consequences of deeds and has power to deliver the instructions of invisible consequences of deeds.

1.3.3.2 Karmic Particles

But this presupposition raises a question about the source of subtle matter. Scientists believe that the entire space of the universe is filled with dark matter and dark energy, but they are unsure what they are and how they operates. It is possible that the universe is filled with the subtler form of matter which modern science has not yet discovered. According to Jain metaphysics, the universe is packed with the subtler form of matter and one class of particles of the subtler form of matter is called karmic particles (*k rmana vargan*). It is logical to infer that karmic body (*k rmana-sarira*) made of the karmic particles (*k rmana vargan*) is the carrier of invisible consequences of deeds.

But the concept of karmic matter as the material carrier of the invisible consequences of deeds raises the following questions: How does karmic matter come in contact with a soul? What are the factors that control the amount of karmic matter that comes in contact with a soul? How does karmic matter transform into different species that carry different invisible consequences of deeds? How long does a species of karma remain attached to a soul? What are the factors that control the intensity of the effect of a species of karma at the time of its fruition? We will deal them one by one.

1.3.3.3 Amount of Karmic Matter

The karmic body (*k rmana-sarira*) is continuously in a state of vibrations due to the physical action of mind, speech, and body of the living being, i.e. yoga, which in turn is affected by the degree of volition with which the physical action is carried out. The vibrations in the karmic body capture karmic matter that is packed in the universe. The amount of karmic matter captured at any instant depends on the intensity of the vibrations of the karmic body. If the vibrations of the karmic body are feeble, as would be the case during meditation, the amount of karmic matter captured is small. On the other hand, if the vibrations of the karmic body are intense, as would be the case during rage and excitement, the amount of karmic matter captured is large. Thus it stands to reason that the amount of karmic matter that comes in contact with the karmic body increases in proportion to the intensity of yoga. Where is the karmic body located? It is conjectured that the karmic body, similar to the DNA structure, is located in each body cell, but the karmic body is subtler than the genetic body.

1.3.3.4 Karma

Karmic particles are nonliving matter, but they transform into living matter of karmic body after coming in contact with the mundane soul, just as do other particles of matter. The living karmic particles, termed karma, serve as a repository and a carrier of the invisible consequences of deeds. Karma transforms into appropriate species that carry different invisible consequences of deeds, which in turn affects different properties of the soul and living matter. The transformation of karma into its appropriate species is similar to the digestion process of living beings. It is a well known fact that particles of food ingested by a living being get transformed into different constituents of the body which remain in the body for different durations. Food particles are nonliving matter with no knowledge of that transformation. Food particles upon association with the soul transform into living matter that acquires the capability of transformation. Similarly, karma acquires the capability of transformation into different species that remain attached to the soul for different durations. It can, therefore, be posited that karma, similar to DNA, is the material carrier of the instructions of the invisible consequences of deeds and has capabilities to deliver them.

1.3.3.5 Time and Intensity of Fruition of Karma

A deed has two aspects: physical and spiritual actions. The degree of volition with which the physical action (yoga) is carried out, as described above, controls the amount of karmic matter that comes in contact with the soul and determines the different species of karma assumed by the undifferentiated karmic matter. The spiritual action that is steered by *kas ya* controls the time and intensity of fruition of karma. The liberation of the soul from the bondage of embodiment of a person who performs a deed with intense *kas ya* occurs later than a person who conducts the deed with mild *kas ya*. The time of fruition of karma, therefore, increases with the increase in the intensity of *kas ya*; the longer the karma remains attached to the soul, the more delayed is the time of its liberation. In the same way, the intensity of the effects of karma depends on the intensity of *kas ya*. The intensity of *kas ya*, while the intensity of retribution of good (*punya*) deeds decreases.

1.3.3.6 Species of Karma

The invisible consequences of deeds affect the properties of the soul and living matter. Each species of karma carries a different invisible consequence of deeds, which in turn affects a different property of the soul and living matter. There are four species of karma that affect the three intrinsic properties of perception, knowledge, and *virya* and the one extrinsic property of *moha* of the mundane soul. The three species of karma that prevent the full manifestation of the intrinsic properties of perception, knowledge, and *virya* of the soul are respectively the perception-obscuring, the knowledge-obscuring, and the *virya*-obscuring karma.

Due to the fruition of the perception-obscuring karma the mundane soul possesses only partial perception of the substances. The fruition of the knowledge-obscuring karma hinders the attainment of knowledge; the mundane soul possesses only the partial knowledge of the substances. The *virya*-obscuring karma prevents a living being from achieving its spiritual advancement. The fourth species, namely, the nature-deluding karma, affects the extrinsic property of *moha* of the soul. Due to the fruition of the nature-deluding karma, the mundane soul develops misperception-cum-*kas ya*. The property of bliss of the mundane soul is completely obscured by the nature-deluding karma. Bliss manifests only for the duration when the nature-deluding karma is not rising.

There are four more species of karma that affect four extrinsic properties (physical senses, means of physical actions, respiration, and age) of the living matter. The fifth species, termed physique-determining karma, determines the number of senses, which in turn determines the types of senses, types of means of physical action, and type of respiration system, and provides the appropriate body, senses, means of physical action, and respiration system. The sixth species, termed age-determining karma, determines the duration of the embodiment. The seventh species, termed feeling-determining karma, affects the performance of the senses and is responsible for mundane experiences of pain and pleasure. The eighth species, termed action-determining karma, affects the performance of the means of physical action, namely, body, speech, and mind and is responsible for the physical conduct of the living being. It should be pointed out that each species of karma is further divided into several subspecies.

It should be mentioned that the means of happiness and misery as well as the high and low family status are the visible consequences of deeds; hence they are not governed by the karma doctrine. The commonly accepted explanation that the

vedaniya karma controls the means of happiness and misery and the gotra karma is responsible for high and low family status needs reinterpretation.

1.4 Metaphysical Karmic Model

The basic elements of the metaphysical model of the karma doctrine are deeds, invisible consequences of deeds, and karma that acts as the carrier and deliverer of the invisible consequences of deeds. A brief summary of the karmic model is as follows. The karmic matter comes in contact with the soul through the karmic body and transforms into different species of karma which remain attached to the soul for different durations. At the end of their duration of attachment, karma executes the invisible consequences of the deed, detaches from the soul, and transforms back into karmic matter. The fruition of the old karma affects the modes of the properties of soul and body and results in a new deed which, in turn, binds new karma and the cycle continues. The new karma performs another very crucial function, as explained in the ensuing section.

1.4.1 Interactive Karmic Field

The attached karma creates an interactive karmic field inside and around the living being. The karmic field is analogous to the electric field that occurs in the natural world. As the electric field is affected by introducing new electric charges, the karmic field is influenced by the newly attached karma of subsequent deeds which continuously and automatically "update" the karmic field and alter the nature of the old attached karma. Therefore, the nature of karma at the time of its attachment to the soul need not be identical to its nature at the time of its detachment from the soul when it fructifies. In other words, the invisible consequences of deeds can be different than the *karmaphala*.

The storage of karma can be depleted by obstructing the inflow of the new karma and increasing the outflow of the matured karma. The obstruction of influx of the new karma is termed *samvara* (inhibition) and the detachment of the matured karma is termed *nirjar* (dissolution). The storage of karma is exhausted by the processes of samvara and *nirjar*. In order to understand the mechanism of *samvara* of the new karma and *nirjar* of the past karma, we must analyze the interaction between the newly attached karma and the karmic field of the past karma. The attached karma can be considered as a load, termed "karmic load", which a soul carries with it. The karmic load is primarily determined by the intensity of *ka? ya*; the karmic load increases with the increase in the intensity of *ka? ya*.

attached karma of the new deeds affects the average intensity of ka? ya of the old attached karma of the past deeds. A new deed whose newly attached karma increases the average intensity of ka? ya of the old attached karma, and hence the karmic load and average time of fruition, is termed an evil (p pa) deed. By the same token, a new deed whose newly attached karma decreases the average intensity of kas ya of the old attached karma, and hence the karmic load and average time of fruition, is termed a good (pu?ya) deed. The newly attached karma has the power to increase or decrease the average time of fruition of the old attached karma by increasing or decreasing the intensity of ka? ya respectively. Although the newly attached karma of our new deed fructifies in future, it instantly and automatically "updates" the karmic field so that we also experience its effect right along with our new deeds.

The effect of the various processes on the attachment of the new karma to, and the detachment of the matured karma from, the karmic body can be understood from the following scenario. Suppose during the next few days you perform on average more good deeds than evil deeds, so that your old karmic load goes down; consequently, the average time of fruition of your old karmic load decreases. There is only one way for karma to fructify in the shorter period; that is, on average a higher number of karmic particles should fructify. The average number of karmic particles detaching from the karmic field increases with on average more good deeds than evil deeds. In other words, the good deeds increase *nirjar*. The decrease in the intensity of the *ka? ya* of the rising karma promotes more new good deeds, which in turn attach less karmic load. In other words, the good deeds increase *samvara*. The good deeds result in reducing the karmic load, which in turn promotes more good deeds that further reduce the karmic load, and the cycle continues. The reverse must be true if you perform on average more evil deeds than good deeds.

1.4.2 Metaphysical System

The karma doctrine is governed by the universal laws that cannot be tinkered with even by the Supreme Being. There is an innate moral order to the cosmos, which is self-regulating through the workings of the karma system as follows.

The karmic body is continuously in a state of vibrations due to the physical action of mind, speech, and body of the living being, which in turn is affected by the degree of volition with which the physical action is carried out. The vibrations in the karmic body capture karmic matter that is packed in the universe. The amount of karmic matter captured at any instant depends on the intensity of the vibrations of

the karmic body. Karmic matter captured by the karmic body comes in contact with the soul and transforms into eight fundamental species of karma that carry invisible consequences of deeds. The four species of karma affect the properties of the mundane soul. The other four species affect the properties of living matter. Due to *ka? ya*, the species of karma remain attached to the soul for different durations. The duration of karmic bondage with the soul increases with the increase in the intensity of *ka? ya* with which the deed is performed. The intensity of retribution of karma of evil deeds increases and good deeds decreases with the increase in the intensity of *ka? ya*. At the end of its duration of attachment, karma executes the

invisible consequences of deeds, detaches from the soul, and transforms back into karmic matter. The fruition of the old karma results in new deeds which, in turn, bind the new karma and the cycle continues.

The accumulated karmas of past deeds create an interactive karmic field inside and around living beings. Although the newly attached karma of our new deeds fructifies in future, it instantly and automatically "updates" the karmic field so that we also experience its effect right along with our new deeds. The newly attached karma of new good deeds decreases the duration of bondage of the old attached karma, decreases the intensity of retribution of the old attached evil karma, and increases the intensity of retribution of the old attached evil karma, and increases the intensity of retribution of the old attached good karma; and the process increases *samvara* and *nirjar*. In contrast, the newly attached karma of new evil deeds increases the duration of bondage of the old attached karma, increases the intensity of retribution of the old attached karma, and decreases the intensity of retribution of the old attached evil karma, and decreases the intensity of retribution of the old attached evil karma, and decreases the intensity of retribution of the old attached good karma; and the process decreases *samvara* and *nirjar*. We have the ability and power to control the interactive karmic load by controlling our new deeds.

2. Free Will

The karma doctrine has features that have a vital bearing on the question of free will and *purus rtha* (human effort). According to the Jain karma doctrine, the fruition of the old karma attached to the soul by the past deeds results in new deeds which, in turn, bind the new karma and the cycle continues. Though this statement about the fruition of karma is true, it does not tell the complete truth. The incomplete truth gave rise to the notion that a man is a prisoner of his past deeds; he has no control over his present deeds. Such a notion raised several issues concerning moral responsibility of human beings and their liberation from the cycle

of rebirth. If the present deeds of a person are fully controlled by his past deeds, then he would not be morally responsible for his deeds and would not deserve retribution for them (Reichenbach, 1990). Moreover, he would not be able to achieve liberation (moksa) as he has no control over his present deeds.

The doctrine of free will presupposes that human beings are free to determine the aims of their life and are capable to make an effort to fulfill them. In Jainism the issue of free will is resolved by invoking *anek ntav da* (doctrine of manifold aspects). According to *anek ntav da* human conduct is controlled by five factors, namely, time (k la), nature (*svabh va*), past karma (*purva*-karma), destiny (*niyati*) and human effort (*purus rtha*). These five factors are called 'panca *samav ya*'. *Anek ntv da* offers justification for rejecting the notion that human actions are fully controlled by any one of the five factors.

The '*pañca samav ya*' can be analyzed also from a different viewpoint. A human being has no control over *k la*, *svabh va*, and *niyati*. Though he has no control also over past karma, he can control the karma *phala* by *purus rtha*; hence past karma and *purus rtha* play roles in controlling free will. Their respective roles in controlling free will can be explained by analyzing the causes of *purus rtha*.

In western philosophy the question of free will is decided by analyzing the nature of causal conditions. The analysis gave rise to three points of view relating causation and free will: deterministic, non-deterministic, and compatible. Determinism holds that the causal conditions are sufficient to determine the present deeds by the past deeds and rejects the notion of free will. According to the non-deterministic view, humans are free to choose their course of action when the causal conditions are not sufficient to cause them to act in a certain manner. Compatibilists argue that determinism is compatible with free will. As the law of karma is a causal law, it should concur with one of these three viewpoints.

2.1 Puru? rtha

The precise definition of the term *puru? rtha* will be useful in the analysis of the causal connection between the law of karma and *puru? rtha*. The term *puru? rtha* has several meanings. *Puru? rtha* in common parlance is considered as human efforts to achieve specified aims in life. But *puru? rtha* has a broader meaning in the context of the karma doctrine. All deeds are considered to be purposive in character as they are willed to attain certain goals. This characterization of deeds implies that all present deeds are *puru? rtha*. Ac rya Mah prajña (2002) has given a similar

definition of *puru? rtha*. According to him the present deeds are *puru? rtha* and past deeds are karma. Hence, *puru? rtha* just like deeds is an activity performed by yoga-and-ka? ya.

We perform *puru? rtha* all the time in our life. We do *puru? rtha* of performing activities which include selection of means (nimitta) of activities for satisfying certain goals. For example, we do puru? rtha of eating foods after selecting them to stay alive or to satisfy the cravings of the tongue, wearing clothes after selecting them to protect our body or to satisfy the cravings of the touch, earning livelihood after selecting a profession to fulfill the sensuous desires, and so on. In these examples, eating, wearing, earning livelihood, etc. are the activities for realizing certain aspirations; food, clothes, profession, etc. are the means of activities achieving certain aims; and staying alive, protecting the body, fulfilling the sensuous cravings, etc. are the goals. All new deeds in the beginning appear *puru? rtha* as they need special efforts to perform them, but after performing them repeatedly they do not require any special efforts. A large proportion of daily activities of humans after some time in the life become automatic. The automatic activities imply that the selection of means of activities among the potential means of activities also becomes automatic and does not require any special human effort. The routine human deeds by definition are *puru? rtha*, but in common parlance they are not considered puru? rtha because of the absence of special efforts to perform them.

2.2 Causes of Purus rtha

We perform *puru? rtha* all the time in our life; consequently, we bind new karma to our soul at every instant. Three processes occur simultaneously : 1. performance of *puru? rtha*; 2. fruition of the past karma and 3. attachment of the new karma. For example, you are currently doing the *puru? rtha* of reading this book, but at the same time you are attaching new karma and experiencing the karma *phala* of your past karma. During these three processes that occur simultaneously, the destruction of the old modes (*pary ya*) and the origination of the new modes, referred to hereinafter as change in the modes, of the properties of the soul and body (living matter) keep occurring.

Means are required to perform *purus rtha*; it is not possible to perform *purus rtha* without the means. For example, this book is the primary means of your *purus rtha* of reading the book; you could not perform the *purus rtha* of reading this book without the book. This space (*k*?*etra*) and time (*k la*) required for reading the

book and the substances (*dravya*) and their modes (*bh va*) required to prepare the book, i.e. *dravya*, *k*?*etra*, *k la*, and *bh va* are the secondary means of your *puru*? *rtha* of reading the book. The *puru*? *rtha* of reading this book cannot be performed without the support of these means. The primary and secondary means of *puru*? *rtha* together are termed *no-karma*. Different *puru*? *rtha* need different means, i.e. *no-karma*. For example, you could perform a different *puru*? *rtha* of, say, watching a television program instead of reading the book, but that different *puru*? *rtha* would need a TV instead of the book and different secondary means, i.e. different no-karma. In other words, the makeup of the no-karma determines the nature of the *puru*? *rtha*.

During the *puru? rtha* of reading of the book the modes of the properties of your soul and body keep changing. The fruition of the old karma and the attachment of the new karma occur simultaneously with the puru? rtha of reading the book. A question arises about the interrelation between the puru? rtha of reading the book and the changes in the modes of the properties of your soul and body. The answer to this question can be found by identifying the material and efficient causes (up d na k ra?a and nimitta k ra?a) of the changes in the modes of the properties of your soul and body during the puru? rtha of reading the book. The change in the modes of the properties of your soul and body includes two modes : the modes before you begin reading the book, i.e. old-modes of your soul and body and the modes after you finish reading the book, i.e. new-modes of your soul and body. The old-modes are the cause of the new-modes and the new-modes are the effect of the old-modes. The old-modes of your soul and body are the material causes of the new-modes of your soul and body. The makeup of the no-karma that acts as means of the puru? rtha of reading the book and the old attached karma that fructifies during the period of the puru? rtha of reading the book are the efficient causes of the newmodes of your soul and body.

There is one major distinction between the two efficient causes of the postmodes. While the old attached karma is governed by the law of karma, the *no-karma* is not. The *no-karma* is the visible consequences of deeds which are not governed by the karma doctrine. The karma doctrine controls karma only, not *no-karma*.

Karmaphala i.e. fruition of Karma is the new-mode of the properties of your soul and living matter, which, not only depends on the old-modes and karma, but also on *no-karma*. *Karmaphala* would be different if you choose the television, instead of the book, as the means of the *puru? rtha* of watching the television program.

Though your old-modes and the state of the fructifying karma do not change with the *puru? rtha* you are going to perform, but your new-modes would be different for your different potential means of *puru? rtha*. It is possible for you to choose any one of the countless potential means of *puru? rtha*, such as *puru? rtha* of writing a novel, listening to music or a discourse, watching television or an entertainment program, analyzing natural or man-made events, thinking about the nature of soul and other *dravya*, and so on. In these examples of potential *puru? rtha*, book, novel, music, discourse, natural or man-made events, soul, *dravya*, etc., in addition to *dravya*, *k?etra*, *k la*, and *bh va*, are the potential means of *puru? rtha*, i.e. *no-karma*.

It should be mentioned that *puru? rtha* is a constituent of the karma *phala* and if one changes, the other also change. As karma *phala* depends on the past attached karma and the *no-karma*, so does *puru? rtha*. The karma *phala* of the action-determining (*gotra*) karma determines the intensity of the yoga component of the *puru? rtha* and the karma *phala* of the nature-deluding (*mohan ya*) karma controls the intensity of the *ka? ya* component of the *puru? rtha*. The *no-karma* controls the relative contributions of the three elements of yoga, namely, physical actions of body, speech, and mind, and the relative contributions of the four elements of kas ya, namely, anger, pride, deceit, and greed.

The above analysis of *puru? rtha* explains that there are two efficient causes of *puru? rtha*, namely, the past attached karma and the *no-karma*. Only one of the efficient causes, i.e. the past karma is governed by the karma doctrine. The other efficient cause, i.e. *no-karma*, is not controlled by the karma doctrine. It may be noted that if *karma phala* is fully controlled by the karma doctrine, the free will has no role to play. But that is not the case. The karma *phala* is also controlled by *no-karma* which is not controlled by the karma doctrine as explained above.

2.3 Accessibility of No-Karma

We perform *purus rtha* all the time. We cannot perform *purus rtha* without *no-karma*, which is essential for performing *purus rtha*. There are countless *no-karma* in the universe, but all no-karma is not the potential no-karma of every *purus rtha*. Only those *no-karma* which is accessible to a person is the potential *no-karma* of the *purus rtha* of a person. For example, a person wishes to perform a *purus rtha* of owning a diamond. The diamond would become a potential *no-karma* of his *purus rtha* only if he has resources to own the diamond. Similarly, if a person lives in a country where no Jain saint comes for visit, then the means of listening the discourse of a Jain saint cannot be the potential *no-karma* of his *purus rtha*. The

accessibility to *no-karma* is not controlled by the karma doctrine; it is controlled either man-made laws or natural laws other than the law of karma.

Every person has countless potential desires that would require countless *purus rtha* by him to satisfy those desires. Based on his existing mode of his soul and body, he selects the *no-karma* among the potential *no-karma* to meet one of his desires. Though the person selects the (actual) *no-karma* among the potential *no-karma*, but his freedom to select the *no-karma* has some constraints. He cannot select the *no-karma* beyond the potential *no-karma* and in opposition to the existing modes of his soul and body.

2.4 Determinism

The question of free will can be resolved by analyzing the causes of *puru? rtha*. It is interesting to note that: if none of the causes of *puru? rtha*, namely, old-mode, past karma, and *no-karma* is controlled by the karma doctrine, then *puru? rtha* (present deeds) does not depend on karma (past deeds) and the karma doctrine becomes meaningless; and if all the three causes of *puru? rtha* are fully controlled by the karma doctrine, then *puru? rtha* is fully controlled by the karma doctrine, then *puru? rtha* is fully controlled by the karma doctrine, then *puru? rtha* is fully controlled by the karma doctrine and free will has no role to play in performing *puru? rtha*. As only two of the causes of *puru? rtha* are controlled by the law of karma, free will has a role in performing *puru? rtha*. The (actual) *no-karma* of *puru? rtha*. The selection of the *no-karma* is controlled by the new-mode of the soul and body of the person.

The above analysis of the karmic process points out that the karmic process is not deterministic as the presents deeds are not completely determined by the past deeds. Is the karmic process then non-deterministic? Are the causal conditions not sufficient to cause humans to act in a certain manner? Once a person chooses *no-karma* among the potential *no-karma* of *puru? rtha*, the causal conditions are then sufficient to cause him to act in a certain manner. It implies that the karmic process is not non-deterministic. Does it mean that humans are not free to choose their course of action? Humans do choose *no-karma* of *puru? rtha*, but they are free to choose *no-karma* with some constraints. A freedom to choose *no-karma* of *puru? rtha* is determined partly by the past karma and partly by *no-karma* and humans are free to choose *no-karma* of *puru? rtha* with some constraints. Such a karmic process is considered as compatibilistic.

2.5 Conclusions

For the karma doctrine to be meaningful in the context of free will, the law of karma should not control all causes of *puru? rtha*. The analysis of the characteristics of *karmaphala* shows that two cause of *puru? rtha*, namely, old-modes of the soul and body and the past karma, are controlled by the karma doctrine and the cause of *no-karma* is not controlled by the karma doctrine. Humans have the freedom with some constraints to choose *no-karma* of *puru? rtha* among the potential *no-karma*.

3. Rebirth

According to the Jain karma principle, living beings have been wandering in the cycle of life, death, and rebirth since beginning less time and will continue to do so as long as they carry the karmic load of their karmic (*k rma?a*) body with their soul. Mundane souls transmigrate in the four birth categories (*gati*): hellish (*n raki*), celestial (*deva*), human (*manu?ya*), and subhuman (*tiryañca*) (*Tattv rtha S tra*, 1994). The *gati* of a living being in the next birth is determined by the nature of karma performed by the living being. The causes of life span (*yu*) karma have been described in the *Tattv rtha S tra*; auspicious karma leads to birth in higher *gatis*, such as human and celestial *gatis* and inauspicious karma leads to birth in lower *gatis*, such as infernal and subhuman *gatis*. But the superiority between human and celestial *gatis* and inferiority between subhuman and hellish *gatis* are unspecified.

Living beings in every gati occur with a wide range of bodies that differ in the number and the potentiality of their vital powers (pr ?a) (Gomma ?as ra J vak ??a, 1990). The physical development/deterioration, termed evolution/devolution, of the life form of living beings can be characterized by the number or the potency of the vital powers of their bodies. It should be emphasized that term evolution/devolution in this paper carries a specific connotation which is quite distinct from that of the term used by Charles Darwin (Whitfield, 1993). The evolution/devolution of the life form occurs on increasing/decreasing the number of vital powers or the potency of the vital powers. It is hypothesized that the evolution/devolution of the life form of living beings is governed by the "load" of their attached karma, termed karmic load, defined later. Based on this hypothesis a conceptual scheme between the number or the potency of the vital powers and the karmic load of living beings is presented to explain their evolution from a less developed to a more developed life form and their devolution from a more developed to a less developed life form. The conceptual scheme also identifies the categories of mundane souls that transmigrate from one gati to another.

3.1 Living Beings

Living beings possess a soul and a gross body (*aud rika- ar ra*) or a protean body (*vaikriya- ar ra*). Human and subhuman beings have a gross body; and hellish and celestial beings have a protean body. The gross or protean body of living beings has ten vital powers (*pr ?a*) described earlier. The least developed beings, such as *nigodas* and plants, have only four vital powers. All one-sensed to four-sensed and some five-sensed subhuman beings do not have the vital power of physical action of mind. Hellish, celestial, and human beings and most five-sensed-subhuman beings have the vital power of physical action of mind. Thus living beings can be divided into ten classes given below :

Living Beings	Number of Vitalities
Human	10
Celestial	10
Hellish	10
Five-sensed-samanaska subhuman	10
Five-sensed-amanaska subhuman	9 (without mind)
Four-sensed subhuman	8 (without mind, hearing)
Three-sensed subhuman	7 (without mind, hearing, vision)
Two-sensed subhuman	6 (without mind, hearing, vision, smell)
One-sensed subhuman	4 (with touch, body, respiration, age)
Nigoda	4 (with touch, body, respiration and

3.2 Karmic Load

The karmic matter that comes in contact with the karmic body transforms into eight species of karma, but only seven species of karma excluding the life span (*yu*) karma attach every instant to the karmic body; the *yu* karma attaches to the karmic body only once in a life time among eight time-opportunities, called *apakar?a*. The moment when a living being binds the *yu* karma of its next life is termed as age-bonding moment. It is said that the subspecies of the *yu* karma depends on the regular nature of volition activities of a living being. Though the causes of karmic bondage of the eight types of karma are described in the scriptures, the factor that determines the regular nature of the volition activities of a living being being is not explicitly mentioned. As the new deeds of a living being depend on the

karmaphala of the old karma, it is logical to assume that the regular nature of the volition activities of the living being depends on the karmic load of their karmic body and the birth-species in the next life depends on the karmic load at the agebonding moment.

Karmic load is determined by four parameters, namely, the amount (*prade a*) of the karmic matter, species (*prak?titî*) of karma, duration (*sthitî*) of attachment of karma, and intensity of fruition (*anubh ga*) of karma. The amount of karmic particles and the species of karma are governed by the intensity of yoga and the duration and intensity of fruition is controlled by the intensity of *ka*? *ya*. In other words, karmic load is governed by the intensity of yoga-plus-ka? ya; the higher is the intensity of yoga-plus-*ka*? *ya*, the larger is the karmic load.

3.3 Conceptual Scheme of Evolution

The evolution of the life form of living beings is characterized by the number or the potency of the vital powers, which in turn are determined by the karmic load of their karmic body. Life form evolves with the increase either in the number or the potency of the vital powers. The evolution of the life form is, therefore, of two types: upward and lateral. In the upward evolution of the life form the number of the vital powers increases from four to ten. In the lateral evolution of the life form the potency of the vital powers increases while the number of the vital powers remains the same.

The evolution of the life form of living beings is based on the rule of the karma doctrine, termed 'Rule of Development' (Lodha, 2010). According to the rule of development, both the spiritual and physical developments/deteriorations of living beings that occur with the decrease/increase in their karmic load take place simultaneously and mutually influence each other. The rule of development will become meaningless if one development/deterioration happens, not the other one. For example, if the karmic load of a human being at the age-binding moment is so large that he is born as a three-sensed-subhuman being in the next life; not only the number of vital powers of the gross body of the living being reduces from ten to seven, the qualities of its soul also deteriorate. Though the soul of both the human being and the three-sensed-subhuman being is the same, the qualities of the soul of the former are more advanced than that of the latter. The rule of development will become meaningless if either the qualities of the soul of the latter are more advanced than that of the former or the qualities of their souls are same.

According to Jainism, there are infinitely infinite (anant nant) numbers of

living beings in the universe, called *nigodas*, which have the least developed life form. *Nigodas* are the organisms that are much smaller than the microorganisms; they are in the universe since beginning less time (Kachhara, 2014). Living beings in the increasing order of the developed life form are: *nigoda* beings; one-sensed-, twosensed-, three-sensed-, four-sensed-, and five-sensed-amanaska (without mind) beings; and five-sensed-samanaska (with mind) beings. The five-sensed-*samanaska* beings, which can be subhuman, human, hellish, and celestial beings, have all ten vital powers. The mind of the *samanaska*-subhuman beings is far less developed than that of the human beings; the life form of *samanaska*-subhuman beings is, therefore, less developed than that of human beings. The ranking of the life forms of the hellish and celestial beings is explained later making use of the rule of development.

Several notations are used in the article. Some notations shown in column 1 below are used for the maximum value of the karmic load at the age-bonding moment of a living being to take next birth in the birth-species mentioned in column 2 If the karmic load, K, at the age-bonding moment of a living being is greater than K_{ss} , i.e. $K > K_{ss}$ (or $K_{ss} < K$), then its life form in the next birth, according to the notations shown above, would be less developed than that of five-sensed-samanaska-subhuman (fsss) beings; and if K is less than or equal to K_{sa} i.e. $K \le K_{sa}$ then its life form in the next birth would be five-sensed-subhuman beings. In other words, if K is $K_{ss} < K \le K_{sa}$ then its next birth would be five-sensed-amanaska subhuman (fsas) being.

Column 1	Column 2
Max karmic load	Birth-species
K _N	Nigoda
K ₁	One-sensed subhuman being
K_2	Two-sensed subhuman being
K_3	Three-sensed subhuman being
K_4	Four-sensed subhuman being
K_{5A}	Five-sensed-amanaska-subhuman being
K_{5S}	Five-sensed-samanaska-subhuman and hellish being
K _M	Human being
K _c	Celestial being
K _H	Hellishbeing

3.4 Upward Evolution

The conceptual scheme of evolution of living beings to the various birthspecies is based on several presuppositions which are described below:

Presupposition 1. The number and potency of the vital powers of a living being in the next life increase with the decrease of its karmic load at the age-bonding moment in the present life and vice versa.

Presupposition 1 is based on the rule of development described earlier and will be utilized in formulating the conceptual scheme of evolution. For example, as the vital powers are fewer in *amanaska*-subhuman beings than human beings, a human being will be born in the next birth as an *amanaska*-subhuman being only if his karmic load at the age-bonding moment is sufficiently large as explained later.

Presupposition 2. The karmic load of *amanaska*-subhuman beings always decreases with time; hence, they always transmigrate in their next life to a more developed life form.

Amanaska-subhuman beings are not judicious and do not have the discretion to choose between good and evil actions as they do not have a mind. Their karmic load must always decrease with time; otherwise they would never be able to escape from the cycle of transmigration. In other words, the increase in their karmic load due to the attachment of new karma of their new actions is less than the decrease in the karmic load due to the detachment of the old karma of their past actions. As a result, they always attain in their next life a more developed physique with either the same number of vital powers of increased potency or one more vital power. For example, a two-sensed-subhuman being will be born as either a two-sensedsubhuman being with increased potency of vital powers or a three-sensedsubhuman being.

Nigoda beings have only one sense and innumerable souls of *nigoda* beings share one gross body. The karmic body of the *nigoda* beings carries a large quantity of the karmic load that decreases with time at an infinitesimal small rate. Therefore only a finite number of *nigoda* beings advances to the next developed life form of a one-sensed beings with only one soul in each gross body. These are termed one-sensed-subhuman beings.

The karmic load, K, of an *amanaska*-subhuman being at the age-bonding moment determines the birth-species in its next life, as shown in Table 1.

Present Birth-species	Next Birth-species
Nigoda	if $K_1 \leq K \leq K_N$
One-sensed subhuman	if $K_2 \leq K \leq K_1$
One-sensed subhuman	if $K_{2} \leq K \leq K_{1}$
Two-sensed subhuman	if $K_3 \leq K \leq K_2$
Two-sensed subhuman	if $K_3 \leq K \leq K_2$
Three-sensed subhuman	$if K_4 \leq K \leq K_3$
Three-sensed subhuman	if $K_4 \leq K \leq K_3$
Four-sensed subhuman	if $K_{5} \leq K \leq K_{4}$
Four-sensed subhuman	if $K_{5} \leq K \leq K_{4}$
Five-sensed-amanaska subhuman	if $K_{55} \leq K \leq K_{5A}$
Five-sensed-amanaska subhuman	if $K_{55} \leq K \leq K_{5A}$
Five-sensed-samanaska subhuman	if $K_{M} \leq K \leq K_{55}$

Table 1. Possible birth species in the next life for the given *amanaska*-subhuman birth-species in the present life.

Table 1 is explained by using illustrations. For example, if the present birth-species of a living being is the nigoda, then its next birth-species would be nigoda if $K_1 < K \leq K_N$ and one-sensed subhuman if $K_2 < K \leq K_1$. Similarly, if the present birth-species of a living being is the three-sensed subhuman, its next birth-species would be three-sensed subhuman if $K_4 < K \leq K_3$ and the four-sensed subhuman if $K_{5A} < K \leq K_4$. A mundane soul of an fsas being would transmigrate to the fsas birth-species if $K_{5S} < K \leq k_{5A}$ and the fsss birth-species if $K_m < K \leq K_{5S}$. Note that $K_N > K_1 > K_2 > K_3 > K_4 > K_{5A} > K_{5S} > K_M > 0$.

Presupposition 3. The karmic load of hellish beings always decreases with time; they always transmigrate in their next life to a more developed life form, which is either the samanaska-subhuman being or human being; and they cannot transmigrate to a celestial birth-species in their very next birth.

Hellish beings are in hell to bear the fruits of their past karma; therefore, their karmic load decreases with time. The life form of hellish beings is more developed

than the life form of the fsas beings, because the former have vital power of mind and the latter do not. The karmic load at the age-bonding moment of a living being to transmigrate in the next life to the hellish birth-species should, therefore, be less than or equal to K₅₅. In other words, the karmic load of a living being in the hellish birth-species cannot be greater than K_{ss}; hence a hellish being cannot transmigrate in the next life to the amanaska birth-species. It should be noted that the minimum karmic load to take birth in the fsas birth-species is greater than K_{ss}. The life form of hellish beings is less developed than the life form of human beings; the minimum karmic load at the age-bonding moment of a living being to take birth in the next life as an hellish being, denoted by K_{H} should be greater than K_{M} , i.e. $K_{H} > K_{m}$. It may be mentioned that hellish beings are capable to rise only up to the fourth spiritual stage. Hellish beings cannot transmigrate to the celestial birth-species, because of a rule that a living being cannot acquire protean body in succession. It implies that celestial beings also cannot transmigrate to the hellish birth-species and hellish and celestial beings cannot be born in the same birth-species in the next birth. Hellish beings, therefore, transmigrate only to human or samanaska-subhuman birthspecies; they transmigrate in the next life to the samanaska-subhuman birth-species if $K_M < K \le k_H$ and the human birth-species if $K^4 < K \le K_M$ where K^4 is the minimum value of the karmic load of a living being in the fourth spiritual stage.

The fsas beings cannot transmigrate to the hellish birth-species; the reason for it can be recognized by considering the responsibility for the karmic load of an fsas being who acquired this birth-species for the first time since beginning less time. The karmic load of an fsas being is the result of the karmic process governed by Presupposition 2 that is beyond its control; hence, the fsas being is not responsible for its karmic load. A living being transmigrates to the hellish birth-species because of its inauspicious past karma for which it is responsible. But the fsas is not responsible for its karmic load and should not transmigrate to the hellish birth-species. Therefore, living beings in their downward devolution, not in their upward evolution, transmigrate to the hellish birth-species. For example, an fsas being transmigrates to the fsss birth-species, not to the hellish birth-species if $K_{\rm M}$ <K \leq K_{\rm ss}; and the human and the fsss beings transmigrate to the hellish birth-species if $K_{\rm M}$ <K \leq K_{\rm H}.

Presupposition 4. The karmic load of five-sensed-samanaska-subhuman beings can both increase and decrease with time; hence, they can transmigrate to five-sensed-amanaska-subhuman, hellish, human, and celestial birth-species.

The fsss beings have mind, but their mind is not as developed as that of human beings; and they are not completely responsible for their actions. They are

capable to rise up to the fifth spiritual stage. Hence, their karmic load cannot become larger than K_{5A} and less than K^5 , where K^5 is the minimum value of the karmic load in the fifth spiritual stage. They can, therefore, transmigrate to the fsas birth-species if $K_{5S} \le k \le k_{5A}$; the hellish birth-species if $K_H < K \le K_{55}$; *samanaska*-subhuman birth-species if $K_M < K \le k_h$; the human birth-species if $K_C < K \le K_M$ and $K^5 < K \le K^4$, and the celestial birth-species if $K^4 < K \le K_C$ where K_C is the maximum value of the karmic load at the age-bonding moment of a living being to take birth in the next life as a celestial being, as explained later.

Presupposition 5. Human beings can transmigrate to all birthspecies.Human beings have the discretion to choose between good and evil actions and are, therefore, responsible for their actions. Depending on their actions, their karmic load either increases or decreases. Their karmic load can become larger than K_1 consequently, they can transmigrate to the nigoda birth-species. On the other hand they can completely annihilate their karmic load reducing it to 0; consequently, they can be liberated. Their karmic load can vary from zero to a value larger than K_1 they can, therefore, transmigrate to all birth-species, including the celestial birth-species, as shown in Table 2.

Table 2. Possible birth species in the next life for the human birth-species in the present life

Nigoda	if $K_1 < K \le K_N$
One-sensed-amanaska subhuman	if $K_2 < K \leq K_1$
Two-sensed-amanaska subhuman	if $K_3 < K \le K_2$
Three-sensed-amanaska subhuman	if $K_4 < K \leq K_3$
Four-sensed-amanaska subhuman	if $K_{5A} < K \leq K_4$
Five-sensed-amanaska subhuman	if $K_{55} < K \le K_{5A}$
Hellish	if $K_{H} < K \le K_{55}$
Samanaska subhuman	$if K_M < K < K_H$
Human	$if K_{C} < K < K_{M}$
Celestial	if $K^4 < K \le K_c$
Human	if $0 < K \le K^4$

(178)

Presupposition 6. Celestial beings transmigrate to either human birthspecies or five-sensed-samanaska subhuman birth-species. Celestial beings, similar to human beings, are responsible for their actions; their karmic load can either increase or decrease depending on their actions. But there are restrictions on the lower and upper limits on their karmic load. Their karmic load cannot become larger than K₅₅ hence, they cannot transmigrate to an *amanaska*-subhuman birthspecies. The celestial beings are not capable to achieve a spiritual stage (gu?asth na) higher than fourth stage; hence, their karmic load cannot become less than K⁴. The life form of celestial beings is more developed than the life form of human beings in the first spiritual stage (mithy d????), because a mithy d???? human being can transmigrate in the next life to the celestial birth-species by reducing his or her karmic load. The maximum karmic load, K_c at the age-bonding moment of a living being to take birth in the next life as a celestial being should be greater than K¹ and less than K_M or equal to K^1 i.e. $K^1 \leq Kc \leq K_M$ where K^1 is the minimum value of the karmic load of a *mithy d??1* living being. A celestial being transmigrates to the fivesensed-samanaska-subhuman birth-species if $K_M < K \le K_{55}$ and to the human birthspecies if $K^4 < K \le K_M$.

The value of K for the various life forms can be determined using the above propositions. It can be seen from Table 2 that a human being born with the karmic load less than or equal to K_M and greater than K_C , i.e. $K_C < K \le K_M$ can transmigrate to the celestial birth-species by reducing his or her karmic load at the age-bonding moment to less than or equal to K_C and greater than K^4 , i.e. $K^4 < K \le K_C$. It implies that human beings with the karmic load of $K_C < K \le K_M$ are spiritually and physically less developed than celestial beings with the karmic load of $K^4 < K \le K_C$. On the other hand human beings in spiritual stages higher than four with $K < K^4$ are spiritually and physically developed than a category of subhuman beings, and vice versa. The *samanaska*-subhuman beings with the karmic load $K_M < K \le K_{SS}$ and *amanaska*-subhuman beings with the karmic load $K_M < K \le K_{SS}$ and *amanaska*-subhuman beings with the karmic load $K_H < K \le K_{SS}$.

3.5 Lateral Evolution

In the lateral evolution of living beings the potency of their vital powers increases, but the number of the vital powers stays the same. The potency of the vital

powers of living beings born with the same number of vital powers are not identical. Some are born with more potent vital powers than others. According to the 'rule of development' if two living beings carrying different karmic loads during transmigration reincarnate in the same order of the developed life form with same numbers of vital powers, the living being that carries the less karmic load during transmigration reincarnates with more potent vital powers. For example, two living beings A and B carrying karmic loads of K_A and K_B during transmigration are born as human beings, A with the first type of bone joint (*vajra-??abha-n r ca sa? hanana*) and B with the second type of bone joint (*??abha-n r ca sa? hanana*). Because the former bone joint (*sa? hanana*) is more potent than the latter bone joint (*sa? hanana*), karmic load K_B .

Similar illustrations of the 'rule of development' to the other subclasses of the physique-determining karma (N ma karma) can be given. Moreover the potencies of their vital powers keep changing during their life span and increase with decreasing karmic load they carry with their karmic body. As the karmic load of a human being decreases, he or she climbs up the 'ladder' of the fourteen spiritual stages; and then the intensity of fruition of the auspicious nondestructive (*agh ti*) karma increases, the intensity of the inauspicious nondestructive karma decreases, and the potency of the vital powers increases.

The spiritual and physical development of living beings is depicted graphically in Figure 1. The rate of change of the karmic load of a living being gradually increases as the living being evolves from the least developed life form of *nigoda* to the most developed life form of human beings. It is logical to assume that the change in the karmic load is negligible in the *nigoda* birth-species. The karmic load in the *nigoda* birth-species decreases at an infinitely small rate so that $K_1 \gg K_N$, where K_N is the maximum karmic load of the *nigoda* beings since time immemorial. The rate of change of the karmic load in the *amanaska*- and *samanaska*-subhuman birth-species is small. The rate of decrease of the karmic load and the development process, proceed at a higher rate in the human birth-species and at a significantly much higher rate after the fourth spiritual stage.

For sake of discussion, we may assign some arbitrary values of the karmic load to various species as follows: $K_{ss}/K_{N} \gg 95\%$, $K_{H}/K_{N} \gg 90\%$; $K_{M}/K_{N} \gg 85\%$; $K_{c}/K_{N} \gg 75\%$ and $K^{4}/K_{N} \gg 60\%$. It follows from these arbitrary values that the decrease in the karmic load in the *amanaska*- and *samanaska*-subhuman birth-species is only about 5 and 10 percent of the maximum karmic load, respectively. Generally all living
beings, except celestial beings born beyond *kalpopapanna* and a few exceptional human beings like Bhagw n Mah v ra, are born *mithy d???* with the karmic load less than K_M =0.85 K_N and greater than K^1 =0.70 K_N . It means that to achieve liberation, almost 85% of the karmic load is to be annihilated in the human birth-species and almost 70% of the karmic load is to be eradicated beyond the first spiritual stage. Purging of the large amount of the karmic load will require constant practice of wholesome moral conduct. To be born as a celestial being in the next birth, human beings have to reduce their karmic load from K_M/K_N =0.85 to K_c/K_N =0.75, i.e. about ten percent only; they should be able to do it by performing karma with mild yogaplus-kas ya. On the other hand, human beings with an increase in the karmic load from K_M/K_N =0.85 to K_H/K_N =0.90 and K_{ss}/K_N =0.95 i.e. about five to ten percent only will be born as an hellish being in the next birth. Human beings should, therefore, be very careful in performing their deeds if they wish to avoid transmigration to the hellish birth-species.



Figure 1. Evolution with karmic load from sub-human to *samyagd???i* human

3.6 Conclusions

The development of the life form of living beings is characterized by the number and the potency of the vital powers, which in turn are determined by the karmic load accumulated in their karmic body. The development of the life form of living beings is based on the rule that the spiritual and physical development of living beings occur with the decrease in their karmic load. Based on this rule a conceptual scheme between the number and the potency of the vital powers and the karmic load of living beings is presented to explain their evolution from the least developed to the most developed life form.

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Future Research Topics

- 1. Develop an expression for the karmic load as a function of the intensity of yoga and kas ya.
- 2. Quantify the karmic load.
- 3. Quantify the interaction between the old and new karmas.
- 4. Quantify the effect of good and evil deeds on the karmic load.
- 5. Modify the conceptual model of transmigration to include the paryaptaka and aparyaptaka living beings.
- 6. Explore the character of the age-bonding moment.

8. Scientific Exploration of the Existence of Soul

Paras Mal Agrawal

Abstract

The present status of the knowledge of soul and spirituality is discussed in this article. Logical discussion of the Big Bang theory, Uncertainty Principle of quantum mechanics, artificial intelligence, concept of soul as given in Jain scriptures, etc. show that something beyond the basic physical constituents of the universe is required to explain many observed phenomena. George Wald has raised a question about the location of 'I' inside our physical body to arrive at the possibility of eternal soul beyond the atoms, molecules, and physical energy/matter. Further, some of his experiments and interpretations attempt to answer the meaning of 'I' in the sentences such as 'I see'. Views of some scientists regarding the possibility of soul are appealing in this context and are quoted here to strengthen the possibility of existence of soul.

Key Words: Soul, Quantum Mechanics, Big Bang, Consciousness

Scriptures quoted: Tattv rtha S tra

1. Introduction

The spiritual science starts with the consideration of soul. When somebody talks of soul, it is generally considered against science. This attitude is not rational because science has not seriously explored the characteristics of soul; neither it has proved nor disproved the existence of soul. Even in the study of subjects like biology and medicine, the scientific community is largely concerned with procreation and functioning of different parts of animal and human bodies. Even so, many scientists have developed the logic favoring the existence of soul. Science deals with space, time, matter and motion etc. These aspects of the universe are attributed to five non-living substance of Jainology. For example, one may refer to

the fifth chapter of Tattv rtha S tra authored by Acharya Umaswami, about 2000 years ago. *j va* or *tm* (soul) is considered as an independent *Dravya* in Jainology. Thus according to Jainology there are six substances. If *j va* is established scientifically then there would not be much difference between the descriptions in science and that in Jainology regarding the explanation of events and processes occurring in the universe.

Almost all religions believe in the existence of soul associated with the physical body of a living being and many scientists endorse this fact even though, due to some reasons, it is not yet recognized as a topic of scientific research. Many arguments can be raised against the existence of soul: we do not see it (soul); our day-to-day life is possible without accepting it then why should we spend our time in knowing about the soul?; there are many persons who do not believe in it but are prosperous, influential, and are enjoying good life; India is lagging behind the West due to its belief in soul; without recognizing it, the modern civilization could reach the moon and could invent many useful medicines and gadgets that have made our life pleasant; the level of spirituality, moral, and ethics of many so called religious persons shows that the talk of soul is meaningless; there have been many wars and violence in the name of religion; and so on. It is, therefore, important to bring to light the facts and their interpretation to show that all such arguments are based on ignorance and wrong interpretation of facts. In this article we explore the existence of soul and shall attempt to answer some of the concerns pointed out above. We would specially focus our attention on the logic behind the existence of soul put forward by some renowned scientists.

2. Search of Consciousness

The soul as an eternal substance or *Dravya* is not formally recognized by science. But several scientists have advanced the logic in favour of its existence. Some of these arguments are summarised below.

2.1 Logic Provided by George Wald

Noble Laureate George Wald (Medicine 1967) advocated the existence of soul as a real eternal substance different from matter and waves described in physics and chemistry. In his words "And as Upanishads tell us, each of us has a share in Brahman, the tman, the essential Self, ageless, imperishable....."[1]

For soul he has used different words such as mind, consciousness, Atman, essential self etc. In the same article, Wald has discussed in detail the logic behind the existence of soul.

2.1.1 Location of Consciousness

Wald argues that when light falls on his eyes he responds to it. Similarly, a photo - electrically activated door also responds to the radiations falling on it. Just as a computer does not feel elated when it beats a human player at chess, the photo - electrically activated garage door does not know about its performance. He also says that as far as his performance is concerned, he knows that he sees...... With this assumption that he knows but a garage door or the computer does not know, he proceeds to the light falling on the eyes of a frog. Wald claims that he is sure that a frog reacts to the light falling on its eyes. However, as a scientist he cannot prove that the frog is self-aware of its reaction. In his words [1]:

"But I know that I see. Does a frog see? It reacts to light; so does a photoelectrically activated garage door. Does the frog know that it is reacting to light, is it self-aware? Now the dilemma: there is nothing whatever that I can do as a scientist to answer that kind of question."

Does a frog know that it is reacting to the light falling on its eyes? Does a frog have consciousness? If answer of the questions is yes, what is the location of the consciousness inside the body? To get the answers of such questions, Wald consulted a Canadian brain surgeon, Dr. Wilder Penfield. Penfield was once hoping to find the centre of consciousness in the brain. But by his experiments he arrived at the conclusion that 'it will be impossible to explain the mind on the basis of neuronal action within the brain'. It has been found that mind can neither be located in the brain nor in the nervous system nor in the cerebral cortex. Penfield investigated this issue in depth and published his results [2]. One of his findings conveys that consciousness gives us no physical signals and, therefore, it is not possible to locate the center of consciousness in the body. In the concluding section he writes: "… I am forced to choose the proposition that our being is to be explained on the basis of two fundamental elements … mind and brain as two semi-independent elements."

These conclusions are explained by Wald with the logic that mind or consciousness could not be located simply because 'consciousness gives us no physical signal'.

The whole situation is thus quite clear. The scientists, like Penfield, on one hand infer that the consciousness may exist and, on the other hand, they admit that it cannot be located as it does not give any physical signal. Wald at this juncture suggests that both these points can be valid if we consider consciousness as

something made of a stuff beyond the domain of material particles and waves of modern science. Wald names such stuff as mind stuff or *Atman*. In other wards, the consciousness neither consists of chemicals nor is due to chemicals. It is a special class of stuff that may be called soul or *j* va *Dravya*. Similar is the conclusion of Erwin Schrodinger who won the Noble Prize of Physics in 1933. Schrodinger in his famous book 'Mind and Matter' [3] writes: "Mind has erected the objective outside world of natural philosopher out of its own stuff".

2.1.2 From Big-Bang to Human Beings

Another logic advanced by Wald is based on the wonderful nature of the universe that breeds life. This logic arises when one studies the development of the universe and human beings starting from the Big-Bang that occurred nearly 13.7 billion years ago. The universe came into existence just after the Big bang. At that moment there were only very tiny particles in the universe. These elementary particles then converted into electrons, protons etc. which further combined to form atoms and molecules. By the union of such particles, stars and celestial bodies were formed.

The life originated when favorable chemicals and suitable environment became available. If we calculate the number of odds in such happenings, the chance of formation of excellent systems such as human bodies is as negligible as the chance of formation of an aeroplane out of material blown out from a junkyard by a hurricane. Deepak Chopra [4] in his book, 'Perfect Health' has expressed this argument:

"The universe, after all, is not energy soup; it is not mere chaos. The incredibly exact fit of things in our world above all, the astonishing existence of DNA, argues for an infinite amount of intelligence in nature. As one astrophysicist put it, the likelihood that life was created randomly is about the same as the likelihood that a hurricane could blow through a junkyard and create a Boeing 707."

Wald summarized the difficulties in the formation of human beings by a random process in the following words:

".....If there had not apparently existed a one - part - per billion inequality in the number of particles and antiparticles that went into the Big bang; if the atomic nuclei were not so much massier than the electrons weaving about them; if the electric charge on the proton did not exactly equal that on the electron; if ice did not float; if the forces of dispersion and aggregation in the universe were not in exact balance - then, there might still be a universe, but lifeless [1]".

At this juncture Wald also asks: "From our self centered point of view, this is the best way to make a universe. But what I want to know is - how did the universe find that out? This leads me to my other great problem, that of consciousness."

Just to appreciate so many 'ifs' raised by Wald, we can take one simple example of floating of ice on water. Our common experience shows that usually a substance in solid form is heavier than that in its liquid form. However, ice is an exception that it is lighter than water and as such it floats on water. Is it by chance? One can say that the properties of water molecules are such that ice is lighter than water. But the question may be asked that why does 'nature' make such an exception that ice can float on water? By such property of water the creatures can survive inside the water below the floating ice. In his words:

"If ice did not float, it is hard to see how any life could survive a cold spell on any planet in the universe, if a freeze occurred even once in millions of years, that would probably be enough to block the rise of life, and to kill any life that had

arisen." Wald [1], therefore, concludes, "If ice did not float I doubt that life would exist in the universe."

This highly favorable course of development of the universe is accepted in physics under a term known as 'Anthropogenic Principle'. According to this principle the whole creation since the Big Bang was designed expressly to lead to the existence of the human beings [5]. Is it not a back door entry of intelligence in physics?

2.1.3 Acceptance of Soul

The whole explanation can be very simple if the presence of soul or *j* va *Dravya* from the time immemorial is recognized. In such a case it would be easy to say that nature is such that souls and material bodies can co-exist. In the words of Wald [1]:

"....I have propounded two riddles: One, the very peculiar character of a universe such as ours that breeds life; and two, the problem of consciousness, mind, a phenomenon that lies outside the parameters of space and time, that has no location."

These riddles are solved in the following words "it occurred to me that these seemingly very disparate problems might be brought together. That would be with

the hypothesis that mind, rather than being a very late development in the evolution of living things, restricted to organisms with the most complex nervous systems - all of which I had believed to be true - that mind instead has been there always, and that this universe is life breeding because the pervasive presence of mind had guided it to be so."

He further clarifies the word 'mind' by recognizing it as 'mind stuff' which is a real stuff addition to material particles and waves described in physics and chemistry. He uses word '*Atman*' or 'Brahman' as synonym of mind stuff or consciousness. By the word 'stuff' Wald wants to emphasize that it is a concrete eternal entity. As in case of matter, the form of substance changes but the substance always remains, similarly, a soul is also a substance in the sense that its form changes but it always remains. The equivalent term for the 'stuff' word of Wald in the Jain Philosophy is '*Dravya*'. Different words such as mind or consciousness may have different meaning to different writers and religions. However, the conclusion is that tman (or soul or *j va Dravya*) is an eternal stuff. This stuff is of different kind and as such tman cannot be detected by physical instruments. Further, the eternal presence of such stuff has been responsible for the favourable nature of the universe that breeds life.

3. Quantum mechanics and Consciousness

It is a notion of a common man that science has understood all the basic details of matter and various forces operating in the universe, as has been demonstrated by man going to the moon and beyond. This notion is not true and much remains to be understood about life and processes governing it.

To summarise, the connection of the following points with the existence of soul has already been discussed:

- (A) It will be impossible to explain the mind on the basis of the neuronal action within the brain.
- (B) The mind can neither be located within the brain nor in the nervous system nor in the cerebral cortex.
- (C) The Big Bang model of the universe does not provide a satisfactory scheme of the evolution of life. Starting from the Big Bang, the chance of formation of excellent systems such as human bodies is negligible.

We would further like to add that the scientific theories cannot describe the motion of an atom with certainty. Quantum mechanics [6], the branch of physics

dealing with small particles, emphatically asserts that there is uncertainty in the behavior of atoms. Heisenberg's uncertainty principle is considered as one of the most fundamental principles of quantum mechanics which leads to the probabilistic rather than deterministic behavior of Nature. The effect of the probabilistic behavior at atomic and subatomic level appears to be so dominating that even a basic law- the law of causation- fails. By scientific as well as any ordinary logic or common sense we expect that a specific cause would give rise to a specific effect. This is, however, not true in quantum mechanics. Under exactly the same conditions, two identical hydrogen atoms must behave in the same way - but they do not, according to quantum mechanics. For example, from the third excited state, one hydrogen atom may come to the first excited state whereas the other identical hydrogen atom may come to the second excited state under identical conditions. This failure of the law of causation is related to the probabilistic nature of quantum mechanics.

Because of such uncertainty one finds a book with the title, 'The Ghost in the Atom' from Cambridge (1986) [7]. This book describes the concepts of quantum mechanics with the exploration of the probable cause of the uncertain behaviour of atoms.

"The uncertainty is inherent in Nature" - such statement cannot prevent the scientists to think further in other directions. Different theoretical physicists have used different words to express their concern about such a behaviour- though we do not know the cause of the uncertainty in the behavior of atoms- there may be a fundamental reason behind it. Scientists are checking such a behaviour again and again in different ways with different kinds of sophisticated experiments. But the uncertainty prevails. Some physicists think that due to the effect of some unknown source, the atoms are disturbed such that their behavior appears uncertain. Some have invoked the effect of mind or consciousness on atoms to explain such strange and unpredictable behavior of atoms.

In this connection a quotation from the above mentioned book is worth noting [8]: "Heisenberg's uncertainty principle usually permits a range of possible outcomes for any given physical state, and it is easy to conjecture that consciousness or mind could have a vote in deciding which of available alternatives is actually realized."

While making any interpretation of the above quotation we should remember here that a physicist is resorting to consciousness or mind because he is

not finding any atom or molecule or wave or a combination of all such material things to be responsible for the observed uncertainty given by Heisenberg's Uncertainty principle. Thus in the above quotation the meaning of word 'consciousness' or 'mind' should not be taken as brain or a combination of atoms, molecules, or physical waves. The distinction among the words 'consciousness', 'mind' and 'soul' are not important here; the important point is the idea of something not made of atoms or molecules or sub-atomic particles or waves or energy of physics.

In view of this situation, as already mentioned, Schrodinger accepted the presence of a new kind of stuff. It would be appropriate to emphasize here that Schrodinger is one of the founders of quantum mechanics. In the year 1925-26 when he published his famous research papers on quantum mechanics for which he was awarded the Nobel prize, he also wrote the philosophical articles with citations from the Indian philosophy.

In short, we may say that modern science admits either ignorance or the existence of some unknown mysterious factors that give rise to the Uncertainty principle and probabilistic behavior of Nature at fine levels. In other words, the existence of soul may be permissible by quantum mechanics to explain Uncertainty principle. Alternatively, one can say that uncertainty principle has created space for a new theory and the hypothesis of the existence of soul may well fill this space.

To clarify the concepts we now attempt to answer some questions which are usually raised in connection with the soul and spiritual theories.

4. Can we accept an entity which is invisible?

Two questions arise with respect to the existence of soul:

Question 1: We do not see the presence of the soul either through eyes or by any scientific instrument. How can then we agree to the existence of soul?

Question 2: If soul is a real substance, then it must have some physical characteristics like mass (weight). Thus the weight of a person or an animal must decrease at the moment he dies. The scientific observations do not confirm this point. How can this be explained?

Answer : It is true that we do not see any soul by eyes or by any scientific instrument. It may also be true that there is no decrease in the weight of a person or an animal at the time of death. But how can we conclude from these facts that the

soul does not exist? Space is also weightless but it is a real accepted entity. Photons have zero rest mass (weight) but are real material particles. At microscopic level we do not directly see by eyes or observe by any scientific instrument the presence of some of the elementary particles (quarks, gluons, some mesons, etc.) but we accept their presence simply by their requirement in some successful theories.

The same is true with the theory of existence of soul. On one hand it does not contradict any laboratory experiment, and on the other hand it helps in understanding the existence of the life in the universe. By existence of soul, living creatures/animals/human beings can be easily explained. According to the modern science after the Big Bang that occurred 13.7 billion years ago, only small elementary particles were present. These particles then randomly united to form electrons, protons, atoms, molecules, water, DNA molecules, plant, insects, animals and eventually human beings. Does this sound reasonable? The law of increase in entropy says that by random blows disorder increases, order cannot increase.

George Wald at this juncture admits the eternal presence of souls. According to him, the universe breeds life because of the presence of souls everywhere.

Invisible Electric Current

We know that when electric current flows inside an electric bulb then it glows. The same electric current gives shock when we touch a live wire. Such electric current also gives deflection in the ammeter. Thus we know that electric current exists. However, we do not see the current. The glow of bulb together with a theory suggests the existence of the electric current. The glow itself is not the current. Similarly, the shock experienced or the deflection in the ammeter is not electric current. The shock or deflection together with a suitable theory establishes the existence of the electric current. If we go further we would see that even the well established electron is also not visible even by the most powerful microscope. All that one can see in such cases is its effects. Such effect together with a proper theory or interpretation establishes the existence of an electron. Thus we see that some things can be accepted by their effects, even when we cannot see them.

5. Do many scientists believe in soul?

Answer: (i) Stephen Hawking, one of the proponents of the Big-Bang model, in his famous book, 'A brief history of time', has frequently used the word 'God'. As an example, on p.143 of the book [9] he writes, "God may know how the universe began, but we cannot give any particular reason for thinking it began one way or the other."

Question 3: As mentioned above, it is difficult to digest the Big Bang theory or the presence of intelligence without the existence of soul as in independent eternal substance. If it is so, why do many scientists not accept the presence of soul?

(ii) Because of the historical development of science it is not fashionable to talk of soul/God, but it is becoming more and more popular in recent years among the scientists. The scientists who have pursued research at the most fundamental level of the theoretical physics or similar allied areas are more likely to realize the incompleteness of the materialistic description of the universe. Such science of micro- matter is close to philosophy. This is one of the reasons that many scientists such as Newton, Einstein, Bohr, de Broglie, Schrodinger, Pauli, Josephson, Wigner, and others have been spiritual.

When a similar point has been raised before Charles H. Townes [10], Nobel prize winner of 1964 (Physics), he gave the following reply:

"I think one reason physicists tend to be more philosophical is that physics is a very basic science. Physics is concerned with fundamentals, and it leads one to a very basic attempt to understand the universe. But there are others; for example, astronomy leads one in that direction, too."

(iii) It we look at the history of development of science we would find that there has been many occasions when the current theory has been either not accepted or not pursued for a long time. We may quote Maurice H. Wilkins [11] who received the Nobel Prize in Medicine in 1962:

"Most scientists today are being led increasingly away from the fundamental aim of science to achieve unity into rather limited ways of thinking without much open-mindness and are doing things merely to meet limited material needs [11]."

In the same article the Noble prize winning scientist further cautions the scientists that only materialist research is a narrow-mindedness. He writes:

"It's not just a question of the war danger. It is also a question of how science is developed through educational institutions and through institutionalized science. I agree with Einstein that the sort of scientific education we have now has produced a narrow-minded way of thinking amongst scientists, so that they give no proper attention to the moral and psychological dimension [11]."

(iv) The following statement of Dr. B.D. Josephson [12] who won the Noble Prize in Physics in 1973 is also a strong evidence to show that some scientists are very enthusiastic about the intelligence/soul/God, we mean, something other than the materialistic things:

"And we might hope that appropriate mathematical tools will be developed, so that in not too many years from now we'll have a new paradigm in which God and religion will be right in the middle of the picture, instead of being pushed out almost entirely as is the case at the present time [12]."

(v) Dr. Fritjof Capra, a well known physicist and author of 'The Tao of Physics', strongly believes in soul/God and the ancient Eastern traditions. According to him his belief is based on the modern science. In an article, he writes [13]:

"...I realized that not only modern physics but modern science in general leads us to a world view which is very much in agreement with the ancient Eastern tradition."

(vi) If there is no separate existence of soul inside a human body then the human beings would be simply an advanced form of machines which are composed of material substance consisting of atoms and molecules. Dr. Eugene Wigner, another highly respectable scientist of modern era, who won the Physics Noble prize in 1963, has touched this point to express his views in favor of the existence of soul. In an interview on Sept. 3, 1985, he remarks [14]:

"We are not machines. If man were a machine, then it should be possible to describe him in terms of atoms and molecules, and I don't think that is possible."

This list of topmost scientists believing in the existence of soul/God is not complete and many more can be added. In addition, we should keep in mind that

many scientists are not in a position to address the issue of the existence of soul because of their focus on the material goals, and the nature of training as revealed by the fact that about half the world's scientists and engineers are engaged in war programs.

6. Artificial Intelligence and Emotions Versus Soul

Question 4 : After some more advancement in the computer technology, it may be possible to create a robot with artificial intelligence such that it can share and express emotions such as fear, sorrow, joy, and anger. Would it not then mean that memory, fear, anger, joy, sorrow are attributes of the material atoms, chemicals and electrical signals? After accepting this point we may not have any special role of

soul. Then would it prove that a man is an advanced form of robot made by material particles and electrical signals only?

Answer : This question is helpful in understanding the real attributes of soul. For example, Acharya Kundakunda in Samayasara [15] clearly explained that emotions such as anger, fear, joy, etc., and the knowledge achieved through senses are not real attributes of the soul. Had these attributes been real attributes of soul, Siddhas (pure souls) would also have possessed those emotions. According to the Jaina philosophy, Siddhas are without any material body. They do not have brain, lungs, heart, bones, skin, nerves, emotions etc. They are always in the state of bliss which does not depend on any electrical signal or atom or chemical. The state of bliss is a real attribute of a soul. [More details about the soul as described in Jaina philosophy are presented in Appendix-1]

A great philosopher of modern times, J. Krishnamurty, also discussed a similar situation of emotions in a robot. For example, an article [16] in the Sunday Review discussed this point along with the philosophy of J.Krishnamurty. If a person accepts emotions as the soul then his faith would disappear when such a powerful robot would be a reality. Taking into consideration this point, above mentioned article has been concluded thus: "The only mind that can survive the challenge of the new technologies would be such a mind which is the truly religious mind."

7. Common Arguments against Soul and Spirituality

Question 5 : The science is all powerful. The science can send man on the moon, where and why do we need the faith in soul?

Answer : A large number of persons for a large part of their life span are in a state of unhappiness. The materialistic possessions always lead to the desire for more and more, and comparison with others that cause unhappiness. The absence of the materialistic possessions also creates frustration, pain and unhappiness if the internal fulfillment does not exist. What is remedy of this unhappy situation? Should we not look for the source of bliss and happiness within?

Question 6: With the advancement of science, the control of birth, illness, and death is coming into the hands of the science. If the science can manipulate these processes then how can we believe that there is something like soul?

Answer : Let us answer this question by asking a parallel question: you are

watching a TV. You are watching a singer singing the song. Now you know that by the remote control in your hand you can raise the voice or lower the voice. If you wish you can shut 'his' mouth. You have power to manipulate many things. Does it mean that the singer does not exist, or, many components inside the TV and electronic signals through TV antenna do not exist?

If you can manipulate some processes to some extent, then it does not mean that other things do not exist. Further, can the science and technology manipulate birth and death with 100% success? A detailed dabate over this point can also be helpful in understanding the nature.

Question 7 : There are so many lives in the form of insects, animals, plants, and a large population of human beings. How can they all be so glorified and precious souls?

Answer : Why not? You can see many big books on the structure of an atom. Millions of research papers have been published on the properties of atoms. A layman now asks you, "There are so many atoms in the dust, river, air and everywhere. Why are you giving so much importance to an atom? How can so many atoms in the world be so important that thousands and thousands of scientists are devoting their time for research on an atom?"

What will be your answer to that layman? You would say that the significance of an atom does not decrease by its abundance. It can also be added that it would be inappropriate to reduce the expenditure of billions of rupees over its research simply because in one drop of water there are more than 3 billion times one trillion hydrogen atoms.

Question 8 : The western world has made more progress by making scientific advancement without bothering for soul. Is it not true?

Answer: The financial progress of the western world is mainly due to the honesty in their business and hard team work. Similarly, their family life is unsatisfactory due to dishonesty in the family. The scientific and technological advancement in India lacks mainly due to lack of the coordinated team work. It is not true that the western world is not religious. A scientifically advanced country like USA writes, "IN GOD WE TRUST", on every coin and currency note (bill). In the name of God the donations given by the western public is huge. The president of USA takes the oath of his office in the name of God with a religious book in his hand. With all these known facts it would be wrong to assume that the western world is

unconcerned about God/soul. Many persons in the western world are highly religious. Not all persons in India are religious. Happiness and unhappiness are everywhere. Thus real question is to look for the statistical figures that show correlation among the religious attitude, health, happiness, and prosperity. In recent years many scientific studies are showing a positive correlation between health and religious attitude.

Question 9 : Spiritual persons differ. They quarrel. They are not very intelligent. They mislead. Then why should a person try to become a spiritual?

Answer: (i) Dr. S. Radhakrishnan, a noted philosopher and a former president of India, once remarked that a religious person may become nonreligious when he thinks deeply, but again becomes religious when he goes deeper. The question which you are asking may be based on your observation of former kind of religious persons. Such persons may not be religious in true sense. The true faith gives fearlessness, confidence, and purpose of life.

(ii) It would not be difficult to visualize highly intelligent and forgiving religious persons. A vast treasure of knowledge and art has been contributed by the religious persons of all times.

(iii) Without deep thinking it is easy to say that many religious persons mislead, but one should also note that it is difficult to find a person in one's life by whom one would like to be lead in all walks of life.

8. Concluding Remarks

Our lifetime is limited. We cannot afford to wait for more powerful green signal in favor of the existence of soul from the scientific laboratories. Instead, we may try to experiment at our own level. For example, through *Samayik* or *Kayotsarg* or *Dhyan* we may have realization of the soul. In this regard, the following method described by Acharya Amritchandra 1000 years earlier may be valuable[17]:

Ayi kathamapi mritva Tattva kautuhali san Aubhav bhavmurttehe Par vavartt muhurtam?

This stanza suggests that for a Muhurta (48 minutes) one should try to experience the soul by pretending oneself as a neighbor of one's physical body (and other related possessions). Further, in stanza 34 of the same, the Acharya suggests us to continue such experiments for 6 months for the realization of the soul.

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Appendix-1: Soul in Jain philosophy

According to Jain metaphysics, the cosmos is a congregation of six kinds of substances or stuff (called *Dravya*). The *j va Dravya* (soul) is one of the six kinds of substances. Nobody can create any soul and nobody can destroy any soul.

In other words, the number of souls in this cosmos remains invariant forever.

In Jain philosophy, the soul is described from two points of view: (1) relative point of view and (2) real point of view. From the relative point of view the emotions such as greed, anger, etc. and thoughts of liking or disliking associated with a living being are also considered as soul along with the real eternal soul stuff. Just as any harm to an employee of a king is considered as the harm done to king, the relative point of view considers the physical body and senses of a living being also as j va[18]. But from the real point of view only the eternal soul stuff is considered as the soul. The temporary associates of soul such as emotions etc. are not considered as the soul. For more details regarding the soul from the real point of view, the following stanza written by Acharya Kundakunda in Samayasara before 2000 years is worth noting.

Arasamaruvamagandhamavvattam cedan gu?amasaddam.

Jñ nalimgaggaha?am j vamanidditthasamth nam ||49||

Meaning: Know that soul is without taste, without odor, without sound, without definite shape, invisible, imperceptible to sensory organs or instruments, realizable not by any mark or symbol, and characterized by the consciousness attribute (*Cetan*) [49].

Explanation: Though taste, color, smell, touch, sound, etc., are associated with the physical body of a living being, yet these cannot be considered as attributes of soul (*J va*). A soul is different from the associated physical body. Here the Acharya highlights that the essential attribute of soul is consciousness (*Cetana*). The word '*Gu?a*' used in the stanza signifies that it is an attribute which is always present.

According to the Jain metaphysics, taste, color, smell, and touch, are specific attributes of matter. They are not found in any soul. Similarly, the sound consists of matter. It is not an attribute of a soul.

Since a soul is a *Dravya* (substance), it is expected to have some volume, i.e., it must have some shape and size. A soul may be of a size of an ant in this birth and the same soul in another birth can have the shape and size of an elephant. (According to the Jain metaphysics, the size and shape of the soul of a living being is close to the size and shape of the associated physical body). This feature regarding the size and shape of a soul has been expressed in this stanza by the word '*Anirdi?*? *Samsthanam*' that means indefinite shape and size (because its shape varies according to the body it occupies).

We know various technologies of detecting material things. For example, ultrasound, X-rays, infrared, gamma rays, etc., are used to detect things which are

invisible to naked eyes. This stanza says that the non-physical soul cannot be physically identified by any present or future technology or device. Acarya Kundakunda has highlighted this point by stating that the soul is invisible and cannot be expressed (*Avvattam* or *Avyaktam*) by any physical analogy.

Here one may ask a question: If the soul cannot be physically identified by any technology or senses then how can it be known? To answer this question, Acarya uses a powerful word '*Alimgaggahanam*'. Through this word Acarya Kundakunda says that the soul can be realized without any mark (*Linga*). In other words, the soul can be realized without the inference of the sense perception, i.e., it is possible to experience the soul directly by the soul.

It may be noted that this stanza is so significant that it has also been included by Acharya Kundakunda in many texts, e.g. Pravacans ra (stanza-172), Niyamas ra (stanza-46), Pañc stik ya (stanza-127), and A??ap hu?a (stanza-64).

9. Mind, Brain and Consciousness: Anatomical, Physiological and Neurological Considerations

Pratap Sanchetee, JPN Mishra and Rudi Jansma

Abstract

The anatomy and physiology of the brain is described from the perspective of medical sciences and the functioning of the mind from neurobiological point of view is discussed, in context of consciousness. These aspects are compared with the views expressed in Jain philosophy. It is shown that medical science and Jainism have much to learn from each other and may provide complementary platforms to understand the nature of consciousness.

Key Words: Mind, Brain, Consciousness, Neurological function, Physiology, Karma, Anatomy, Chakras

1. Introduction

For centuries, scientists and philosophers have been fascinated by the brain but until recently, it was nearly incomprehensible. In earlier period, the heart was considered as the seat of emotion or consciousness. Now we know that the brain is the essence of the mind and the soul and also the seat of intelligence, creativity, emotions, and memories. All of our conscious and unconscious perceptions are filtered, altered, analyzed and organized by a gigantic symphony of neuronal network and then transmitted to other organs of the body via nerve impulses and biochemical messengers. Because of the accelerating pace of research in neurological and behavioural science and the development of new research techniques, scientists have learned more about the brain in the last 50 years than in all the previous centuries.

The human nervous system has unlimited power of functioning and controls all functions of the body. Brain is an organ of 1300-1400 gms containing more than one

hundred billion nerve cells. Nerve cells communicate with one another by a hundred trillion interconnections. It receives and interprets information from the outside world and inner self, interprets and stores them and directs and coordinates the required actions. Electrochemical impulses of the nervous system make it possible to obtain information about the external or internal environment and do whatever is necessary to maintain homeostasis. The fundamental purpose of the nervous system is (1) to receive information from receptors-cells and organs specialized to detect changes in the body and its external environment, (2) to process and store this information and determine the appropriate responses, if anya step called neural integration, and (3) to issue commands to effectors, cells and organs (mainly muscle and gland cells) that carry out the body's responses (Saladin, 2004). While omitting technical details and scientific jargon and taking a simplistic approach, we discuss anatomical and physiological aspects, compare them with the Jain view on structure and functioning of brain and discuss their research potential.

1.1 Anatomical Considerations

Conventionally the nervous system is divided into central and peripheral systems. The central nervous system (CNS) is composed of the brain and the spinal cord. It integrates incoming pieces of sensory information, evaluates it and initiates an outgoing response. The peripheral nervous system (PNS) is composed of spinal nerves that branch from the spinal cord and cranial nerves that branch from the brain (Thibodeau, 1999). In addition, it includes the autonomic nervous system (ANS), which controls vital functions such as breathing, digestion, heart rate, and secretion of hormones.

1.1.1 Brain

The brain is the centre of the human nervous system and is highly complex organ that no computer can yet match. It has virtually unlimited functional power. It is soft and delicate in consistency. The brain of an adult human is one of the largest organs of the body, weighing about 1400 gm or roughly two percent of the body weight. It is composed of three major divisions: the cerebrum, the cerebellum, the brain stem and a large number of deeper structures (Fig. 1). Before describing these organs, we show how the blood is supplied to the brain.



The Human Brain



(Source: http://www.gender.org.uk/about/07neur/74_brain.htm)



Fig. 2. Circle of Willis at the base of the brain

ICA: internal carotid artery, ACA: anterior carotid artery, MCA: middle carotid artary PCA: posterior carotid artery, VA: vertebral artery, BA: basilar artery, Pcomm: posterior communicating artery, Acomm: anterior communicating artery.

1.1.1 Structure of Different Parts of Brain

Cerebrum

The cerebrum is the largest part of the brain and accounts for about 83% of the total. It is divided into symmetric left and right hemispheres by a longitudinal fissure. The hemispheres communicate with each other through a thick tract of nerves, called the corpus callosum, at the base of the fissure. In general, messages to and from one side of the body are handled by the opposite side of the brain. The surface of the cerebrum is composed of the so-called gray matter (cell bodies) 2 to 4 mm thick and is referred to as "cerebral cortex". It contains billions of neurons and consists of six layers of nerve cell bodies. The central or deeper portion of the cerebral hemispheres is of a lighter colour in appearance hence it is referred to as "white matter". It appears white because of the presence of myelin (the insulator which allows nerves to conduct signals more quickly). The cortical region of the cerebrum is folded, thrown into a number of creases and bends which are termed fissures and sulci (Gray, 1988). They separate the surface into a number of irregular eminences, named gyri or convolutions. Deep folds and wrinkles in the brain increase the surface area of the gray matter, so more information can be processed.

Each cerebral hemisphere is further divided into lobes which are named after the skull bones overlying each, viz. frontal lobe, occipital lobe, temporal lobe and parietal lobe. The cerebral cortex contains three kinds of functional areas: motor areas, sensory areas and association areas (Marieb, 1998). Messages within the brain are carried along pathways. Messages can travel from one gyrus to another, from one lobe to another, from one side of the brain to the other, and to structures found deep in the brain (e.g. thalamus and hypothalamus).

Brain Lobes

(i) Frontal Lobes

They are situated in the anterior or front part of head. The frontal lobe primarily provides the neural capabilities for constructing patterns of motor behaviour and social behaviour. The posterior (back) of the frontal lobe consists of the pre-motor and motor areas. Nerve cells that produce movement including spoken speech (Broca's area in left frontal lobe) are located in the motor areas. The premotor areas serve to modify movements. The anterior (front) portion of the frontal lobe is called the prefrontal cortex (PFC).

(ii) Prefrontal Cortex System

The prefrontal cortex (PFC) is the most evolved part of the human brain and often called, the 'executive control centre'. It occupies the front third of the brain. It has extensive connections with the limbic system. It modulates by sending inhibitory signals to the limbic and sensory parts of the brain to reduce distraction.

It is divided into three sections, i.e. dorsal lateral (on the outside surface), inferior orbital (on the front under surface) and the cingulate gyrus (which runs through the middle of the frontal lobes). The dorsal lateral portion of PFC receives inputs from the posterior parietal and superior temporal sulcus and has extensive connections to cingulate gyrus, basal ganglia, and superior colliculus. It is mainly involved in sustaining the attention span and in selection of behaviour based on short term memory. The inferior orbital portion of the PFC receives inputs from the temporal lobes (auditory and visual aspects) and from the somatosensory cortex, amygdala, the gustatory cortex in the insula, and from the olfactory regions. It has extensive connections which project to amygdala and hypothalamus. It is responsible for impulse control, mood control, behaviour and social skills.

The capacity of the individual to generate goals, to achieve them and to learn from mistakes is considered an essential aspect of a mature and effective personality. The PFC controls "executive functions," such as the capacity to formulate goals, time management, to change course and improvise in the face of obstacles or failure, attention span, perseverance, self-monitoring and supervision, problem solving, critical thinking, forward thinking, ability to feel and express emotions, influencing the limbic system, empathy, internal supervision, judgment, behaviour, impulse control, planning, organization and critical thinking.

(iii) Parietal Lobe

The parietal lobe supports perception of the body and its spatial surroundings. The anterior or front portion of this lobe receives and processes sensory information about temperature, taste, touch and movement coming from the body. There is a large association area that controls fine sensation (judgment of texture, weight, size, shape). The superior (top) portion of the parietal lobe is involved in spatial orientation, information on limb position, localize objects around us, detecting stimuli in space and distinguishing left from right. Inferior (lower portion) parietal lobe is involved in spatial cognition such as reading and arithmetic (borrowing complex numbers), create and read visual maps. Current scientific evidences suggest that meditation results in suppression of parietal lobe functions when individuals attain a state of 'No Time and No Place'.

(iv) Temporal Lobe

It is located on each side of the brain at the level of the ears. The temporal lobes process information from senses of smell, taste and sound. It contains areas that provide language functions, memory, emotional stability, socialization, analysis of auditory perceptions, recognition of faces and of rhythmic patterns including those of speech, dance and music. The dominant temporal lobe (usually left) is involved in processing words and language related sound, sequential analysis and intermediate and long term memory. Non-dominant temporal lobe (usually right) is involved in perception of melodies, pitch/prosody, social cues, reading facial expressions and visual learning.

(v) Occipital Lobe

It is situated at the back of the brain and is responsible for processing visual information and links it with images stored in memory (Chalabi et al., 2006). In addition to visual reception, occipital lobe contains association areas that help in the visual recognition of shapes and colours.

(vi) Basal Ganglia

They are a group of functionally interrelated nuclei located bilaterally and include the caudate, putamen and globus pallidus. These nuclei work with the cerebellum to control motor functions and coordinate fine motions. Basal ganglia play an important role in the control of movement and posture and in complex aspects of behaviour (Luciano, 1990). The basal nuclei are functionally associated with the sub-thalamic nuclei and substantia nigra of the mid brain.

(vii) Diencephalon

The diencephalon is located beneath the cerebral hemispheres and consists of thalamus and hypothalamus.

(a) Thalamus: It consists of two oval masses of mostly gray matter organized into nuclei that form the lateral walls of the third ventricle. These two masses are connected in the centre by a small stalk called the intermediate mass. It serves as a relay station for almost all information that comes and goes to the cortex (Fig. 3). It plays a role in interpretation of some sensory impulses, such as pain, temperature,

light, touch and pressure. It is also involved in regulation of motor functions (i.e. movement), memory and behaviour.



Fig. 3a. Side view of brain showing diencephalon (Source: http://www.medbio.info/horn/time%205/ appetite%20and%20weight%20control%20nov06%20v2.htm) (source : www.med p.o.info)

(b) Hypothalamus: The hypothalamus is the most inferior part of the diencephalon located below the thalamus. Though it is a very small structure with a volume of 5-6 cm³, it is an important component of the diencephalon which controls mind-overbody phenomenon and regulates the sleep-wake cycle and biological rhythms. It is crucial to homeostatic regulation and is a principal site for regulating the behaviour and is essential to the survival of the individual and the species. It is the most primitive part of the limbic system and is the source of raw, powerful, undirected feelings and emotions. It plays a major role in regulating hormones, the pituitary gland, body temperature, adrenal glands, and many other vital functions and activities. It plays a role in controlling certain types of behaviours such as hunger, thirst, the ability to feel extreme pain or pleasure, sleep, and sexual response. It also regulates body temperature, blood pressure, emotions, and secretion of hormones.

The functional speciality of the hypothalamus is significant from a human physiology point of view, as it controls and integrates the autonomic nervous system and is responsible for translating our emotional state into physical feelings of relaxation or tension. The front half of the hypothalamus sends calming signals to the body through the parasympathetic nervous system. The back half of the hypothalamus sends stimulating or fear signals to the body through the sympathetic nervous system. It is the principal intermediary between the nervous system and the endocrine system.

(viii) Brain Stem

The lower extension of the brain, which connects to the spinal cord, consists of the medulla oblongata, the pons, and the midbrain. It performs many automatic functions such as breathing, heart rate, body temperature, wake and sleep cycles, digestion, sneezing, coughing, vomiting, and swallowing. Ten of the twelve cranial nerves originate in the brainstem.

(a) Midbrain: It is the smallest region of the brain stem. It is about 2.5 cm in length and contains nuclei of oculomotor, troachees and trigeminal cranial nerves. These nuclei mediate some movements of the eyeballs, changes in pupil size and lines shape, and conduct impulses that move the eye balls.

(b) Pons: The part of the brain stem just superior to the medulla oblongata is the pons (Latin, meaning "bridge"). It measures about 2-5 cm in length and contains ascending and descending nerve tracts and several nuclei. These nuclei relay nerve impulses for chewing and sensations of the head and face; regulate certain eyeball movements, conduct impulses related to taste, salivation and facial expression, and modulate the state of body equilibrium.

(c) Medulla Oblongata: Medulla oblongata (Latin, marrow) is about 3 cm long and is the most inferior part of the brain stem and continues downward to the spinal cord. It contains ascending and descending nerve tracts, cranial nerve nuclei, other related nuclei, and part of the reticular formation. Several medullary nuclei function as centres for reflexes, such as those involved in the regulation of heart rate, blood pressure, respiration, swallowing, vomiting, hiccupping, coughing and sneering.

(d) Cranial Nerves: The brain communicates with the body through the spinal cord and twelve pairs of cranial nerves (CN). The cranial nerves for smell (Ist CN) and vision (IInd CN) originate in the cerebrum. Third to twelfth pairs of CN originate in the brainstem and control hearing, eye movement, facial sensations, taste, swallowing and movement of the face, neck, shoulder and tongue muscles (see Appendix A).

(ix) Cerebellum

The cerebellum (also known as 'Little Brain') is located under the cerebrum at back and represents one-eighth of the total weight of the brain. Its function is to coordinate muscle movements including fine movements, eye movements, coordinate the brain's instructions for skilled repetitive movements and maintain balance and posture.

(x) Spinal Cord

Together with brain, it makes up the CNS. It is a long, thin, tubular structure which begins at the level of the occipital bone as a continuum of medulla oblongata and extends down to the space between the first and second lumbar vertebrae. It is around 45 cm long in men and around 43 cm in women. It is encased in vertebral column. Its primary functions are transmission of neural signals between the brain and the rest of the body through 31 pairs of peripheral nerves. The spinal cord has three major functions: as a conduit for motor information, which travels down the spinal cord, as a conduit for sensory information in the reverse direction, and finally as a centre for coordinating certain reflexes. In mythological and religious literature, kundalini is described as being coiled up at the base of the spine (muladhara chakra) between rectum and umbilicus. There are also descriptions of many other chakras in the spinal cord. However, neuroscientists have not substantiated the chakras and they could be symbolic or philosophical entities rather than physiological in the normal sense of the word. We feel that more research is needed before arriving at a conclusion.

2. Deeper Structures and Systems in the Brain

2.1 Limbic System

In 1937 the neuroanatomist Papez discovered a set of interconnected brain structures that formed a circuit which functioned as the brain's centre for motivation and emotion. The system was later expanded by Paul MacLean in 1949 to include additional structures; it became known as the limbic system in 1952. In addition to regions of the limbic cortex, the primary structures of the limbic system are hippocampus and amygdala. The cingulate gyrus is also associated with the limbic system. The limbic system assumes important roles in emotional states such as pain, pleasure, anger, rage, fear, sorrow, sexual feelings, docility and affection. It is sometimes called the "visceral" or "emotional" brain. Mind, Brain and Consciousness: Anatomical, Physiological and Neurological Considerations



Fig. 3b. Brain as seen from the medial side showing the limbic lobe and other structures (Source: http://guerrillagroup.com/tag/orvel-ray-wilson/)

From an evolutionary point of view this is an older part of the mammalian brain that provides experience and expresses emotions. The subsequent evolution of the surrounding cerebral cortex in higher animals, especially humans, gave the capacity for problem solving, planning, organization and rational thought. Yet, in order for these functions to occur one must have passion, emotion and desire. The deep limbic system adds the motivation, emotional feeling and drive, in both positive and negative ways, to various actions of human beings. As per current research, females have a larger deep limbic system than males. This gives them several advantages and disadvantages. Due to the larger deep limbic brain women are more influenced by their feelings and are generally better able to express their feelings than men.

2.1.1 Amygdala

The amygdala is a limbic structure involved in many brain functions including emotions, basic feelings including fear and sexual responses, learning and memory. It is extremely sensitive to tactile stimulation. It receives inputs from the visual, auditory and sensory parts of the cortex, the hypothalamus, the septal nucleus and the hippocampus with numerous further connections to the frontal lobes. Traditionally, the amygdala has been linked to violent tendencies and behaviour. In humans, its expressions are suppressed by the prefrontal cortex. It has a crucial role in the mediation and control of major emotions like friendship, love, rage and aggression (Chalabi, 2006).

2.1.2 Hippocampus

The Hippocampus is a part of the temporal lobe, and is an important constituent of the limbic lobe. Its function is to work on converting short-term memory into long-term memory. The hippocampus in the right hemisphere of the brain is concerned with visual, emotional, tactile, and nonverbal memories. The hippocampus in the left hemisphere stores verbal and mathematical memories. Ultimately, the memories are responsible for emotional and motivational behaviour.

2.2 Autonomic Nervous System

The autonomic nervous system is concerned with the automatic selfgoverning regulation of three aspects of the body: smooth muscles, cardiac muscles, and the glands. Smooth muscles are found in various places e.g. skin (temperature regulation), eye (pupil size and accommodation of the lens), gall bladder, urinary bladder, blood vessels, and walls and sphincters of the gut. It controls the functions and involuntary muscles of the respiratory, circulatory, digestive, and urogenital systems. The autonomic nervous system has a reciprocal effect on the internal secretions of the glands. Two antagonistic and anatomically separate systems comprise the autonomic nervous system i.e. sympathetic division and parasympathetic division.

The sympathetic division of the autonomic nervous system stimulates the heart, dilates the bronchi, contracts the arteries, and inhibits the digestive system during moments of danger. This system serves to prepare the organism for fighting required to ensure survival in face of an environmental threat. This division has a wider connection to the eyes, salivary glands, sweat glands and blood vessels in the skin, heart, lungs, stomach, kidneys, adrenals, pancreas, intestines, external genitalia, and bladder.

The parasympathetic nervous system is located above and below the sympathetic nervous system and arises from the brain and from the lower part of the spinal cord. It produces the opposite effect of the sympathetic division. The parasympathetic division prepares organisms for feeding, digestion, and rest.

2.3 Pituitary Gland

The pituitary gland is also known as "master gland" or master of the orchestra" as it controls other endocrine glands in the body. It lies in a small pocket

of bone at the skull base called the sella turcica. It is connected to the hypothalamus of the brain by the pituitary stalk. It secretes hormones that control sexual development, promote bone and muscle growth, respond to stress, and fight disease.

2.4 Pineal Gland

The pineal gland is located deep in the brain in the middle. It helps in regulating the body's internal clock and circadian rhythms by secreting melatonin. It has some role in sexual development. It involutes with advancement of age. Though religious literature describes the pineal gland as the highest seat of brain and spiritual gain, anatomical evidences are lacking.

3. Physiology

3.1 Cellular Structure

The brain is made up of two types of cells i.e. nerve cells (neurons) and glia cells.

3.1.1 Nerve Cells (Neurons)

This is the primary functional unit and the brain is made up of billions of nerve cells. All sensations, movements, thoughts, memories, and feelings are the result of signals that pass through neurons. Neurons possess a very high rate of metabolism requiring a constant supply of nutrients and oxygen. Till recently it was believed that the number of neurons was fixed at birth and that they could not be regenerated in adult life. However, recent evidences are contrary to this view. This has provided a big boost to meditation and other techniques which aims at rejuvenating the brain. Based on their functions, neurons have different size and shape. In the human body, certain neurons reach up to a meter long.

Typically a neuron consists of a cell body, dendrites and an axon. The cell body (soma) of the neuron has a limiting membrane (cell membrane), a central nucleus, cytoplasm and other cell components. Inside the nucleus are the nucleolus and chromosomes. Cytoplasm makes up the bulk of the cell and contains many specialised structures such as mitochondria (energy factory), the endoplasmic reticulum (storage and channel for transporting chemicals), Golgi apparatus (cell's recycling centre), lysosomes (contain enzymes to break down waste substances in the cell) and microtubules (transportation of substances within the cell).The axon is

a long single fibre that transmits messages from the cell body to the dendrites of other neurons or to body tissues such as muscles. Axons are usually covered by a myelinated sheath which provides insulation for the axon and helps nerve signals travel faster (up to 120 meter/second). In contrast, nerve impulse cannot travel more than about 2 meters/second in unmyelinated fibres. The dendrites (dendron is Greek for tree) branch out from the soma, resembling branches of a tree. They are short fibres that receive and relay information between neurons.

3.1.2 Glia Cells

Glia (Greek glue) is the cell of the brain that provides neurons with nourishment, protection, and structural support. They comprise about 10 to 50 times as many cells as there are nerve cells.

3.2 Neurotransmission

The transfer of a message from the axon of one nerve cell to the dendrites of another is known as neurotransmission. This process occurs at a tremendous and unimaginable speed. This occurs either electrically or chemically.

The human brain depends on electric signals in the neurons, also called action potentials, to communicate and process multifaceted information. They are an important means by which the brain enables itself to transfer information to and fro from one part of the body to another. Various stimuli of light, sound and pressure act on specialized sensory cells in the eye, ear, and skin to produce action potentials which are conducted from these cells to the spinal cord and brain. Action potentials originating within the brain are conducted to muscles and certain glands to regulate their activities.

A longitudinal current spreads farther along a fibre with a large diameter and a high membrane resistance. As the current spreads along a nerve fibre, it becomes attenuated with distance. The electrical capacitance of the membrane influences the time taken by electrical signals, but not necessarily their longitudinal distribution. In the human brain, segments of the axon are covered by a highresistance, low-capacitance myelin sheath. This acts as an effective insulator and forces currents associated with the nerve impulse to flow through the membrane at the intervals where the insulating myelin wrapping is interrupted (nodes). The nerve impulse jumps from one myelin-free area (node) of the membrane to the next, and thereby the conduction velocity is increased. Myelinated nerves are used by the brain for signaling in pathways where speed is essential.

3.2.1 Synaptic Transmission

Junction between the axon and dendrites of the receiving neuron is called synapse. The nerve impulse electrically travels till the end of axon. There it triggers the release of molecules called neurotransmitters from the axon into the synapse (chemical transmission). These neurotransmitters fit into special receptors on the receiving nerve cell. Thus, neurotransmitters act as chemical messengers, carrying information from one neuron to another.

There are many different types of neurotransmitters, each of which has a precise role to play in the functioning of the brain. These can be either excitatory (e.g. acetylcholine, epinephrine, norepinephrine,) or inhibitory (e.g. gammaaminobutyric acid- GABA, dopamine, serotonin, glycine, endogenous opioids). Acetylcholine is released at neuromuscular junctions and neuroglandular junctions and it leads to excitation in the targeted cell of different organs/glands. Norepinephrine and epinephrine also cause excitation in most instances but it may also be involved in inhibition. Dopamines are clustered in the midbrain and usually lead to inhibitory functions. Serotonin is concentrated in the neurons in the raphe nucleus part of brain stem. Gamma aminobutyric acid (GABA) is highly concentrated in the thalamus and hypothalamus parts of the diencephalon and the occipital lobes of the cerebrum. It has been implicated as a likely target for antianxiety drugs which enhances the action of GABA. Glycine leads to inhibition of the neurons of the spinal cord. Neuropeptides such as enkephalins, endorphins, substance P and dynorphin are a few important neuropeptides. They are more than 200 times powerful in action than morphine and beta-endorphin.

In addition to neurotransmitters, two other types of transmitter substances are released at the terminal buttons of a neuron: neuromodulators and hormones. Hormones are released into the extracellular fluid and travel about the body through the bloodstream. Many other neuropeptides are also found in other parts of the body where they serve as hormones or regulators of various physiological responses under the supreme control of the brain. Few such substances are angistensin II, cholecystokinin (CCK) and regulating hormones (or factors). Angistensin II helps in raising blood pressure with the help of enzyme renin. Cholecystokinin causes the pancreas to release digestive juice and the gall bladder to release bile. Regulating factors, produced by the hypothalamus, regulate release of hormones by pituitary gland.

3.3 Brain Functions

Fundamental function of the brain is to receive, store and interpret the information and use it to plan and execute the required actions. The nervous system modulates various body functions in terms of sensory inputs, integration of inputs, maintaining states of homeostasis, miscellaneous mental activity and control of groups of muscles and glands.

3.3.1 Reception and Interpretation of Information

- 1. Information from the outside world through our five senses: sight, smell, touch, taste, and hearing are received often from many sources at a time.
- 2. Information from various systems of body (cardiovascular, digestive, respiratory, renal etc.) mainly through autonomic nervous system.
- 3. Information from within one's own brain and non-verbal communication from others.

The brain, in association with the spinal cord, processes all sensory inputs and initiates production of appropriate responses, which may be in the form of immediate response, stored as memory for later reaction or ignored completely.

3.3.2 Homeostasis

It is a state of equilibrium in the body with respect to vivid functions, compositions of various body fluids and tissues. For healthy survival, homeostasis is must and various regulatory and coordinating activities of the nervous system are necessary for maintaining homeostasis. The trillions of cells in the human body do not function independently of each other but must work together to maintain homeostasis.

3.3.3 Mental Activity

The brain is the chief centre of all mental activities including the generation of new thoughts, learning and memory, emotions along with a state of consciousness.

3.3.4 Regulation of Muscles and Glands

The nervous system, mainly the brain, controls the movements of the body through the control of voluntary skeletal muscles and those muscles normally contract under the regulated stimulation from brain. In addition, some smooth muscles contract only under the guided stimulation from the brain, supported by hormonal secretions from endocrine and exocrine glands. Cardiac muscles and smooth muscle, such as in the wall of the stomach, although contract autorhythmically and in normal conditions no external stimulation is required for their contraction. Although the brain does not initiate any contraction in these muscles, yet it can cause the contractions to occur with higher speed or lower speed. Likewise the brain also controls the secretions from many glands such as the sweat gland, salivary gland, digestive gland and also several endocrine glands.

4. Specific Considerations

4.1 Right and Left Brain

One of the most apparent visible features of the brain is the division between the left and right hemispheres of the cerebral cortex. Current scientific evidences suggest that the right hemisphere is the creative brain and the left hemisphere, the calculating or logical brain. Mental and emotional differences between men and women are speculated to result from different modes of functioning between the two hemispheres. The left hemisphere is dominant in hand use and language in about 92% of the people. It is well understood that the left hemisphere controls linguistic consciousness, talking, reading, writing, spelling, verbal intelligence and memories, information processing in the areas of math, typing, grammar, logic, analytic reasoning, and perception of details. The right hemisphere plays a large part in interpreting visual information, spatial processing, artistic and musical skills, unconscious awareness (in the sense it is not linguistically based), perception of faces and patterns, comprehension of body language and social cues, creativity and insight, intuitive reasoning, and holistic comprehension.

4.2 Memory

Memory is a complex process that includes three phases: encoding (deciding what information is important), storing, and recalling. Different areas of the brain are involved in memory depending on the type of memory.

I. Short-term memory, also called working memory, occurs in the prefrontal cortex. It stores information for a short period. It is analogous to RAM (random access memory) in the computer.

II. Long-term memory is processed in the hippocampus of the temporal lobe

and is activated when one want to memorize something for a longer time. This memory has unlimited content and duration capacity. It contains personal memories as well as facts and figures. It is analogous to the hard disk in a computer.

III. Skill memory is processed in the cerebellum which relays information to the basal ganglia. It stores automatic learned memories like tying a shoe, playing an instrument, or riding a bike.

4.3 Brain Size and Volume in Humans

Brain size is related to the body size; larger brains are associated with larger bodies but not with greater intelligence (Appendix B). In the course of evolution, the human brain has grown in volume from about 600 cm³ in Homo habilis to about 1500 cm³ in Homo sapiens neanderthalensis. Subsequently, there has been a shrinking over the past 28,000 years. The male brain has decreased from 1500 cm³ to 1350 cm³ while the female brain has also shrunk in the same relative proportion. In spite of significant changes in social capacity, there has been very little change in brain size from Neanderthals to the present day (Thomas, 2006, Wikipedia).

The size of each area in the brain directly corresponds to the amount of information being transmitted to or from the brain. For example, the area of the thumb for also motor control is far greater than that for the little finger. There is a homunculus for the premotor cortex which varies quite a bit from the motor strip's homunculus. Blood-flow studies and functional MRI studies are now shedding more light on the subject of cortical and brain function but we still remain in dark when it comes to understanding all the functions of the human brain.

Studies indicate small to moderate correlations (averaging around 0.3 to 0.4) between brain volume and IQ. The most consistent associations are observed within the frontal, temporal, and parietal lobes, the hippocampi, and the cerebellum. However, they account for a relatively small amount of variance in IQ, which itself has only a partial relationship to general intelligence and real-world performance.

5. Analysis of Basic Senses, Discriminative Functions and Consciousness

Having described the anatomical and physiological aspects of brain, we now come to the main point of how the information is processed in the brain. Human beings respond to the environment in which they live. This environment can be categorized into internal (inside the body) and external (outside). The
awareness about both comes under the functional jurisdiction of brain which receives information from both internal and external environment. A specific stimulus is detected by specific sensory receptors in contact with the inside or outside world. There are more than ten million sensory neurons which transmit information received from sensory receptors to the brain. The number of central neurons which process this information is more than fifty billion and there are about half a million efferent (motor) neurons which respond to sensory stimuli. Hence processing of information, which leads to awareness of stimuli, is very extensive, having a ratio of 20:1 between input and output channels. Sensory information processed by the cortex may or may not reach conscious awareness. If it reaches consciousness, it becomes a sensation. A person's understanding is called perception. Perceptions are outcome of neural processing of sensory information. The processing by which patterns of action potentials become sensations or perceptions are not completely understood.

5.1 Neural Basis of Consciousness

Consciousness is a concept or phenomenon that has eluded both scientists and philosophers. We will briefly describe three important aspects here i.e. definition of consciousness, structural correlate and information processing.

5.1.1 Definition

There is no agreement on what consciousness is and what its constituents are. It is a Latin term (Latin conscientia "moral conscience"). According to the English philosopher John Locke (1632-1704), it is the awareness of all that occurs in the mind of a person, whereas the American philosopher John Searle (2000) defined it as "inner qualitative, subjective states and processes of awareness". Consciousness, according to Jainism and most oriental philosophies, is a property of the soul. In modern science it is defined as a continuous state of full awareness of the self and one's relationship to the external and internal environment, describing the degree of wakefulness in which an organism recognizes stimuli. It is widely agreed that the term "consciousness" does not refer to any single cognitive phenomenon. It refers to arousal and waking state, experiences, particular mental or emotional state, recognizing inner stimuli, unconscious or subconscious recognition of external or internal stimuli and appropriate responses. Consolidating all these processes in a single paradigm is likely to meet with failure.

There is marked disagreement on what constitutes consciousness amongst different philosophies. It is widely agreed that awareness provides basic data to consciousness and intelligence. While science physically correlates it with arousal, Jain and other philosophies assign a wider meaning to it; even an arousal state in the physical sense is not a necessary constituent of consciousness. There is more emphasis on inner arousal and self awareness. Inner arousal or awareness is again an ambiguous term when we compare different philosophies. While scientifically, consciousness may have a physical or structural basis (heart, kidneys, lungs, gastrointestinal tract etc.), ancient literature have laid more stress on mind and soul. There is quite a variance on terms like 'unconscious or subconscious states' also.

The topic of animal consciousness is a subject of great controversy. Gross neuro-anatomy of humans and non-human primates are quite similar and some animal species do possess some aspects of consciousness. Could a machine (artificial intelligence) be conscious? Some philosophers have argued that it might be possible, at least in principle, for a machine to be conscious.

As per our current understanding, consciousness is not a single entity or function. It is a collection of many voluntary and involuntary processes. Thus, as has already been mentioned, it is difficult to identify it in a single term or action. It is possible that all the different aspects of consciousness (smelling, pain, visual awareness, self-consciousness, and so on) employ a basic common mechanism or perhaps a few such mechanisms (Crick and Koch, 1998).

5.1.2 Structural Correlates of Consciousness

The physical basis of consciousness appears to be the most singular challenge to the scientific world. Till five decades ago, research on various processes in the brain was guided by psychoanalytic techniques and self reporting of experiences in control and experimental settings. Recent advances in neuroimaging (e.g. functional magnetic resonance imaging - fMRI, positron emission tomography- PET), electrophysiology (e.g. EEG, evoked potential studies and magnetoencephalography), hormonal assay, molecular biology, and experimental laboratory techniques have given a big boost to its study. Science is now in a better shape to answer structural correlates as proposed by different religions and philosophies (Crick and Koch 1998).

Cessation of blood supply (inactive heart) leads to instantaneous

unconsciousness followed by death. This perhaps was the reason for Aristotle to believe that the neuronal enabling factor for consciousness is in the heart. This view was also shared by philosophers and religious teachers of that time. It is now agreed by medical practitioners as well as philosophers that consciousness is a property of the highly evolved species in the animal kingdom and that the brain is the seat of this phenomenon. Neuroscientists assume consciousness as a physical state of mind, related to awakening or physical arousal of brain. The classical example given is that the brain is not conscious when anaesthetized or there is a small lesion in the midbrain or thalamus. In fact the cause of altered state of consciousness or coma, according to neurologists, is due to either a small lesion in the brain stem or a large lesion on both sides of the cerebral hemisphere. A focal lesion in cerebral hemisphere may affect certain aspects of consciousness.

The most popular belief is that consciousness arises in a very large collection of interacting neurons (Libet, 1993). Localization of these neurons is far from successful. There is complex and dynamic relationship between the physical stimulus and the conscious percept. It is possible that primary and secondary information (visual, auditory, touch, taste and smell, etc.) project to the planning stages of the brain i.e. the limbic system and prefrontal areas (Fuster, 1997). It is likely that a combination of molecular, biophysical, pharmacological and anatomical traits of a group of neurons determine the ultimate output. Thus responses so obtained are not static or stereotyped and keep on changing, depending on the environment and several unidentified factors.

Neuronal substrates include several functional networks that are hierarchically organized and cooperate functionally. Human consciousness requires brainstem, basal forebrain, and diencephalic areas to support generalized arousal, and functioning thalamocortical networks to respond to environmental and internal stimuli. The lowest level is the ascending reticular system (ARAS) and periaqueductal gray matter in the brain stem. These structures are essential for general awareness and influence emotional milieu of an individual. There are diffuse projections from ARAS to cerebral cortex via the thalamus and to the basal forebrain and limbic system via the hypothalamus. Thus ARAS has numerous direct and indirect collaterals from somatic and sensory pathways and acts as a control system of neuronal activities of the cerebral cortex. Activation of ARAS in the brain stem is essential for arousal, attention and consciousness (Baars, 1997). The diencephalon (thalamus and hypothalamus) has reciprocal connections with the cerebral cortex and is very important in determining consciousness related to external world in primates including humans. Important areas in the cortex connected to consciousness, mainly to the internal world or self, are prefrontal cortex, various association areas in the temporo-parietal-occipital cortex. Most experimental work with consciousness is on visual perception. Functional brain imaging in humans undergoing binocular rivalry has revealed that areas in the right prefrontal cortex are activated during the perceptual switch from one percept to the other (Lumer et al., 1998). Future techniques, based on the molecular identification and manipulation of discrete and identifiable sub-populations of cortical cells in appropriate animals, will greatly help in this endeavor.

5.1.3 Information Processing

The specific processes (active neuronal processes in our brain) that correlate with the current content of consciousness are referred to as the neuronal correlate of consciousness (NCC). Cognitive and clinical research demonstrates that much complex information processing occurs without involving consciousness. This includes visual, auditory and linguistic priming, posture adjustments, implicit memory, the implicit recognition of complex sequences, automatic behaviors such as driving a car or riding a bicycle and so on (Velmans, 1991). Thus major information processing occurs in the subconscious mind. No definite structure(s) or connection system has been identified which is common to all processes. The intricate relationship between conscious and unconscious processes is yet to be explored. A great deal of complex cognitive processing occurs at the unconscious level and affects how a person behaves, thinks, and feels. Equally important is to find out how unwanted information is filtered out in unconsciousness and in the sub-conscious mind.

Discovering the NCC and its properties will mark a major milestone in any scientific theory of consciousness. Many secrets of the human mind and brain can be revealed when we look to the "disordered" mind and brain for answers and integrate this information with results from animal, single-cell recording, genetic, and imaging studies. We need to identify process as well as content of consciousness. Thus we see that study and analysis of information on consciousness will create more questions than answers and we are, at present, quite far from a comprehensive understanding.

6. Brain, Meditation and Consciousness

As we have discussed above, in a simplistic way, consciousness may be defined as a state of awareness of one's self, one's environment, and other beings. Very little is known about the neural mechanisms that produce consciousness. Consciousness (awareness) depends on excitation of cortical neurons by impulses conducted to them by a network of neurons known as the reticular activating system. The reticular activating system consists of centres in the brainstem's reticular formations that receives impulses from the spinal cord and relay them to the thalamus and from the thalamus to all parts of the cerebral cortex. Both direct spinal reticular tracts and collateral fibres from the specialized sensory tracts (spinothalamic, lemniscal, auditory, and visual) relay impulses over the reticular activating system to the cortex.

Consciousness also depends on the functioning of the brain but how the brain produces subjective experience still needs validation and scientific explanation. Scientists often find it safer to dispense with explanations and to explore instead which parts of the brain are important for consciousness and which aspects of neural activity accompany it. The level of consciousness is associated with an activated electroencephalogram. Brain lesions and functional brain studies have demonstrated that different brain areas are important for specific contents of consciousness. Consciousness is associated with a distributed neural system; there is no single area where it all comes together. Many neural processes in the thalamocortical system can influence conscious experience yet they do not seem to contribute directly to it. What we see and hear depends on elaborate computational processes in the cerebral cortex that are responsible for object recognition, depth perception, and language parsing; yet such processes remain largely unconscious.

Meditation and its effect on brain activity and the central nervous system became a focus of collaborative research in neuroscience, psychology and neurobiology during the latter 20th century. Recent studies, described in an accompanying article (Shah, 2017) have shown heightened activity in the anterior cingulate cortex, frontal cortex, and prefrontal cortex, specifically in the dorsal medial prefrontal area during meditation. These findings indicate some state of heightened voluntary control over attention during mindfulness meditation.

Cahn (2010) observed a heightened emotional state of meditators. A more complex study, conducted by Lutz et al., (2008) focused on emotional response

during meditation. This investigation involved the creation of a "compassion meditation" state by novice and experienced meditators and testing the meditator's response to emotionally charged sounds. fMRI results indicated heightened activity in the cingulate cortex, amygdala, temporo-parietal junction, and right posterior superior temporal sulcus in response to the emotional sounds (see the article by S.V. Shah, this volume)

Studies have reported an increase in the specific frequencies expressed in the alpha range, increased alpha band power, and an overall slowing (reduction in frequency) in EEG activity in experienced meditators versus less experienced meditators while meditating. The alpha blocking phenomena, observed as a state change in brain function, was investigated as a possible trait change as well. Long-term meditation practitioners have also shown to have a higher tolerance for pain. This effect has been correlated to altered function and structure in somatosensory cortices and an increased ability to decouple regions in the brain associated with the cognitive appraisal of pain (anterior cingulate cortex and dorsolateral prefrontal cortex).

6.1 Triune Brain Theory

The triune brain theory was developed by MacLean and it looks at the evolutionary stages of the brain and postulates that the human brain is actually three brains in one. The three brains of MacLean's triune brain theory are: the reptilian brain, the mammalian brain, and the "human" brain (Fig. 4).



Fig. 4: Triune brain in humans (222)

The reptilian brain includes the brain stem and its primary function is keeping the organism alive. The mammalian brain resides in the limbic system. Its primary purpose is survival and preservation of self and species. Behaviour of the mammalian brain is said to revolve around feeding, fighting, fleeing, and mating. Through the brain, mammals, including humans, feel pleasure when engaged in activities that enhance their preservation or the preservation of their species. Pain is experienced when survival needs are thwarted. From the limbic system's perspective all experiences are judged in the dualistic fashion of pain or pleasure. The limbic brain scans for differences; typically when one is found it is deemed a threat to survival. The cerebral cortex comprises the "human" brain and is associated with advanced functions such as planning, thinking, analyzing, and communicating.

The limbic brain can be seen as receiving its cues from the inside. Whereas the neocortex processes sensory information from the external world, the limbic system has, according to MacLean, a loose grip on reality. Without the reality check of the neocortex, the limbic system is capable of producing sensations of deja-vu, sudden memories, waking dreams, messages from God, even religious conversions.

7. Scientific, Philosophical and Religious View of Cognition

We have seen above that the development in knowledge on the structure and functioning of the brain is extremely interesting and complicated and as yet incomplete. The rapid progress is mainly due to the explosive increase in possibilities of perception through technology and its ever more refined instruments, and the growing understanding of biochemistry that biophysics. It is also due to the human inquisitive mind that these material and psychological factors strangely combine most successfully in what we call 'scientific culture' which developed in the west. This is partly due to economical reasons, climate, etc., and, last but not the least, the discovery and understanding of electricity, electromagnetism, and the divisibility of the atom.

Three ways to human knowledge are available to the humankind: science, religion and philosophy and cognition is where science, philosophy and religion meet. When approaches are taken together these make a 'whole man' (having completely developed *manas*). Science means painstaking perception, collection of hard (undeniable, indubitable) 'facts', categorization. Science is the highest pursuit

of the human intellect in its quest for knowledge. Science on its own is inductive by nature. Theories are 'intellectually fancied' to explain the perceived facts. Science on its own can not reach beyond the human intellect, and therefore never arrive at ultimate Truth, the fountain-source of all truths.

Having described various parts of brain and their functions from the point of view of medical sciences, we now compare it with the Jaina view, as stated in the scriptures.

Any religion involves the faculty of belief and trust. Great men and women, yogis and enlightened beings have gained great transcendental insights and taught parts of it to humankind, often in the far past. They have penetrated beyond the limits where the intellect can go and entered the realm of direct truth or intuition, 'omniscience', bodhi. Enlightened beings see the oneness and connectedness of all phenomena, and understand that there is a still deeper source from which all phenomena originate. This source has been called Parabrahma, Tat, unyat, tman, pure J va (infinite life-consciousness) etc. Those who have accomplished religion in a high sense often become our teachers - but because the limited capacities of nonenlightened beings they can do little more give hints to stir the intuition of those who strive for true knowledge and wisdom. These 'hints' as far as we can grasp them, are like transcendental axioms from which we can deduce conclusions. But most western people do not accept spirituality as a reliable source of wisdom, and therefore discard its axioms. The hints by themselves are reflections of wisdominsight, depicted in symbols, rituals and words for our understanding. When we devote ourselves to efforts to penetrate into the direct source of such hints, we move into 'divine' (or super human) direction. Before we dare to devote ourselves to the words spoken or written by others on their authority, we have to 'give our heart' (credere, Latin - belief) in trust. How many (so-called?) religious teachers and yogis can be trusted nowadays? But we are sure that real great founders and pioneers like Mah v ra, Buddha, Pythagoras, Plato, Zarathustra, Lao-tzu, Jesus, Mohammad and many others through times immemorial were guided by but one principle: noblest compassion for humankind. These we can trust - but not always our own interpretations or the interpretations of those who established themselves somewhere in between 'God' and man, let alone religious dogma. Science gives the boon to be able to compare and check the information of our senses and a logical mind on the physical level at least, with spiritual information given to us by the siddhas - the spiritually (not psychically!) accomplished ones.

In the context of this article, we talk about intellectual truth only. But we know that religion is not only given to intellectuals. It is also for those who evolve in the field of refined emotion, refining sense or extra-sensual perception, art, ethics, spiritual (but not always intellectual) intuition, recognition of the divine or the soul's omnipresence in Nature, etc. A 'whole man' encompasses all these. The intellect represent but one path.

Philosophy uses the information from both science and religion. It combines the two. Philosophy touches the rational mind as well as the spiritual - intuitive mind – the *manas* (mind) as well as the *buddhi*, and thus develops the *buddhi* of the *manas* as well as the mental (or *manasik* aspect of the spiritual - intuitive faculty. Philosophy can build bridges between what we perceive and the source and origin of what we perceive.

To reach true understanding of our universe (*loka*) in all its aspects, science, religion and philosophy, are indispensible to reach both omniscience and transcendental wisdom. This should encompass consideration of 'spirit', cosmic intelligence, cosmic buddhi, ultimate knowledge, creative activity, transcendental experiences, or tuition by beings of more than just intellectual capacity. We have thus to devote ourselves wholeheartedly to all the things given to humankind throughout the ages.

8. Jain View on Structure and Functioning of Brain

One of these great ancient systems of knowledge and wisdom is Jainism. In itself Jainism is philosophical, religious and scientific at the same time. The risk of any religion based on doctrines that are not completely graspable by average humanity is dogmatization and crystallization: only some claim to know the 'right' interpretation, and 'nothing may change because it would be an assault to the original preceptor'. But did not all systems teach us that change (movement) is the very nature of being? Did not all religions show us a path towards ever more perfect intellectual and spiritual accomplishment? True Jainism does not just mention half-understood sayings of the scriptures, but progresses by means of modern scientific investigation – without causing suffering and harm to guinea pigs or whatever beings who can experience pain and/or psychological suffering. All modern tools are at the disposal of any intelligent human to make intellectual progress. Jainism has much to say that may help science go forward without ever jumping to man-made dogmas like fancies about creative and designing gods.

The scientific knowledge gained by thousands of students and investigators throughout many centuries which are reflected in Jain scriptures is amazing. How could ancient people without the technology of today have sound theories about atoms, molecules, chemistry, space, time, mathematics, the number zero, medicine, psychology, biology, cosmology measured and calculated in quantities comparable to 'light-years' (i.e. the *rajjus*), distances and speeds, while being aware of other worlds, including many imperceptible for the normal senses (indeed most of them), and possibly other solar systems and galaxies?

The time has come that ancient wisdom and modern investigation should join hands. Science should undo itself from its unrealistic assumption that there is nothing to believe outside the superficial phenomena that we perceive with our senses. However great our instruments (and our pride of them), they are as nothing compared to our inner faculties still to be developed in future human evolution. We should study and enlighten our scientific facts by the universals of ancient knowledge.

This article deals with brain, mind and consciousness. From a spiritual point of view, consciousness is eternal and in its infinite scope, always beyond grasp. Conscious beings 'swim' in that universal consciousness and can unify themselves with parts of it. Consciousness brought forth and manifested itself as Mind in order to develop self-consciousness. The mind needed a vehicle in (physical) matter and developed it. Not the limited human mind – a minute splinter of the cosmic or ja vika mind – because we can not even make a technological copy of the simplest ganglion. The ja vika mind is not 'somewhere in heaven', but is the essence of ourselves. The ja vika mind 'steps down' through various phases of subtler matter into physical matter, in order to perceive and self-consciously understand our present small world – the tiny Middle World or Madhyaloka, and then, only the central portion of it.

It is interesting that the ancient thought systems, though probably ignorant about nerve cells, axons, synapses and the physiological details about functional regions in the brain (described above in this article), were aware of the aspects of consciousness that the brain serves (the sense- and extra-sensory perceptions – potentialities which existed already in the j va before it surrounded itself by matter of our plane), and were also aware of the inner physiological system in the form of energetic information channels (tens of thousands of n ?is), centers of energy

(chakras, 'psychic centers', kendras). Especially Jainism and tantric Buddhism have given much attention to the n ?is and their deities in order to bring about specific magical potentials. Also the various acupuncture systems use detailed knowledge about 'energy channels' for healing purposes, though these are not directly related to the occult-physiological n dis.

There are seven main chakras along the spine which are related to physiological processes. There are actually many more mini and micro chakras and we discuss them in some detail below. Chakras are considered as vortices of energies of a grosser and the next more subtle plane of matter. According to clairvoyant reports these are whirling centers (perceived in various colors) of energy running in fixed numbers of loops¹. In yoga these loops are often referred to as 'petals of lotuses.' The chakras are the interfaces through which the subtler body (in the Hindu systems called li?ga ar ra and pr ?amaya-ko a, probably an aspect of the Taijasa ar ra of Jainism) communicate with the physical plane, and relate directly to our ganglia and the endocrine system. All have a communicative function, and can transfer information from subtler plains of matter. In this way, we may suppose, the k rma?a ar ra, for example, communicates with the level of the taijasa and the audarika and vaikriyika (see the accompanying article by Kachhara et al.). Moreover there are seven chakras in the brain, related to specific brain functions - which still have to be correlated scientifically with the functional regions in the various brain lobes. Some are associated with known parts of the brain, such as the hypothalamus and the glandula pinealis (which even in Europe was mentioned as 'the principle seat of the soul' and 'the third eye' by the French-Dutch philosopher Descartes in the 17th century [25] as has been frequently confirmed by yogi's and occult writers, but this has also not yet been confirmed by medical science. Moreover the chakras relate to the hollows (fluid filled ventricles) - which are physiologically just 'empty' for science. Besides the seven chakras along the spine, from which branch out groups of n ?is to provide pr nas to all parts of the body, there are said to be 49 minor chakras (smaller centers with less loops) and 7 x 7

^{1.} This remark is based on works of C.W. Leadbeater, Alan Hopking (2004), A.A. Bailey, A.E. Powell and others published by the Theosophical Publishing House, Adyar TN India, Wheaton II USA which include (i) Leadbeater, Charles Webster, The Chakras; A Monograph, 1927; (ii) Clairvoyance, 2010 (19th reprint) (iii) Powell, Arthur E., The Astral Body and Other Astral Phenomena, 2009 (second reprint); (iv) The Etheric Double – The Health Aura, 2005 (second reprint) and (v) Bailey, Alice. A., Esoteric Healing (Volume IV of Treatise on the Seven Rays, 1951-1970).

x 7 = 343 micro chakra (Hopking) [26]. Apart from these, there are interfaces or chakras on cellular level where the soul, through subtler matter, communicates with the physical matter of the cell and thus steers information which impacts the processes inside the cell [27]. This, if the perceptions are correct, means that every single nerve-cell has its interface with its own individual j va. All chakras have a physiological representation in the nervous and endocrinal system or by an organized structure inside the cell. However, the chakras are not the ganglia etc. themselves. The ganglia and the physical brain structures are just their representatives (cf. Hopking, 2004), developed (by the j va) on our present plain of functioning. Comparable systems must exist for all invisible beings in the many gatis and subspheres described by Jainism and other systems.

These findings by modern clairvoyant investigators confirm ancient knowledge, but are not yet recognized by scientific techniques because their findings can neither be checked nor falsified. This is the right attitude from the point of view of brain scientists or neurologists, because science needs much effort to protect itself from humbug. Regrettably the ancient sacred, and once secret physiological knowledge of *chakras*, *n* ?*is* and *pr nas* has partly fallen in the hands of people who do not have a scientific mind and who are more interested in the 'romantic' feel-good and pseudo-scientific side of this information. This knowledge, once scientifically established, can become a boon or a curse for medical science. Not only can one heal, but one can also exert unsolicited influences on human subjects, and thus perform black magic – not an option till the state of world and individual ethics is ready to handle.

As the physical matter of which our visible bodies including its sense organs and brain is built is supposed to be the grossest of all types of matter, we may suppose that the more subtle bodies, and most of all the substance of jîva itself, is much more refined in structure and 'chemistry' (or information) than what we know about the physical matter. Then we might ask, 'do we need a brain at all?"

8.1 Do we need a brain at all?

Brain research has shown that human beings with sharply reduced brain volume (perhaps 10%), as can be the case in Hydrocephalus can in exceptional cases function rather normally, though generally such patients may be mentally retarded. Apparently a limited amount of nerve cells and connections in a heavily distorted brain can do most of the work². Only a relatively small part of the brain is active in

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known fields. Yet, there exists no human being without a brain. And a human without a developed cerebrum would not be a human, even if he could perform all locomotory and physiological functions of an animal.

Then, if we look from the Jain point of view, the hell-beings (i.e. mainly bad humans after their death) and heavenly beings, including great scholars and highly developed people on earth, are in possession of a mind, even when they have no physical body. Hells and heavens are probably states of consciousness which are created by the mind itself and present themselves before the consciousness of the deceased human being. So does the mind exist there without a brain? Is there a complete brain consisting of vaikriya matter and if it does, why do we need a physical brain at all? Is a subtler brain as complex as the physical brain or more, and is it comparable (would it 'look like' a physical brain – if we could see it?). Is it otherwise comparable to a physical brain in its more subtle pudgalic v rgana material? Jainism ascribes the same characteristics of pudgala to all its v rganas, so their structures will be based on the same principles.

It is said that the vaikriya body is formed immediately after physical death according to the experiential needs of the j va: innumerable indeed are the infernal and celestial forms. And they change at will.

2. One interesting case of hydrocephalus was a man whose brain shrank to a thin sheet of tissue, due to buildup of cerebrospinal fluid in his skull. As a child, the man had a shunt, but it was removed when he was 14 years old. In July 2007, at age 44, he went to a hospital due to mild weakness in his left leg. The doctors after learning man's medical history, performed a computed tomography (CT) and Magnetic Resonance Imaging (MRI) scan, and were astonished to see "massive enlargement" of the lateral ventricles in the skull. Dr. Lionel Feuillet of Hôpital de la Timone in Marseille said, "The images were most unusual... the brain was virtually absent [15]". Intelligence tests showed the patient had an IQ of 75, below the average score of 100. This would be considered "borderline intellectual functioning", just above what would be considered mentally challenged. The patient was a married father of two children, and worked as a civil servant, leading an at least superficially normal life, despite having enlarged ventricles with a decreased volume of brain tissue. "What I find amazing to this day is how the brain can deal with which you think should not be compatible with life"', commented Dr. Max Menke Institute, periatric brain defect specialist at the National Humain Genome Research. If something happens very slowly over quite some time. may be over decades: the different parts of the brian take up functions that would normally be done by the part that is pushed to the side. (From Wikipedia: Hydrocephalus; sources: "Man withmy tiny brain factors", NewScientist.com (2007-07-25); "Tiny Brain, Normal Life", (2007-07-24). "Man Lives Normal Life Despite Having Abnormal Brain", and Mail, july 19, 2007. Archived from the original on August 28, 2007. July 15, 2012. "Man with tiny brain shocks doctors". New Scientist and Reuters. 2007. Retrieved 8 Jun 2013. Feuillet, L; Dufour, H' Pelletier; J (Jul 21, 2007). a white-collar worker", Lancet 370 (9583) : 262. doi: 10.1016/s0140- 51127-1. PMID 17658396.

If it has the same brain complexity as the physical brain, it must have been formed by the physical brain while all information about its structure as well as its experiences is copied to the vaikriya ar ra. Without physical human existence with a brain and mental activity on earth, there is no experience of hell or heaven. The non-physical worlds in the universe are no karma bhûmis, they are no causal spheres – they are world of experiencing effects.

For western scientists, these considerations would be irrational. Still there are innumerable reports of yogis leaving their bodies for considerable time, have experiences outside their body and then return. Also they can temporarily 'borrow' the body of another being (either human or animal) who wishes to cooperate and stays aside. There are also reports about bodiless ghosts who communicate with the living, and convey information that they could not possibly know from others. Then there are reports of near-death-experiences, including cases (such as a particular form of meningitis) in which the cerebrum is totally non-functional. There are psychedelic drugs like ayahuasca (Banisteriopsis caapi) and 'the spirit molecule' which trigger out-of-the-body experiences combined with hallucinations due to distorted nervous brain functions which can be perfectly remembered afterwards by the experimenters. Many ghosts as well as psychedelic experimenters report communication with other non-physical beings. People also report about states of consciousness that can not be described in human words, because the basis of understanding of our normal consciousness is totally absent in our physical mentality. No scientific study of mind and consciousness is complete when it can not satisfactorily explain - and prove - such phenomena.

The Jain answer is rather clear: there are other phases of pudgala, and there are sensory perceptions other than physical sensory perception. The highest substance (dravya), j va, has no human limitations and thus can experience all and know all that can be known in the universe. Moreover, Tibetan Buddhists for example, in the Bardo Thödol ('Book of the Dead'), have discovered and described minute details about many different experiences between physical incarnations.

There are differences between physical and subtle bodies. It is said that the subtle body has full sense perception and mental perception, but at its own level. Thus the dead can see the dead. In exceptional cases, the dead can see the living.

The body made of vaikriya v rga? can pass through physical objects

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without obstruction. One can transport oneself, virtually within no time, to a destination thought of or wished for.

Thus fear, anger, hatred, jealousy and other negative thoughts and feelings create immediate hell for the dead man or women, whereas higher or spiritually positive thoughts create pleasant states in his or her experience. One 'goes to' where one feels attraction - compare a pub to a temple. However, independent decisions, based on scientific perception, logical reasoning or religious contemplation can not be made. The essential knowledge including that gained by scientific study and experience, which is accepted by the j va, will be part of the dead entity even clearer than during life. There are chakras (kendras) on different levels, which are the interfaces between different phases of matter through which the different layers from soul down to the various physical structures communicate in both directions. In conclusion, a living being from soul down to all its vehicles is even much more complex and intelligent and amazing than we would conclude if we just study the complex brain. Though such studies are far beyond the possibilities of modern science, the very facts given to us from ancient literature and also modern occultism could open us for at least the acceptance of the possibility that soul, inner subtle bodies and energetic processes truly exist and interwork. Even taking notice of this very idea could save science from its rigid materialistic dogmatism that narrows its views, hampers its progress, and creates vast amounts of suffering due to ignorance among humankind. But if we can function with no physical body and no physical brain, why do we have one? Why did the soul develop physical sense organs and a physical brain? Here too, Jainism has partly an answer: our gross material sphere is the only karmabh mi in the universe, the only circumstance which is 'rigid' enough to make spiritual progress and reach liberation through self-effort. Even the highest gods in the heavens have to return at least once to our physical sphere in order to accomplish total emancipation or liberation. Both Jainism and Buddhism teach this. Therefore, the jîva needs to develop an instrument on our physical level. Only during this connection between soul and matter, the inner being of each entity can concentrate enough - or should we say 'is retarded enough' to turn experiences into self-conscious experiences for the jîva. This is the reason for the semi-endless physical embodiments the jîva must take before reaching nirv na. Our soul - who starts as a nigoda (microbes) with maximum limitations has to go the whole cycle of necessity to reach omniscience, and visit every nook and corner - every space point and every time-moment in the universe.

This way we can understand the importance of unity between science, philosophy, and religion in the approach to a holistic understanding of our Universe. We have also discussed the importance of deeper understanding of the relation and influences between soul, mind and body. This may have great benefit for medical health as well as holistic well-being, well-feeling and well-thinking. Whereas science gives Jainism its refined tools, Jainism will give science a spiritual side and a sound ethics. Jainism and modern science are not different but complementary.

9. Research Potentials

We mention here some potential problems for future research and study. There is much scope of further research using the modern techniques.

- 1. Development of the human brain from foetus to address the relevance of various functions to areas of brain at each stage.
- 2. To compare brain size, area and structure in different species in animal kingdom including human and correlate them with their functional efficiency.
- 3. Changes in different areas of brain with meditation.
- 4. Role and relevance of the pineal gland in meditation.
- 5. Role and relevance of spinal cord in kundalin.
- 6. To identify the role of different areas or part of the brain in conscious awareness.
- 7. To scrutinize Jain literature concerning physiological subjects to find confirmation of statements made in this article.
- 8. Jain (occult) physiology.
- 9. Indian (also non-Jain) physiology.
- 10. Developing of supra-religious (supra-sectarian) understanding. The nature and function of chakras (kendras) in relation to the physical physiology of the endocrine system, ganglia, channels of energy transportation (blood vessels, nerves, meridians, n ? s, etc.) through the gross and subtle bodies.
- 11. The influence of spiritual and non-spiritual thought and emotion on chakras, endocrine glands and epigenetic processes.

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Appendix A: Cranial Nerves and Their Major Functions. (Source: http://www.mayfieldclinic.com/PE-AnatBrain.htm#.VAB_zfmSxyU)

Number	Name	Function
Ι	Olfactory	Smell
II	Optic	Sight
III	Oculomotor	Moves eye, pupil
IV	Trochlear	Moves eye
V	Trigeminal	Face sensation
VI	Abducens	Moves eye
VII	Facial	Moves face, salivate
VIII	Vestibulocochlear	Hearing, balance
IX	Glossopharyngeal	Taste, swallow
X	Vagus	Heart rate, digestion
XI	Accessory	Moves head
XII	Hypoglossal	Moves tongue

Appendix B : Brain Facts and Figures

- Human brain% of total body weight=2%.
- Percentage of total cerebral cortex volume (human): frontal lobe = 41%; temporal lobe = 22%; parietal lobe = 19%; occipital lobe = 18%.
- Average brain length x width x height= $167 \times 140 \times 93$ mm.
- Average number of neurons in human brain = 100 billion (octopus = 300 million; leech = 350).
- Average number of glial cells in human brain = 10-50 times the number of neurons.
- Number of synapses for a "typical" neuron = 1,000 to 10,000.
- Number of synapses in cortex = 0.15 quadrillion.
- Length of myelinated nerve fibers in brain = 150,000-180,000 km.
- Conduction velocity of action potential = 0.6-120 m/s.
- Total number of sodium pumps for a small neuron = 1 million
- Number of voltage-gated sodium channels between nodes = 25 per micron².
- Diameter of microtubule = 20-25 nanometer.
- Diameter of microfilament = 5 nanometer.
- Diameter of neurofilament = 10 nanometer.
- Internodal Length = 150 1500 microns (depends on fiber diameter.
- % composition of myelin = 70-80% lipid; 20-30% protein.

Blood Supply

- Brain utilization of total resting oxygen = 20%.
- Blood flow from heart to brain = 15-20% (Kandel et al., 2000).
- Blood flow through whole brain (adult) = 750-1000 ml/min.
- Blood flow through whole brain (adult) = 54 ml/100 g/min.
- Blood flow through whole brain (child) = 105 ml/100 g/min.
- Cerebral blood flow = 55 to 60 ml/100 g brain tissue/min.
- Cerebral blood flow (gray matter) = 75 ml/100 g brain tissue/min.
- Cerebral blood flow (white matter) = 45 ml/100 g brain tissue/min.
- Oxygen consumption whole brain = $46 \text{ cm}^3/\text{min}$.

Table 2. Comparison of white matter and gray matter in oxygen consumption

	White matter	Gray matter
% of brain	60%	40%
% of cerebral O ₂ consumption	6%	94%

	Total surface area of cerebral cortex
Human	$2,500 \text{ cm}^2$
Rat	6 cm^2
Cat	83 cm^2
African elephant	$6,300 \text{ cm}^2$
Bottlenosed dolphin	$3,745 \text{ cm}^2$
Pilot whale	5,800 cm ²

Table 3. Total surface area of cerebral cortex in different species

Table 4. Proportion by volume of different areas of brain in human and rat(Reference: Trends in Neuroscience, November 1995)

	Proportion by Volume (%)	
	Rat	Human
Cerebral Cortex	31	77
Diencephalon	7	4
Midbrain	6	4
Hindbrain	7	2
Cerebellum	10	10
Spinal Cord	35	2

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	6	
Species	Cerebellum Weight (grams)	Body Weight (grams)
Mouse	0.09	58
Bat	0.09	30
Flying Fox	0.3	130
Pigeon	0.4	500
Guinea Pig	0.9	485
Squirrel	1.5	350
Chinchilla	1.7	500
Rabbit	1.9	1,800
Hare	2.3	3,000
Cat	5.3	3,500
Dog	6.0	3,500
Macaque	7.8	6,000
Sheep	21.5	25,000
Bovine	35.7	300,000
Human	142	60,000

Table 5. Comparison of cerebellum and body weight in different species (Source: Sultan and
Braitenberg 1993)

Table 6. Composition of Brain and Muscle (Source: McIlwai n and Bachelard 1985)

	Skeletal Muscle (%)	Whole Brain (%)
Water	75	77 to 78
Lipids	5	10 to 12
Protein	18 to 20	8
Carbohydrate	1	1
Soluble organic substances	3 to 5	2
Inorganic salts	1	1

10. Consciousness, Mind and Brain

Rudi Jansma

Abstract

We compare the ideas on the basic origin of consciousness and the material universe within the framework of modern neuroscience and ancient Jainism. We deal with a number of fundamental questions: Is consciousness causal to, resultant of, and related to physical matter and vice versa? What do both approaches regard as the ultimate essence of the living universe? Is there a conscious mental world apart from the physical brain, and is there a mental world apart from the (gross) material world? We discuss the possible existence of types of matter that are more subtle than physical matter. We compare the concepts of probability with spiritual guidance from an inner source; whether information can stand apart from physical matter; we discuss the modern quantum-physical concept of implicate orders and genetic determinism. How do the latest studies of neuroscience based on its most advanced techniques support the general agreement among scientists that "awareness provides the basic data for consciousness and intelligence" and that "information processing occurs in the subconscious mind"?

Key Words: consciousness, mind, brain, extra-physical consciousness, parapsychology, etheric body, subtle matter, vaikriya ar ra, karman sarîra, implicate order, genetic determinism, Neuronal Correlate of Consciousness

1. Introduction

Materialists believe that consciousness is an inherent property of matter which arises with organisational complexity, whereas Jain scriptures clearly state that consciousness can not arise from matter and is an independent dravya. The brain and its functions have been discussed in detail in an accomapnying article (Sanchetee et al.) and here we first present the Jaina view of consciousness. Then we will quote and discuss briefly the ideas of a number of leading scientists, which can throw some light on these questions.

1.1 Jain Point of View

It appears to us that the best way to understand the relationship between consciousness, mind and brain is to formulate some basic questions and try to answer them from philosophic as well as scientific points of view. In this context five questions seem to be fundamental.

- 1. Is consciousness an inherent (hidden) property of physical matter which is composed, or surfaces, when complex chemical and physical connections are made? Or, is consciousness an emerging quality of complexity of matter?
- 2. Is consciousness a function of the physical brain, which cannot exist when and where there is no physical brain? Is consciousness only a property of individual beings with a mind, or also for those who have no mind and/or nervous system? Does consciousness exist outside the framework of organic chemistry and organisms?
- 3. What is the ultimate essence of the living universe: a) physical matter; b) consciousness; c) life; d) life and consciousness or e) matter, life and consciousness?
- 4. Is consciousness evanescent or eternal and is it ever interrupted?
- 5. Is there a causal relation between consciousness and the composition of material structures resulting in complexity? And if so, is the direction of cause and effect unilateral or reciprocal?

We first try to answer these questions from a Jaina point of view.

Question 1: In Jainism, six substances (*dravyas*) are distinguished: Space (k a), Time (k la), Motion (dharma), Inertia (*adharma*), Soul (*j va*) and Matter (*pudgala*). None of the substances contains properties of other substances. All substances are eternal.

J va = life and consciousness. It is non-physical ('non-pudgalic').

Pudgala = non-life and non-consciousness

Matter is atomic (*param ?u*) and exists as atoms or compounds of atoms ('molecules'). Matter exists in five forms of subtlety serving to form five types of bodies around the j va – the coarsest of which is physical (visible) body made of

matter.

Thanks to motion, inertia, space and time, atoms and molecules of pudgala can move. The *j* va by its vibration (*yoga*) causes karmic influx (*rava*) of particles, so that they move towards the *j* va and cling or bind (*bandha*) to it "like dust to an oily cloth." As soon as *pudgala* particles with their inherent 'chemical or informational' properties have become stuck to the soul they have a specific limiting influence on the soul's freedom. Such specific groups or molecules of *pudgala* are called karmas. Karma consists of the vibrational activity of the soul due to its inherent consciousness of desire and its inherent thought power. The active, soul-part of karma is called bh va karma (psychalogical); the passive, material part is called dravya (karnic particles states) karma.

Concluding the answer to the 1st question is: No, consciousness is not an inherent property of physical matter.

Question 2: In Jainism it is clearly stated that consciousness and soul (jîva) are eternal.

It is also stated that minerals and elementary beings earth-bodied or (prithiv k ya), water-bodied (*jalak ya*), air-bodied (*v yuk ya*) and fire-bodied (agnik ya) beings have a j va. Minerals certainly have no organic brain structure.

When any living being dies, it leaves its physical body (aud rika ar ra) including its complex brain structure. Almost immediately - after the very small interval necessary to move from one place to another - it embodies itself in a subtle ar ra or etheric body. Death is not an end, nor is birth a beginning. Both are just points or events within the cyclic continuity of life and consciousness. Life and death in Jainism do not have the same significance as they generally have in the occidental cultures. This subtle body is invisible and not measurable by any means available to science. Two other bodies, the k rmana and taijas ar ra always remain with the soul between death and rebirth (rebirth either in an audarika or a vaikriya body), and these too have no physical brain at their disposal. It is not logically possible that the imperceptible bodies build or contain structures which are as complex or even more refined and complex than the physical brain. In any case, according to Jainism (and many other thought systems), consciousness and life continue after death. Experiences, conscious states of existence, described as to exist in many different non-physical environments, are the experienced states of consciousness which result from the activity of the mind when embodied in a

physical brain in the most recent life. These experiences, called 'hells' (*naraka*) and 'heavens' (*devaloka*) in Jainism are states of consciousness experience as well as states of embodiment in vaikriya matter.

Therefore the answer to the second question seems to be: No, consciousness is a function of the physical brain; consciousness can not exist where there is no physical brain.

Question 3: What is the ultimate essence of the living universe: a) physical matter; b) consciousness; c) life; d) life and consciousness; or e) matter, life and consciousness?

Consciousness can exist independent of a physical brain; consciousness can exist within physical beings without a brain. Consciousness existed before (as the eternal soul itself) the physical brain came into existence, as well as after its destruction. Also, consciousness can exist without any (organic) brain or nervous system at all, as in minerals.

Modern biological studies have shown that microorganisms are able to perceive and process information without brains, but that conscious processes have a relation with the cytoskeleton and the cell membrane. Moving cells perceive light as well as chemical and tactile information and react in individual ways. Cytologist Albrecht-Buehler (2013) in his web-article Cell Intelligence describes in detail how two perpendicular microtubuli in the centrosome of a moving cell have lightsensitive spots which give the cell the possibility to three-dimensionality and determine the direction of incoming light. The information thus acquired is transported electrically along the cytoskeleton related 'nervous' system in the cytoplasm of cells and the transfer of this information to induce particular parts of the cytoplasm to form pseudopodia that make the cell move in a chosen direction. Perception, and sending out electrical energy into different reactions to influence cytoplasm is focused in the centrosome outside the cell's nucleus, and the processes maintain no direct relationship with the genetic code inside the nucleus. The jîva, takes the initiative to both thought activity (bh va karma) and the formation of a nervous system and brain. The sequence is Consciousness fi Mind fi Brain.

Physical consciousness only makes sense when there is a physical body. If physical consciousness exists outside the physical body (e.g. after death) it must be memory, because the sense organs to receive new input of physical information are absent. Also the vaikriya body has sense perception on its own level, but vaikriyika

pudgala is not hindered by physical obstructions. Emotional, psychological, intellectual and mental consciousness is not confined to the physical body, because as Jainism describes (as do other spiritual thought systems as well as scientific research related to near-death experiences) these forms of consciousness also exist after death in absence of the physical brain. Most living beings react on basis of the inherent properties of the one to five senses they have developed - we would say instinctively - and not always on their own individual discriminating mind. We see, in Jainism as well as modern biology, that simple organisms have a very simple nervous system or no nervous system at all - so no brain either. But the higher they climb, the closer they approach the moment of acquiring an individual mind and mental consciousness. Parallel to this development we see the development, first of a very basic nervous system with a few ganglia (nerve cell clusters) in less than fivesensed beings, and a much extended development of mental activity and a brain structure in the five-sensed beings (animals and humans). So we can conclude that development of an individual mind and complex nervous systems go hand in hand. Therefore, it seems legitimate to conclude that we have to distinguish between a soul consciousness and soul-mind, but that mind is karmically so much limited in the most primitive beings that it cannot express it at all for the individual consciousness, which then is uniquely focused on sense-perception.

The difference with the present mainstream opinion in the western culture is that in Jainism both consciousness and intelligence existed previous to the nervous system and brain structures, and before physical complexity. Consciousness beyond one sense develops in relation to the development of a physical nervous system. However the fact – according to Jainism and occultism – that even minerals and invisible beings are conscious living beings, indicates that consciousness is not an arising property of a nervous system and its complexity. So the conclusion is: consciousness and intelligence and life were always and will always be; mind (discrimination) arises at cyclic intervals within the soul; physical structures are built to provide the j va a fit vehicle on the physical level of Madhyaloka. This is done according to conscious cause and effect, and the jîva is the only conscious substance in the universe.

The mind does not disappear when the physical brain perishes. It only loses the function to take conscious action. Only during physical embodiment, apparently the inertia of matter is large enough for a soul to practice yoga and reach final liberation from all types of matter. After death, and before rebirth, the mind experiences the manifested universe according to what it learned and concluded from thinking during physical life – not more than that.

So we may conclude that the finer bodies can harbour high complexity as does the physical body.

Here again we see that western science shakes on its fundamentals when studying Jainism (and other systems) and occult sciences. From Jain point of view we can completely discard the option of consciousness and mind being a product of matter. So we may conclude that the finer bodies can harbor high complexity as does the brain. Trying to find consciousness as a product of the brain is no option; on the other side we affirm that mind as well as brain is a product of consciousness when it works on different types of pudgala. Also for the manifestations of life and consciousness the other dravyas (space, time motion, and inertia) are indispensible. In that sense we can say that all dravyas are equally essential.

In the above we find all the ingredients we need to explain the relation between consciousness, mind and brain. Therefore, from a Jain point of view matter does not arise from life/ consciousness, nor do life and/or consciousness arise from matter. It is therefore futile to search for consciousness in pudgala or matter itself, however refined the type of matter may be.

Jainism is a dualistic system, and matter (*pudgala*) is regarded as an equally eternal separate substance as are soul and the other substances (*dravyas*). In nondualistic systems, such as Advaita Ved nta, Buddhism and Theosophy, j va (tman, tma-buddhi, monad) and matter are non-separate substances other than in a relative sense and therefore the difference between life and non-life, consciousness and non-consciousness, mind and non-mind does not really exist.

There is but one essence. Spirit and matter are one.

Though *pudgala* and *j* va in Jainism have no properties in common, they can 'recognize' each other, consciously and unconsciously, on the basis of commonality, and a mechanism that creates and maintains bondage (*bandha*) between them. Matter, being lifeless and non-conscious, cannot form meaningful and functional complexities out of itself alone. The main touch properties of *pudgalic* atoms are *snigdha* (smoothness, viscosity) and *r k*?*a* (dryness, roughness) of different intensities. What it means in practice is that some can combine and others cannot. But there is no purposeful guiding faculty in *pudgala*. *J* va on the other hand cannot

build any structure on its own, because it is matter-less.

Question 4: Is consciousness evanescent or eternal – and is it ever interrupted?

We learn from Jainism that consciousness is without beginning and eternal. But what about 'unconsciousness' when we fall asleep or faint? If consciousness is eternal it can never be interrupted, because then it would repeatedly have a beginning and an end. Therefore true unconsciousness cannot exist; or, from an anek ntic point of view, it can be said that both consciousness and unconsciousness can exist at the same time. Consciousness can, however, have different phases, in which one phase is unable to recognize the other. For example in waking consciousness we have no access to deep sleep consciousness. However, , because consciousness itself is unbroken, there must be another reason. This reason lies in the memory: memory is unable to carry conscious experience from one phase of matter to another. In deep sleep or death, in which the physical body or audarika ar ra is paralyzed while the k rma?a and the taijasa ar ra are active, the consciousness takes place in a phase of matter which is too refined to be 'translated' towards physical matter. Even though the physical mind is inactive, consciousness is fully alive, as Jainism teaches also in relation to after-death states. Great yogis live consciously in a very high state in the higher heavens. Therefore the so-called unconscious states during hypnosis, anesthesia, sleep and death are not at all nonconscious.

Trained yogis can remember their consciousness in unbroken sequence, and thus transfer some of their knowledge gained during their sam dhis to common, untrained people. This explains the fact that some people have been able to give detailed information about heavens and hells and other states to which we normally have no access.

A materialistic scientist however excludes himself *a priori* from even inquiring into these worlds which are connected with finer states of matter and consciousness. The science of consciousness and mind can only make progress if it very seriously and systematically investigates reports of near-death experiences, mystical experiences, (eastern) spiritual literature, and mythology beyond its externally phrased expressions. The subtle types of matter as well as other phases of consciousness in relation with these have their own laws of nature in which many concepts which are defined within the realm of physical matter have no value.

An example is that in Jainism 'gods', i.e. beings in a vaikriya ar ra, can move with speeds which are higher than the speed of light, and that the *jîva* can move from one place to another 'instantly.' This information comes from true knowledge about a 'trans-physics' about which present day quantum physics can but vaguely speculate, all the while building the weirdest theories. If we wish to understand the true workings of the mind, we must first develop some understanding of what is beyond the brain mind. True science will include and, after research, be able to explain all psychic and 'paranormal' phenomena and 'miracles' as well as the many unknown aspects of astronomy and cosmology. Humanity will need this knowledge to explain the genesis and workings of the universe. Without making this step that is so clearly pointed out by Jainism and many other thought systems which are, or originally were, based on actual knowledge of the occult sciences (i.e. the true and complete knowledge about the universe), western science will remain in its self-created material treadmill. Luckily, many progressive scientists are already beginning to have an intuition about such things. Consciousness exists in many phases and forms, and each of these has built its proper substantial vehicles, but not (only) of physical matter.

Question 5: Is there a causal relation between consciousness and the composition of material structures resulting in complexity? And if so is the direction of cause and effect unilateral or reciprocal?

Causality is in Jainism (as well as Buddhism, Hinduism, Theosophy and pre-Columbian Native American, ancient Greek and ancient European religions) expressed as karma (using different terms of course) – an absolute, consciousnessconnected and universal tendency or working or natural law. Karma is complex, because it plays in all phases of consciousness up to and beyond the divine. Every action (including mental and emotional inner action) of every living being (*jîva*, soul) leads to its proper and just result. It is due to karma that infinite change and diversity exist in the universe, and it applies to the tiniest microbe as well highest divinity in the visible and invisible cycles of existence.

This implies that from a religio-philosophical point of view a system like quantum physics, in which fake concepts like 'absolute chance' and 'absolute unpredictability' are presupposed, has no real value. It is rather an absurdity; because when the link between cause and effect would be interrupted or collapsed, 'good' can turn into 'bad' and nothing can be predicted. Such a system, at least in

some interpretations would lead (and has led already) to regarding the universe as a completely chaotic and lawless mixture of matter. Any system that tries to explain the existence of consciousness, life as an emergent product of physical matter as seen by quantum physics will fail, and can, from a Jain point of view immediately be thrown in the garbage bin. Karma is the only explanation for order and logical causality in the universe, and for the existence of the intuitive fact of justice.

Still, the results of research of the nervous system and the brain, including the details about information transfer between synapses etc., either though a cell membrane of through an open bridge, is extremely exciting, and even becomes more interesting when we realize that it will lead to an increasing understanding of our most miraculous power of soul-consciousness. A good example is found in the research by Stuart Hameroff, among others, to which ample attention is given by Dr. S.S. Pokharna in this volume. However, science should stop trying to find the cause of consciousness, life and mind in the brain, because it is the other way round: consciousness, life and the desire to perceive and think are the cause of the brain. It is awe-inspiring to see how the tremendous complexity and intelligence of consciousness of the inner being of all living beings reflects itself in a physical structure of which at present we know only but a very little bit. The research should however try to leave quantum physics behind and try to penetrate more subtle phases of matter and its laws and habits; it's innate but 'implicate' orders. Quantum physics intuits in the direction of some of the properties of such finer matter, but a concept 'absolute chance' is speculative and only expresses our ignorance of finer pudgalas. There is a deeper order within every order.

To summarize, from a Jain and occult point of view, the ideas of consciousness as an emergent property inherent in physical matter, as well as the role of 'chance' should be discarded.

2. Views of Some Scientists about Consciousness and the Brain

It may be useful in the context of the above discussion to recall what some of the great scientific brains in the west, like Eccles, Albrecht-Buehler, Willis Harman, Karl Popper, Richard Dixey and David Bohm, many of them Nobel laureates, have said about consciousness. Especially in the last quarter of the twentieth century and after, more intuitive voices began to rise within the scientific community. One example is John Eccles, a brain scientist, and Nobel Prize winner in 1963 for his work on synapses (contact structures connecting nerve cells). He wrote some fifteen books about brain and consciousness, and notable are his last published works, before he died in 1997: Evolution of the Brain (1989), Consciousness explained (1991) and How the Self Controls the Brain? (1994). His view was that "we have a non-material mind or self which acts upon, and is influenced by, our material brains; there is a mental world in addition to the physical world, and the two interact." Elsewhere he accepts the possibility that this non-material mind may survive physical death. Eccles, with philosopher Karl Popper (1902–1994), was of the view that there are three worlds:

1. Physical objects and states (including the physical brain);

2. States of consciousness (the experience of: perception by the (five) senses, thinking, emotions, dispositional intentions, memories, dreams, and creative imagination). It also includes the 'self.', or, as Jains would say, *j va*. As to this second world, Eccles also says: "In addition (to the coarse levels of perception) there is a level of inner sense, which is the world of more subtle perceptions. It is the world of your emotions, of your feelings of joy and sadness and fear and anger and so on. It includes all your memory, and all your imaginings and planning into the future."

3. Knowledge in the objective sense (which includes culture and written records). Eccles thinks that the mind is not a substance at all, whereas the brain of course consists of matter. However meditative and sophisticated Eccles' views on the world of consciousness are, being a devout Christian apparently unaware of other religious systems, could not solve the problem of: How do the mental world (mind/ consciousness) interact with the physical brain? Eccles has more or less solved this problem in the following way. He writes about this in his How the Self Controls Its Brain? He says that there are fundamental neural units in the cerebral cortex, called 'dendrons,' which are cylindrical bundles of neurons arranged vertically in the six outer layers or laminae of the cortex, each cylinder being about 60 micrometres in diameter. Eccles proposed that each of the 40 million dendrons is linked with a mental unit, or 'psychon,' representing a unitary conscious experience. In willed actions and thought psychons act on dendrons for a moment, increase the probability of the firing of selected neurons through quantum tunneling effect in synaptic exocytosis, while in perception the reverse process takes place.

2.1 Probability

Here, speaking about 'probability', he leans on quantum theory: physical units (i.e. mathematical wave functions) can, according to one interpretation, 'dissolve' instantaneously 'in a superposition of probability waves'. Then later, the 'wave packet' is supposed to spontaneously 'collapse' in some random or unexplained way, into a localized particle again. As the processes are random, causality plays no role in the relation between the first and the second event. Nevertheless Eccles speculates that the mind can influence the probability of neural events. But this is just Eccles' speculation, not knowledge. If the probability is influenced, it is still probability, expressing ignorance of the true processes of cause and effect.

The existence of karma as a fact in Nature can only be accepted by modern science and philosophy if the existence of more subtle types of matter beyond luminous matter is accepted and understood, and not just hinted at, as quantum theory does. It may appear then, in future scientific research, that what nowadays is called 'chance' is just our present ignorance about what Jains call karma pudgala (matter), and k rma?a ar ra (body). When science has left its self-created obstacles of absolute non-causality and of the uniqueness of physical matter, grand new fields of understanding may open up in the next centuries. But, of course, such knowledge of subtle matter and its infinitude of properties, characteristics and processes, cannot be directly acquired by physical instruments. By meticulous systematic study of 'oddities' and of 'paranormal' phenomena, we will discover that concepts of time, speed, size, causality etc., have a different meaning or no meaning at all, in these types of finer-than-ordinary matter. For example, the speed of thought transference may not be limited by the speed of light. It may be faster or instantaneous. Some atoms or composites of atoms of particular types may move much faster than light which is the supposed fastest speed for ordinary matter. In the substance *jîva*, i.e. consciousness/ life, information transference through own gati (realm of existence) universe is instantaneous or in a maximum of four 'moments (samay)' if the soul has to 'travel' from one gati to another.

Apart from our material sense-based instruments and our methods of cognition, future scientists will need to involve their own, subtle, inner 'instruments' or faculties of perception, now a days vaguely called 'clairvoyance' 'spiritual intuition' and ultimately alluded to as 'omniscience.' This however means

that science and western philosophy have to take the major step from the so-called (but not truly existing) objective (independent) cognition to subjective cognition.

2.2 Subtler Matters

If Eccles had known of Jainism, occult Theosophy or other oriental and ancient thought systems (and taken them seriously) he would have immediately understood that the mind which stands over matter itself had to be substantial – or at least common in nature with physical matter - to such an extent that information is communicable between these two substances. He could never have said that mind was completely non-substantial.

What the modern scientific world still has to accept and embrace is the necessity of the existence of degrees or types of matter which are of a more subtle nature, but still, in a deeper, connecting sense, belong to the same Universal Nature of which each and every being and thing is built.

Willis Harman (1994) of the Institute of Noetic Sciences¹ in California says in New Metaphysical Foundations of Modern Science "Modern science is based on two main assumptions: a) separateness – of man from nature, of mind from matter, organism from environment, and b) the separability of the parts of a system or organism of the totality of a system or organism to understand how it 'really' works and by that the scientific picture of reality should be based solely on physical sense data." He calls for an 'extended science' or 'wholeness science,' based on two opposing assumptions: "a) that everything is interconnected, that the physical universe and consciousness, mind and matter, form a fundamental oneness or wholeness; and b) that there are two windows for acquiring knowledge of reality: the objective, through the physical senses, and the subjective, through the intuitive and aesthetic faculties (Harman [2])."

It is notable that Harman said: "Everything is interconnected," like the Jains have said for ages. He also states that "the physical universe and consciousness, mind and matter, form a fundamental oneness" and thus rejects the absolutized

^{1.} The Institute of Noetic Sciences (IONS) (http://www.noetic.org/) is a research institute to encourage and conduct research on noetic theory and human potentials. The institute conducts research on topics such as spontaneous remission, meditation, consciousness, alternative healing practices, consciousness-based healthcare, spirituality, human potential, psychic abilities, psycho-kinesis and survival of consciousness after bodily death. The institute maintains a free database, available on the Internet, with citations to more than 6,500 articles about whether physical and mental health benefits might be connected to meditation and yoga.

duality between life/consciousness on one side and matter as taught by Jainism.

2.3 Information which stands apart from physical matter

Another person contributing to above mentioned institute, Richard Dixey [3], states that 'emergent properties.' like mind and consciousness 'are more than just the product of interactions between the parts of the system concerned.' What has to be added is 'information' This information (Dixey doesn't say where this information is contained or comes from) he says, is "potentially infinite" and "binds itself to matter, giving rise to a law-like behavior of matter, and the new properties that emerge from matter are brought about because matter is arranged in increasingly complex forms on the basis of this information." From a Jain point of view, that 'information' is of the karmic body bound to the *j* va, and the *j* va is infinite in knowledge and time. The difference between Dixey and Jainism is that Dixey puts it the wrong way when he says that 'information is bound to matter.' In stead he should have said: 'information is bound to the soul by the complex arrangement of matter in the form of the karmic body.' He might then have called the 'karma body' the Dixey 'information body' instead. He would then have understood that the refined information contained in this karmic matter would be the blueprint for not only physical matter, but for the tendencies of the mind and feelings as well. Consciousness per se is the j va, but individual experience is karma. Nevertheless he moves in a direction which is closer to the ancient wisdom of many non-western cultures.

2.4 The Mind always Existed

George Wald, a biologist who won the Nobel prize in 1967 for his work on the retina, has stated that "rather than being a very late development of evolution of living things, restricted to organisms with the most complex nervous systems, mind has always existed" and he was of the view that "the universe is life-breeding because the pervasive presence of mind has guided it to be so." "A genetic program can define the molecular composition of the developing organism at any moment in its development, but this is insufficient to explain the processes that lead to a heart, a nervous system, or other morphological features of the organism (Wald [1]). Creation (i.e. the sequence of forms of existence) proceeds from mind and is guided in eternity in each successive creation. George Wald also adds that "the new biology needs to recognize that organisms are 'self-organizing wholes".

2.5 Many Implicate Orders

A progressive thinker was an American quantum physicist who contributed to theoretical physics, philosophy of mind, and neuropsychology. David Bohm is, apart from his own work, famous for his public videotaped discussions with the Tamil Nadu born philosopher J. Krishnamurti and had repeated contact with the Dalai Lama. David Bohm attacks the common view of quantum theory in which 'absolute chance' is the central theme, and he sees no need for a counter-intuitive notion as 'wave-function collapse'. Wave-function collapse in corroboration with the 'absolute-chance' concept destroys the notion of causality. In common quantum theory events can take place without a connected preceding cause. This of course contradicts the Eastern ideas of causality, connectedness and karma. He states, quite logically, that although we are (with our knowledge of the materials of the cosmos) unable to measure the exact locality and motion of a minute particle, they nevertheless follow causal trajectories, guided by a subtler force (the 'quantum potential') - subtler forces I would rather say - operating from a deeper, implicate, more mind-like level of reality. So David Bohm is one of the few scientists who support the idea of a subtler level of force than the forces known and studied by present-day science. He speaks of an 'implicate (i.e. enfolded, involved, connected) order' beyond physically perceptible ordered reality. Bohm argues that "consciousness is not simply a byproduct of (physical) matter, but is rooted deep in the implicate order, and is therefore present to some degree in all material forms." This is in agreement with spiritual and esoteric teachings. He adds that "quantum theory in its present form is incomplete; the wave function does not provide a complete description of quantum systems, and there is, therefore, no need to introduce the ill-defined notion of 'wave-function collapse' (and all the paradoxes that go with it). Instead he proposes that, although we cannot measure their exact motion, particles nevertheless follow causal trajectories, determined not only by conventional physical forces but also by a subtler force, the quantum potential, which operates from a deeper, implicate, more mind like level of reality. Although he believes that human consciousness does not bring quantum systems into existence, and does not significantly affect the outcome of a measurement (except in the case of genuine psycho-kinesis), he argues that consciousness is not simply a byproduct of matter but is rooted deep in the implicate order, and is therefore present to some degree in all material forms." He suggests that there may be an infinite series of implicate orders, each having both a matter aspect and a

consciousness aspect. In Bohm's words, "everything material is also mental and everything mental is also material, but there are many more infinitely subtle levels of matter than we are aware of".

2.6 Several Bodies within One Man

From a Jain point of view, the physical world is just the outer layer of a grand totality, and is formed and maintained from within. It is the *tejas k ya (agni)* or fire body which forms a model of the physical body on basis of the karma body, and within these 'astral' or 'etheric' bodies (to use occidental terms) is impressed the information from within, i.e. the stored desires and thoughts and tendencies brought over from former existences – which are the being's karma – as well as from the continuous immersion of the total being by the monadic or *ja vic* aura. So from the Jaina point of view, David Bohm is close to the truth when he speaks of 'many more ... subtle levels' and an 'implicate' (or innate or inherent) order as well as when he speaks of a multitude of implicate orders.

2.7 Genetic Determinism

If we compare this with the classical Jain teachings, we see that the *j* va has omniscience (universal knowledge and wisdom) as an inherent property, and that the *j* va is the true conscious actor behind every outward event. It is surrounded by the karmic code (the 'information' code of the karmic matter). The five sense-organs themselves, the individual mind and all recent as well as long-past thoughts, emotions are being transferred to the physical level in the (next) body; also our reactions to sensual, psychological and mental impressions are continuously influencing the course of events in near and remote future. What Jains can still teach to science, as I stated repeatedly, is the fact that there are different grades of matter, most of which are more subtle than the coarse form of material body Pudgala which science nowadays studies. Jains can also teach to modern science that, though the cosmic conglomerates of the various material bodies may disintegrate (e.g. as a result of good actions, good thoughts, austerity etc.), the essential being - *j va* - the life and consciousness, never disintegrates, and that thus we ourselves create ourselves; and that external influences, through they may be obstructive or temporarily destructive, do never take away our responsibility for what we are and what happens to us. It would be a great break-through and liberation of the human mind in the world at large if humanity is freed from the belief in genetic or material determinism as taught by the classical neo-Darwinists and the quantum-physical
belief in non-causal events. Another interesting discovery is that our body reacts to stimuli like pain before our personal consciousness becomes aware of it: in other words, the process of transmission within the physiological system is quicker than the transmission of the information to the mental consciousness. By means of a particular instrument, researchers are able to magnetically 'confuse' the part of the brain-nerves through which the information towards mental consciousness is transported - and the patient never becomes aware of the information of say, burning his finger, even though the physiological system has already withdrawn the finger. We should not make the mistake to think that every process of our bodies necessarily has to touch our personal, mental consciousness. Many processes are fully automatic as it were. Information transfer can take place at different speeds; physiologically because it follows different pathways from source to reactive agent. Jainism however teaches that speeds can be enormously greater outside the physical field.

We all know that in the field of psychology particular traumatic experiences may become completely suppressed to below the level of personal consciousness, but they can continue to manifest in dream consciousness or when awake under specific circumstances of stress. Consciousness has many layers, which may be connected by 'blockades' of forgetfulness or by channels of communication, and that such may be sometimes closed and at other times partly or fully open - as far as a lower consciousness can contain the transferred information of the higher.

Willis Harman of the Institute of Noetic Sciences mentioned earlier said when he referred to main stream science: "... the modern scientific world view is inherently flawed and misleading in ways vital to the well-being of individuals and societies, and inimical to the future viability of human civilization.'

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11. Jain And Other Systems of Yoga : Scientific Perspective Sohan Raj Tater and L. C. Jain

Abstract

Yoga is a way to attain the state of union of individual self with the divine spirit or tman. The ultimate aim of yoga is to emancipate the soul. By following different yogic processes, we try to minimize passions, thereby reducing chances of binding of karmas (rava) with the soul. The various yoga systems are described in the paper.

Though Jain yoga has many processes similar to other yoga procedures, there is a well defined distinction which may lead one to get salvation. In the scripture Aac r nga s tra, Jain yoga is explained in detail. Acharya Kundakunda in Samaya sara and Pravachansara, Acharya Umaswami in Tattvarthas tra and Shubhachandracharya in Jn n r?ava have brought out the details of Jain yoga. Jain yoga suggests rules for the conversion of an ordinary soul also known as external soul (bahir tm) to internal soul (antar tm) and finally to super soul (super tma, parm tm -arihant or siddha). The fourteen spiritual developmental stages in the path to attain Siddhahood are discussed.

Key Words: Yoga, Karma

Scriptures Quoted: Ac r nga S tra, Pravacanasara, Rigveda, Patanjali Yoga Sutra

1. Introduction

The word 'yoga' has been derived from the Sanskrit root, '*yuja*' which means binding or union of two or more things. Yoga is a form of mysticism that developed in India from the very ancient times. The philosophy of yoga deals with the nature of the individual soul and the cosmos and the way of unifying them. The practice of yoga, on the other hand, can be any activity that leads or brings the practitioner closer to this mystical union- a state called self realization. Yoga is also known as the spiritual activity which aims at emancipation of the soul [1]. It is the process of getting free from the karmas associated with our soul which force us in continual bondage of reincarnation. The yoga techniques cover a wide range covering physical, mental and spiritual activities. Yoga improves every aspect of physical fitness; the mind/body energy exchange supports a mental clarity and concentration. The strength improves posture/alignment to support daily activities. The flexibility helps to prevent injuries and keeps the body supple and youthful. The breathing practices are the basis and the link between the mind and the body, providing a precious tool for releasing tension and reducing stress. The practice of yoga gives the way to quieten the mind by placing attention on the breath and also on the movement (stillness) of the body [2]. "*Yoga citta-vrtti-nirodha*. Yoga is the inhibition of the activity of the mind " that is how Yoga S tra (1.2) defines it.

Yoga is a healing system of theory and practice; it is the combination of breathing exercises, physical postures and the nervous system and balances the body, mind and spirit. It is thought by its practitioners to prevent specific diseases and maladies by keeping the energy meridians (*n* ?*is*) open and life energy (*pr* ?) flowing. Yoga is a way to attain the state of union of individual self with the divine spirit. In Jainism it is the process of purification of the soul leading to self realization. According to yogic science, this state of union is the highest state in the life of every living being. This state is defined as *Moksha* (liberation/salvation) [3].

The meaning and definition of yoga has been discussed by philosophers and commoners - that yoga is a philosophy that nurtures and connects the body, mind, spirit and soul within ourselves and to one another. Yoga is a way of life, an art of righteous living or an integrated system for the benefit of body, mind and inner spirit. The Geeta [4] defines yoga as evenness temper, it is true union of j v tm (soul) and *Param tman* (omniscient or God) [5]. Yoga means union of the mind, body and spirit with the divine and while this refers to a certain state of consciousness, both individual and universal, it is also a method to help one to reach that goal.

The word yoga occurs in Rigveda in various senses, such as yoking or harnessing, achieving the unachieved [6]. Eliade [7] has rightly suggested that, 'The four basic and interdependent concepts that bring us directly to the core of Indian spirituality are 'karma, 'm y (wealth)',' *nirv* ?*a* (salvation)' and 'yoga''. There are a

large number of yoga systems; each one has its own importance. Twenty two of these systems are tabulated below in Table 1.:

			<u> </u>
1	Jain Yoga	Spiritual practices for purification of soul	
2 Vedic Yoga		<i>Yogic</i> teachings of Rig-Veda	
3 Astanga-Yoga		Eight fold Yoga taught by Patanjali in	
		his Yoga-S tra (198 s tras).	
4	<i>Yoga</i> in	Spiritual yogic traditions in	
	Vedanta	Upanishads-realization of ultimate	
		nature of reality (Brahman)	
5	Jnana Yoga	Union by knowledge	-
6	Bhakti Yoga	Union by love and devotion.	
7	Karma Yoga	Union by action and service	
8	Raja Yoga	Union by mental mastery- the path of will	
9	Hatha Yoga	Union by bodily mastery (principle of	
		breath)	
10	Mantra Yoga	Union by voice and sound.	
11	Yantra Yoga	Vision and form.	
12	Laya and	Union by arousal of latent psychic power	
	Kundalini Yoga		
13	Tantric Yoga	A general form for the physiological	
		discipline	
14	<i>Yoga</i> in	Vipassana meditation	
	Buddhism		
15	Zen Yoga	Attainment of awakening by	
		meditation (Mah y na Buddhism)	
16	<i>Yoga</i> in	Chinese religion- path or way of	
	Taoism	expansion of awareness	
17	<i>Yoga</i> in	Process of making one to understand a	
	Judaism	concept well through analytical study	
18	Yoga in	Way of attaining inner stillness	
	Christianity		
19	Yoga in Islam	Establishing the connection between	
		the creator and creation which guides	
		the soul to truth.	
20	Yoga in Sufism	Inner transformation of heart for	
		extinction of ego.	
21	<i>Yoga</i> in	There are 10 gates (chakras- energy	
	Sikkhism	centers) and top is dasam dwar which	
		is highest stage of attainment	
22	Kriya Yoga	Movement of Consciousness	

Table 1. Various yoga systems and their approach

1.1. The Jain Yoga System

Jainism like other systems of 'Indian Philosophy' does not aim only at intellectual explanation of meditation known as Yoga (merging of the finite with the infinite) Dhy na, (meditation) and Sam dhi [8,9]. The history of the Jain yoga, based on an extensive research of ancient literature, Temples and statues, and archeological sites is very nicely documented in the DVD by Deepika Kothari and Ramjee. The Jain Yoga dates back to the first T rtha?kar Rishabhdeva [10]. The statues of Jain T rtha?karas in *K* yotsarga or meditative posture can be seen in nearly all Jain temples which confirm that Jain yoga is as old as Jain religion. Meditation is the backbone of Jain religion. Lord Rishabhdeva, dating back to the prehistoric era of end of the stone age and starting of the agriculture age, practiced meditation and attained enlightenment on Mount Kailash [10,11]. Bahubali, son of Lord Rishabha deva, practiced meditation for twelve months maintaining same standing posture K yotsarga and Kha?ag sana [12] and attained enlightenment. Bharat, the elder son of Rishabhdeva, entered a trance state by fixing his gaze on his image in the mirror and got deep into meditation and finally attained enlightenment [13]. This idea of fixing the gaze on an object for meditation has been an important technique of Jainism [14]. The Jain yoga has been described in the Jain literature like c r ?ga S tra and Samayas ra [15]. The S trak?t ?ga, Bhagavati Ar dhana and Sthananga S tras also give directions on contemplation, sanas and meditation. The Aupapatika has an organized presentation of Tapo-yoga which is a kind of right conduct. Acharya Bhadrabahu of 400 BCE, practiced Mah pr ?a meditation for twelve years [16]. Description of practice of Sam dhi (meditation) by many Acharyas is also found. Acharya Kundkunda of first century was the pioneer scholar and a great saint who wrote books like Samayas ra and Pravacans ra etc. which deal with Jain Yoga and meditation methods. The holistic approach to the path of salvation, was written and compiled in a single book, "Tattv rth S tra" by Acharya Umaswati also known as Umaswami [17,18,19].

Acharya Bhadrabahu II, Jinbhadra and Pujyapada Devnandi were great spiritual experts during the 4th, 5th and 6th centuries CE. They made remarkable contributions through their literature. Haribhadra in the 8th century and Acharya Hemchandra in the 12th century, presented meditation through different approaches and view points. During the 18th century, Acharya Vinay Vijay wrote

h ntsudh rasa on contemplation practices. Upadhyaya Yashovijaya in the same century wrote extensively on meditation [20].

Acharya Mahaprajna formulated Preksha Meditation in 1970 and presented a well organized system of meditation [21,22]. Numerous Preksha Meditation centers came into existence afterwards (see Appendix 1 for more details).

1.2 Dependence of Yoga on Karma

As the karmas play very important role in spiritual yoga, we have different definitions of spiritual or Jain yoga depending on the different types of karmas. These are : 1) Intention type yoga. This type of yoga depends on the intention of work done by mind, speech and body [23]. 2) Influx type yoga (*a hrava* type). The influx of karmas takes place as a result of activities of mind, body, speech and passions, known as *ka*? *ya* [18,19]. 3) Resultant type yoga. The vibrations produced in the soul as a result of activities of mind, speech and body [24,25,26].

1.3 Three Jewels of Jainism (Ratnatraya)

Rational perception or faith (samyak dar ana), Rational knowledge (samyak jñ na) and Rational conduct (samyak c ritra) together constitute the path to liberation (mok?a m rga). These are the opening lines of famous book "Tattv rth Sutra" written by Jain Aacharya Umasvati in second century CE [18, 19]. These are known as the three Jewels (Ratnatraya) of Jainism. Aacharya Umaswati`s Tattvartha S tra is a systematic and comprehensive presentation of Jainism. As the name implies, it is a brief treatise on aspects of reality (Tattva), which include living beings (*j va*), non living entities (*aj va*), influx of karmic matter (*asrava*), binding of karmic matter (bandh), stopping of karmic influx (a rava stoppage of Karma) (samvar), shedding of karmas (nirjara) and liberation/salvation (mok?a). In the process of discussing these aspects of reality, Acharya Umaswati presents the theory of karma and path to liberation. Rational perception essentially entails an inclination, attitude or frame of mind which is free from any predisposition or preconceived notions. Thus when one gives up all preconceived ideas and accepts the concepts of reality and attains rational perception. As soon as one has rational perception, one's knowledge becomes rational knowledge. The conduct based on rational perception and knowledge is rational conduct.

1.4 Pre conditions for Jain yoga

In Jainism there is mandatory emphasis on purity of mind, speech and body of self and also of ambient environment. The twelve austerities (*Tapas*), six external and six internal, are practices to cleanse mind and body. Discipline in taking meals,

taking less than required to quench hunger, fasting, abstaining from taking certain heavy food such as butter and oil, green vegetables and many such items, not caring for comforts while sitting, sleeping etc. are external *Tapas*. Repentance for one's wrong deeds, humility, to renounce worldly material things, study and meditation are internal *"Tapas."* There is mention of postures in scriptures. *'Kayaklesha'* prescribed in Jainism implies practices of sitting, standing, sleeping etc. to condition the body to tolerate hardship or discomfort and for the sake of having proper self control (*Samyam*) in daily routine [27].

Pranayama has been described in Jain scriptures essentially in the same way as in vedic scriptures. Acharya Shubhachandra in his very famous Jain scripture Jñ n r?ava [28] says, A yogi who has won over his senses by practicing pranayama can destroy his intense demerits (*P pa*) accumulated over hundreds of births within 48 minutes. But he also states that a practitioner may feel pain during the period of retention of breath; inside or outside, and during such periods there is a possibility of *rtadhy na*, in which case a knowledgeable person also may divert away from the very goal of *pr ? y ma*. The *pr ? y ma* should not be done by those who intend salvation.

1.5 Classification of Practitioners Performing Jain Meditation and Various Stages of Spiritual Development (*gu? sthana*)

As an individual achieves spiritual progress, his mental states become successively immaculate. Consequently, he progresses along the various stages of spiritual development (*Gu?asth na*). The fourteen stages of spiritual development are :

1. Having deluded or irrational knowledge (*mithy d?sti*), 2. With slight test of right knowlege (*Sasadana*), 3. Mixed or partially rational (*Mi ra*), 4. Vowless rational (*Avirat Samyakatva*), 5. Partial vow (*De avirat*), 6. Imperfect vow (*Pramatta Virata*), 7. Perfect vow (*Apramatta Virata*), 8. New thought activity (*Apurva Karana*), 9. Advanced thought activity (*Aniv?ti karana*), 10. Slight delusion (*Suk ma Sampar ya*), 11. Subsided delusion (*Upa anta moha*), 12. Delusion free (*K?i?a moha*), 13. Active Omniscient (*Sayog keval*), 14 Inactive omniscient (*Ayog keval*) [17]. The complete details of the above fourteen stages can be obtained from Jain scriptures. [18, 19, 26]. Now, the practitioners of Jain yoga are divided into three categories based upon these stages of spiritual development [29, 30, 39]:

(a) External souls (Bahir tm) practitioners from 1 to 3 spiritual stages

(b) Internal souls (Antar tm) practitioners from 4 to 12 spiritual stage

(c) Omniscient (*Param tm*) practitioners in 13 and 14 spiritual stages

External soul persons are defined as those who don't have faith in soul, God, heaven-hell, merit-demerit etc. These persons are greedy of all the worldly pleasures. There are many inherent weaknesses present in external souls e.g. lust, anger, pride, greed, attachment, aversion and fear etc. These weaknesses are the serious causes for binding of Karmas. There are three corrective measures to minimize these: 1. Self control (*Damana*), 2. Legal-check (amana) and 3. Direction - change (*Di a Parivartana*) [31].

An external soul (*Bahir tm*) transforms into internal soul when one develops faith in the existence of soul, merits and demerits and other tenets of Jain Philosophy. The inner soul persons are divided in three categories as per their behavior [29,32]. It is to be noted that real yoga and meditation begin only when one develops inner soul. The three categories are :

- A. Crude Inner Soul (Jaghanya antar tm) First stage of yoga practice.
- B. Medium Inner Soul (*Madhyam antar tm*) Second stage of yoga practice.
- C. Ultimate Inner Soul (Uttam antar tm) Third stage of yoga practice.

A. Crude Inner Soul (jaghanya antar tm) - First Stage of Yoga Practice

Those persons who believe in the existence of soul, omniscients, merits, demerits, heaven, hell etc. but give preference to worldly comforts and may even digress away from religion in favour of worldly wealth, are known as crude inner souls persons. Such persons are very enthusiastic towards the various religious observances like fasting etc. but they are not very firm about them.

Penance and vows (*vratas*) are very essential for purification of soul. Some of the vows to be followed by the persons of this category include seven restraints - not eating meat, not drinking liquor, not taking honey, not eating five fruits (*udamber*), not causing intense violence, avoiding gambling and prostitution. He should be submissive, do charity, do self study (*Sw dhy ya*), should have self-control (*Sa? yama*) and should practice tapa everyday. Such a person is known to having achieved the fourth stage. Normally, all persons are born in the first stage of spirituality, but, all the T rtha?karas are born in the fourth spiritual stage.

B. Medium Internal Soul (Madhyam Antar t
m $\,$) - Second Stage of Yoga Practice

When an individual is face to face with reality he/she starts thinking about the self i.e. about the soul. They start keeping away from all the worldly comforts

and climb eleven spiritual steps known as stages of renunciation (pratimayen). This then becomes the transition period of their life. These medium internal soul persons are supposed to be in fifth spiritual stage. Jain followers in the 4th and 5th stages mandatorily observe five vows of non violence, truthfulness, non stealing, non consumerism and celibacy. The medium internal soul persons practice other religious procedures like *K yotsarga* and *S m yika* etc. for higher spiritual development.

K yotsarga

K yotsarga literally means rising above the body level coupled with higher degree of conscious awareness. *K* yotsarga is the mandatory part of meditation. In practice, it is conscious suspension of all gross movements of the body resulting in relaxation of the skeletal muscles and drastic reduction of metabolic activities. This physical condition results in relieving mental tensions. *K* yotsarga is required for the concentration of mind and body. In the living condition, renunciation of body is known as *K* yotsarga [31, 33]. As we know, there is maximum attachment towards one`s own body hence, it is quite difficult to practice this. The process is completed in four steps.

1. *Gupti*, 2. *Sanyam* (self-restraint) 3. *Samvara* (stopping of karmic influx) 4. *Ty ga* (Renunciation).

Gupti- Gupti is the process of protecting the mind, speech and body from all types of activities.

<u>Sanyama</u>- It is self-control on the various activities of mind, speech and body. At the time of fasting or in the observance of big vows, self restraint is very essential.

Samvara- The mind and sense organs are responsible for many unwanted activities. The process of stopping of influx of karmas by controlling the mind, speech and body is known as *samvara*.

Ty ga- A common human being is very conscious of his body. An ascetic is not supposed to have any such attachment. He has to have tolerance power to bear extreme hot and cold weather and other extreme conditions and to remain hungry/ thirsty during fasting periods. This renunciation of body charm is known as body charm renunciation (*kaya mamatva ty ga*).

S m yika

S m yika is one of the most important spiritual practice of Jainism during which we try to come closer to our soul. During s m yika we sit down at one place in

meditating state for forty eight minutes isolating ourselves from our daily household and business works [32, 34, 35]. It is the process by which the practitioner starts feeling the presence of his soul. For this, he is to concentrate deeply and has to think only about his soul forgetting about everything else. The word S m yika has been derived from the Sanskrit word "*Samaya*" - meaning tman (soul). There are eight requirements for correct performance of S m yika.

1. Appropriate time: (a) in the morning about two hours before sunrise is supposed to be the best time, (b) in afternoon between 12 to 12.30 pm, and (c) in the evening before sunset or in the night before sleeping.

2. Appropriate place: The place should be isolated having entry of fresh air. As far as possible, *samayika* should be performed at the same place every day.

3. Appropriate sitting material: Some soft material (*chat i*) may be used.

4. Appropriate posture: *Padm sana, Vajr sana, Siddh sana, Kha?g sana* etc. may be selected. *Sukh sana* is a very comfortable posture.

5. varta: When both palms are brought together and the combination is rotated circularly in the right hand direction and the *Navakar Mantra* is continuously recited, it is known as *varta*. The *varta* has to be performed thrice both in the beginning and in the end of S m yika.

6. *Shironati*: In standing position, bring both palms together and keep forehead on this combination and bow head before *Jinendra Deva* directly or indirectly. This is known as *ironati*. In each direction after three *varta*, one *ronati* has to be performed.

7. Facial Expression: The practitioner`s face should appear just like that of a newly born child who has a smiling face without any tension.

8. Reverence: The practitioner should have a feeling of respect for all the living beings of the world. He should not have any pride, passion or boasting in his mind. He should apologize to all living beings and should forgive every being before starting *S m yika*. In *Sm yika Namaskar Mantra* should be recited 108 times which is known as *Japa*. The recitation is for 108 times for the reason that the merits of the five great souls are of 108 types.

(ii) Benefits of Japa

- 1. Unwanted wandering of mind is stopped.
- 2. Mind becomes fresh.

- 3. Demerits are shortened.
- 4. Mind gets peace and stability.
- 5. Mind gets ready for meditation.

The details of various Japa may be found in Jain scriptures. [31,32]

C. Purest Internal Soul (uttam antar tm): Third Stage of Yoga Practice

When a person with medium soul has practiced self restraint on all sense organs and mind, has adopted eleven stages of renunciation and has become disciple of some Jain ascetic, he is known as a sage with ultimate internal soul. Such an ascetic has to follow all norms as prescribed in scriptures. He/she is now on the spiritual path of emancipation. The liberation seeker ascetic always tries to prevent the inflow of karmas. There are six ways to accomplish such prevention - Gupti, Samiti, Dharma, Anupreksha, Par sahajay and C ritra [26,31]. Gupti consists of properly restraining the mental, vocal and physical faculties. Samiti consists of maintaining vigilance while making movement, while speaking, while accepting the required articles, while moving any object and while disposing the waste (excreta). These are called Irya Samiti, Bhasha Samiti, E?a?a Samiti, Adana nishchepan Samiti and Utsarga Samiti. Gupti and samiti are meant to protect the life of minute organisms. Dharma means the attributes that constitute a spiritually purposeful religion. These attributes are : forgiveness, mildness, straight forwardness, purity, truth, self restraint, austerity, renouncing, absence of possession and celibacy (26,32,40). Forgiveness necessitates the spirit of forbearance and a sense of equanimity. Mildness means humbleness, which is a prerequisite for forbearance. Straight forwardness denotes absence of crookedness, deceit, duplicity, etc. and a positive sense of sincerity and honesty of purpose. Purity means cleanliness, a sense of removal of attachments that pollutes the soul. Truth means verbal truth, absence of ambiguity etc. Self restraint implies restraining of five sense organs, observance of five major restraints, overcoming of four defilements and refraining of mental verbal and physical faculties. It stipulates refraining from every activity that hurts the true self. Austerities are of two kinds, external austerities and internal austerities. Fasting, eating less than required, curtailing the varieties of eatables, control over tastes, lonely habitation, and facing the hardships constitute the external austerities. Repentance, modesty, service, self-study, renouncing and meditation constitute the internal austerities. Renouncing can also be of two types,

external and internal. Giving up the worldly possessions is external renouncing. Giving up attachment for sense objects and overcoming of craving, aversion, anger animosity, arrogance etc. constitute internal renouncing. Absence of possession is a refinement of renouncing. It emphasizes on giving up the sense of belonging than on merely giving up the tangibles. Celibacy is not only non- indulgence in sexual pleasure but staying within the self, tuned to the soul. Contemplations on the evanescence, helplessness, worldliness, aloneness, otherness, nature of universe, rarity of right guidance and tenets of Lord [36] constitute Anuprek?h . Pari?haha jay consists of bearing hardships for the sake of staying on the right path and for eliminating the bondage of karma. Hunger, thirst, cold, heat, insect bite, unclad state, despise, seduction, moving about, steady posture, rough bed, reproach, injury, going for alms, facing disadvantage, disease, thorny grass, dirtiness, honor or award, intelligence, nescience and failure to comprehend some thing disired are the main hardships. These hardships are of twenty two types. Only eleven hardships remain in the omniscient stage and none in the liberated state. Charitra means putting the precepts into practice [26,27]. The term is used in context of monastic life. The first requirement of monastic life is gaining of equanimity. A monk undertakes special types of penance and austerities. With spiritual progress, the monk overcomes all types of defilements except the very subtle, wholesome attachments. Finally the monk reaches a stage of total detachment. For the preservation of equanimity one should cultivate friendship (ma tri) with all beings, appreciation (Pramoda) for the superior, compassion and sympathy (Karu?) for the afflicted and indifference ((Madhyasthata) for the unruly.

The *C* ritra is of five types depending on the different states (*Bhava*) in the soul. The five types are: 1. Samayik charitra, 2. Chedopsthapna charitra, 3. Parihar vishuddhi charitra, 4. Sukshma charitra and Yathakhyat charitra.

1.6 Meaning of Jain Dhyana (contemplation)

When a monk, meditating on an object, has a deportment, devoid of aspiration, it is said that he has reached the state of absolute meditation or *Dhyana*. The other way of defining *Dhyana* is : "Don`t act, don`t talk, don`t think at all, so that the soul is steady and is content in the self. This is the supreme meditation or *Dhyana*" [37].

Types of Dhy na : There are four types of Dhyana, namely - Arta Dhyana,

Roudra Dhyana, Dharma Dhyana and *Shukla Dhyana*. Out of these, *Dharm Dhyana* and *Shukla Dhyana* are effective in attaining salvation and are discussed here [28, 42].

- i. Dharm Dhy na : To worship '*Panch Parmeshthi*' (*Arihant, Siddha, Acharya, Upadhyaya* and all sages), to read Jain scriptures, to meditate over the basic Jain ideological principles, to concentrate mind on the *Ratnatraya* and self discipline, is known as *Dharm Dhy na*.
- ii. *ukla Dhy na* : In the soul having right faith, right knowledge and right conduct, there is gradual decrease in the worldly attachments that produces the state of *Shukla Dhy na*.
- iii. *Preksha-dhy na* : When breath is inhaled and exhaled, vibrations are generated throughout the body which stimulate inner body organs, knowledge-centers, consciousness-centers and internal power-centers. When all these centers are visualized with fullest concentration, it is known as *Preksha-dhyana* meditation [20,21,22].

In this meditation, length of the breath is increased slowly, concentration is on the nostrils, eyes are kept closed and respiration is visualized. Full effort is made to concentrate only on the breath entering and leaving nostrils. Under very deep concentration state, various psychic centers of the body are activated, as shown in the following Table [28,31,32].

1	Anus	Center of energy	Body power increased
2	Abdomen	Center of health	Body power increased
3	Navel	Luminous (tejas)	Strength produced
4	Throat	Center of purity	Purity of brain
5	Nostrils	Center of vital energy	y Extreme vitality
6	Heart	Center of bliss	Utter pleasure
7	Eye brows	Center of intuition	Right faith
8	Forehead	Center of enlightenme	ent Immense peace of mind
9	Brain center	Center of knowledge	Knowledge of Truth obtained
10	Brain`s back	Super knowledge	Expanded clairvoyance
		center	obtained

Thus, it is found that in the long breathing perception the pineal gland, which is situated at the back of the brain, is activated and results in attaining right knowledge and many other super natural powers (*Riddhis*) [26] as shown below.

Group no.	Name of the group & no. of <i>Riddhis</i> (in bracket)	Names of <i>Riddhis</i>
1	Intellect Riddhi (11)	Omniscience (Kevalajñ na Riddhi)
		cognition of mental state
		Riddhi (Mana?paryaya Riddhi),
		clairvoyance Riddhi (Avadhi
		<i>jñ na Riddhi)</i> etc.
2	Body formation riddhi	Large (A?im), small
	(Vaikriya Riddhi) (11)	(Laghim), Shining(Mahim) etc.
3	Activity Riddhi(Kriya	Walking above ground surface
	Riddi)(9)	(Ja?gh c ra?a Riddhi),
		skywalking riddhi (Vyom c ra?a
		<i>Riddhi</i>) etc.
4	Austerity Riddhi (Tapa	Strong austerity(Ugra tapa),
	Riddi)(7)	Deept tapa, Tapt tapa etc.
5	Strength Riddhi (Bal	Mental power (Mano Bala), Speech
	Riddhi)(3)	power (Vacana Bala) & Body
		power (K ya Bala)
6	Medicine Riddhi	mar?au?adh, Khillo?audh etc.
	(Aushadha Riddhi)(8)	
7	Juice Riddhi (Ras Riddhi)	shivish rasa, Dhrishtivish rasa
	(6)	etc.
8	Locality/Area Riddhi	Ak? na, Mah nasa, Mahalya
	(K?iti/K?etra Riddhi (2)	

The meditator is blessed with the Riddhis for two different purposes:

- (1) For procuring powers which may be used for destructive purposes. The famous example is that of Deepayan Muni who blazed Dwarika.
- (2) For the purpose of attaining salvation, which are used only for spiritual purposes. Total number of *Riddhis* is sixty four; the details of which may be found in any of the referred books.

In the above context it is to be noted that <u>Keval jnana Riddhi</u> is obtained only by the omniscient and other intellect *Riddhis* are obtained by the ascetics possessing higher order of *Gunsthan*. Aacharya Kund kund was possessing "*Kriya Riddhi*" due to which he could travel in the sky. He had visited "*Videh Kshetra*"- a place in Jambudweep and attended "*samvasaran* of Lord *Seemandhar* Swami which clarified many of his doubts. He composed scriptural texts like Samayasar, Niyamsar, Pravachansar etc. [30, 43, 44, 45, 46]. Mahamuni Vishnu kumar saved lives of seven hundred Munis (ascetics) using "*Vaikriya Riddhi*".

Param tm (Oomniscient)

Param tm (omniscient) is the supreme soul possessing infinite knowledge, infinite perception, infinite happiness and infinite vigour after eliminating four Ghatiya karmas. There are two types of *Param tm*, namely *Sakal Param tm* and *Nikal Param tm*.

(i) Sakala Param tm - Thirteenth Stage of Yoga Practice

The meaning of *sakala* is along with body. Thus that supreme soul which has destroyed all the *Ghatiya Karmas* and is having physical existence, is known as *Sakala Param tm* or *Arihant*. *Arihant* has forty-six qualities which are divided into five groups which are known as *Panchashcharya* [1,31,43].

In the early thirteenth stage of spiritual development of *Arihant*, there are four *pr* ?*a* (life energies): speech *pr* ?*a*, body *pr* ?*a*, life span *pr* ?*a* and breathing *pr* ?*a* but at the end of thirteenth stage of spiritual development only two *pr* ?*a* remain-life span *pr* ?*a* and body *pr* ?*a*.

(ii) Nikala Param tm - Last stage of Yoga Practice

In the fourteenth stage of spiritual development, the *ayoga kevali* - *Arihanta* is *nikal Param tm*. The meaning of *Nikal* is bodyless. Before entering into the last and the final, fourteenth spiritual stage of absolute motionlessness, static omniscient state (*nikal Param tm* or *siddhaparam tm*), the soul stops all activities, gross and subtle. It then enters the third stage of *ukla-dhyan* which is accompanied with 'subtle vibration' (*suksma kriya*) and steadies and stops the subtle bodily activity by means of the activity itself for there is none other than itself. Due to this *dhyana*, the soul contracts and fills the cavities created in embodied stage. It is now reduced. Then it enters the fourth stage of *shukla dhyana* which is bereft of all vibrations (*samucchhinna kriya*) and is infallible (*apratipatin*). It is now as motionless as a mountain rock (*shailesa*). Here all the remaining karmas are annihilated. This state lasts only for the period of time required to pronounce five short syllables at the ordinary speed. At the end of this period the soul attains un-embodied state of emancipation.

In Jain Yoga practice the internal journey starts from the '*prani sanyam*', compassion towards all living beings and ends on '*pran sanyam*' leaving the pr?a. After *pr*?*a sanyama* interaction with one`s own soul becomes possible which is the

last aim of Jain Yoga practice. As *pran* comes to an end, the physical life also comes to an end and the *atman* (soul) becomes *paramatman* (liberated omniscient).

Jain Yoga and Scientific Perspective: Jain religion is the most scientific religion. The philosophy propounded by Jain Tirthankaras thousands of years ago, is proving to be right as has been found by the modern scientific researches. The various steps in Jain Yoga are similar to scientific experiments being conducted in laboratories. The laboratory is within the mind, speech and body of the ti practitioner. We, now briefly describe other Yoga systems.

2. Vedic Yoga

There are four Vedas which are important, Rigveda, Yajurveda, Samaveda and Atharvaveda. In these Vedas, there is no mention of the word Yoga, but the word '*dhira*' is mentioned. The meaning of *dhira* is self realization. The sitting posture i.e. *asana, pranayam, mudras*, meditation techniques, *yama* and *niyama* and the *dharanas* are explained in Vedas. The *asanas* are mainly for the purpose of meditation.

The sun salutation was a part of routine activity at that time. The various types of meditation techniques are also explained there. The Vedas also explain about the *tapas, vratas* and the ultimate aim of these are to attain *Moksha* (liberation) [6]. The Vedic Yoga was developed by many seers of the Angiras and Bhrigu families, of which the most important were the seven great seers were Vashistha, Vamadeva, Bharadwaj, Gritsamada, Vishvamitra, Kanwa and Atri. They all set the spiritual path for humanity [47].

3. Ashtang Yoga

Patanjali, who is considered the father of modern Yoga compiled 195 aphorisms which are called the Yoga sutra. In the Yoga sutra [48], he described eight aspects of a yogic lifestyle and called it the eight limbs of Yoga. These are:

1. *Yamas - Yama* is our attitude towards others and the world around us. There are five yamas

(i) non-violence, (ii) truthfulness (iii) non-stealing (iv) non- lust and (v) non-possessiveness.

2. *Niyams- Niyam* is how we treat ourselves and our attitude towards others. These are five (i) cleanliness (ii) contentment (iii) austerity (iv) *swadhyaya* or self study of religious books and (v) awareness of the divine or almighty.

3. *Asanas* or Physical Postures - The *asanas* are designed to free our mind and body from tensions and stress.

4. *Pranayama* or Breath Control- The breath is regulated and controlled through the practice of breathing exercises. The duration of inhalation, retention and exhalation of breath is regulated with the aim of strengthening and cleansing the nervous system and increasing the source of life energy.

5. *Pratyahara* or Withdrawal of the Senses - Our focus turns inwards and we are no longer distracted by the outside events.

6. *Dharana* or Concentration- *Dharana* is training the mind to focus without any distraction.

7. *Dhyana* or Meditation - It is an uninterrupted flow of concentration aimed to heighten one`s awareness and oneness with the universe.

8. *Samadhi* or Enlightenment - This is the ultimate goal of the eight limbs of Yoga. It is a state of peace, awareness and compassion with detachment.

4. Ved nta

Ved nta is a spiritual tradition explained in the vpanishads that is concerned with the self realization by which one understands the ultimate nature of reality. Ved nta is based on immutable spiritual laws that are common to all religions and spiritual traditions worldwide. The literal meaning of the term "Ved nta" is 'Beyond vedic knowledge' or 'the ultimate knowledge'. The traditional vedic karmakand or ritualistic components of religions, continued to be practiced by Brahmins as meditative and propitiatory rites to guide the society to self knowledge and jñ na. These are mystical streams of vedic religion that focused on meditation, selfdiscipline and spiritual connectivity rather than on rituals. In Hinduism, meditation is considered to be an instrument to gain self knowledge, separating maya (illusion) from reality to help attain the ultimate goal of salvation [49].

5.Jñ na Yoga

 $J\tilde{n}$ na Yoga is the process of converting intellectual knowledge into practical wisdom. It is a discovery of human religion in relation to nature and universe. $J\tilde{n}$ na Yoga is described by tradition as a means to obtain the highest meditative state and inner knowledge. Some of the components of $j\tilde{n}$ na Yoga are : 1. Not believing but

realizing, 2. Self awareness leading to self analysis, 3. Experiencing knowledge, 4. Realizing the personal nature, 5. Developing intuitive wisdom, and 6. Experiencing inner unity [50].

6. Bhakti Yoga

Bhakti is Yoga of devotion or complete faith. This faith is generally in the almighty. It may be Lord Rama, Krishna, Christ, Buddha etc. It may be a guru for his disciples. Important thing is that the person interested in following this path should have very strong emotional bond with the object of faith. Because of the devotion the flow of emotional energy is directed to this object.

Mostly people suppress their emotions and that often reflects in the form of physical and mental disorders. This *Bhakti* Yoga releases those suppressed emotions and brings the purification of inner self. Continuous meditation of God or object of faith gradually decreases the goal of the practitioner, which further prevents new distractions, fickleness or even pain and induces strong bond of love. Slowly the practitioner looses the self identity and becomes one with the object of faith; this is a state of self realization [51].

7. Karma Yoga

Karma Yoga is a path of devotion to work. One loses his identity while working, only selfless work remains. This state is very difficult to achieve. In the initial stages of karma Yoga, an individual possesses strong sense of ego and consciously or unconsciously he is attached to the fruits of his efforts or at least praise or recognition, but by continuous involvement in the work and change in the mental attitude, one can surely disassociate himself from the ego and his own personality. The essence of karma Yoga, as extracted from 'Bhagvad Geeta' says : the world confined in its own activity accepts when actions are performed as worship of God [52].

8. Raja Yoga

Raja Yoga usually refers to the system of Yoga that is described in the Yoga s tras of sage Patanjali. In this ancient text Patanjali describes eight stages of Yoga which are known collectively as *Raja* Yoga. *Raja* Yoga is a comprehensive Yoga system which deals with the refinement of human behavior and personality [53].

9. Hatha Yoga

The term Hath Yoga has been commonly used to describe the practice of

sanas (postures). The syllable 'ha' denotes the *pranic* (vital) force governing the physical body and '*tha*' denotes the mental force, thus making *Hatha* Yoga a catalyst to an awakening of the two energies that govern our lives. More correctly the techniques described in *Hath* Yoga harmonize and purify the body systems and focus the mind in preparation for more advanced chakras and *kundalini* practices.

The *Hatha* Yoga system includes *sanas* along with the six *shatkarmas* (physical and mental detoxifying techniques), *mudras* and *bandhas* (psychophysiological energy release techniques) and *pr ? y ma* (*pranic* awakening practices). Fine tuning of the human personality at increasingly subtle levels leads to higher states of awareness and meditation [54].

10. Mantra Yoga

Mantra Yoga has its origin in Vedic sciences and also in *Tantra*. In fact, all the verses in Vedas are called *mantras*. It is said that any person who can chant or sing Vedas can achieve the ultimate salvation. Only chanting the *mantras* is called as *Mantra* Yoga. *Mantras* are words, phrases or syllables which are chanted attentively and thoughtfully to attain certain goals. In the process the super consciousness is discovered and achieved [55].

11. Yantra Yoga

It is a part of *Tantric* Yoga. *Tantras dh na* includes *yantra, mandala* and *mantra* practices to invoke deities like Shiva and Kali [56].

12. Kundalin Yoga

This system of Yoga is concerned with the awakening of the psychic power of of chakras, which exist in every individual. There are six main chakras in the human beings. The mind is made of different subtle layers. Each of these layers is progressively associated with the higher levels of consciousness. Each of these levels is related to the different chakras or psychic centers located throughout the body. In *Kundalini* Yoga, higher level chakras are awakened and also the activities associated with these higher psychic centers. The basic method of awakening involves deep concentration on these chakras and forcing their arousal. *sanas, pr n y ma, mudra* and *bandh* and other forms of Yoga such as *mantra* Yoga are also used to stimulate the awakening [57].

13. Tantric Yoga

Tantra consists of practices and ideas which has among its characteristics the use of ritual, energy and work for the identification of the microcosm (human being) with the macrocosm (universe). The *tantric* practitioner seeks to use the divine power that flows through the universe to attain *Nirvana*. The process of working with the energy includes yogic practices, chanting of *mantras*, visualization etc. Yoga is used to unite the individual consciousness with the cosmic consciousness [58].

14. Buddhism Yoga

Meditation is the central part of Buddhism. Gautam Buddha himself is said to have achieved enlightenment while meditating under the Bodhi tree. Most forms of Buddhism distinguish between two classes of meditation, *Shamatha* and *Vipassana. Shamatha* consists of practices which develop the ability to focus the attention single pointedly whereas *Vipassana* includes practices which develop insight and wisdom through seeing the true nature of reality. Both of these are necessary for attaining enlightenment. There are four deeper states of meditative absorption called the immaterial attainments. Sometimes these are also referred to as the 'formless' *dhy nas* (meditation). The suffering caused by the karmic effects of previous thoughts, words and deeds can be alleviated by following the noble eight fold path which is as follows : 1. Right view, 2. Right-intention, 3. Right-speech, 4. Right-action, 5. Right-livelihood, 6. Right-efforts, 7. Right-mindfulness and 8. Right-concentration [59].

15. Zen

Zen is the school of Mahayana Buddhism. It gives emphasis on practice and experiential wisdom particularly as realized in the form of meditation known as zazen which leads to the attainment of awakening. It deemphasizes on both theoretical knowledge and the study of religious texts. It gives great importance to the direct individual experience of one's own true nature. Zen training emphasizes daily life practice, along with intensive period of meditation. Practicing with others is an integral part of Zen practice. According to Japanese Zen masters, Zen is a way of life. Meditation as a practice can be applied to any posture. Walking meditation is called *kinhin*. Successive periods of *zazen* are generally interwoven with brief periods of walking meditation to relieve the legs [60].

16. Taoism

'Tao' (or dao) means path or way, but in Chinese religion and philosophy it has taken in more abstract meaning. Tao is really an object of worship, being treated more like the central Asian concept of *tman* and *dharma*. Taoism is a cosmic thought. The aspiration of Taoism is to bring all elements of existence- heaven, earth and men- into harmony. The individual must empty himself of dogma and knowledge, act with simplicity and humility and above all seek nature [61].

17. Judaism

Judaism has had meditative practices that go back thousands of years. In the old testament, there are two Hebrew words for meditation : *haga*, which means to sing or murmur, but also to meditate and *sia*, which means to muse or rehearse in one`s mind. Judaism is the religion of the Jews. It is a monotheistic religion, based on principles and ethics embodied in the Hebrew Bible, as further explored and explained in the Talmud and other texts. In addition to prayer services, observant traditional Jews recite prayers and benedictions throughout the day performing various acts. Prayers are recited upon waking up in the morning, before eating or drinking, after eating and so on [62].

18. Christianity

Christian meditation is associated with prayer or study of scriptures. It is rooted in Bible which directs its readers to meditate. The Bible mentions meditation twenty times a day. Christian practice includes such as acts of personal piety prayer, Bible reading and attempting to live a moral life style, to include not only obedience to the ten commandments, but also love for one's neighbor whether friend or enemy, Christian or non- Christian, in both attitude and action. Christianity teaches that it is impossible for people to completely reform themselves, but that moral and spiritual progress can only occur with God's help through the gift of holy spirit, who dwells in all faithful believers [63].

19. Islam

In Islam the foundation of its creed and way of life is meditation. A Muslim is obligated to pray, focus and meditate on Allah through reciting Quran five times a day namely before dawn, noon, afternoon, sunset and night. Thus, the whole day of the practitioner transforms into meditation and when he/she goes to sleep nothing

but another phase of meditation. Pious Muslims follow the deeds of Prophet Mohammad. The word "Islam" is a verbal noun originating from the trilateral root sl-m, and is derived from the Arabic word Aslama, which means to accept, surrender or submit. Thus, Islam means acceptance of and submission to God. The word is given a number of meanings in Quran. The word Quran means "recitation" [64].

20. Sufism

Sufism signifies the esoteric dimension of Islam where spiritual evolution is sought through inner transformation of heart as opposed to the rigid theology and of religion. The path of Sufi is centered on fundamental doctrine of the transcendental unity of being and a universal or perfect man. The concept of extinction of ego is the very heart of Sufism. Sufism is a mystical dimension of Islam. Sufism spreads the message of divine love and selfless service. A practitioner of this tradition is generally known as a Sufi. However, some devotees of the tradition reserve this term only for those practitioners who have attained the goals of the Sufi tradition. Another name sometimes used for the Sufi seeker is dervish. Sufism in its early stages of development referred to nothing more than the internationalization of Islam. According to one view point Sufism is directly derived from the Quran, persistently recited, meditated and experienced. According to others, Sufism is the strict emulation of the way of Mohammad, through which the heart's connection to the divine is strengthened [65].

21. Sikhism

In Sikhism, the practices of *simran* and *n ma japa* encourage quiet meditation. This is focusing one's attention on the attributes of God. Sikhs believe that there are ten 'gates' to the body. 'Gates' is another word for chakras (energy centers). The top most energy level is called tenth gate or '*da am dw r'*. When one reaches this stage through continuous practice, meditation becomes a habit that continues while walking, talking, eating and even in sleep. Followers of Sikh religion also believe that love comes through meditation on the Lord's name . The first guru of Sikhs, Guru Nanak Dev ji preached the equality of all human beings and stressed the importance of leading a householder's life instead of wandering around jungles. Sikhism is the fifth largest religion in the world, founded on the teachings of Nanak Dev ji and nine successive gurus in fifteenth century [66].

22. Kriy Yoga

The word '*Kriy* ' means activity or movement and refers to the activity of consciousness. '*Kriy* ' also refers to a type of practice leading to total union of body mind and couscousness. *Kriy* yoga does not curb mental fluctuations, but purposely creates activity and awakening in consciousness. The *Kriy* practices are inscribed in numerous tantric texts written in Sanskrit. The practices of *Kriy* Yoga were propagated by Swami Satyanand Saraswati from secret teachings described in *tantra* [67].

23. Swara Yoga

Swara is a Sanskrit word, meaning sound or note. It involves continuous flow of air through one nostril. Swara yoga is a science which is realization of cosmic consciousness through control and manipulation of breath. In Swara Yoga is association of breath in relation to activities of sun, moon, various seasons, physical and mental condition of individuals etc. [68] The scientific research so far, support the yogic concept of *i*? and *pi*?gal as the two main channals that handle very specific aspects of our perception, thinking, emotions and behavior. In the integrated evolution of human beings, the right hemisphere or *i*? , the mental energy domain, takes care of music and art awareness, three-dimensional perception, creativity and imagination, insight and intuition. The left side, the domain of vital energy takes care of written and spoken language, dealing with numbers and abstract problems, rational decision-making, accurate judgment and discrimination. To live life fully and evolve in a harmonious way we need both kinds of abilities. Therefore, achieving and maintaining balance between the right and left brain, between i? and pi?gal, has very real implications in our daily life, in the way we function, interact, grow and evolve and here swara yoga does come in the picture.

24. Integral Yoga

Integral Yoga has become a significant choice of many persons. In integral yoga, it is not only to see and feel the conscious evolution of life, but also to embody a fully harmonized life of matter and spirit. An integral yogi is he who sacrifices his life to become a bridge between the earth and heaven. In the teachings of shri

Aurobindo, integral yoga (or purna yoga, Sanskrit for complete yoga, sometimes also called supramental yoga) refers to the process of the union of all the parts of one's being with the divine and the transmutation of all of their jarring elements into a harmonious state of higher divine consciousness and existence.

Sri Aurobindo defined integral yoga in the early 1900 as "a path of integral seeking of the Divine by which all that we are is liberated out of the ignorance and its un-divine formations and converted into a truth beyond the Mind, a truth not only of highest spiritual status but of a dynamic spiritual self-manifestation in the universe."

He describes the nature and practice of integral yoga in his opus, 'The synthesis of yoga'. As the title of that work indicates, his integral yoga is a yoga of synthesis, intended to harmonize the paths of karma, jnana and bhakti yoga as described in the Bh gavad G t . It can also be considered as a synthesis between Vedanta and Tantra, and even between Eastern and Western approaches to spirituality [69, 70].

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Appendix 1

Jain Yoga

To bring out the salient features of Jain Yoga we quote from Kachhara [1] below. The scholars like Acharya Haribhadra Suri (8th century), Acharya Hemchandra (12th century), Subhchandracharya, Upadhyaya Yashovijay and some other acharyas systematically compiled and wrote treatises exclusively on Yoga. In recent times Acharya Tulsi, Acharya Mahaprajna, Acharya Nanesh, Acharya Shivmuni and others have contributed in popularizing Yoga concepts and practices. There is no substantial difference except in some nomenclature and modification in Jain and other systems of Yoga.

In Jainism 'Yoga' has two connotations. One is Samadhi and other Samyoga, union i.e. which connects. In ancient Jain scriptures the word 'Yoga' has been used generally for activities of mind, speech and body and disciplining and regulating them. Umaswati (or Umaswami, 2nd century) in Tatvartha Sutra says that Rational belief (attitude), Rational knowledge/understanding and Rational conduct, the three combined and simultaneously imbibed and followed will put the aspirant on right path, making his life/journey happy, peaceful, harmonious and eventually lead to salvation, the state of highest purity and enlightenment. Right attitude or samyag-darshana is the predilection or love for truth. Every soul has such predilection in some measure. But unless and until it develops into a self-conscious pursuit of truth, it does not help spiritual progress. It is the self-conscious effort for spiritual advancement that this love of truth is called samyag-darshana. The soul is conceived as groping in darkness before it acquires this love of truth in an appreciable measure. The soul has to undergo a number of processes before the acquisition of this characteristic as explained in chapter 14. It is generally believed that the Jains, from the very outset, put their whole stress on physical austerity and more or less neglected the aspect of meditation and contemplation. But this belief is not true. Physical austerity is only an index of spiritual detachment.

The Jaina mind was always conscious of the efficacy of meditation for the achievement of final emancipation. But it abhored the acquisition of supernormal powers by means of yogic practices. Self-realization was the only aim to be fulfilled by yoga. It is unanimously believed by Indian mystics that the yogic practices are attended by supernormal powers which bring about the fall of the practitioner if utilized for selfish aims. The Jaina ascetics devoted themselves absolutely to the purification of the soul and acquisition of the power of detachment, and the result was that they were indifferent to everything else, even to their bodies.

Jain Acharyas, Yoga scholars adopted more or less the eight stages of Patanjali Yoga system with changed or unchanged nomenclature and necessary modification in conformity with Jaina tenets. For instance, Haribhadra Suri in Yogadrishtisamuchhaya says that "The eight stages of Yoga are *Mitra, Tara, Bala, Dipra, Sthira, Kanta, Prabha* and *Para* corresponding to the eight organs of Patanjali Yoga. According to him the five traits of *Yama* are by intention, by activity, by firmness and by accomplishment.

In Jainism there is mandatory emphasis on purity of mind, speech and body of self and also of ambient environment. The twelve austerities (*Tapas*), six external

and six internal, are practices to cleanse mind and body. "Discipline in taking meals, taking less than hunger, fasting, abstaining from taking certain heavy food such as butter and oil, not caring for comforts while sitting, sleeping, reading are external tapas. Repentance for one's wrong deeds, humility, service to help others in sickness, needs etc., to renounce material things, study and meditations are internal *tapas*."

There is mention of postures in scriptures. 'Kayaklesha' prescribed in Jainism implies practices of sitting, standing, sleeping etc. to condition the body to tolerate hardship or discomfort while undertaking various activities. But Shubhchandracharya has warned against practicing of odd and articulated Asanas. Pranayama has been described in Jain scriptures essentially in the same way as in Vedic scriptures. Shubhachandracharya in Jnanarnava says that a yogi who has won over his senses by practicing pranayama can destroy his intense demerits (papa) accumulated over hundreds of births within 48 minutes. But he also states that a practicner may feel pain during the period of retention of breathe; inside or outside, and during such periods there is a possibility of Aartadhyana, in which case a knowledgeable person also may divert away from the very goal of pranayama. He further says that pranayama is not worth doing for aspirants of ultimate salvation as it is an impediment. This, to my mind, should be interpreted with caution. Pranayama not practiced properly may be harmful and that it is helpful only up to a certain stage of spiritual development, after which all intentio- onal activities including pranayama are to be discontinued to go in the state of Samadhi.

Pratyahara is a very important step and enjoins on the aspirant to control and withdraw the mind from indulgence in objects of five senses of touch, taste, smell, sight and hearing. In Jain scriptures it has been ordained as an essential ingredient both for the laity as well as the ascetic.

Dharana (Concentration), Dhyana (Contemplation) and Samadhi (Identification) are progressive stages intensifying gradually from concentration on an object, continuing it is contemplation and intensification or complete absorption is identification. In Jain system of Yoga there is great emphasis on meditation and it is not confined to just sitting and contemplating but also implies carrying out all activities of mind, speech, and body with awareness and mindfulness.

Appendix 2: Suggested topics for further research

- 1 Compilation of scientific studies of various Yoga systems, which are being carried out through out the world.
- 2. To study the effect of various Yoga systems on the health, brain, intelligence and other organs of persons. Here, it is sufficient to mention that a lot of work is going on in India and abroad in this direction.
- 3. To study the medical effects on various diseases using "*Bhaktamer Stotra*" of Aacharya Mantungacharya. As is well known, forty eight locks were broken the moment Mantungacharya recited, '*Bhaktamer Stotra*'. These days, some persons are curing some diseases by reciting some verses of *Bhaktamer Stotra*.
- 4. To study the effect of activation of third eye towards the improvement of memory, wisdom and ageing of different yogis, Jains and non Jains. It is said that by meditation, fasting and observance of various religious processes, the activation of third eye is getting fulfilled. There may be a good number of sages whose help may be sought for such work.

12. The Art and Science of Meditation

Sudhir V. Shah

Abstract

Recent physiological, neuroelectrical, neurobiological and neurochemical studies of brains of meditation practitioners using modern techniques such as fMRI, SPECT, EEG etc. have provided quantitative assessment of changes induced by meditation. Results of some of these studies, related to activation of specific areas of brain, blood flow etc. are summarised and it is shown that meditation is not hallucination but has a physical basis. Health benefits of meditation are described.

Key Words: meditation, physiological effects, neuroelectrical effects, neurobiological effects, neurochemical effects

Scriptures Quoted: P tanjal Yoga S tra, Yoga stra, Dhy na D pik .

1. Introduction

Every human exists in at least three forms: physical body, mental-emotional body and spiritual body. We spend most of the time every day of our life and our whole energy looking after our physical body: its care-taking, its exercises, well being and its pleasures. Somehow, we are not trained to take care of our mental and spiritual bodies, their exercises, their pleasures and their wellbeing.

Meditation is one powerful way to correct these mistakes. You can call it as the exercise of mind to keep it healthy and free of perversions. Actually, in the depth of meditation, one experiences a dialogue with one's own self/soul. However, let us keep the discussion of soul aside for a while; at least we are aware of our faculty of mind.

Our miseries as human being are primarily due to our thoughts, emotions, desires-aspirations, ego, perceptions, liking-disliking (*r ga-dve?a*), attitude and our

constant shifts between past and present tense. If we carefully analyze, these are all the functions of our mind. If we learn to improve on these, our miseries would be gone. And meditation teaches us to improve on all these aspects.

Peace and happiness are sought for by each and every person. But we search them in the outer world. At some stage, we realize that peace and happiness actually reside in our own selves. The day we begin internal journey, we start experiencing peace and happiness. This internal journey is gifted and guaranteed by meditation.

All great prophets, religious path makers and saints have meditated in some form or the other to achieve the greatness and enlightenment. From the oriental and western spiritual texts, it is clear that right from Lords like Shiva, Mahavir, Buddha to Rama, Krishna, Patanjali and from Christ to Prophet Mohmmed, to Osho, Jarthushtra to the most recent saints.....all have meditated for a prolonged time during their self realization or enlightenment process.

Therefore, if we really want peace and happiness and eliminate our miseries or if we want to experience God, we must meditate.

1.1 Definition

Meditation is thinking deeply or spiritually about a subject; as per the definition given in dictionary. Actually, it is a complex cognitive task. It is more than relaxation, concentration, contemplation or posturing. One gets illuminated and achieves enlightenment through it. It is a state of altered consciousness, 4th stage, according to some neuroscientists [1]. It is a spiritual ecstasy with neurological manifestations. It is certainly not hallucination.

There are different views about defining meditation: some call it as "stability of mind", some call it "concentration on one target". One can say it is "unified thought process", while others call it a "thoughtlessness state". Some consider it as "introspection", others claim it to be "lack of activity" or "leaving giving away". While others define it as either "intentional self regulation" or "dedication process or "staying connected constantly to supreme force"..... Whatever one calls it, basically it is hard and long process. It demands highest form of discipline which comes through constant awareness, not only of things about you outwardly, but also inwardly. According to J. Krishnamurthy, it is an effortless, choiceless, constant neutral awareness.

2. Benefits of Meditation

There are several advantages of meditation. Real meditation can restore physical, mental and emotional health. It can be helpful in controlling several lifestyle disorders, psychosomatic disorders including high blood pressure, coronary artery disease, diabetes, asthma, rheumatism, etc. It is a powerful weapon or antidote to acute as well as chronic stress. It improves concentration and sharpness. It reduces reactivity to a situation or a person, so one remains serene and calm under all circumstances.

The neurochemistry of meditation is entirely the reverse of stress. Meditation up-regulates parasympathetic system, while stress up-regulates sympathetic system - responsible for increase in heart rate, respiration, blood pressure etc. [2, 3].

As per the oriental spiritual texts and spiritual masters, the benefits of meditation are much higher than the above mentioned physical and mental benefits. The real purpose of meditation is taming the mind, elimination of ego and then elimination of mind itself, thus attaining Samadhi- total bliss. In such a state, the soul remains uninhibited, manifesting its complete knowledge, complete revelations etc. The state of self realization, God-realization is attained here. This is the part of Enlightenment and Liberation as per our masters and texts.

"However meditation is not a pushbutton system. One has to have patience, courage, hard work and perseverance. This coupled with right guide, right technique, right understanding and real conviction and dedication can bring success. There is a high failure rate amongst meditators; usually this is due to non-fulfilling of these criteria. It is sad that meditation has become a business of billions and many opportunists have misused and abused this sacred spiritual science. Therefore one should be careful.

3. Meditation Techniques

There are several techniques of meditation. Essentially, all the methods and practices of meditation are based on eight techniques.

One can meditate by focusing on breathing, or on an object (e.g. light), on a sound, on a thought, on sensory perceptions, or on a sensual object. It could be a guided imagery or the meditation on the soul by the soul itself. Let us take one technique here as an example i.e. focus on breathing.

3.1 nap n Sati

This technique is about moment to moment awareness of one's own breathing. It is concentration or focus on breathing, but not a *pranayam*. *Pranayam* is controlling breathing, but here one has to 'see' and 'know' every natural breath that goes in and comes out without alternig it; there should be no other thoughts, no other objects in mind. Be aware of your own natural breathing, moment to moment in an effortless, choiceless way. Do not lose sight of a single breath. When the mind gets distressed, as it usually happens with every beginner, one has to bring it back to breathing very quietly, without criticizing or cursing the mind. With months and perhaps years of practice, one learns to be with every breath for several minutes to hours. This facilitates the awakening process or enlightenment.

In this process, there is no deity, no sect, and no religion is involved; hence it is perfectly a secular technique. Breathing is a vital process, without it nobody can survive; therefore it is a vital technique. Breathing is always with you wherever you are and wherever you go; hence this is an intrinsic, hassle-free, easy and handy technique.

Breathing is the carrier of our emotions. Our breathing changes with different emotions and perversions. With anger and hatred, the breathing becomes fast. With jealousy, it becomes irregular. With love towards living beings, it becomes slow and regular; with compassion it becomes even slower and smooth. When one observes one's own breathing, it surely becomes slow and the parasympathetic system becomes operational, replacing sympathetic (stress response) system.

So, for a regular practitioner of breathing meditation, it becomes a feedback of one's own emotions and perversions. It is an auto check mechanism and whenever there is a negative emotion; one becomes alert, as one's own breathing tells: "look here, something is wrong, control it". This is a wonderful reason, why breath practitioner becomes quiet, calm and compassionate and is always full of positive emotions/energy.

Most importantly, our breathing is our own present tense, present moment. When we stay on breath, we actually remain in the present moment i.e. "Now"! Our mind always fluctuates, between past and future that is one of the major tragedies, root of our miseries. This meditation technique is a straightforward training of staying in the present tense. Though it is not easy to dwell on breathing, without losing a single breath, with hard work, dedication and commitment, this can be

achieved. Finally, breath is a truth, the real truth. It is proclaimed, that by mastering this technique focusing on truth, one can reach to "ultimate truth" one day.

The same is true of all other meditation techniques. There is a definite science and some logic in each one of them. In meditation on thought, one has to either pursue one thought and remain unified with the thought process e.g. a good or noble thought or just simply watch the stream of thoughts, as they come by one after the, other, and the next, in a non-judg mental way, a bare neutral, uninvolved awareness. Similarly for sound meditation, one can chant a mantra several times (loudly or internally without vocalizing) or listen calmly in a quiet place at night or in a jungle the subtle sound that enters the ears and concentrate on that. In object based meditation, one stares at the object continuously even without blinking the eyes. Object meditation can also be done with closed eyes.

Based on these techniques, several masters have designed different methods. We know them as Patanjali Rajyoga, Anapan Sati, Smriti Upasthan, Vipashyana, Prekshadhyan, Jaindhyan, Transcendental meditation, to name a few important methods. Amongst others are Mantra dhyan, Zen meditation, Yoganindra, Nyas, Dynamic (Hoo Dhyan) meditation, Sahajdhyan, Tratak, Kayotsarga, Atitdhyan, Bhavidhyan, Swapnadhyan, Tahata, Spand dhyan etc. So technically, either there is *focused attention* (Concentration), *open monitoring* (Contemplation) or *Transcendation*.

If one understands the basics of meditation, one can really design one's own tailor-made system, suitable to one self. Initially one should learn one standard method, follow it for a few years, then after mastering it, at some stage one can modify it to suit one self.

Most of these oriental techniques have come from teachings of Lord Shiva, Patanjali, Buddha, Adinath, Mahavir, and several others. No particular method is really better than the others. All methods are great and equally beneficial. Comparison is dangerous and meaningless. One has to choose the method that suits one. One should remember that all methods teach us to remain in the present tense, this particular moment, choiceless, effortless, non-judgmental awareness. This brings happiness and joy. As nicely described in Vipashyana Method, actually speaking, meditation is an operation of the mind, by the mind. The tools of mind are calm and quiet mind, awake and attentive mind, an equanimous mind. When this state is practiced regularly over weeks, months or years, one achieves what is called 'mindfulness' practice. Here meditator remains in a state of constant awareness in whatever he/she does, and is continuously immersed in meditation, eating meditation, sitting meditation, working meditation and walking meditation.

For the beginners, it may be worth observing total silence (no speech and no movement of body), as a pilot exercise. Total isolation from all distractions is useful. *Pranayam* is helpful as warming up before each meditation session, though it is not a prerequisite. A beginner may find it easy to do chanting (sound) meditation. Later focusing on an object may be considered, with open eyes initially, followed by closed eyes. Focus on breathing and thought are harder meditation techniques, but are equally rewarding.

4. Health Related Effects of Meditation

- 1. During meditation oxygen consumption is reduced by 16 %, even greater than the reduction of 12% that occurs during sleep [4].
- 2. Diurnal fluctuation in secretion of stress hormone is much controlled, in favour of peace and harmony.
- 3. Neural structures that are intimately related to the control of the autonomic nervous system are activated, more of parasympathetic drive.

Because of several good effects on health, including control of several diseases, many doctors, psychotherapists and other health professional are increasingly adding meditation techniques to their practice of mainstream medicine, as prescription. They consider meditation a key element of an integrated health program [5].

There are certain diseases, in which effect of meditation in alleviating them or reducing their severity in varying proportions have been documented [5]. We find several studies of the positive effects of meditation in these diseases in medical literature on internet or journals.

- 1. Arthritis
- 2. Allergies
- 3. Asthma
- 4. Hypertension

- 5. Coronary artery disease [6]
- 6. Irritable bowel disease
- 7. Heart burn
- 8. Constipation
- 9. Tension, headaches and migraines [7]
- 10. PMS and menstrual discomfort
- 11. Menopausal problems
- 12. Pain in the back, hips and knees. Fibromyalgia
- 13. Depression and anxiety [8]
- 14. Substance abuse
- 15. Skin disorders, e.g. Psoriasis [9]
- 16. Chronic fatigue syndrome
- 17. Stroke
- 18. Over weight with Obesity
- 19. Sleep disorder
- 20. Terminal cancer related pain and other problems [10]
- 21. Multiple sclerosis [11]

In general, many psychosomatic and lifestyle disorders can be totally or partially eliminated with practice of meditation over a sufficient period. Stress can be very nicely tackled with learning art of meditation [12].

It is estimated that people who meditated over a period of five years had over 50% reduction in doctor visits and hospital admissions [13].

4.1 Contraindications

Certain persons, however, should not practice meditation. Those who are suffering from psychosis, severe depression or confusional states extreme anxiety states and people who are demented cannot and should not practice meditation.

5. Physiology of Meditation

Meditation produces a specific physiological response pattern that involves
various biological systems. Effect of meditation are on metabolic, autonomic, endocrine, neurological and psychological systems. These effects are multidimensional and interactive.

5.1 Neuroelectrical Effects

(a) EEG changes

There are usually four types of waves in EEG: alpha, beta, theta and delta. The meditation brainwave pattern is a combination of alpha and theta waves; the theta waves provide the depth and profundity of the meditational experience, the subconscious inner space from which creativity, insight and healing spring and alpha waves provide the bridge or the link to the conscious thinking mind so that one can actually remember the content of meditation.

Awakened mind brainwave pattern emerges with people engaged in meditation over years with perfection. Regardless of their theology, philosophy or meditation technique, in higher states of consciousness, the meditators achieve peak experience that can be found in all forms of creativity and high performance.

In general, amplitude of alpha waves improve with slowing down of its frequency. Rhythmic theta waves appear and there is an increased synchronization pattern of alpha waves [14,15]. There can be transcendental signals and dissociation of perception from the external sense organs. In chronic meditator, we find even gamma waves [16].

During calm and focused attention type of meditation, alpha waves are found. During highly focused concentration high beta activity is seen, while theta pattern is seen during imagery and reverie and it improves creativity. It has been observed that even after the first meditation session in a beginner (common person), there is perceptible changes of waves.

(b) Evoked Potentials (EP)

Meditation sometimes changes wave amplitude with the practitioner seeming to demonstrate decreased amplitude and latency for sensory EPs [14] with mindfulness inducing a decrease in habitation.

5.2 Neurobiology of Meditation

Neuroimaging with MRI (Magnetic Resonance Imagin), rCBF (regional cerebral blood flow), MEG (magnetoencephalography) and improved EEG (electroencephalography) allow detailed studies in understanding the effect of meditation on neural behavior.

Dr. Andrew Newberg et al. (2001) from Philadelphia published a path breaking paper that revolutionized the belief of the scientific world. It was a SPECT study on Buddhist Lamas. It proved that higher meditative states are not hallucinations; these are actual neurological events and genuine neurobiological phenomena [17]. The main results are summarised below:

1. The parietal lobe of the brain is thought to be responsible for giving us a sense of our orientation in time and space. By blocking all sensory and cognitive inputs into this area, meditation results in the sense of 'no space' and 'no time'. During SPECT study, it was demonstrated that there was significant reduction of rCBF during depth of meditation by Lamas.

We may note that orientation to time, place and person is needed to manifest or express our ownself. Our ego, attitude, and to a good extent our desires, emotions, thoughts and perversions depend on our interaction with people and places etc. so with meditation, these activities or functions of mind get suppressed or controlled. Thus we may conclude that meditation can effectively control mind.

2. The second important finding was observed in prefrontal lobe. As we know, this area is well developed only in human race and therefore humans have higher cognition, capacity of judgment, intuitive memory and executing functions including complex tasks, tactfulness along with evolved rational behavior with social etiquette. The more the developed area, more intelligent the person is. During deep meditation, it was recorded that rCBF increased in this area. I, therefore, think that all meditators practicing over a few months to years, are cognitively more evolved and their behavior is more compassionate. Also it tells us that meditation is a higher state of consciousness.

These findings of SPECT study are reproducible, with different types of meditation. fMRI studies also were conducted by different groups and the results were similar. In fact, fMRI studies literally unfolded the whole circuitry involved in meditation process and demonstrated that significant signal increases in the dorso lateral prefrontal and parietal cortices, hippocampal/parahippocampal formation, amygdala, temporal lobe, pregenual anterior cingulated cortex, striatum and pre and post central gyri during meditation [18]. This indicates that the practice of meditation activates neural structures involved in attention and control of the autonomic nervous system.



Fig. 1. Beta waves brain images before (left) and after (right) meditation sessions., showing decrease in brain activity due to meditation

5.3 MRI Changes During Meditation

PET, SPECT and fMRI allow examination of changes in regional blood flow, metabolism or receptor (sites of neurochemical and drug actions) activation in the brain in response to various tasks [17, 19, 20].

Most types of meditation, which involve an initial focusing of attention, are associated with increased regional blood flow or glucose metabolism in the prefrontal and cingulate cortex, areas that are important in selection of mental tasks.

The frontal lobes, especially the prefrontal regions help to organize, prioritize, plan and focus attention.



Fig. 2. SPECT images of the brain showing baseline stage (left) and during meditation (right), indicating increase in blood flow in areas associated with attention [17].

During visualization regional blood flow increases in the "visual cortex" and visual association areas in the occipital lobes.



Fig. 3a. During visual imagery, occipital lobes are activated (17).



Fig. 3b. Images showing symbolic representation of the "Self" [17].

- + Meditation appears to begin by activating prefrontal and cingulate cortex, associated with the 'will' or 'intent' to clear one's mind of thoughts or to focus on an object.
- + There also occurs differentiation of PSPL(Posterior Superior Parietal Lobule), implying a decrease in arrival of distracting stimuli to striate cortex and PSPL, enhancing sense of focus during meditation which results in altered perception of self-experience during spiritual or meditative practices.
- + Thalamus is a relay station and filtering station for sensory information that reaches the cerebral cortex for further processing
- + During meditation, the thalamus filters sensory input to part of the parietal lobe, the posterior superior parietal lobule or PSPL, involved in "body awareness" resulting in decreased activation of the PSPL.
- + Increased thalamic blood flow during meditation implies that this is an active process of filtering of information and processing of information about the body.



Fig. 4. SPECT Images of the brain for Baseline and meditative stages [17].

- + Some studies during meditation show increased activity in the Hippocampus or inner aspect of the temporal lobe.
- + Hippocampus has close functional connections with hypothalamus and autonomic nervous system.
- + During meditation, integration of autonomic nervous system activity with different parts of brain involved in meditation is increased.
- + fMRI studies of Kundalini yoga support increased activity of hippocampus and amygdala during meditation.
- + Stimulation of right lateral amygdala results in stimulation of ventromedial hypothalamus and peripheral parasympathetic system associated with a subjective sensation, first of relaxation and later, of a more profound sense of quiescence.

Caution: one should realize that every spiritual experience cannot be reduced to mere physiological prenomena. Many of them are beyond science.

5.4 Neurochemical Effects

Meditation has been shown to increase serotonin production. Serotonin is an important neurotransmitter and neuropeptide that influences mood and behavior in many ways. Meditation has also been associated with increased melatonin availability. In general, during meditation GABA is increased in dorsal raphae nuclei, cortisol is decreased in paraventricular nucleus and B-endorphin diurnal rhythms are changed for better i.e. peace and pleasure feelings [19]. Heart rate and breathing slows down during meditation and stress response is reduced. There is a relatively greater parasympathetic nervous system activity during meditation, so production of catecholamines are reduced. Thus, the patients with hypertension, coronary disease and other stress related diseases are benefited by meditation. Increased serotonin level helps improving mood of person with meditation. It is observed that there is increase skin resistance with meditation. There is decreased limbic arousal which, in turn, explains how meditation strengthens and enhances the ability to cope up with stress and reduces reactivity of a person. So these are the good effects on autonomic nervous system during meditation.

Effects of meditation on Central Nervous System are further seen as it accelerates neural conduction or augments the release of neurotransmitters, thereby decreasing synaptic time. This results in a change in muscle firing threshold and pattern. By inhibiting the left cortical hemisphere, the sense of time and logic no longer dominates consciousness during meditation. Therefore, manifestation of ego is suppressed. The thoughts, desires, perceptions, perversions and duality etc. are all reduced. As we know, all these are functions attributed to mind and hence this faculty of mind is reduced more and more with the depth of meditation, particularly in long term practitioners. Once this faculty of mind is reduced or controlled, the meditator enjoys enormous bliss and peace. This is because the root of our miseries is our own mind which is normally not in our control.

5.4.1 Recent Hypothesis

- + When meditation acts as a constant repetitive stimulus, certain permanent qualitative and quantitative changes develop in nervous system.
- + Neurotransmitters and neuromodulators may stimulate growth of dormant neurons to develop a centre higher than neocortex i.e. God module (G-spot).
- + This higher centre will exert inhibitory control over present neocortex and thereby over the mind as a whole, thus suppressing consciousness and all

mental activities.

+ Spiritual ascent is from the least evolved state of consciousness to near perfect state with which the mind itself will cease to be and there will remain only non-dual experience.

Thus, when meditation acts as a repetitive stimulus, certain qualitative and quantitative changes occur permanently and only 'nondual' experience remains.

As we see the effects of meditation on metabolism, we realize that there is decreased heart rate, decreased breathing and decreased B. P. By well documented studies, it is shown that the blood flow to liver and kidneys is reduced with increase in cardiac output. The oxygen utilization is decreased in muscles.

It may be worth noting that the metabolic changes arise from a natural reduction in metabolic action at the cellular level, not from a forced reduction of breathing. All these transpire in to longevity and delayed aging, which we often observe in real saints and meditators.

At psychology level, meditator achieves improved cognition, increased concentration and reduced susceptibility to stress. Meditation enhances perceptual sensitivity. Most importantly, the studies reveal that it improves the attitude and personality of a person. The creativity and productivity of a person improve. Also the mood and sleep of meditator improves.

If we talk about most recent findings on neuroplasticity, a recent study has shown that the brain regions associated with attention, introspection and sensory processing like the prefrontal cortex, right anterior insula were thicker in meditation practitioners [21]. Thickness of Prefrontal cortices was most pronounced in older participants. This can be explained by the fact that meditation probably offsets age related cortical thinning. In general, meditation practices promote neuroplasticity.

Actually, pain may be inevitable, but suffering is optional. We all have several problems. But, we must realize that there is a cause behind our problem. If we pinpoint the cause (root of our miseries) then we also know that there is a way out. If we follow that path, our problems will be solved. We will get peace, joy and inner happiness.

The root cause of our problems/miseries is our own mind. The thoughts, desires, emotions, ego, perceptions, attitude, etc. cause the problems. If we tame our

mind, the miseries will be gone. The powerful way to tackle our mind is meditation.

Looking to all the above positive benefits of meditation, at physical, mental, emotional and spiritual levels, we can conclude that meditation is an invaluable treasure that we have lost in the stride of day to day hassles and plights.

6. Concluding Remarks

I would like to end this article by recalling some immortal statements of versatile masters and teachers of meditation and salvation.

(1) Lord Mah v ra: Remain aware every second, every fraction of a second. Do not be unaware (*pramada*). Watch and guard your every thought, every word and every action.

(2) Lord Buddha (at his death bed) : Monks! whatever is composed will decay. Continue working in the direction of your salvation, sincerely, incessantly.

(3) Swami Vivekanand : (last message) Wait and meditate, till I call you back.

So let's meditate from today and now! From this moment on!

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13. Biological Concepts in Jainism and Modern Science

G.C. Jain, S. Godawat and S. Jain

Abstract

The paper addresses conventional views associated with Jain biological concepts and modern science especially those related to origin of life and its evolution. A good agreement between Jain philosophy and modern biology is seen. Although the modern science has proposed several hypotheses for origin of life on the Earth, none of them are universally accepted. According to Jain principles, the universe is eternal, not created, has always existed, exists and will continue to exist with its core elements with certain changes in their form on account of ongoing unending exposures and pressures of physical, biological and biochemical processes without formation of new species. Jainism explains the nature of all substances that undergo the process of creation, destruction while maintaining their intrinsic nature without bio-evolution. The universe exists by virtue of six real substances which sustain it. Essentially the life possesses consciousness, one to five senses, three powers (thought, speech, and action) and respiration and undergoes ageing. The seed body is known as Karman Sarira; which always remains attached to the soul in the mundane state. All body functions are regulated by the living cells, inbuilt codes and decoding systems. A detailed genesis of subtle J vas (nigoda), fertilization, embryogenesis, organogenesis, allied body descriptions and events are described by Vattakeacharya(2006), in Mulachara Part-2 and Slvarya(2008) in Bhagwati Aradhana. Phenotypic and genetic expressions of different characters are expressed as per the "law of independent assortment and union". French geneticist H. Frydman (2004) had shown that karmas were bound since eternity and play their role through genes in the living body. Even the modern biotechniques like embryo transfer and cloning were known and practiced in ancient India (~ 600BCE) as revealed by the transfer of living embryo from the womb of Devananda, a Brahmin

lady to Trisla, the mother of Lord Mahavira mentioned in the Swetambara texts. However, death is permanent termination of all vital functions of life and the remains of an organism reenter the biogeochemical cycle (rebirth). A new concept of "Biocentrism" suggest that scientists need to place biology before all the other sciences to produce a "Theory of Everything" and the modern bio-theories of the physical world are inadequate until they account for life and consciousness.

Key Words: Jain Ethics, biocentrism, embryo transfer, embryogenesis, genes, yoni, J va, soul, karma, rebirth

Scriptures Quoted: Gommattsaar Jivakanda, Moksha Marg Prakashak, Mulachara, Tattvarthasutra

1. Introduction

Physical, chemical, electrical, protein synthesis, DNA, spectrum of light rays, memory etc. are some characteristics exhibited by even non living materials. Science so far could not infuse sensory character into any non living substance and it is still beyond the reach of scientific techniques. Some vital characters of a living substance such as movement, respiration, sensitivity, growth, reproduction, excretion, nutrition and responses have been recognised but the sense of feeling, thinking process, memory impressions, consciousness, dreams, purification of soul, doctrine of karma, rebirth and wisdom in the form of Jnana, Charitra, Darshana and finally Nirvana do not form the subject matter of modern biology. For understanding the origin of life one has to study several gene-less, pre-genetic, genetic and post-genetic stages of life. Gene's sequence characterization, gene mapping, assortment, infusion and their assortment and selection of a particular character of gene have been studied but no studies have been made to understand the connection between gene and karma and the nature of karmas.

The systemic definition of life is that all living beings are selforganizing and self-producing. Aristotle (384-322 BCE) mentioned that all things are a combination of matter and soul. There are three kinds of souls- the vegetative soul, the animal soul, and the rational soul, with a source of consciousness and reasoning, found only in man. Current understanding considers life that exhibits all or most of the following characteristics or traits (Hickman, 2012).

Organization: Composed of one or more cells — the basic units of life.

Metabolism: Transformation of energy into cellular components (anabolism)

and decomposing organic matter (catabolism).

Growth: Maintenance of rate of anabolism higher than rate of catabolism.

Adaptation: The ability to change over time in response to the environment.

Response to stimuli: Contraction of a unicellular organism to external chemicals and to complex reactions involving all the senses of multi-cellular organisms.

Reproduction: The ability to produce progeny, either asexually from a single parent organism, or sexually from two parent organisms.

Homeostasis: Regulation of electrolyte concentration or sweating to stabilise the normal temperature of the body.

The processes leading to emergence of life on earth is not understood, although many schemes have been formulated. While considering the meaning of life, other points related to its significance, origin, purpose, and ultimate fate and its relation to existence and consciousness should also be considered.

2. Classification of Living Organisms

2.1 Modern Concepts

The most accepted classification is based on prokaryotic and four eukaryotic kingdoms (Margulis and Schwartz, 1997).

2.1.1 Blooded Animals

- 1. Viviparous quadrupeds (mammals)-Eggs are laid within the female body, fertilized inside the body and delivered after full gestation period in form of a young one.
- 2. Oviparous quadrupeds (reptiles and amphibians)-Eggs are laid outside the female body and fertilized outside the female body.
- 3. Birds
- 4. Fishes, and
- 5. Whales
- 2.1.2 Bloodless Animals
 - 1. Cephalopods

- 2. Crustaceans
- 3. Insects (which included spiders, scorpions, and centipedes.
- 4. Shelled animals (such as most molluscs and echinoderms) and
- 5. Zoophytes

As microbiology, molecular biology and virology developed, non-cellular reproducing agents, such as viruses, were discovered. As viruses lack characteristics of life such as cell membranes, metabolism and the ability to grow or respond to their environments, whether these are alive has been a matter of debate.

3. Jain Concepts

Biological science and Jainism have their own individual system of classification. Unlike biological classification, all living organisms whether they are plants, animals or microorganisms are described only in one domain of *J va* in Jain scriptures, . In one aspect, i.e. on the basis of type of birth (uterine, samurcchan and *up-pad*), number of sense organs and bio-potentials (*paryapti*), all *J va* (*jivasamas*) are categorized broadly under 98 groups (9-human beings, 85-*tirianch*, 2-celestial and 2-hellish) in Jainism. In another aspect, i.e. on the basis of feeling/attitude (*bhava*) the souls are of 14 kinds of *margana* and of 14 stages of spiritual growth (*Gu?asthana*). In comparison, in the modern science, all living beings are classified as plant kingdom, fungal kingdom, animal kingdom and further on the basis of their morphology, body structure (internal and external), habit and habitat etc. into phylum, order, class, genus, species and varieties. All living beings perform most of the common i.e. vital and non-vital activities, like respiration, feeding, reproduction, excretion, multiplication, locomotion, fear, pleasure, etc.

The body may have one sense (touch), two senses (touch and taste), three senses (touch, taste and smell), four senses (touch, taste, smell and vision), five sense-*asanghi* (touch, taste, smell, vision, hearing but without mental development) and *sanghi* with mental and emotional development (Umaswami, 1992). Five sensed organisms may be born either sexually or by agglutination (Jain, 1975), and are aquatic (fish, turtle, crocodile), terrestrial (reptiles, quadrupeds), and aerial (birds). The quadruped animals may be again of four types - (i) animals with single hoof like a horse (ii) two hoofs like an ox, (iii) padded foot like an elephant and (iv) animals with paw like lions. The reptiles may be either with arms like lizards and creepers like snakes, whereas birds may have skin feathers like bat and goose.

Based on the type of birth the mobile beings are of eight types:

- 1. Oviparous: born from eggs e.g. birds.
- 2. Vertebrates: born without placenta.
- 3. Viviparous: born with placenta e.g. cow, humans.
- 4. Fermentation origin: worms and bacteria produced in curd, juice etc.
- 5. Sweat origin: produced from sweat, e.g. louse, ticks etc.
- 6. Birth by agglutination: asexual birth as in case of flies, ants etc.
- 7. Sprouting animals: produced below earth surface e.g. locusts.
- 8. Instantaneously manifested: non fetus beings e.g. celestial and infernal beings, without body.

3.1 Mobile J vas

Mobile means *Trasa J va* - those that can move at will. They are multi-sensed organisms and are divided into the following categories (Todarmal, 2005; Jindevi, 2011).

A. Vikalendirya

- (1) Two sensed beings (*dwi-indriya J va*): Two sensed beings have the senses of touch, and taste. e.g. shells, worms, insects, microbes in stale food, termites, etc.
- (2) Three sensed beings (*tri-indriya J va*): Three sensed beings have the senses of touch, taste, and smell, e.g. bugs, lice, white ants, moths and insects in wheat and other grains, centipedes, etc.
- (3) Four sensed beings (*chatur-indriya J va*): Four sensed beings have the senses of touch, taste, smell and sight, e.g. scorpions, crickets, spiders, beetles, locusts, flies, etc.

B. Sakalendirya

(4) Five sensed beings (*Pañcendriya J va*): Five sensed beings have all the five senses of touch, taste, smell, sight and hearing e.g. human beings, cows, lions, fishes, birds, etc.

The following are four sub-categories of the Pañcendriya J vas.

a) *Naraki*: Infernal beings *J vas* living in hell.

- b) *Tiryancha*: Non-human beings i.e. elephants, lions, birds, fishes, insects, etc.
- c) *Deva*: Celestial heavenly beings.
- d) Manushya: Human beings.

Among the five sensed beings some have minds, while others do not. Those having a mind are called *Sanjni-Pañcendriya* and those without a mind are called *Asanjñ -Pañcendriya*.

3.2 Immobile J vas

Immobile means (*Sth var J va*): those that cannot move at will, Vattakeacharya (2006). They are one-sensed called *ekendriya* and are further divided into the following five sub-categories.

- (1) Prithvik ya or earth bodied: Seemingly inanimate forms of earth are actually living beings and are found in 36 forms e.g. clay, sand, metal, and coral, etc. They have earthly bodies, hence the name Prithvik ya which is derived from the Sanskrit term for earth, Prithvi.
- (2) Jalak ya or water bodied: Found in 7 different types of waters, e.g. dew, fog, iceberg, rain, etc. (*ausa, hima, kohara, motiboonde, chotiboonde, suddhajal* and *ghanjal*).
- (3) *Agnik ya* or fire bodied: Found in 6 different types of fires e.g. flames, blaze, lightening, forest fire, hot ash, etc. (*angare, jwala, lau, moormur, shudhagni, Agni*).
- (4) *V yuk ya* or air bodied: Found in 6 different types e.g. wind, whirlwinds, and cyclones, etc. (*ghoomtivayu, utkaliroopvayu, mandalakaravayu, gunjavayu, mahavayu, sariravayu-prana, apana, samana, udana, vyana*).
- (5) *Vanaspatik ya* or plant bodied: Trees, plants, branches, flowers, leaves and seeds, etc. They are found in 7 forms e.g. *mulabeeja*-plants having seeds located in roots, *agrabeeja*-plants having seeds located on the top, parvabeeja-plants having seeds located in the knots, *kandabeeja*-plants having roots as seed, *skandhabeeja*-plants having seeds located in stem, *beejabeeja*-plants having grain as the seed, *sammurchhana*-plants growing without seeds by the process of agglutination.

3.3 J va Sam sa

In Jain view, life is characterized by soul and is classified in different ways. Classification of living beings (organisms/souls) is known as J va sam sa. Primarily J va sam sa is of two types:

- 1. *Paryaptaka*: The souls possessing all the six type of powers i.e. bio-potential (food, body, sense organ, respiration, speech and mind) are fully developed, i.e *Paryaptaka* and these are of 7 types.
- 2. *Aparyaptaka* If any one of the six power is missing in the soul, it is called *Aparyaptaka* and these are of 7 types.

These total 14 kinds are further divided into 98 classes according to the type of birth by the soul (hellish, animals, humans and celestial beings). Each class is further differentiated into several categories.

Swami Kartikeya (1990) and Acharya Nemichandra (2008) Siddhanta Chakravarti in Gomma?as ra (Jivak ??a) have broadly described four categories of *J va*. They are:

Human beings (9 types)

Sub-human (85 types)

Celestial (2 types)

Hellish (2 types)

Human beings are differentiated into 4 categories according to their living place in *Arya Khand, Mleccha Khand, Bhog Bhumi* and *Karma Bhumi*. Each category has two kinds of human beings: (i) *paryaptaka* and (ii) *aparyaptaka*.

On this basis, there are 8 kinds of human beings which have uterine birth. One special kind of human being, born only in Arya Khand by *Sammurchan* (spontaneous generation) process, is called *labbdhiparyaptaka*, which die before attaining bio-potentials.

Sub-human J va are of two kinds (a) uterine birth (b) sammurcchana birth

(a) Uterine birth: These J vas are of 3 types- (1) aquatic (2) terrestrial (3) aerial. Each of them is of two types- *Sanghi* (with mind) and *Asanghi* (without mind). Their habitats are in Karma Bhumi. Likewise *sanghi* terrestrial and aerial *J va* are found in *Bhog Bhumi* only. Thus total 16 kinds of uterine birth *J vas* exist in Karma Bhumi and Bhog Bhumi.

(b) *Sammurcchan* birth: These are also of 3 types- (1) aquatic (2) terrestrial (3) aerial. Each of them have *Sanghi* and *Asanghi* category. They are found in Karma Bhumi only. So there are a total of 6 type's of *sammurcchan* births in Karma Bhumi. Some aspects of *Sammurcchan J vas* have been discussed in an accompanying article by Jain et al. (2015).

Two, three and four sensed *J va* (*viklendriya*) are born only in Karma Bhumi by sammurcchan type of birth. Thus 3 kinds of viklendriya J va are found in Karma Bhumi.

One sensed *J* va (ekendriya) are classified into 4 classes (sammurcchan type of birth); earth bodied (*Prithvik ya*), water bodied (*jalkaya*), fire bodied (*taijaskaya*) and air bodied (*vayukaya*). Each of them is found in two forms i.e. subtle (*suksma*) and gross (*badar*). Thus 8 classes have been defined in the first four type of ekendriya. Vegetable bodied (*vanaspatikaya*) is grouped into two important categories such as Individual-bodied (*pratyeka vanaspati*) and Common-bodied (*sadharan vanaspati*).

Individual bodied (*pratyeka vanaspati*): Each soul has its own gross body. They are of two types.

1. Apratisthit: general body is free from nigodia badar J va.

2. Sapratisthit: *nigodia badar J va* are living in general body.

Common bodied (*sadharanavanaspati*): Infinite souls have a common gross body. They are of two types (a) *nitya nigodia*, (b) *eitar nigodia*. Each of them is again of two types-subtle and gross. Thus 6 classes are there in *vanaspatikaya*. In this way total 8+6=14 classes of one sensed (*ekendriya J va*) are found in the *loka*. By summing all *tiryanch J va* in *Karma Bhumi* by *sammurcchan birth* i.e 6+3+14, we find there are 23 types.

On the basis of bio-potential (*paryapti*) each class has 3 divisions viz. *Paryaptaka, aparyaptaka* and *labbdhi paryaptaka*; therefore there are 23x3=69 divisions of *sammurcchan tiryanch J va* in *Karma Bhumi*. The sum total of 69+16=85 of *tiryanch J va* are thus found in *Bhog bhumi* and *Karma bhumi* which have uterine and *sammurcchan* types of birth.

Hellish (*Naraki*) and Celestial (*Deva*) *J vas* are born by instantaneous birth (*Up-apad*). Each has two types and thus *paryaptaka* and *aparyaptaka*, together are of 4 types.

Thus we see that, in general, a total of 98 kinds, *tiryanch* (85) + human beings (9) + hellish (2) + deva (2), of mundane *J vas* (organisms), *Jivasamas*, are found in loka. According to Jain scriptures these *jivasamas* are further classified into 84 lakhs (10^5) yoni classes and 199.50 crore (10^7) kula families.

3.4 Samsari J va

Acharya Nemichandra (2008) has described the mundane souls (*samsari J va*) on the basis of two other criteria.

Attribute or Feeling /attitude i.e. Margana

Spiritual growth i.e. Gu?sthana

3.4.1 Margana

On the basis of Margana, there are 14 kinds of souls.

- 1. Gati (realm) Margana: Hellish, tiryanch, humans and celestial beings.
- 2. Sense Margana.
- 3. Body *Margana*: Immobile being/*sthavar* (earth body, water body, fire body, air body, plant body) and mobile beings (*trasakaya*).
- 4. Yoga Margana: physical, mental, vocal activities.
- 5. *Ved Margana* (sex desire): Male, female and bisexual desire.
- 6. Kashaya (passion) Margana: Anger, ego, pride, deceit and greed.
- 7. *Jnana* (Knowledge) *Margana*: empirical (*mati*), articulate (*sruti*), clairvoyance (*avadhi*), mind reading (*manahparyaya*) & perfect knowledge (*kevaljnana*).
- 8. Sanyam Margana.
- 9. Darshan (Awareness) Margana: chaksu, achaksu, avadhi & kewal darshan.
- 10. Lesya Margana: krishana, neel, kapot, padma, shukla lesya.
- 11. Bhavya Margana: bhavya, abhavya.
- 12. Right faith *Margana*: Full subsidence, full destruction, part destruction, part operation, part subsidence.
- 13. Quasi passion Margana.
- 14. Food intake *Margana: audarika, vaikriya, aharaka, tejas* and karmabody, up to 14 stages of gunasthanas.

Classification of *J va* on the basis of *Gunasthana* is described in an accompanying paper on Jain Yoga in this volume.

4. Biopotential

Single-sensed organisms possess four bio-potentials (*paryapti*) — food, body, sense organ and respiration. They lack the other two bio-potentials of speech and mind.

Two, three, four and five sensed irrational souls possess all the bio-potentials except mind. Rational five sensed souls have all the six bio-potentials and are fully developed (see Table 1).

Vital powers (Praná)

Ten vital powers viz; age, respiration, 5 sense organs and 3 *bala* provide *prana* in living organisms.

Table 1. The vital powers in different kinds of organisms.

Sensedorgan	Paryaptaka*	Aparyaptaka**
One sensed	4 prana	3 prana
Two Sensed	6 prana	4 prana
Three Sensed	7 prana	5 prana
Four Sensed	8 prana	6 prana
Five Sensed rational	10 prana	7 prana
Five Sensed irrational	10 prana	7 prana

**Paryaptaka -J va* possesses of all 6 types of bio-potentials /powers (food, body, sense organ, respiration, speech and mind)

***Aparyaptaka* (*Nivratparyaptaka*): Missing of any one bio-potential out of 6 biopotentials (*J va* doesn't obtain all six *paryapti*).

- 5. Jain and Biological Classification (A Comparison)
- 1. Jain *agam* is a complete science. Science is not as complete as Jain *agams*.
- 2. In Jain scriptures all living organisms are divided into two domains-mobile (*tras*) and immobile (*sthavars*). In Biological science all living organisms are divided into two kingdoms-animal kingdom and plant kingdom.

- 3. In Jainism, all living beings are classified on the basis of number of sense organs, kind of birth, land of habitat i.e. *karma bhumi, bhog bhumi* etc., while in biological science they are classified on the basis of physical characteristics, presumed natural relationship, body structure (internal and external), morphology, features, habits, habitats, etc.
- 4. Sequential pattern of classification is not found in Jain scriptures as in biology, where every individual is broadly classified in a sequence of domain, kingdom, phylum, class, order, family, genus, species, variety etc.
- 5. In Jainism classification of *Bhog bhumi* and *Karma bhumi*, *J vas* have different characteristics and features. In science there are no such geographical area (lands) identified and differentiated.
- 6. Differentiation of organisms on the basis of vital powers (*prana*), *paryaptaka*, *aparyaptaka* and *labdhiparyaptaka* are found in Jainism classification. Biological classification has no such consideration.
- 7. According to Jain scriptures, *Akshay anant* (infinite) *J va* (organisms) present in the *loka* are known to omniscient (*sarvgya kevali*) only. However 8.4 million yonis and199.5 crore (*kula*) families of *samsari J va* are mentioned. In biological science about 8.7 million species have been estimated and many more are being discovered every year. About 1.8 million have been given scientific names. Indefinite numbers are still unknown.
- Jainism classification was well documented in Jain scriptures like Kashayapahud, Shatkhandagam, etc. about 2250 years ago. Biological classification came in existence only about 250 years ago and Linnaeus (1707-1778) system of classification was followed first and later on it was refined by many biologists.

6. Embryogenesis and Organogenesis

Fertilization occurs by the union of sperms of the male and eggs from the female in the female reproductive tract within seven days of mating (Yashodhara Charitra) where it remains up to the full gestation period of about nine months. A full description revealed the process of embryogenesis, stating the size of the embryo during the first month of fertilization, the embryo becomes a lump in the third month, formation of bones and skin in the fifth month, body hair in the sixth month, discomfort and discontent feeling in the seventh month which grows

strongly in the eighth and ninth months, and may come out within 7 to 10 months of gestation. Similarly in the book by Shivarya (2008) in Bhagwati Aradhana, a detailed description by Shital (1994) in Sahaj-Sukha-Sadhna, Chullak (2002), Vattakeacharya (2006), in Mulachara Part-2, Swami (1990) in Karttikeyanupreksa, it is mentioned that in 24 hours after fertilization there is a ball (*Kalila*), after seven nights it becomes a bubble (*budbuda*) and other details of embryogenesis, gestational development, parturition and minute body anatomical descriptions are given. In fact the body is made of seven main elements (*dhatus*) and of seven minor elements (*upadhatus*) in the form of body fluid, blood, muscles, fat, bones, semen, *minji, vata, pitta, sleshms, sirras*, tendon, ligaments, intestines, lubricant, skin, and greasy material. There are nine major external openings like two eyes, two ears, two nostrils, mouth, rectum and reproductive organ (*linga*) and sub organs like two hands, two legs, hips, back, heart, brain, cheeks, upper and lower lips, chin, palate, tongue, and eye brows. The living body remains in a state of uniform balance through the process of regeneration and degeneration.

The major outlines of the embryo and fetal developments are as follows:

First 10 days - remains in a floating state (kamal avastha)

Second 10 days - No movement (kala avastha)

Third 10 days - fixed in the uterus (Implantation-*sthir avastha*)

Second month - soft attachment with the uterine inner wall

Third Month - Hardness due to bone formation

Fourth month - muscle development

Fifth month - Organogenesis and development of brain from the mid region, two hands from the upper and two legs from the lower regions.

Sixth month - Organs development

Seventh month - Skin, hair, nails and discomfort feeling

Eighth month - starts moving in the womb

Ninth month - grows strongly and commencement of uterine contractions in the end of the month

Tenth month (first week) - parturition (delivery)

Besides organogenesis, there are other qualitative and quantitative descriptions in

the form of tissues, bones, ligaments, joints, and body fluids such as bones-300, ropes-2, organs-7, *kandra*-16 (large blood vessels in the chest region), *seeramoola*-6, kinds of skin-7, number of cells-eighty lacs crores (8x10¹³), *Kaleyak*-7, hair-8x10¹⁵), brain one *anjali* (250- 300 grams), *sthoori*-3, implantation points-107, asraya of fecal matter-7, *peestha* of intestines-16, body orifices-9, *medha dhatu*, formation of semen (one *anjali*) takes 30 days, fat content in muscles (500-700 grams), bile and cough-6 *anjali* (1-1.5 litres), blood-4 litres, urine- 4 litres, fecal matter-5.5 kgs., nails-20, teeth-32, eyes disorders-96, body ailments-56899584 (Vattakeacharya, 2006).

Various types of bone-joints, number of ribs, position and weight of various parts representing anatomy of human body are discussed along with some references about embryology in Tandulveyaliya, Payanna (2008). Reproductive systems of men and women are also described.

Development of body constituents (major elements-*dhatu*): The digested food in the form of liquid (*rasa*) in the intestines is absorbed and converted in to *raktta* (blood) within 8-9 *kastha* (157 *pala*), after remaining in the form of *rasa* for the same period. The other constituents of the body in various forms are converted from blood to meat, meat to *maida, maida* to bones with bone marrow, to semen and from semen to *praja* (offsprings). Similarly minor elements (*upadhatu*) in the form of *vata, pitta, sleshm, siras*, tendon, ligaments, catgut, lubricants, skin and digestive juices are formed subsequently. The body of all living beings to the smallest unit are all made up of combinations of physical particles (*skandha*) constituting a net work of subtle channels (*nadi*), winds (*prana*) and essences (*bindu*) (Swami, 1990).

The Jain and modern views do not reveal much difference during the process of embryogenesis and organogenesis as is clear from the following table (Table 2).

Table 2. Summary of Developmental Time course of human embryo in modern biology

Stage	Weeks	Days	Event
Pregnancies and development	4	24	Primordial germ cells (PGCs)
Organogenesis	5-8	29-56	begin their migration to
Phenogenesis	9-38		parents' gonads

7. Modern Biological Concepts

7.1 The Cell Doctrine

The familiar idea that the cell is the basic unit of life is known as the cell doctrine. In the first place the cell doctrine states that the life exists only in cells. However, in a very exact sense, it includes not only the cell but some of its smaller components, such as genes and chromosomes. With the advancement of modern cytological tools, it seems that there exist relations between structure and function called the principle of complementarity, that the biochemical activities of cells occur within, and indeed are determined by, structures organized in a definite way. There are two primary types of cells. Prokaryotes are cells without a nucleus and other membrane-bound organelles. Although they have circular DNA and ribosome, as in bacteria and archaea, and cell division occurs through a process of fission in which the DNA is replicated, and then the two copies are attached to parts of the cell membrane. The other primary type of cells are the eukaryotes, which have distinct nuclei bound by a nuclear membrane and membrane-bound organelles, including mitochondria, chloroplasts, lysosome, rough and smooth endoplasmic reticulum, and vacuoles as in animals, plants, fungi and microorganisms (Gardner, 1972).

7.1.1 Germ Cells

Germ cells are essentially involved in reproduction. The most well known examples of this type of cells are gametes in which the sperm and eggs come together to create a zygote which can develop into a fetus. All germ cells carry the germ line, the genetic material which an organism can pass on to its offspring. In humans, these cells are haploid, meaning that they carry only half the number of chromosomes necessary to create an organism. When germ cells from two different people meet, their haploid genetic material combines to create diploid cells which can replicate themselves through cell division, ultimately turning in to a baby forming the male and female internal and external genitalia.

7.1.2 Genotypic Sex

Genotypic sex is determined by the type of sex chromosomes an individual receives from the parents. The sex chromosomes establish the blue print for genotypic sex. However, autosomal genes cannot alter this blue print drastically in most higher vertebrates, but they may be responsible for the variations in the expression of phenotypic sexuality that are observed in most higher animals including man.

7.1.3 Sex Ratios

Three different types of sex ratios are generally expressed as primary at the time of fertilization, the secondary at the time of birth and the tertiary at the time of procreative age (Nalbandove, 1970).

7.1.4 Somatic Cells

Cells which do not carry the germ line of an organism are called somatic cells. The bulk of the cells in the body are somatic cells. Somatic cells are diploid, containing all of the information needed to make an organism and many of them have special tasks to perform. Most living organisms are made up of cells that contain a substance called deoxyribonucleic acid (DNA) containing four chemicals adenine, thymine, cytosine, and guanine (A, T, C, G) as extremely thin, coiled strands in the cell. Each cell in the body contains about 150 cm of DNA thread, for a total of about 5 billion kilometers of DNA inside. Genes are made of DNA, and different patterns of A, T, G, and C code for the instructions for making things the body needs to function (like the enzymes to digest food or the pigment that gives colour to the eyes). As the cells duplicate, they pass this genetic information to the new cells. DNA is wrapped together to form structures called chromosomes. Most cells in the human body have 23 pairs of chromosomes, making a total of 46. Individual sperm and egg cells, however, have just 23 unpaired chromosomes. One receives half of the chromosomes from mother's egg (XX) and the other half from father's sperm cell (XY). A male child receives an X chromosome from his mother and a Y chromosome from his father whereas females get an X chromosome from each parent. Because each chromosome occurs in pairs, one has two copies of every gene (except for some of the genes on the X and Y chromosomes in boys, because boys have only one of each). Some characteristics come from a single gene, whereas others come from gene combinations. Because every person (genome) has about 25,000 different genes, there are an almost endless number of possible combinations. It is worth pointing out that when 25,000 different types of genes can result in almost endless number of possible combinations, what would happen in a situation when different types of countless (infinite) character-carrier subtle karmas, according to Jain concepts, take part in unions of male (XY) and female (XX) living beings.

7.2 Carrying Messages within the Cell (Genetic Code)

A piece of gene is a coded message which is read by the cell. This message is eventually translated into a particular kind of protein, or enzyme. A message, of course, has a beginning and an end. According to the Jain point of view, karmas are much smaller, subtler, stronger, non-structural entities compared to genes, beyond the capabilities of any measurement techniques. They are infinite in number and carry all sorts of innumerable (countless) characters of expression and impression. These characters may be expressed within the present life, in off springs, in different generations, even after death and reincarnation. These are, in fact, life impressions and the main source of inheritance. We think, consequent to practicing various yogic purification exercises of sadhana and mantras, the karmana sarira can influence the genome by operating on molecular levels or even at subtle levels to decide and modify the genome and DNA sequence (Bhandari, 2010).

7.2.1 Changing Genes (Mutation)

A person can be born with gene mutations, or they can mutate over a lifetime. Mutations can occur when cells are aging or have been exposed to certain chemicals or radiations. Fortunately, cells usually recognize these types of mutations and repair them by themselves. At other times, however, they can cause illnesses, such as some types of cancer. If the gene mutation exists in egg or sperm cells, children can inherit them from their parents. When the mutation is in every cell of the body (meaning a child is born with it), the body is not able to "repair" the gene change.

7.2.2 Induced Mutations

Sometimes scientists alter genes for a special purpose through genetic engineering in plants/animal cells to produce other plants/species with special characteristics, such as an increased resistance to disease and pests or the ability to grow in unfavourable environments.

7.2.3 Gene-less theory

Woolfson (2000) proposed that development of life went through three distinct stages: the gene-less, the pre-genetic and the genetic ages and then went on to depict when and how the gene-less world existed. He further stated the laws of chance and complexity to describe the space of all possible worlds, all possible organisms and all possible life forms and as such genes may, in fact, be neither necessary nor essential for life and thus there is a possibility to have gene-less cell

division. Life without genes is quite different from any other popular concept of science. Christine (2011) generated simple nonliving model "cells" and established a symmetric division- the process by which a cell splits to become two distinct daughter cells- possible even in the absence of complex cellular components, such as genes. The new modeling techniques seem to suggest that simple chemical and physical interactions within cells, such as self assembly, phase separation, and partitioning can result in seemingly complex behavior like a symmetrical division, even when no additional cellular machinery is present. Furthermore, the fact that the rudimentary process of cell division, (excluding cell differentiation and a pyramid of cell functions) can occur in the absence of genetic material is indeed a scientific possibility but will be in contradiction to Jain concepts as livingness and non-livingness are basically two different identities and cannot be interchanged into each other.

8. Origin of Life

One possibility for how life began is that genes originated first, followed by proteins. The other alternative is that proteins came first and then the genes. However, since genes and proteins are both required to produce each other, the problem of considering which came first is like the "chicken and egg" paradox. Most scientists have adopted the hypothesis that genes and proteins arose independently. Therefore, a possibility, first suggested by Francis (2002), was that the first life was based on RNA which has DNA-like properties of information storage and the catalytic properties of some proteins. This is called the RNA world hypothesis, and it is supported by the observation that many of the most critical components of cells are composed mostly or entirely of RNA.

8.1 Soup theory

Life is a soup of RNA-DNA molecules. They continue to mix into the soup till it lands on a planet that has one more molecule which brings it to life or at least has one cell capable of reproduction. Robert (2009) has summarized the "primordial soup" theory of Oparin (1952) in its "mature form" as follows:

The early Earth had a chemically reducing atmosphere. This atmosphere, exposed to energy in various forms, produced simple organic compounds (monomers). These compounds accumulated in a soup, which may have been concentrated at various locations (shore lines, oceanic vents etc.). By further

transformation, more complex organic polymers and ultimately life developed in such a soup.

8.2 Genetic Engineering

The frontier between "good" and "bad" genetic engineering depends on whether or not the embryo is considered to be "animate". "If, (for example, the human) embryo has a soul, then it is endowed with a human life (karma sarîra) as well as biological life and any attack on its integrity is seen as a crime" says French geneticist Frydman (2004). This is to say that even geneticists and religious texts, both believe in karmas playing a role through genes in this gross body. However, there is no concept of soul for a living entity in the modern science. The soul is an essential component of all living entities including cells and even subtle organisms, according to Jain view point. Furthermore, the soul is a non structured identity which is able to enter/penetrate through any material structure, including cells, tissues, organs, bones and body as it is Asankhayat-pradeshi. Moreover, the soul possesses the property of elasticity and thereby it is adjusted and modified according to the shape and size of the body and extends throughout the body in every cell, organ or component organelles of the living body.

8.3 Gene Therapy

It is a promising field in medical and bio-research. In gene therapy, researchers try to supply copies of healthy genes to cells with variant or missing genes so that the good genes will take over. Viruses are often used to carry the healthy genes into the targeted cells because many viruses can insert their own DNA into the targeted cells. But there are problems with gene therapy. Huge scientific efforts like 'The Human Genome Project' and related projects have completed a map of the entire human genome (all of the genetic material in a living being's chromosomes), but it will take many years to find out what each gene does and how they interact with one another. Karmas cannot be eradicated by gene therapy as karmas and genes are altogether different entities. Karmas are subtle in nature whereas genes are not subtle. However, both are character (gu?a) carriers but there is no relationship between them as karmas remain attached with the soul until the soul is liberated. Two kinds of genes have been recognized: 1. Structrual gene - which is a code for the synthesis of a great variety of cellular polypeptides 2. Regulator gene - which is not a code for any protein and is governed by karma of the soul. Their function is to regulate the functioning of structural gene. This regulatory

gene is nothing but a sort of karma carrier which regulates the functioning of structural genes and synthesizes polypeptide protein (hormones/enzymes) which controls the entire functioning of a living system. Karmas of a person cannot be changed by altering DNA (genetic engineering) because karmas are associated with atmapradesha and control functioning of structural genes through regulatory gene.

8.4 Cloning

Cloning is formation of identical twins from germ cells or somatic cells, (Jain, 2012). Cloning may be either reproductive or somatic, depending upon the resource cells used. In reproductive cloning the mature blastocysts are used to produce more embryos and it is mostly done in vivo or in vitro fertilizations or by non surgical aspirations of blastomeres from a mature blastocyst. The aspirated blastocysts are hatched in to full grown blastomeres after treating with culture media and by placing them in the BOD incubator for a certain period of time. The blastomeres (clones) may either be stored frozen or transferred in to synchronized recipients for the production of identical twins. Another most common cloning method, known as "somatic cell nuclear transfer" (SCNT) or simply "nuclear transfer (NT)" requires two kinds of cells. One is a somatic cell, which is collected from the animal that is to be cloned (known as the "genetic donor"). A somatic cell is any cell other than a sperm cell or egg cell, and contains the complete DNA, or genetic blueprint, of the animal it came from. For cloning purposes, somatic cells are typically obtained by a routine skin biopsy performed by a veterinarian/human surgeon. The other kind of cell required for cloning is an egg cell, which is collected from a female of the same species (known as the "egg donor"). In the laboratory, a scientist extracts and discards the nucleus of the egg cell, which is part of the cell that contains the egg donor's genes. The scientist then inserts the somatic cell from the genetic donor into the egg and "fuses" the two with electricity. The resulting fused egg contains the genetic donor's DNA. The clones are not identical from behavioral point of view. However, they look identical from phenotypic and genotypic point of view. This is because all living cells have a soul and the soul is never without karma. Cloning gives rise to identical species but their karma is different. By cloning technology or vegetative reproduction many offspring/progenies are developed. Every individual possesses his own karma. Innumerable (infinite) nigodia J va are there in one common body but each J va has its own karma.

8.5 Stem cells

Stem cell researcher L. Robert (2009) hopes to save thousands of lives, doing

what is "right" that involves working with therapies based on human stem cells. The blind shall see again; the paralyzed shall walk again; the hemophiliac shall not bleed anymore. In fact, the US business magazine Fortune called him "the standardbearer for stem cell research.

9. Embryo Transfer in Ancient India

'Swetambaras' believe that Mahavira (~ 600 BCE) was first conceived in the womb of Devananda, a Brahmin lady. The embryo was later transferred to the womb of the Royal queen Trisala (Kalpa Sutra), as the gods thought that Tirthankaras were not born in Brahmin family (Jacobi, 1884, retrieved 2007). 'Digambaras' do not subscribe to this story of transfer of embryo. However, it is fascinating to know that such techniques were known to ancient people as far back as ~ 600 BCE which are not even known to many bioscientist, medical practitioners and veterinarians in the present era. This genesis did not reveal the scientific ideology since the attributes of a person, in this case a Tirthankara, lies in inheritance of genes rather than to non-genetic phenomena. In such situation Trisala served as a surrogate mother of Mahavira and not as a donor (genetic mother) for transferring high genetic material. Similar work of embryo transfer in dairy animals including cloning and I.V.F. was done and reported (Jain, 1989, 1990,1994, 2012, 2013). The uterus of the mother provides only the nourishment to the fetus through the placenta connected to the mother and is in no way, responsible for transferring the genetic material. Dr. Wolfgang (2012), a veterinarian working at Walsenburg, found the description of embryo transfer in Jain texts of ancient India. In yet another text in Sanskrit (Instructions on the existence of man before and after birth, Tandulaveyaliya (2008), it is written that "the yoni (ovaries) of women spontaneously arise and perish 400,000 000 to 900 000 000 primordial follicles, the precursor of eggs", while in modern science, the number reported is much less, about 4000,000 (four million).

10. Biocentrism

Robert (2009) proposes a biocentric theory (A New Theory of the Universe) which ascribes all phenomena to the observer rather than the observed and argues that biology should replace physics as the foundational science in our understanding of the universe. Biocentrism states that life and biology are central to being, reality, and the cosmos; life creates the material universe rather than the

other way around. It asserts that the current theories of the physical world do not work, and can never be made to work, until they fully account for life and consciousness. Biocentrism claims that scientists will need to place biology before other sciences to produce a theory of everything (Aaron, 2009).

Robert and Berman (2009) were of the opinion that consciousness conceives, governs, and becomes a physical world. It is the ground of our Being on which both subjective and objective reality come into existence. Biocentrism shatters the ideas of life, time and space, and even death. At the same time, it releases us from the dull worldview that life is merely the activity of an admixture of carbon and a few other elements; it suggests the exhilarating possibility that life is fundamentally immortal.

11. Male and Female Dominance

Overall, males are seen as more skillful than females (Deaux, 1974) and more males than females are found in occupations requiring the highest levels of intellect (Leharke, 1972). Higher human intelligence arose out of a mutation, or series of related mutations, on the X-chromosome (Lehrke and Gordon ,1997). The present concept put forward by Leharke is in agreement with the Jain Philosophy (Digambara tradition) believing that only male can attain full level of intelligence in the form of *Kevalya Jnana* and finally *mukti* (liberation) of soul. Besides this, great differences of physiological and sports norms and vital body functions exist between males and females, confirming sex linked inheritance.

12. Summary

In this article, we have compared various Jain biological principles with modern biology. The universe is immortal, eternal and self sustaining; it is neither created nor sustained by any one. The soul is a living substance (*chetan dravya*) and is in two forms, the pure (*mukta*) and impure (*sansari*). The *karmana sarira* is a sort of diary of karmas and soul. The law of independent assortment, selection and union decides the expression of various characters of living beings through the karmic code.

The body may have one sense (touch), two senses (touch and taste), three senses (touch, taste and smell), four senses (touch, taste, smell and vision), five senses-*asanghi* (touch, taste, smell, vision and hearing) and <u>sanghi</u>, with development of mind.

Science so far is not able to ascertain the existence of soul- the living substance having a unique characteristic of feeling (sense) of touch, eating, smelling, vision, hearing and, on top of it, the most important being the power of thought, thinking process, expression, *Darshana, Jnana* and *Charitra*. Science justifies these functions as due to various vital sensory organs. The living organisms are classified as stationary (non-motile) and probationary (motile). Whereas, *J vas* are constitution of complex amalgamation (*J va sam sa*) of soul, karma, body, force and *prana* (and respiration) and may be found in the form of one and multi sense bodies like air, earth, fire, water, plants, animals, humans and in subtle forms of *nigoda*. The states in which *J vas* are found are known as 14 kinds of *Marganas*.

Phenotypic and genetic expressions of different characters are expressed as per the law of independent assortment and union of karmas in the present, past and future lives depending upon the dominance and excessiveness in different species of plants and animals. The science of embryogenesis, embryo transfer, cloning, and *in vitro* fertilization are mentioned in various ancient texts and were probably well developed.

Woolfson (2000) classified evolution of life in three distinct epochs- the geneless, the pre-genetic and the genetic ages and then went on to depict when and how the gene-less world existed. Leharke (1972) was in agreement with the Jain Philosophy (Digambara tradition) believing in the superiority of males.

Death is the permanent termination of all vital functions of life processes in an organism or cell. Based on its karma, a soul undergoes transmigration and reincarnates in various states of existence like heavens or hells, or as humans or animals. There is nothing mightier in the world than karma. It is supreme and is responsible for the phenotypic and genetic expressions in a living being.

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14. Evolution and Neo-Darwinianism

Varsha Shah

Abstract

Neo-Darwinism does not provide a satisfactory explanation for evolution. In this article we discuss the failure of paradigm of science within the fold of Neo-Lamarckians and Neo-Darwinianism. Various western ideas of evolution are summarised and these models of evolution are compared with the Jain views.

Key Words: Darwinianism, Neo - Darwinianism, Neo-Lamarckianism, evolution.

Scriptures Quoted: Bhagavati S tra, Tattv rthas tra, Mul c ra, Gommattas ra, Jiv bhigam S tra, Dravya Sangraha, Acaranga, Dasavaikalika, Panavana.

1. Introduction

The theory of evolution of life can be classified from different points of view e.g. philosophical and scientific. Every scientific theory has a philosophical substrate. In this case, the philosophical part is the teleological argument and the scientific side is the proposal of certain models to validate the theory using observations and scientific methodology. Thus scientific formulation tries to express the basic principles of the evolution of man, the origin of life and of evolution in general.

We first list some of the important ideas proposed by various western scholars for understanding evolution.

1.1 Theories of Evolution

1. Carolus Linnaeus's (1707-1778) contribution to classification provides an evolutionary relationship among the organisms. He also supported the idea that no species is new. Each and every species originate from some pre-existing species.

2. Jean Baptist Lamarck (1744 -1829) tried to explain the evolution process in his book Philosophic Zoologique. The theory, dubbed as Lamarckism, is known as the theory of inheritance of acquired characters. According to this theory use and disuse of an organ leads to acquiring change in features of that organ. These changes are also inherited by the offspring. Favourable changes after long period of time result in evolution of new species. Lamarckism was strongly criticized by August Weismann. Charles Robert Darwin (1809 - 1882) explained the principle of evolution in his book 'The origin of species'. The theory proposed by him is popularly known as 'Theory of natural selection' or Darwinism. Darwin explained that despite having the enormous potential of fertility, the population of an organism remains within a limit. It is due to struggle between members of the same species as well as different species for food, space, mating, etc. Struggle eliminates the unfit individual. The fit organisms possess some variations which are favourable and they leave the progeny to continue the favourable variation. The variation when accumulated for the first time gives rise to origin of new species. With progress in genetics, the sources of variation were explained and Darwin's theory was modified. Now, the best accepted theory of evolution is Modern Synthetic Theory, in which the origin of species is based on the interaction of genetic variation and natural selection.

With the publication of 'On the Origin of Species' in 1859 Charles Darwin had denied saltational evolution (new species arise as a result of large mutations) by writing that evolutionary transformation always proceeds gradually and never in jumps.

1.2 Dominance of Neo Darwinianism

There appear to be two reasons for continued dominance of Neo-Darwinism. The first is that it is the only theory of evolution which seems to be consistent with the 'paradigm of science'. The second is that the Neo-Darwinists like Julian Huxley (1957), George Gaylord, Simpson (1953) and Theodosius Dobzhansky (1937) have not provided a coherent alternative theory, but rather sought to modify Darwinian theory in different ways to accommodate their various criticisms. The 'synthetic theory' is the latest version of neo-Darwinism.

1.3 Alternative Theories

The advocates of 'punctuated equilibrium', Stephen Jay Gould, Stanley and
Niles Eldridge (1972), proposed another explanation which they called 'punctuated equilibrium'. That is, species are generally stable, changing little for millions of years. This leisurely pace is 'punctuated' by a rapid burst of change that results in new species.

James Mark Baldwin (1896), Conrad Hal Waddington (1942), Ivan Schmalhausen (1949), Jean Piaget and a number of other scholars of evolution, have tried to get round the problem by postulating a feedback mechanism of a type that is compatible with the paradigm of Neo-Darwinism. Conrad Waddington's (1957) view of evolution ('neutralist school') is a "genetic assimilation" which simulates Lamarck's inheritance of acquired characteristics and reconcile it with the Neo-Darwinism. They tried to show that a large proportion of mutations could be regarded as neutral vis-à-vis adaptation. Waddington's view is that ontogeny (the development of an individual organism) and phylogeny (the evolution of a species) are fundamentally different and consequently subjected to different laws. But it is only when ontogeny, behaviour and evolution are seen together as parts of a single process that we can begin to understand their vital interrelationship.

Francis Crick (the co-discoverer with James Watson of the genetic code for which both won Nobel prizes) considers that our complex biosphere could not have evolved in the short time available to it, that is, the 3.5 billion years since life began on earth. Instead, claims Francis Crick (1990), life must have originally come to earth from some other planet in the form of bacteria sent over in a rock of some sort, like cosmic dust or meteorites. It is indeed ironic that scientists should regard it as more scientific to trace the ancestry of living things on our planet to bacteria which arrived in a rock 3.5 billion years ago than to admit that living processes such as evolution are goal-directed, dynamic and creative.

1.4 Modern Synthetic Theory

There are significant differences between the Modern Synthetic Theory of evolution and the Darwin's theory. Some of these points of difference are listed below:

- It accepts random genetic changes as a mechanism of evolution, in addition to the mechanism of the natural selection.
- It assumes that the traits are inherited through genes. The variations of the population are due to the presence of multiple variations of a gene.

• It assumes that the specialization is due, usually, to small random changes in the genetic information.

In other words, Synthetic Theory (see Appendix-1) incorporates the aspects related to the microevolution and assumes that the macroevolution is simply the accumulation of the microevolution.

To understand evolution is to understand ontogeny and behaviour - the processes that have actually undergone change. Yet neither of these evident facts has been accepted by those within the neo-Darwinist fold.

1.5 Features of Living Processes

The basic features of living processes are:

- I) The hierarchical organization of living beings.
- II) Unity of life and similarity of all life processes.
- III) Living things are dynamic and creative and self regulating.
- IV) Maintain the integrity and stability of the larger systems of which they are a part.
- V) It should be seen as a process of change from a low level to a high level of organization.

The word living 'being' can be defined as -

- 1. Essence or nature
- 2. Entity (that exists).

1.6 The Hierarchical Rganization of Living Beings

'Paradigm of science' seems to have failed in giving an appropriate reason for hierarchical organisation of leaving beings. It is only when one recognizes the hierarchical nature of the biosphere and of its component systems and sub-systems that one realizes the true nature of the environment. The Neo-Darwinists have never defined the environment, it is just something that is 'out there'. The failure to accept the hierarchical nature of the biosphere leads scientists studying evolution to insist that selection only occurs at the level of the individual. Evolutionary changes affecting populations as a whole are seen by Neo-Darwinists as exclusively the result of changes occurring to their individual members. Thus they deny that adaptation (by natural selection or whatever other processes may be involved) occurs at any other level of organization, whether it is that of the cell, the organ, the family, the community, the population, the ecosystem or the biosphere itself.

2. Jain View on Evolution

As given in Bhagwati *Sutra*, Roha Muni asked Lord Mahavira, "Bhante ! What comes first?

a) Universe (Loka) or Empty Space (Aloka)

b) Living (Jiva) or Non living (Ajiva)

c) Egg or Chicken

Lord Mahavira explained that the either- or question does not arise because all three are intrinsic by nature, they are beginningless (*an di-ananta*) and eternal (*sh svat*). There is no evolution, neither of universe nor of a living being (*Jiva*). But Jainism believes in the hierarchical nature of the biosphere. In Jainism, living beings rather than being atomistic are highly organized and hierarchical. Texts like Pannavana S tra, Jiv bhigam S tra, Uttar dhyayana S tra, Mul c ra, Gommattas ra Jiva-k nda, Tattav rtha S tra give detailed classification of living beings.

2.1 Unity of Life and the Similarity of all Life Processes

If we were to face the principle of the unity of life and the similarity of all life processes, we would realize that the mutual adjustment of systems to their specific environment within the constraints imposed on them by the larger systems of which they are a part, must occur at all levels of organization within the hierarchy of the biosphere. To think otherwise implies that systems are incapable of mutual adjustment and must be controlled from the outside by forces occurring at other levels of the hierarchy. Such a tenet is contrary to the principle of self-regulation and suggests that such systems are passive rather than dynamic; and robot-like rather than life-like.

It should be evident that living things affect their environment in the same way as they are affected by it, that in fact, living processes are interactive or two-way rather than uni-directional. If we accept such multidirectional influences we should no longer accept the Neo-Darwinist thesis that evolutionary change is merely "selected" by the environment. We would instead, like Piaget, have to see such changes as the result of "mutual adjustment" and as subject to the constraints imposed by the hereditary endowment of the systems involved as well as those imposed by the larger system of which they are part.

2.2 Jain View

There is unity of life i.e. all beings are mutually dependent on one another. And there is similarity of all life processes i.e. Jainism mentions about common developmental processes (*Pary ptis*) and vital forces (*Pran s*) in various beings (*Jivas*) showing physical development. Jainism speaks of nine such common attributes in all worldly beings (*Sopadi Jiva*). They are as follows - vital force (*Jivo*), awareness (*uvaogamao*), formless (*amutti*), agent of one's own action (*karta*), equal in extent to one's own body (*sadeha parimano*), enjoyer of one's own action (bhokta), existence in the world (*samsarattho*), right to get liberated (*siddha*), having the characteristic of natural upward motion (*vissaso-hagai*). There is no discrimination as far as the nature of the soul is concerned, the distinction being only in respect of the degree of their intelligence, intuition etc. owing to the difference in karmic veils that cover/distort them.

2.3 Living Things are Dynamic, Creative and Self-regulating

Scientists insist that living beings are passive rather than dynamic and creative. The alternative theory to phenotype (interaction between genes and environment) is 'epigenesis' (development in a sequence) which took a long time to be accepted and is still impossible to explain. The refusal to accept the creativity of the evolutionary process has forced those scientists who take the Neo-Darwinist paradigm seriously to provide science fiction explanations for the origin. The individuals are made to evolve by gene mutations selected by their environment and are considered to do so through no effort of their own. While environments select responses from living organisms, those same environments are themselves subjected to modification by such responses. Yet neither of these two evident facts has been accepted by those within the Neo-Darwinist fold.

There are certain characteristics of a living thing in the modern science. And if these characteristics are fulfilled, living beings would be dynamic and not static or passive. The characteristics are as follows:

- Movement
- Metabolism (heat)
- Inhalation and exhalation
- Consumption and excretion
- Reproduction

• Growth, decay and death.

Even in the text Ac r nga, S yagadao and other subsequent texts like Dasavaikalika S tra, the doctrine of six classes of living beings has found universal acceptance.

One sense beings have life is proven. Panavana S tra states that these one sensed beings are underdeveloped and we cannot notice any sign of activities like breathing.

2.4 Integrity and Stability of the Larger Systems Living Things Maintain the Integrity and Stability of the Large Systems of which they are part.

Ontogenetic development is clearly goal-directed since it leads to the development of a relatively standard phenotype (observable structure, function or behavior of a living organism). It is also dynamic and highly coordinated since all the different stages are closely interwoven into a single strategy. It is also highly stable ("homeothetic" in Waddington's language) since it avoids any diversion from its optimum course (or "chreod" as he referred to it). Thus it displays precisely all those features that are religiously denied to the evolutionary process, both by neo-Darwinists in general and by Waddington himself.

2.5 Jain View

Being (*Jiva*), though is addressed as body i.e. matter (*Pudgalika*) in the Bagawati Sutra, has not originated from non-living matter. Living beings are eternal- constant- formless (*nitya-avastitha-aruppin*), it cannot become non living matter (*ajiva*) and vice-versa. Jaina system admits only the dynamic reality in a soul substance (*jiva draya*). It is an identity expressing through difference, a permanency continuing through change (modes). It corresponds to the modern conception of organic development. Stability is undoubtedly the goal of living organisms and their ability to maintain their stability in the face of change (modes) is perhaps their most impressive achievement.

It should be seen as a process of change from a low level to a high level of organization. Rather than being random, living beings are ordered and highly purposive. i.e. Indian philosophy believes in teleological goal. Distinguishing and demarcation between living being and non-living is the presence of knowledge. The knowledge is built up systematically as part of a coordinated strategy among living beings, functioning as homeostatic (harmonious) parts of the biosphere.

Empiricism, the scientifically acceptable method of acquiring information is very difficult to reconcile with the knowledge of perception and cognition. Knowledge is not just an accumulation of data, it is an organization of data and organizing activities can go on in the mind without their being triggered off by external stimuli. Thinking is a source of knowledge as is observation which involves thinking, since observation involves interpreting data in the light of the mental model or 'cognitive map' that is built up in the mind and which reflects the experience of species, culture and upbringing of human beings. The knowledge is built up systematically as part of a coordinated strategy among living things functioning as homeotelic parts of the biosphere.

Jean Piaget's stages of development show cognitive development. Sensory motor as the 1st stage of crawling child within age 2, who understands through senses and action, preoperational as the 2nd stage of a child within 7 years who understands through language and mental images, concrete operational as a 3rd stage of adolescent within the age group up to 11 years, who understands through logical thinking and formal operational as the fourth stage of an adult who understands through scientific reasoning (see appendix for chart).

Organicists Alfred North Whitehead, Paul Weiss, Arthur Koestler, Ludwig Von Bertalanffy, Jean Piaget and Conrad Waddington also hold that it is the level of organization that we associate with living processes that confers on them their specific features those that distinguish them from inanimate objects. The Neo-Darwinist thesis, however, fails to provide an explanation for the development of organization.

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Appendeix-1: Synthetic Theory - Genetic Drift

In this simulation, there is fixation in the *blue* "allele" within five generations. In this example, if no *red* marbles are selected, the jar representing the new generation contains only blue offsprings. If the protein is not changed it will not effect the phenotype and the fitness of the organism (neutral therory).

Jean Piaget's stages of development show cognitive development.





15. Jain Concepts of One Sense Beings, *Sammurchhan* Beings and Modern Microbiology

Ashok K. Jain and Jeoraj Jain

Abstract

In Jainism, based upon the number of senses and mobility, living beings (*Jivas*) have been classified into a) Non-mobile or *Sthävar Jiva* – those that can not move on their own and have only one sense; and b) Mobile or *Trasajiva* – those that can move on their own and have two to five senses. The non-mobile living beings are further divided into i) *Prithvikäya* or Earth Bodied ii) *Apkäya* or Water Bodied, iii) *Teukäya* or Radiance Bodied, iv) *Väyukäya* or Air Bodied and v) *Vanaspatikäya* or Plant Bodied. Plant bodied beings are already grouped under living category in modern science but it is really amazing that in Jain scriptures the components of nature like earth, water, air and fire have also been considered as living entities having various properties of living beings, e.g. sense, ingestion, respiration, aging, anger, grief, sexual feeling, death etc. Scientific work to probe the livingness in such entities is now being carried out by many researchers. The present article is an attempt, though speculative in some ways, to provide some scientific support for existence of one sensed beings.

Key Words: One-sensed (*Ekendriya*) living immobile beings, Water Aura, *Bhasma Jala*, Life criteria, Gaia hypothesis, Flag Configuration, Spontaneous Reproduction, Plasma *Yoni, Nigoda J va*

Scriptures Quoted: Uttaradhyayan sutra, Thanam, Bhagvai, Tattvartha sutra, Acharanga sutra, Panchastikaya.

1. Introduction

Jain scriptures state that there are 8.4 million species of living beings i.e. J va, found on the Earth (lands, water, air, and sky), and also scattered all over the universe. Earth, water, fire and air have been considered to be non-living materials

in modern science but Jainism considers all such components as live. It is mentioned in various Jain scriptures that Gautam Ganadhara, the prime disciple of Lord Mahavira, raised several questions to Lord, regarding the presence of life in such bodies. The Lord quenched Gautam's thirst of enquiry by giving suitable examples [1]. All these forms are based on the body types made of different kinds of material aggregates. Such one sensed living beings are named as 'Ekendriya J va' because they possess only one sense of touch (sparshan indriva). Mobile living beings can move from one place to another on their own, while the immobile ones do not. This is a rather cursory criterion. For example, a chick developing in an egg does not move on its own accord but it is indeed a mobile being, and blowing wind is immobile though it is observed to flow due to external causes. In fact, the mobile living beings possess rising mobile-physique-determining karma and the immobile living beings have rising immobile-physique-determining karma [2]. It is stated that they also possess various properties of living beings, e.g. sense, ingestion, respiration, aging, anger, grief, sexual feeling, death etc. All these five types have been discussed below one by one.

1.1 Yoni: Birth Place having Conceivable Structure

Scientifically, animals and plants have been classified into various categories/groups according to their morphology. The animals have been classified from very simple protozoan to higher vertebrates in different phylum, and plants from lower cryptogams to higher angiospermic plants. The processes of reproduction and formation of new generation vary from species to species. In Jainism, the methods of birth have been described in a very elaborate manner [2]. It is mentioned by Acarya Umasvati in, "Tattvarthasutra" that the birth of all living beings on earth, hellish and celestial beings takes place by the following three ways:

- 1. Spontaneous or Agglutination (sammurchhana)
- 2. Conception (garbha) and
- 3. Precipitous manifestation (Upapada).

Agglutination is a form of asexual reproduction where sperms and ovum do not meet. In this type, the soul absorbs the material particles that lie at the spot of its birth and uses the power of its karma to convert them into an agglutinate. All one sensed, two sensed, three sensed and four sensed living being are supposed to be born through agglutination. Some five sensed animals including certain human beings (*labdhi paryaptak*) are also born through agglutination. Another kind of

agglutination involves reproduction in which the sperm and ovum meet outside the parent's bodies; such reproduction does not occur in a womb. Five sensed beings without a backbone (invertebrates), those having both male and female sexual organs (hermaphrodites) and those without mind are born through this kind of agglutination.

The birth through conception involves meeting of sperm and ovum in the womb, which leads to the development of fetus or embryo. Some living beings, such as humans, buffalos, cows etc. are wrapped in a placenta through which the fetus receives nourishment in the womb. Certain living beings, such as birds, lizards and snakes, are enclosed in shells called eggs in the womb. Others, such as a mongoose, rabbits and rats, are not wrapped in the placenta or enclosed in an egg. They are seen to run and jump as soon as they are born. All these animals are born through conception.

Whenever any kind of species in the world appear in the form of new embodiment with the signs of livingness and vitalities, it is said that a new J va has taken birth. Jain biology suggests that a new embodiment, which is formed by assimilation of materials is capable of transforming them into the body, senses etc. The birth of a new *J va* (life) takes place by two possible mechanisms: (a) Spontaneous generation and (b) uterine birth. The first involves the primary life as assumed from non-living (abiogenic or chemical origin of life). The second category of birth involves living from the living one. These mechanisms may be equated to the asexual and sexual reproduction. Normally, the lower organisms and plants are supposed to take birth through asexual reproduction. It is also known as uterine birth.

In Jainism, the word 'Yoni' has been defined as biological conceiving structure or material or place of compounding of different types of bodies (physique) according to Pannavanna Sutra (9th Yoni-pada). Thus 'Yoni' is equated with the form of life from which has a special structure, capable of conceiving. However it has some other meanings too. It is said that a *J va* can bear 8.4 million 'yonis', including '1-sensed bodied to 5- sensed human-beings, hellish and celestial beings. This is formalization of cause (karma) into effect (birth), thus it is suggested that 'yoni' does not only represent the conceiving structure but it also tells us about the different forms of living species. Conceiving structure is a container of species

taking birth for its proper development before it becomes independent. Each species has its special types of conceiving structure. As many species, as many *yonis* are assumed. These are classified on the basis of many general conditions under which the living body is conceived and grown [2, 3]. The body may grow by assimilation of proper extracts or material from surroundings under suitable conditions of (a) cover (b) climate and (c) temperature. The combination or withdrawal of these conditions make the total variety of birth places to be nine-(i) *Sacitta* (living), (ii) *Sita* (cold) (iii) *Samvrata* (covered), (iv) *Acitta* (life less), (v) *Usna* (hot), (vi) *Anavrata* (non-covered), (vii) *Sacitta-acitta* (living and non-living), (viii) *Sitosna* (cold-cum-hot), and (ix) *Samvrat-anavrata* (covered cum uncovered).

The livingful (*Sacitta*) *yoni* is defined as the structure where consciousness exists. The cold *yoni* is a specific type representing its thermal quality. This also denotes the entity having coldness. The covered means a place or an area which is well secured or hidden. It may be a non-visible area. The opposite of these three are also to be taken into account; they are non-living, hot and open or uncovered ones. The mixed denotes the dual nature involving living-cum-non-livingful, cold-cum-hot and covered-cum-non-covered.

In addition to the number and types, Jain Biology gives detailed information about the shape of the *yonis*. The birth places could be, (a) conch-shaped, (b) tortoise shaped and (c) bamboo-leaf like flat shaped. It is suggested that the abortive birth takes place out of conch shaped birth place, common humans are born out of flat shaped birth place and great men, kings and saints are born out of tortoise-shaped birth place. In contrast, the modern biology suggests five types of vaginal shape, 1. flat (single), 2. duplex, 3. bi-partite, 4. bi-carmate (tri-partite), 5. simplex. However, it is silent on classification of the birth of general, great men etc. as Jain biologists had suggested.

When a new offspring comes out of its birth place, it is already developed. For example, the newly born human baby is nine months old. It has spent this time of its life, since conception, living as a parasite within the body of its mother. Others spend the time under the shell of egg. During this period, it increases from a single microscopic cell to a developed body having certain amount of protoplasmic constituents and integrated into various functional systems. The whole process follows a series of division of cells. The cells divide again and again in a long process of development in which many changes occur in a precise sequence. The nucleus of

the fertilized and animated cell contains complete instructions needed to make all the different proteins of all the different types of cells in the body (a liver cell, a nerve cell and so on). Using these instructions, the embryo produces different organs in a precise sequence following a harmoniously regulated time-schedule and spelled out in DNA blue prints contained in the nuclei of the fertilized ovum.

Agglutinated living beings (*sammurchhana*) are born in animate, inanimate, partly animate and partly inanimate conceiving structures. In such types of structures of birth the souls of *sammurchhana* receive appropriate inanimate matters (*pudgala*) and form a body. According to Jainism, agglutinated living beings are sexless i.e do not have either male or female sex organs and are impotent. They have huge desire for sex, but do not have capability of conceiving.

1.2 Earth-Bodied Beings

'*Ekendriya* living beings, the earth bodied beings or '*Prthvikayika J va*' have been considered as living organisms in Jainism [3]. A large number of earth bodied beings are found in nature which belong to various categories e.g. sand, gravels, rock salts, stone, orpiment, vermilion red, chalk, tin, copper, iron, lead, silver, gold, antimony, diamond, coral etc [4]. According to Jain philosophy innumerable numbers of independent souls live in a lump of soil. Similar is the case with other minerals, metals etc. They are alive till not separated or detached from the source with the help of some instrument/implement [5]. Such earth bodied beings perform several functions like other living beings, e.g. respiration, pain, grief, excitement, consciousness, metabolism fatigue, aging, death etc. Their physiological and metabolic activities are not seen physically like other living beings but they certainly possess them and pass through various stages of living beings.

1.2.1 Body Structure

The body of *prithvikayik* beings is so ultrafine that it cannot be seen with naked eyes but they can be seen in a cluster or lump. Even while making them in powder form, some outer particles are touched and those inside are not [6]. Their body structure varies according to their category and nature. With high-resolution electron microscopes, some of the nano-sized particles, which are extremely tiny (~100 nm) and homogeneous in size, consisting of polybasic materials, and possessing multiple functions, have been discovered and described since the middle of the 20th century [7]. Such ultrafine particles include (i) the nano-sized meteorite (5–40 nm cosmic dust), (ii) the natural gold particles with diameters of

7–10 nm in the Carlin Gold Deposit, and (iii) the nano-sized metal particles such as Au, Ag, Sb, As, Zn, Fe, Cr, Sc, Cu, and Mo, as well as gold and other particles with diameters greater than 1000 nm, all captured from gaseous and eruptive volcanic materials. They exhibit polyhedral structure. These fine nano particles are organised in various shapes and sizes and form a specific structure. They may be in form of thin layers, heavy solid mass or loosely arranged particles.

1.2.2 Life Supporting functions

According to Jainism, all ten kinds of instincts i.e. appetite, fear, copulation, possessiveness, anger, pride, deceit, greed, inherence and collective mind, are possessed by earth bodied beings. They possess a feeling of love, hate and anger i.e. passions. Since they do not have any organ other than the body, the faculty of expression and their live activities are not seen [8].

A desire of food has been described to occur in them and to fulfill it, continuous absorption of food takes place. Their entire body surface is capable of absorbing food. Infinite food particles are ingested as they have the feeling of strong appetite. They have ability of selecting appropriate materials having different colors, tastes, smell and touch. The ingested materials are transported by their sense of touch.

They do respire from all directions of their body, except at the sites of obstruction. Process of exhalation and inhalation goes on continuously from all directions [9]. Although they do not have sexual desire, they enjoy it by tactile movement. The sensations which they enjoy are auspicious or non-auspicious and not without purpose. They are unable to listen but possess the power of grasping the vibrations caused by speech and mind of human beings. It is due to the property of having a kind of tacit linguistic potential on account of elimination-cumsubsidence of relevant karmas.

Like other living beings, earth bodied beings also possess '*Lesyas*' (Mental propensity). According to the Jain theory of karma, *lesya* is the hypothetical coloring of the soul on account of its association with the karmic matter. Six main categories of *lesy* are represented by six colours viz. black (*krishna*), blue (*neel*), grey (*kapot*), red (*tejo*), yellow (*padma*) and white (*shukla*). The colour of lesy varies depending on the psychic states and mental activities behind an action [10]. The coloring of the soul is explained by the analogy of crystal that acquires the color of the matter associated with it. In the same way, the soul reflects the qualities of color, taste, smell

and touch of the associated karmic matter.

Four kinds of *Lesyas* are said to occur in the earth bodied beings. These are black (*krishna*), blue (*neel*), grey (*kapot*) and fiery (*tejo*). First three *lesyas* are considered to possess lowest state of mind. A being in this state of mind shows no compassion or mercy. However some signs of good state of mind appear from fiery *lesya*. In case of earth bodied beings, *lesyas* may be compared with their properties, action and utility. Many kinds of earth bodied beings are harmful; however, some precious metals and minerals like gold, diamond, silver etc. may be classified under fiery (*tejolesya*).

Earth bodied beings also possess a strong feeling of physical pain when they are harmed or attacked. Since no mental pain is there, they have no bewailing [11]. The life span of earth bodied beings ranges from a minimum of intra hour to a maximum of twenty thousand years [12]. No scientific evidences are available in this regard.

1.2.3 Scientific Views

Newton was the first to compare earth with living organisms. Hutton (1863) gave an analogy between circulation of blood and circulation of nutrients in the earth and the way sunlight distills water from the oceans so that it may later fall as rain and so refresh the earth. He used it along with his neo-logism; geo-physiology to draw attention to the similarity between earth and a living body.

Lovelock first expressed his idea as "Gaia Hypothesis" [13]. The science behind the hypothesis was still sketchy, and it provoked a storm of criticism. It also provoked a lot of research, and the resulting body of information has encouraged Lovelock to publish his second book, a more confident and complete exposition of the Gaia hypothesis. This hypothesis holds that earth's physical and biological processes are inextricably connected and form a self-regulating, essentially sentient, system. One of the early predictions of this hypothesis was that there should be a sulfur compound made by organisms in the oceans that was stable enough against oxidation in water to allow its transfer to the air. Either the sulfur compound itself, or its atmospheric oxidation product, would have to return sulfur from the sea to the land surfaces. The most likely candidate for this role was deemed to be di-methyl sulfide.

Lord Mahavira propounded that a lump of soil contains innumerable number of souls with individual entities and physiological characteristics, however

Gaia hypothesis doesn't believe in this concept. On the basis of Gaia theory, some scientists seriously tried to prove that 'Earth' is a living organism, but due to lack of evidences it remains as an unproven hypothesis. The Jaina concept that the earth is a living system also faces many challenges because the science doesn't accept the existence of soul.

J.C. Bose provided many evidences about the presence of life in earth. In his experiments, the curves produced by slightly warmed magnetic oxide of iron showed striking resemblance to those of muscles. In both, response and recovery diminished with exertion and consequent fatigue could be removed by gentle message or by exposure to warm water. Experiments on other metal components exhibited many similarities with that of animals [14].

According to Jainism, the Himalayan crystal salt is a kind of earth bodied being, a living entity. This salt is considered as one of the purest, highest grade salt that has been formed for over 50 million years under enormous pressure, maturing without exposure to pollutants. Over time, its energy was built up, forming a crystalline structure with a high concentration of life force energy. Carefully harvested by hand (Without explosives or heavy machinery), the life force within the salt remians preserved.

In the process of diagenesis as mentioned by earth scientists (Larsen and Chilingar, 1979), changes occur in the character and composition of sediments, beginning from the movement of deposition and lasting until the resulting material (rocks) are either moved into the realm of metamorphism or get exposed to atmospheric weathering [15]. In 1953 Strakhov [16] divided the history of sedimentary rocks in the following three stages:

- 1. Sedimentogenesis i.e. formation of sediments.
- 2. Diagenesis or transformation of sediment in to sedimentary rocks.
- 3. Catagenesis, which is a long stage of secondary changes in already formed sedimentary rock.

The phenomenon of diagenesis of rocks is not considered as a live activity by earth scientists but looking to various changes and transformations it may be compared with a living process.

1.3 Water-Bodied Beings

We understand DNA and RNA to be the basic building blocks of the

traditional life forms. A few forms of Life, without any carbon molecules have also been discovered in the recent past. However, to explore the feasibility of other forms of life, first of all the basic traits of life have to be understood and defined. In modern biology, a living-being is defined to have at least three fundamental attributes, viz, the ability to (i) exchange energy (ii) remember and pass on information and iii) have sensitivity to external stimulation. We have studied water, which not only supports the organic form of life, but also exhibits certain interesting and euphoric properties. The study encompassed the following 5 related fields, i.e. i) life-sciences: pertaining to the basic attributes of a living-being and its applicability to water, ii) structure of water-cells and its interaction with air, iii) non-living water and its shelf-life, iv) aura photography as a handy tool to identify and differentiate living from non-living water and v) science of potable water and mass health.

1.3.1 Structure of Water-Cells

The bi-polar molecules of pure water form self-assembled 2-dimensional nano-structures in hexa- or pentagonal shape, such as $H_{12}O_6$, called quantum crystals, where the position of the constituent atoms/molecules in the crystal is not defined as shown in fig. 1 [17]. It is also reported that biologically active molecules can cooperatively form icosahedral expanded water networks. They are similar to the minimal energy related poly-tetrahedral Dzugutov clusters to achieve stability based on the principle of minimum surface energy. Jain [18] also arrived at a similar conclusion that water molecules assemble themselves in a sperical form. This structure then moves on to become a stable 3-D tubular structure (fig. 2), after it absorbs air from the atmosphere.



Fig. 1. Self-assembled Crystal like Hexa-unit of Water-Molecules $\rm H_{\rm ^{12}}O_6$

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Fig. 2 Bee-hive Configuration of Tubular-Net (Living-Cell)

Xiao et al. [19] stated that the magnetization effect on water, during its heating and cooling cycles is different. It is found to be irreversible during increasing magnetization and demagnetization cycles. This abnormal effect is assigned to the possible complex microscopic water structures. Different types of water clusters may have different motion states and hysteresis effects.

When the structure of water or clusters changes due to application of magnetic field its optical heterogeneity would also change [20]. Water has another important quality. It starts absorbing air from the atmosphere, till it reaches its saturation point. It interacts as follows:-

The dissolved air releases molecules as well as singlet oxygen. Some molecules get converted into oxygen radicals (anions). They transform the spherical net-structure of water into hollow cylindrical form. Vinogradova et al. [21] and Ninham et al. [22] investigated the role of dissolved gases and nano-bubbles on the behavior of water and discovered the intrinsic presence

of nano-bubbles (10 nm diameter) in water, which interpenetrate into the networks formed by water molecules. Any change in water/bubble interface may change the water structure and surface forces between ions and molecules in water. It modifies the water cluster size and its reactivity.

- ii. The bonding strength between water molecules in the nano structure is comparatively high. A plausible scientific explanation is that radicals are absorbed by the tube in its hollow space and in its "quantum-vacancy" to form a so called Zygote (*Yoni*). In that case it would be surrounded by its own bio-magnetic field. These structures may be termed as stiff, because they vibrate at high frequencies.
- iii. The beehive structure of nano-tubes allows the oxygen ions to move effortlessly through it. The movement generates a particular type of pulses or energy-field, probably the Holtz field. This cell-energy keeps the movement of oxygen radicals in dynamic balance (Fig. 2). Thus it can act as a transducer. Its Potential Energy is 'fixed' in the nano-tubes.
- iv. Such water-cells, saturated with radicals, can store this energy (criteria 1). The naturally available untrained cell - clusters are also capable of delivering back its stored energy on demand, in form of "bio-photons", called somatids, from one quantum end, as detected by Dr. Schweitzer and E.W Rusal [23,24]. Sonoluminescence is also produced by ultra sound treatment of water.
- v. Eberlein [25] proposed a Quantum Vacuum Radiation theory for explaining it. While treating with electro-magnetic fields, the water-gas bubble interface gets perturbed. The EMF application on water produces not only reactive oxygen species, but also singlet oxygen and free radicals.

1.3.2 Memory in Water

The second trait of a live-being is memory. It should be able to learn and be trained by external means. Colic et al. [26] proposed a hypothesis to explain the existence of the magnetic "memory" of water. They assigned this effect to relaxation of perturbed water/gas interface and the production of reactive oxygen species. Luc Montanier and Xano-Peng Pang have reported that, apart from the capability to retain em-memory, water also exhibits the well proven Mpemba effect, whereby water remembers whether it has been recently heated, even after it has been subsequently cooled. However, further studies are needed to understand the effect of dissolved gases on water structure, bubble stability, bio-effects, and mechanism

of memory and sensitivity of water cells/ clusters. Memory phenomena probably depends on the resonance of nano-structures derived from water solutions.

It is known that during training of water structures (called 'potency' making in homeopathy), a small quantity of mother tincture is mixed with the base water. It is then shaken vigorously by mechanical means. The ions of the minuscule quantity of the chemical in the water mass, get attached or implanted in the quantum vacancy of the living water-cells as 'impuritons' thus forming a hybrid structure (Fig. 3). This structure is naturally imparted the physical properties of ions in form of electro-magnetic and mechanical vibrations of the ion, possibly by means of induction or by conduction and resonance. Apart from the frequency transcription on the cell-body or the specific hydration envelope, certain other properties of the chemical are also transferred to the surface contours, body-surface, texture and touch sense of the cell-clusters. Such water cells can carry unique-signature of the chemical as well as surface energy in form of surface curvature. This may be called Initial Mode of Vibration (IMV).



Fig. 3 Hybrid Water-Structure (Due to quantum Vacancy)

It means that the pure water cells are taught to vibrate at IMV through noninvasive technique. The required energy is supplied to the cells through its breathing of oxygen. The mixing of 'impuritons' in the pure water structures affects these properties. The quantum structure of polar molecules of water retains its special configuration during sequential dilution and exhibits its special static and dynamic properties. The host cells of water continue to become purer and better

trainer (Criteria 2), as hybrid structures are washed away. Hence they are termed as characterized/dynamatized water-cells.

In potency making, homeopathy samples are required to have memory as well as capability of its amplification by the solution.Further research is required to prove the second aspect. The pre-trained water cells of the remedy are used as agents /catalysts to modify or stimulate the required type of genes in human body cells (Fig. 4).

The practice-proven effectiveness of Homeo-remedies corroborates the hypothesis that water has some sort of memory and it can pass on information.



Fig. 4 Interaction of Homeo-remedy with Bio-cell at Genetic level

1.3.3 Sensitivity in Water

Dr. Masaru Emoto of Japan has conducted a number of experiments on water to ascertain the effect of sound, thoughts and emotions on it. After subjecting water to different phenomena like prayers, abuses and harsh noise etc., the water was deep frozen at - 25°C to form ice crystals. These crystals were photographed by a special technique [28]. He found that thought and speech vibrations have marked effect on the capability of water for forming its crystalline structure, shape and size. A few photos of water, subjected to vibrations caused by speech and thoughts of human beings are shown in Fig. 5 (Criteria 3). Abusing altered the water structure and snatched away its capability to form crystals, as seen in the second photo. Like human beings, water seems to be sensitive to types of thoughts, as shown in these photographs. Hence water, possessing sensitivity to different types of thoughts, may be termed as pseudo living-being. Jain Concepts of One Sense Beings, Sammurchhan Beings and Modern Microbiology





Different shapes of snow-flakes

Dead water (No crystals)



Crystals of living water

Fig. 5 Different Shapes of Water-Crystals (from Dr. Masaru Emoto)

1.3.4 Revalidation of Sensitivity

Experiments were recently conducted to assess by alternative means, whether water-bodied living beings have sensitivity towards external stimuli.

The sensitivity of tap water towards prayers etc. was tested by the author (JJ) in 2014 with the help of Mr. Arpit Shah [29] by a different technique, called Radionics. The water bodied living-beings exhibited its sensitivity to prayers etc. revalidating the earlier conclusion of Masaru Emoto. However, scientific credentials of Radionics are yet to be accepted universally.

1.3.5 Process to Make water Non-living and Proposed Explanation

Water cell, whose tubular body structure is either destroyed or choked or disabled to breathe air, is termed as non-living cell. Water obtained from natural sources is normally living water. It can be made non-living by mixing some solute to form colloid (because the electrical activity across the molecular gap joints is

affected by colloidal substance) or by boiling it. The following postulates are given in this context:

- i. When foreign particles, above a critical quantity, are mixed thoroughly with living-water mass, it blocks the hollow, net-like spaces of nano-cells. Its oxygen radicals also get converted back into molecules. Thus due to mechanical rubbing and friction, the water-cells (*'yonis'*) are broken apart.
- ii. Due to heating to boiling temperature, the water becomes non-living. In this process, the "cells" (*yonis*) are completely disintegrated, due to vigorous thermal vibrations. The dissolved air is driven out, because of its zero solubility at boiling point. Thus the water becomes non-living. It becomes devoid of free radicals also. When such water is used for drinking, it can, in turn, reduce the level of free radicals in the user's blood-stream, just as the intake of external doses of de-oxidants do. In small quantities, the free radicals fight bacteria and virus inside our body. But in larger quantities, they attack living body-cells and tissues anywhere in the body. These oxidants are considered as the major cause of ageing. They can even cause some deseases. Hence, it is desirable to reduce these radicals. The other alternative method of removal of free radicals from the body is to take doses of anti-oxidants.
- iii. Science of Shelf-Life of non-living water: Pure non-living water takes some time to again become living-water. Due to electrostatic forces between its molecules, water starts forming net-like nano-tubular structures. When left exposed to atmosphere, it starts absorbing atmospheric air in it. This absorbed air re-transforms the structure into *yonis*, which can breathe and become "live".
- iv. The rate of absorption of air depends on the temperature and humidity of the environment, as well as on the area of the water surface. It goes on absorbing air, till a saturation point is reached. Because these conditions of temperature and humidity are different in different seasons, the minimum time-span of non-living water, to get converted back into live-water, would vary with season.
- $1.3.6\,Identification\,and\,Viewing\,of\,`Livingness'\,of\,Water$

A pertinent question arises now, whether one can directly check and view the

livingness of water! The simplest and affordable method for trial and testing of livingness of water looked to be the "aura-photography" by Kirlian method. First the authenticity and repeatability of the technique was tested and then experiments were conducted using Direct Imaging and Image Transfer techniques with digital camera and suitable aura software. The images were studied for structure, shape, colour of the nucleus as well as its rings. The water samples were subjected to the following three types of operations:

- i. Boiled water samples were prepared by heating the filtered tap water at around 95° C.
- ii. Some samples were prepared by mixing thoroughly 100g of easily available Cow Dung Bhasma Powder (CDBP) in 10 litre of filtered tap water and then decanting it after 30 minutes. These samples were termed as *Bhasmi-Jala*.
- iii. Some samples of trained water (termed as water based homeo-remedies) were specifically prepared and supplied by the laboratory of the worldrenowned German company, M/s Willmar Schwabe India. The preliminary experiments were conducted in Dr. J. M. Shah's laboratory at Parsi Panchayat, Mumbai and Dr. Amresh Mehta's lab. at Ahmedabad (Fig. 6)..
- 1.3.7 Results

Observations of different sapmles revealed that:

- i). Aura of tap water and boiled water are distinctively different, particularly in the type of energy of Aura.—Postulate- II (Fig. 6),
- ii). Aura of boiled water is similar to that of *Bhasmi-Jala*. (Fig. 6, 7) Postulate-I,
- iii). Intensity of aura energy increases with increase in potency of trained cells
 [29] and
- iv). The experiments are reproducible.

The experiments of aura photography further revealed that the boiled and ash treated waters show green area (Fig. 6). Since these waters are non-living, we may assign green colour to *acitta* waters. Mineral and tap waters show patches of light orange superimposed on green. Intensity of patches is less in mineral water compared to that in tap water. The area is mostly orange in case of tap water. This may be considered to be the characteristic of living (*sacitta*) water. The mineral water thus falls in a mixed category, i.e. it is not completely non-living. In Figure 7,

obtained using another technique, the transition from living to non-living is characterized by disappearance of the kern in the nucleus like structure of its aura. It also exhibits intensification of violet color in the surrounding rings.





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Aquaguard water



Tap water



RO Water



Bottled mineral water



Water treated with *Gobar* Ash

Tap water boiled and cooled



Distilled water

Fig. 6 Aura photographs showing the existence of two types of water-living and non-living (Note the Green colors in the lower Rectangular aura field)

a) Bhashma Series



Fig. 7 Distinctive Transition from Living to Non-living water under different parameters (Quantity of CDBP and Temperature) (Note the color changes in the nucleus of Aura). (See colour image on page 658)

Further experiments revealed through aura photography that the quality and structure of boiled water gets transformed back to that of tap water type, after 24 hours. This can easily be assigned to the re-formation of new water-cells and interaction of absorbed air with them. – Postulate- III: These conclusions were later on independently validated in Dr. Vinod Shah's Lab. [30].

1.3.8 Science of Potable Water

Subsequent experiments conducted on *Bhasma*-water, established that a minimum of 10g CDB Powder per litre of live tap water is required to transform it and produce dead water [33] as shown in Figs. 6 and 7. Below this threshold limit, water will not become non-living. Astonishingly, such water has always tested as alkaline with pH > 8 [34]. Even slightly acidic tap water, containing some bacteria, becomes alkaline and bacteria-free after this type of *bhasma* treatment.

Alkaline water is considered to be more healthy. This mineral-treated water helps in reducing acidity-producing wastes from body, as established by Dr. William Kelly, author of the book "Cancer Cure", College of Metabolic Medicines, U.S.A. and Dr. Hidemitsu, Director of Water Institute, Tokyo, Japan. It promotes conversion of free radicals of potable water into singlet oxygen molecules. Thus it works as scavenger to remove harmful oxidants. Consequently, it prevents mutagenic changes and its associated disorders.

1.3.9 Conclusions

From the above observations it can be concluded that water molecules assemble themselves into a particular type of cell structure, which after absorption of air, function as alive. It has an inherent nature and an external form with certain electrical and vibratory properties. The theory of Water-bodied beings has led to the understanding of the actual mechanism of 'training' of cells, as imparted during the Potency making process of Homoeopathy. The mechanism of boiling or colloid formation by foreign materials, like CDB-powder to convert it into non-living water has been scientifically understood.

Further experiments have proved that non-living potable water has a definite 'shelf-life', after which it would again become living-water. Aura photography has provided a handy tool to identify and differentiate living from non-living water. Use of CDB-powder provides a low-cost, practical solution to get alkaline water, which is also devoid of free radicals. This technology, being

ecofriendly and affordable, is potentially useful for the mass health programme especially for poor countries. CDB-powder is freely available as waste product in form of *Bhasma*, in Indian rural households, for treating potable water [32]. Alternatively, such inexpensive *Bhasma* powder can easily be supplied to individual house-holds in villages for improving mass health.

1.4 Radiance-Bodied Beings

Whether electricity falls in the living or non-living category, is an important question in the context of Ãgamic texts. Since this issue is related to the Mah vrata of non-violence, it is desirable if scientific studies can be conducted to show the existence of radiance-bodied living-being (*Tejask yika*).

In view of its importance, a study was undertaken involving the following four entities: radiance-bodied living-beings, fire-bodied living-beings, artificial electro-bodied living-beings and natural blitz-bodied living-beings. Finally they are intercompared to find out their relative status.

1.4.1 Radiance-bodied living-beings

In Jaina Ãgamas, the term Radiance-bodied living-beings denotes both types, the fire-bodied and the electro-bodied living-beings. It has been mentioned that radiance-bodied living-beings are immobile and one-sensed. Fire is one-sensed living-being. The flashing Blitz (Bijju) in the sky is declared as sentient [33, 34]. By understanding its constitution from different perspectives, as well as by investigating the series of phenomena taking place during its initiation and extinguishment at micro level, we can compare it with the nature of artificial electricity to judge its livingness.

1.4.2 Burning of Fire (Agnik ya)-Scientific View

In general, light, flame and heat are mentioned as attributes of gross firebodied living-beings [38]. Several types of fires have been listed as living [36]. Scientific analysis reveals that it is the fuel, heated to its ignition point, which is involved in the chemical reaction of burning.

 $\tilde{A}gamas$ reveal that at least the following five symptoms or conditions are exhibited by the gross fire-bodied living-beings:

- i. The fuel is heated to its ignition point.
- ii. The oxygen (air) is chemically combined in the burning process. The air is used and consumed. Chemical energy gets converted into heat and light

energy.

- iii. This implies that emission of heat (infrared rays) and visible light from it is mandatory.
- iv. Burning is to be an autotrophic (spontaneous) chemical reaction, which is usually exothermic.
- v. It may occasionally produce sound.

1.4.3 Physical Reactions in Fire at Micro-level

In general, the initial flame supplies the activation energy to the kinetically stable fuel mixture to break the bonds. The heat given out by the molecules that react first is more than enough to supply the activation energy for the next molecules to react - and so on.

Scientific analysis of fire at micro-level reveals that when it burns, the electrons of the outer orbits or valence shells jump down from their high potential energy to lower but stable energy state. The energy difference between the two positions is converted into heat and light energy. In this activity, neither the potential energy nor the heat and light energy are considered to be sentient (*Sacitta*), but the temporary state of matter created by displacement of electrons during the transition period is assumed to form a *yoni* suitable for a soul to occupy it and make it live (*sacitta*) in the short span of time.

1.4.4 Mechanism of fire formation

The initial fire comes into existence from the moment an electron leaves its orbit. The life of fire at microscopic level ends, as soon as the ejected electron enters into its lower orbit. Its higher potential energy (PE) starts converting into light and heat (L & H) as soon as the electron leaves the higher orbit and becomes zero on entering the lower valence shell. During this transition, the molecule exhibits itself in form of fire which is a living entity according to Jain Ãgamas. The initiation of fire means starting of electron's journey or initiation of the process of conversion of PE. As such, as soon as the electron starts from the higher orbit, the molecule is presumed to behave like a capable *yoni* to receive a soul. It is this living *yoni* that is called fire-bodied living-being. The moment, the process of conversion of PE into L&H ends, the fire gets extinguished, making that molecular cluster insentient. However, this being an exothermic reaction, the process of production of fire continues in the fuel lump, so long the supply of fuel is maintained.

1.4.5 Light Radiating matter

According to \tilde{A} gamas [5], the particles (rather wavicles) of light, emitted even by living matter like Earth-bodied living-beings, are considered as non-living. The Sun and Moon are made up of earth-bodied matter. As such, they fall in the category of living-beings. But the photons emitted by them are devoid of karma*lesy* (passion/*bh va*) and as such, they are non-living. However, in practice, they are called particles of *karma-lesy*, because of their origin from such earthly matter.

1.4.6 Electro-bodied Living-beings: A Comaprison

Artificial electricity was not known in ancient times, even then the Omniscient has mentioned blitz by the word '*Viddhyut*' [36,37]. They also declared it to be a living-being. They placed it in the category of Radiance-bodied living-beings (*Teuk ya*) and not in the category of fire- bodied living-beings. It is to be noted that where ever *Agnik ya* is mentioned in Ãgamas, only *Agnik ya* is to be perceived and not *Teuk ya* or *Viddhyutk ya* [38]. Blitz was generally understood and regarded by a layman as an expression of anger of some God or Nature.

1.4.7 Blitz-Formation

Lightening is a physical process of flow of electricity through gaseous medium. Ordinary gas or air is a bad conductor of electricity. It requires high voltage for the flow of current (electrons or ions). The voltage required for lightning depends on the thickness of air strip between the boundaries of two clouds, carrying opposite charges and humidity of the air. This current flow is generally similar to the flow of current through solid or liquid medium. If free electrons are available in the conducting medium, the medium is termed as good conductor. Less energy is spent for flow of electrons through it. Hence less heat and light will be generated by it.

If the amount of free electrons is negligible, then displacement of electrons from the outer valence shells would be required, necessitating application of higher voltage. Its amount will depend on the resistance of the conductor. To establish current flow during lightning, the applied high voltage 'ionizes' the air by removing the electrons from the molecule of bad conducting air. This flow of ionized air is termed as plasma.

In this process, the energy of electron-bonding gets released and appears in the form of intense heat and light in plasma.

1.4.8 Plasma in Other Mediums

It has now become possible to produce electric current in any medium including solids and liquids. Although electron transfer in the molecules of these mediums also takes place, it is not necessary that plasma is formed in every case. Plasma is formed only in gases. Hence the appropriate view is that only flow of current in the transition period should be considered as a condition for it to be a living-being. In other words, the plasma becomes sentient due to current flow.

1.4.9 Sacitta (Living) Plasma

Since plasma formed by electric current falls under the category of radiancebodied living-beings, it is worthwhile to summarize various phenomena occurring in the plasma:

- The gaseous medium is ionized by high voltage,
- The electrons in ions are exchanged during their flow in the medium,
- The conversion of electric energy results in emission of intense heat and light,
- As long as the voltage remains applied across the medium, current continues to flow.

This indicates that the temporary phenomena of sparks (switches), welding arcs, arcs in melting furnaces, sparks in Erosion machines etc. fall under the category of living-*Teuk ya*, termed as electro-bodied living-beings. Here all the above four events occur in them. When the high voltage across the thin air layer between the two cloud-bodies is discharged as blitz, the ionized plasma extinguishes. The extreme heat generated during ionization may promote burning of the residual gases after blitzing is over. No chemical burning takes place in the plasma.

1.4.10 The Birth Process

The molecules, where the kinetic energy of electrons is converted into heat and light due to exchange of electrons, change their type and form momentarily. This transient form possesses the capability to build appropriate *yoni*. It suitably attracts transitory soul to enter into it to make it alive.

$1.5\,Relationship\,with\,Air\,Body$

For Fire-body, it is mentioned in Bhagvati Sutra (16/1/5) [39] that fire cannot

burn without using air (gas) and without producing air (gas). In fact, in chemical reaction of burning, gases like CO_2 are produced. It may be living or non-living air. But no where in the Ågamas, it is mentioned that electro-body cannot be formed or sustained without using air and without producing air (gas), as is mentioned for fire-bodied living-beings (*agnik ya*). For producing plasma, it is not at all necessary to have the process of burning /ignition. However, participation of a gaseous medium is necessary in formation of plasma.

1.5.1 Respiration

Bhagvati Sutra (9-34-4) [40] mentions that living-beings accept and relieve *pudgalas* (matter) in the form of respiration *vargan* (*sw sochchhav sa*), during internal and external respiration. The *pudgalas* of respiration have only four types of basic touch senses. Hence they are ultra-microscopic. When living-beings breathe externally, they may be taking in *pudgalas* of respiration along with the 8-touch sensed air. It seems that fire-bodied living-beings take in oxygen and exhale carbon di oxide. The *yoni* of electro-bodied living-being is different. It takes in molecules and gives an output of their ions.

1.6 Conclusions

- Radiance-bodied living-beings denote both types, the fire-bodied and the electro-bodied living-beings.
- In fire-bodied living-beings, the potential energy of participating electrons and in electro-bodied living-beings, the kinetic energy of participating electrons, get converted into heat and light energy.
- Artificial electricity, which can produce plasma and release heat and light energy by ionization due to application of its voltage, (e.g. in tube-light), should fall in the category of living-beings.
- Scientifically in both the cases of artificial electricity and the lightning (*Tejask ya*), electric current is produced by flow of electrons. The kinetic energy of flowing electrons is converted into different forms of energy.
- Light particles are non-living.

It has been noticed from various translated Ãgamas that the two types of *Tejask yik* organisms have not been understood well by the Hindi translators of Ãgamas. The word *Teuk ya (Tejask ya)* in most cases, particularly in Uttar dhyayan Sutra (41), is translated as *Agnik ya*. In fact *agnik ya* represents only one form of

Teuk ya. As has been discussed above, this has led to misinterpretation of the real meaning of *Teuk ya* (*Tejask ya*).

1.7 Future Investigations

* As the fire-body becomes living only after fulfilling some basic conditions, does the electro-body also become living by current flow, after it fulfills its few basic conditions?

* Since cloud/blitz plasma has been categorized as electro-bodied livingbeing, it's difference with the living-Fire-body needs further investigations. In the above analysis, it was proposed that all current flows should be able to create living *yonis* i.e. forming electro-bodied living beings. It may need further investigations for proper understanding of the phenomena at microscopic level.

* In the above analysis, it is presumed that the current flow in plasma and in other type of electricity has the same nature. However, it is possible that the variation in the mode of knocking molecules/atoms by flowing electrons may produce different conditions.

* It may need further investigations to find out as to in which category the other type of electricity, whose flow through a medium does not emit so much heat and light (e.g. domestic bulbs and heaters) should be treated?

* Is there any deficiency in the basic conditions created by current flow in glowing bulb and heater from that in plasma of the blitz?

We now list some unanswered questions in Agamas:

* During the sequential events of burning process, when do the particles of the materials achieve *Pary pti* to become living fire-body and emit heat and light?

* Similarly, during the sequential events of electron displacement in the molecules to form a current flow, when do the molecules of the material achieve *Pary pti* to become living electro-body? It may emit or produce different types of energy. At microscopic level, electrons participate in both the cases, releasing either potential energy or kinetic energy.

Pary pti is the bio-potential energy (or rather capability), acquired at the time of conception of life itself, by which the mundane soul accepts material particles and transforms them into its body, food, senses and breathing etc. Although nothing much is scientifically known about the mechanism of formation of *paryaptis*, it is assumed that flame or stripped molecules may be forming gross body of electro-

bodied living-beings; participating electrons may function as its gross food and its body may be providing the capability of one sense.

The proposed mechanisms mentioned above for fire and electro and blitzbodied living-beings, remains to be proven scientifically.

1.8 Air-Bodied Beings

The air comprises large varieties of living and non-living entities in innumerable numbers. The fungal spores, bacteria, virus, fragments of plant and animal origin etc. form various airborne biocomponents. The atmosphere has been divided in to four layers, based on its thermal structure: (i) the troposphere near the ground (ii) the stratosphere that houses the ozone layer (iii) the mesosphere, a colder and lower density layer with about 0.1% of the atmosphere and (iv) the thermosphere, the top layer, where the air is tenuous. The atmosphere comprises a variety of gases like nitrogen, oxygen, argon etc. Air molecules are pulled close to the Earth's surface by gravity. This causes the atmosphere to be dense near the Earth's surface and it thins out rapidly with height. The air molecules flow with the wind and move randomly in the atmosphere by their thermal energy and they are so far apart that their force of attraction plays no role. The molecules are not affected by other molecules unless they collide.

In Jainism the air has been considered as a living entity, with many life supporting activities like the earth bodied beings. It comprises only one sensed bodies (*Ekendriya*), but its body is invisible and can only be felt. The air bodied beings are innumerable and independent souls. They are alive (*sacitta*) until they interact with an instrument or implement when they are converted into nonliving (*acitta*).

On the basis of movement, the wind has been classified in the following categories [16]:

- 1. Utkalika- intermittent winds (squalls).
- 2. *Mandalika* which goes round or whirlwind.
- 3. *Ghanavayu* thick or dense wind- these winds blow on the oceans which are situated below the Ratnaprabha hell and support the heavenly *vimanas.*
- 4. Gunjavayu- high winds that make sounds.
- 5. *Suddhavayu* low winds (stream line flows) which lack the above qualities.

1.8.1 Structure

The structure of air bodied beings is similar to that of a flag, which can expand by its protean power. The power creating varied shapes in the air bodied beings is limited [8].

1.8.2 Physiological evidences

Several properties of air bodied beings show that they are living entities. According to Jainism they breathe in and breathe out i.e. inhale and exhale material clusters of infinite number of substance-units (*parmanus*) and occupy innumerable space – units for any plausible duration of time, and have color, smell, taste and touch with regard to qualities. They breathe in, breathe out material clusters of one color, up to five colors.

1.8.3 Life Span and Obstacles

The life span in the present birth is intra hour in the minimum and three thousand years in the maximum [17]. These living beings die many hundred thousand times in one breath of humans to be born as an air bodied again and again. The air bodied beings die when they come in contact with various types of obstacles/ weapons on their way as mentioned in *'Niryuktikara'* of *'Uttaradhyayana'*:

- i. *Bijan-* a small fan, *talvrinta-* a fan made of palm leaves, several other types of fans, *patra* (paper), *vastra* (cloth).
- ii. *Abhidharca*, obstruction in the passage of air by a person who is fully wet with perspiration.
- iii. Aroma of fragrant objects such as sandal wood, khus etc.
- iv. Agni flame or heat of fire.
- v. Svakayasastra, cold or hot hostile air.

In Nisitha Bhasya and Churni, one *'vayu'* is prescribed as enemy of another *vayu*. A very lengthy discussion is given on *sacitta–acitta vayu* in Brhatkalpa Bhasya based on space and time [8].

Acharya Kundakunda in his Panchastikaya has advanced the following arguments in order to prove the animate character of one sensed beings, even as the animate character of the substances in an egg or in an embryo or in a person in coma is accepted, though there is no perceptible intelligent activity in them; exactly so is the animate character of one sensed beings. There is similarity of the nonperceptibility of intelligent behavior in the one sensed being on the one hand and of the five sensed one inside the egg [8]. The life in these cases lies in latent state.

1.9 Plant Bodied Beings (Sammurchhana J va)

Gommatsara (Jivakanda) mentions that the plant bodied beings are of two types:

a) Pratyek and b) Sadharan.

Pratyek: means every one. Such plants have one soul in one body. Therefore, they are called *pratyek vanaspatikaya*. Trees, plants, bushes, stems, branches, leaves, and seeds, etc. are examples of *pratyek vanaspatikaya J va*.

Sadharan: means common. In such plants, many souls occupy the same body making this type of plant life as multi-soul. Therefore, such plant life is called *sadharan vanaspatikaya*.

Such plants, having an infinite number of souls in one body, are called *"Anantkaya"*. Roots such as carrots, onions, garlic, beats, etc. belong to this category.

Sadharan are further classified as *suskma* (subtle) and *badar* (gross) categories. This arises due to *sukshma* and *badar naam karma*, and *pratyek* and *sadharan naam karma*, one of the eight karmas.

1.10 Nigod

When infinite souls share one physical body and all souls possess only one sense, it is called *nigod* and are classified as vegetation. The *J* va in the nigod body are called *nigodiyajiva*, which share a common body, common touch sense (*sparshindriya*), common *swachhoshwash* (breathing), common *ahara* i.e. nutrition etc.).

Further, *nigod* are sukshma or badar. *Suksma* nigod are present in all *lokas* and are un-stoppable by physical barriers, non graspable by *indriya*- senses, and are only kown through *kevalgyan*. However the total number of *nigod* bodies in entire *loka* is *asamkhyat* (uncountable). The total number of *J* va in one *suksma nigod* body are infinite and the total number of all *suksma nigodiya J* va in entire *loka* are also infinite.

Badar *nigodiya* are opposite i.e. stoppable by physical barriers, may or may not be graspable by senses, in some part of *loka*. The numbers of *badar nigod* are also *asamkhyat* (innumerable). Each *badar* body also contains infinite *J va*, and total *badar nigodiya* J va is also infinite. *J va* of underground roots and other parts of

plants etc. are badar nigodiya J va.

As stated earlier, the *sammurchhana J va* accumulate inanimate matter (*pudgala*) from their environment. It means that the soul is surrounded by such matter which enables it to form its body.

2. Modern Biology and Jaina Concept of Reproduction

The modern biology does not subscribe to the concept of total vegetative/asexual reproduction in some categories of living beings as described in Jainism, which explains that all living beings from one sensed to four sensed and a few five sensed beings (*labdhi paryaptak*) take birth by agglutination (*sammurchhana*). Many plant species reproduce by means of different techniques, e.g. cutting, budding, grafting, bulbs, tubers, rhizomes, layering etc. Several kinds of asexual spores are also produced by many plant species. Such spores after germination give rise to new plants. The scientific concept also mentions that many such living beings reproduce by sexual methods, by way of producing various types of sex organs. In lower plants such organs are called, antheridia and archegonia/oogonia. However, in plants, sexual reproduction takes place by sex organs produced in strobilus/cones or sporophylls (in pteridophytes and gymnosperms) and stamens and ovary in flowers (in higher plants i.e. angiosperms). The male reproductive units i.e. antherozoids/ pollen grains fertilize the female unit (in archegonia or ovary) and zygote formation takes place. This zygote further divides and forms embryo, which later on metamorphoses in to various organs. Jainism propounds that all sammurchhana living beings are sexless or impotent, i.e. neither male nor female. It may be explained in the following way: according to plant science, the so called sex organs in case of plants are produced only for a limited period of time, just to perform the process of reproduction and then get abolished. For example in trees, bushes and climbers etc. flowers have a very short span. In pteridophytes and gymnosperms strobilus or cones are produced for a short period and similarly, in lower plants, antheridia and archegonia have a short duration. During the vegetative phase of all plant species, it is not possible to ascertain their sex, whether male or female. Thus from the view of Jainism, their category as sexless or impotent can be justified. Further, since such species are not capable of conceiving sexually as in case of five sensed beings, their sexless category can be justified

In case of five sensed beings (*panchendriya J va*) like man, elephant, cow, horse, dog etc., the sex organs happen to be permanent organs of the body and
remain throughout their life, thus can be differentiated into different sexes.

Scientific observations prove the occurrence of sexual reproduction in various categories of invertebrates (two sensed to four sensed living beings as per Jainism). In many animals (two sensed to four sensed as per Jainism and of different phyla as per modern biology) sexual reproduction takes place outside the body, where the fertilization occurs in water and formation of zygote takes place. The sperm and ova are released by parent's body without any sexual contact. In some kinds of insects, the eggs are produced even without fertilization. This phenomenon is called 'Parthenogenesis'. According to Jainism any kind of birth other than *jarayuja* (umbilical), *potaja* (non-umbilical) and *andaja* (incubatory) should be considered as *sammurchhana* birth, in spite of the fact that sex organs are present in the body. One aspect seems to be important that Jainism does not mention the type of reproduction (sexual or asexual) but classifies *J va* by the types of birth [45].

Biologists do not accept that life depends upon a non-material soul but some scientists accept the presence of a vital essence, or force which is peculiar to living organisms and different from all other physical forces. This vital force is not explainable in terms of physico-chemical phenomena and cannot be studied. This vital force is produced by some unique and large molecules, which are organized into living organisms [19].

In summary we can state that, from the view of Jainism, it is evident that earth bodied, air bodied and subtle plant bodied are living entities and perform various life supporting functions/ activities. Various arguments have been put forth in this article to justify this concept but they will need scientific investigations to establish.

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Appendix-1: Various yonis along with number of living being types.

S.N.	Types of Living Beings	Number
1.	EarthBodied	700,000
2.	Water Bodied	700,000
3.	Fire Bodied	700,000
4.	AirBodied	700,000
5.	Above Ground Plants	1,000,000
	(With one soul in every independent living body)	
6.	Below Ground Plants	1,400,000
	(With multiple souls in every independent living body)	
7.	Two Sense Beings	200,000
8.	Three Sense Beings	200,000
9.	Four Sense Beings	200,000
10.	Heavenly Beings	400,000
11.	Hellish Beings	400,000
12.	Five Sense Beings	400,000
13.	Human Beings	1,400,000
	Total	84,00,000

16. Evolution and Development of Life in Jainism and Modern Science

Rudi Jansma

Abstract

This article seeks to prove the existence of an inherent evolution theory in Jainism. First the meaning of the *indriya*-based classification is discussed in relation to modern viewpoints, as well as the meaning of the *anek nta* doctrine for hierarchical biological taxonomy. The occidental, chance and 'selfishness-based' concept of evolution is discussed in comparison with Jain ethics. The Jain concept of *parin ma* (transformation) is discussed in relation to the western concept of transformation – taken to be the same as evolution. Then the inner impulses that lead to progress towards higher stages of existence as well teleology are discussed and compared with the idea of chance changes without apparent purpose. In the second part the concept of 'mutation' is discussed from a Jain viewpoint in relation with modern knowledge of chemistry-based evolutionary progress and epigenetics.

Key Words : evolution; *parin ma*; biological transformation; *anek nta*; *bhavyatva*; *n makarma*; epigenetics, *yath pravrtti karana*; plant communication.

Scriptures Quoted : Tattvarthasutra

1. Introduction

There is no explicitly stated theory of evolution in Jainism. While cosmology, biology, chemistry and physics and other sciences as well as karma and spiritual teleology are very well developed and elaborated upon in detail by Jain saints and scholars through many centuries, a concept of evolution in the modern sense of the term of progressive development of life-forms out of each other does not exist in Jainism. In my opinion, there is no mention in Jainism comparable to physical genetics, chance mutations or a chemical basis to explain form transformations and

progressive development of intelligence and consciousness through time. It is however an undeniable fact that there is evolution in nature. In this article it is argued that there is indeed an implicit doctrine of evolution, and the explanation of the evolution of Nature by Jainism touches a more essential and fundamental level than modern evolution theories.

2. Evolution from Within

The soul, the eternal life-consciousness, has ever been and will ever be. Jains have no need of a creative god who performs "miracles" to create life-forms. All beings are nothing but forms of manifestation in which nature presents herself to our eyes and consciousness.

Jainism teaches that the nigodas are the simplest forms of non-elemental life, in which dwell the most inhibited souls, a class of which eventually, following their inherent inner urge towards liberation attract higher types of karmas and then may cloth themselves in the bodies of a more complex nature. In which form of existence a soul clothes itself is due to its karmas only, not to any outward circumstance though of course as a reaction to the environment a soul may adjust its body. Particles of karmic matter (karma pudgala) are attracted to the soul due to its vibrations as a result of the thoughts of the incarnated soul. Such thoughts or desires immediately attract particles of subtle matter, called karma-pudgala, which cling to the soul or *j* va. Together these particles-no doubt with their own complex chemical, molecular, structure - form the karmic body around the *j* va or soul. It is this subtle matter which carries the information of past actions and thoughts and feelings. Then, in a next incarnation or embodiment of the *j* va, it are these karmas which determine our destiny in detail: where we will be born, what will be the features of our body, how long we will live, and how clear or obstructed our mind and other faculties will be, what attractions we feel - and this attraction may well be scientific knowledge, as in our case.

If the soul has reached a stage where a higher type of body is appropriate, it develops more than one sense-organ to relate to the outer world. Thus develop beings with two, three, four or five sense organs, and some of the five-sensed, including humans, will be endowed with mind.

In the Jain system ten different *pr nas* or vital energies/powers are distinguished:

One yus: life sustaining vitality; three balas (the powers of body, speech and

mind) one called ucchav sa-nisv sa or nap na: inhaling-exhaling; five functions of the sense-organs. yus, body-power-bala, nap na and the pr na of touch are always present in living beings. The others develop together with the higher powers and sense-organs. For details see the accompanying article on evolution of life by Varsha Shah else where in this book.

It is of crucial importance in Jain thinking that the soul in its development is more important for the classification of life than is the outer form of the body. The classification runs, like in western science, parallel to evolution. Though the various life-forms of the minerals, vegetable bodies, animals, humans and other beings are described rather extensively, the number of sense organs remains the first to be mentioned. This reflects the inner development as such which, as cause, reflects itself into an outer form. The outer form is important for the soul's expression and experience, but secondary compared to the action of the soul itself.

The sense organs always occur in the same order: touch, taste, smell, sight and hearing, and personal mind supported by a brain develops only after the fifth sense organ has been evolved. Only the combinations of the first two, the first three, the first four or all five are possible.

Minerals, plants, elemental beings and nigodas seem to have only a 'skin' or outer boundary to perceive the outer world. But it is not scientifically correct that plants for example can only feel. It has been scientifically proved that plants can smell (see Appendix-1), perceive light and sound.

They can smell and also actively produce smells to communicate among each other; but they have no noses. For example, information about predators which eat leaves: the plant then produces chemicals (pheromones) which can be carried through the air and then be perceived by other related plants – that is smell. These than take measures of chemical defense against the approaching predator. There are plants that emit alarm pheromones when grazed upon, resulting in tannin production in neighboring plants. These tannins make the plants less palatable for the predator. Trees are also known to communicate in this way. Plants also can produce smells perceived by certain insects to attract them who eat the plants' 'enemies', e.g. caterpillars. Messages are also carried underground through the root system – then we might call it taste. Plants could not grow to the light if they had no means to perceive light, but they have no eyes. They seem to react 'paranormally' on the emotions or thought vibrations of other living beings, including people. Plants

have developed tasty nectar and lovely smelling flowers satisfying the desires of specific pollinators (and humans). Some plants, especially orchids, have adjusted the forms of their flowers as well as their colors and even smells to visiting insects – which proves that they have rather complex perceptive abilities, and show use of intelligence. Fruits may have developed tastes that are attractive for birds and animals. Plants as well as minerals, and also animals seem to have a 'feeling' for esthetics: a direct expression of the soul. But plants souls have not developed (i.e. have not attracted the karmas) for specialized external organs in order to actively investigate light, sound, smell or taste. A feature Jainism seems to have paid no attention to in its classification is other senses than these obvious five, such as for example electric and magnetic perception, active warmth perception, balance perception and chemical perception other than smell and taste as micro-organisms and individual cells do.

It is known through modern research by Albrecht-Buehler and others that one-celled beings who can move from one place to another can detect light and the direction from where it comes by means of cleverly placed light sensitive spots within the cell¹.

I think, therefore, that the Jain classification of living beings is based on external organs (not sense perceptions) and these are the specific gateways through which the soul wishes to perceive and investigate the universe. As the senses are hierarchical they represent the progressing unfoldment of the soul in relation to the elements of earth, water, air and fire (light) and the elements of sound and thought. Thus the senses which have developed specific organs themselves are hierarchical: the further the development of the soul in its eternal pilgrimage through the realms of the various worlds, the higher the sense-organ added to it. From this point of view, the Jains do have a concept of evolution: the progressive manifestation of inherent properties. The word 'evolution' means literally 'rolling out from within', unrolling, developing. Each sensual and mental potentiality has always – 'from beginningless time' – been inherent in the nature of the soul.

There is no explicit theory on evolution in Jainism that can be compared with the western scientific philosophical idea behind evolution – which is rather a theory of external transformation than a real idea about evolution, in the sense of "bringing forth from within."

^{1.} See for example the article "Cosmic Mind in the Microcosm" by Rudi Jansma: www.theosophynw.org/theosnw/science/sc-jans4.htm)) and many entries in Google.

Jainism knows however the concept of parin ma which means transformation, change, bending. The *Tattv rtha S tra* (TS) says about this (V. 42): "Parin ma or modification of a substance is the change in the character of its gunas (attributes, qualities)." Within the framework of the anek ntav da doctrine (knowable things can be viewed from many different standpoints), any existing thing is comprised of three aspects: dravya (substance), guna (quality, attribute) and pary ya (mode). Substance may have many qualities. The qualities always depend on substance (*dravya*) and are never without it (TS V. 41). An example is a change from one color to another. The qualities have no qualities of their own (otherwise they would be called substances), but all the time they undergo changes (parin ma) by acquiring new modes (pary ya) and losing the old ones. All changes in physical properties of organisms as found in western evolution theory are contained within this term parin ma. *Parin ma* may also indicate change or bending of mentality or direction, resulting in inner progress, which then results in external progress. The soul is seen as a substance, as something that supports qualities. Examples are knowledge, energy, compassion, happiness. The innumerable qualities may increase or decrease, but are always there to some extent in many possible modes.

A consequence of the anek nta (multiple conclusion) doctrine is that, because of the complexity of the manifold aspects, concepts such as unity and multiplicity, or such as eternity and transience, can exist at the same time. For example, a body is a unity, but is also at the same time a multiplicity of cells; living beings are eternal in their soul-aspect, but transient in their external forms. This is of crucial importance to understand the hierarchical classification (taxonomy) of nature in biology. Thus, for example, all the different species and varieties of roses have, despite their differences, at the same time their inherent "roseness" in common, which unifies them together in the Rosaceae or rose-family. And, speaking as a biologist: we can continue along a hierarchical line, and understand likewise that the Jain doctrine of anek nta explains that the Rosaceae can be united with the Ranunculaceae (buttercups) into the class of Rosales, and so on. All living things and groups of living things, on their own taxonomical level of manifest nature, have their own fundamental characteristics, due to specific groups of qualities and modes of these qualities. This, of course, does not only apply to the physical appearance, but also to inner, psychological, mental and spiritual properties, and to the phenomena a living being is attracted to.

To know the distinction between *bhava karma* and *dravya karma* is of key

importance for understanding the Jain teaching on karma. The first refers to the thought activity of the soul, the second to the karmic matter which is attracted due to the action of the soul. Whatever thought or emotional vibration may have been produced by the jîva, will result in a particular form. To this there is no exception possible. It is therefore the inner activity of a living being which determines the form it will clothe itself in when a future embodiment occurs. This can include aberrations and failure in nature, because living beings make choices within their limit of individual consciousness. It is karma. The transformations of forms in nature are thus guided from within, and not from outside influences, beyond the control of the inner being that lives within its particular body, as is the traditional western science-based belief. Evolution in the western sense of the word can thus wholly be explained by the choices and attractions of the souls, and these are reflected in the psychology, mentality as well as outer appearance of humans, animals, plants, and even minerals and invisible beings below and above the human kingdom.

One is reaping the fruits only of one's own karma. Karma is the absolute working method of the universe, and there is or are no God or gods who interfere, 'forgive' in the sense of annihilating karma (because not even a god can undo the laws of nature). This philosophy was not restricted to the Jainas; both Hindus and Buddhist writers have produced doctrinal materials stressing the same point. Each of the latter traditions, however, developed practices in basic contradiction to such belief. We find among Hindus widespread adherence to the notion of divine intervention in ones fate, while Buddhists eventually came to propound such theories like boon-granting bodhisattvas (such as Avalokiteshvara as advocated in the Saddharma Pundarika (Lotus, S tra), transfer merit, or take on someone else's karma so that he or she may be relieved of suffering. Jainas (and modern Theosophists) have been absolutely unwilling to allow such ideas to penetrate their philosophy, despite the fact that there must have been tremendous amount of social pressure on them to do so. This is most crucial. In the Jain (and Theosophical) doctrines as well as original doctrines of other cultures, results follow a cause like 'a track follows a wheel of a cart' (as the Buddhist Dhammapada expresses it). This does not mean that the universe is 'heartless', indifferent or without compassion: all beings, including highly spiritual men and women, exist in order to help each other: by teaching and example. However no being in the universe can undo a cause and a choice: a seed sown will produce its proper fruits. The karma doctrine implies that

there is and can be no other creator in evolution that the individual Self, the jîva or conscious living soul. Evolution and all life-forms existing in the universe as well as pleasant and unpleasant situations and experiences are entirely due to the soul's responsibility. This also applies to evolution: no god can change a fly into a bee, or a mouse into an elephant. The only way to influence evolution is by one's own mental choice and by inspiring others to do the same. Thus the path of spirituality determines the true path of evolution.

The question of evolution itself - whether there is a real - gradual or stepwise - unfoldment of the inherent qualities of the less evolved toward the more evolved is a matter of discussion within Jainism. Some Jains suggest that the soul moves 'haphazardly' up and down through all high and low forms of existence according to its karmic behavior - and thus, due to bad or good behavior and thought a man may either fall back or take promotion to life-forms which have developed another number of sense-organs and therefore are in an entirely different evolutionary and experiential phase. It is difficult to understand how a one-sensed being would be able, in view of this limitation, to act or vibrate in such a way that it can at once jump to a two, three or more sensed body or into a mental state. Nor can it be understood how a creature of higher development can easily spoil all his previous effort of perhaps many ages that brought him in this present lifetime to its present state and fall down into a kingdom it had already reached ages ago. Moreover it seems that the average Jain does not believe that: there are many stories about the relation between karma and former/future lives in the Jain tradition, and these stories almost invariably show human beings having been humans, except in some cases where incarnations in higher animals that understand or speak noble words are involved, to be followed afterwards by human incarnations again. It seems plausible that evolution is always in the direction of the pressure exerted by the soul, and that only minor modifications towards more or less fortunate circumstances and more or less obstructive physical variations may occur.

P. S. Jaini of the University of California, Berkeley discusses the question of evolution in his article "Karma and the Problem of Rebirth in Jainism" ² and states among other arguments: "... every soul is said to exist along a virtual continuum of consciousness, from the minimal but ineradicable trace of awareness (nitya-udgh tita-jñ na) possessed by a nigoda to the omniscience of a siddha [one who has accomplished liberation] ... we have here a model which is both linear and evolutionary in its conception."

But it is conceivable that any living being may due its present karmic action create obstacles for progress, or on the other hand, through strenuous effort, erasing obstructions, may develop higher faculties quicker. However, emancipation toward final liberation can only be reached through the human stage. Liberation can be consciously reached by right action and right thinking, such as nonviolence toward all life-forms, and purification. High yogic faculties may evolve, such as spiritual clairvoyance (*avadhi*) and the ability to see karmic relations between lives, and infinite compassion. And finally omniscience will be reached: the soul achieving its full unlimited bloom. This is evolution in its real sense of the word.

Related to evolution is the question of exhaustion of the stock of jîvas: jîvas are reaching liberation, the highest state of being all the time. If there were no supply from below, one day all souls would be emancipated – but as there has been no beginning to creation and the number of souls is infinite, this problem does not arise. But not all souls that are in the run at this moment, are the same as in the past. Many have reached emancipation, while the stock has been continuously supplied from below. If some souls leave this condition to supply the souls that are "lost" for the cycles of non-liberated existence by reaching liberation, the average movement is upward, which means that at least on average there is evolution.

Another question relates to the origin of the most primitive life-forms – which, after all, are also inhibited souls. Jainism states that there is an infinite supply of *nitya-nigodas*, the lowest state of one-sensed existence of the soul. But how did these reach their particular karmic condition? This would only be explicable within the framework of the karma doctrine if there has been something before the *nitya-nigoda* state.

Every living being has some instinct for progress according to the direction it has chosen by previous longings, and that despite many set-backs and failures, that striving always remains as a leading soul vibration, finally leading all souls to humanhood and ultimately liberation. In the most primitive beings, the *nityanigodas*, this instinct may be dormant, but in time in can be awakened.

A second concept, after *parin ma*, that should be discussed in relation to the question of evolution is "*bhavyatva*" (from *bh*, to be, to become), the capability to

^{2.} Jaini, Padmanabh, ed. (2000). Collected Papers on Jaina Studies (1st ed.). Delhi: Motilal Banarsidass Publishers. p. 137; 'Karma and the problem of rebirth in Jainism', IN: Wendy Doniger O'Flaherty (Editor) (1980), Karma and Rebirth in Classical Indian Traditions, University of California Press, pp. 217-239.

become free, which is an inherent quality of the soul. This quality has always been waiting for the moment at which it is activated. We should always keep in mind that the soul of its own nature is pure and omniscient and omni-compassionate, and that it is only the individual consciousness of the karmic vehicle of the soul – that is, every individual karmic manifestation of consciousness, which is different for each species or individual living being – which is limited in its scope, and experiences suffering due to deluded or obstructed clearness, otherwise called ignorance.

Therefore the soul itself is always ready to shine forth its dauntless energy for the sake of the progress of the suffering consciousness. When, due to karmic conditions, the recipient consciousness center has reached the state of readiness, the "light" can suddenly break through, and redirect the tendency of that conscious living being irreversibly toward the spiritual goal, which is knowledge of the nature of the soul – itself.

It is however not the case that *bhavyatva* takes a person "by the hand" and leads him toward *moksha*. It initiates the process and makes him aware that there is a goal, but one has to climb the path toward truth by one's own strenuous efforts, by living a pure life of determination and self-control. During this path of spiritual growth, the qualities of the soul evolve forth whenever karmic obstructions are removed.

Thus, speaking in terms of evolution, we can distinguish two phases: the first phase in which the soul clothes itself subsequently in innumerable vestures, gaining experience in all kingdoms of nature due to the karmic particles it continuously attracts. It evolves forth one sense organ, or two, up to five, and mind. Until the point is reached where the consciousness can fully and consciously receive the working of *bhavyatva*. From then on the second phase begins: that of self-guided evolution.

Another point of attention is that the knowledge, bliss, energy and compassion of the soul – which is by nature immortal – can never be extinguished. They can only be obstructed in their free flow by the karmic dust clinging to the soul. The karmic dust however, being of a non-living, i.e. soul-less, quality, can be suppressed and finally can and will be definitely removed. So, in the long run the soul with its noble qualities will always conquer and thus the highest evolutionary goal will be accomplished.

A third very important concept in this context in Jainism is called yath -

pravrtti-karana. This term, meaning 'beginning cause', is the urge, which is present in even the most primitive beings, the *nitya-nigodas* – so certainly in humans – to release themselves from the chains of desire, to shuffle off the karmic impediments.

Though 'weakly' present in all living beings, this urge, this energy, at the beginning of the self-guided path of evolution which can be pursued by human beings (yogis) only, suddenly comes to the forefront as an enormous energy, temporarily pushing aside most karmas and bringing the consciousness face to face with all the individual karmas that limit the vision and freedom of the soul. Though after that experience one may slide back a few steps on the yogic ladder due to karmic attraction to the past mundane existence, it can never be totally forgotten, and will later become the motivation to climb up.

Thus, taking *bhavyatva* and *yath pravrattikarana* into account, there is indeed an implicit doctrine of evolution in Jainism. Due to the "pull" of *bhavyatva* and the "push" of *yath pravarttikarana*, the pilgrimage of the soul is, despite local undulations, always in an upward direction. All the changes of form – *parin ma* – move into the direction of serving a soul of ever higher accomplishment, upwards through the kingdoms of nature toward spiritual perfection.

3. Mutations from within

Choices and preferences in nature, even though they are directed without knowledge of the results to which they will lead, cause the psychological, mental as well as physical characteristics of men, animals, plants, minerals, and invisible beings in all worlds. The outer world around us, the environment, is the result of the totality of the inner life of all living beings. So it are the souls of the individual beings which determine the world of forms, making use of the endless possibility of characteristics and modes that nature offers. An aspect of the processes of change of the physical body is that the genetic code (DNA) defining the composition of proteins from amino acids must occasionally be adjusted – mutated.

Many Western scientists still believe that such changes (mutations) take place by chance or by unrelated and unpredicted causes (e.g. lethal cosmic rays). Not so according to Jainism. While accidents may happen due to other karmic causes, "chance" is a non-concept, because karma is universal – causes and effects are unshakably related. All initiatives to change begin with a vibration of the soul, resulting in a change or modification in karmic details. It is then the karmic body built of karmic matter or 'dust', called *karma-pudgala-vargan* which first carries the

information for the change and then transmits it by means of the *taijasa sharîra* to either the *aud rika* (physical) or *vaikriyika* (etheric) *sharîra* or body. Thus from a Jain point of view (supported by other occult-based religions and philosophies) every change, adjustment and progress involves the conscious and living essence of one's being.

Since the unraveling of the genetic code by Francis Crick and James D. Watson (1953), a tremendous amount of research has shown that the processes taking place within and outside the cell's nucleus are extremely complex. Without being able to enter into details in this short article, we may mention the process of chromosomal crossing-over (Lipton, 2005) and the process where homologous chromosomes pair up with each other and exchange different segments of their genetic material to form recombinant chromosomes. It can also happen during mitotic ('normal' - not leading to gametes) division. Crossing-over is essential for the normal segregation of chromosomes during meiosis. Crossing-over also accounts for genetic variation due to the swapping of genetic material during crossing over. So, when the chromosomes go on to the second stage of meiosis and separate, some of the daughter cells receive daughter chromosomes with recombined alleles (variant forms of the same gene), originally stemming from both the parents 'just before becoming grandparents'. Due to this genetic recombination, the offsprings have a different set of genes than their parents do in the first stage of meiosis leading to gender cells, so that is before the combination of the male and female DNA strands in the chromosomes after unification. The first mitosis is different in the progeny from that in the parents. It means that sequences of DNA molecules or genes are unpredictably but not haphazardly interchanged. Could this be done in a useful manner by chance, i.e. without guiding cause?

Another feature in the chromosomes is the continuous activation and suppression of parts of the DNA code (genes) in order to serve local conditions and situations within the body. Thus from the zygote (the fertilized egg cell) which contains all DNA-codes necessary for the differentiation of cells (into nerve cells, bone cells, etc.) and morphogenesis of the organisms are formed to their interior and exterior physical shape. This activity is done by the cell itself by suppression or activation of particular parts of the genome. This activity can be done both by factors embedded within the DNA code itself or by specific chemicals within the cytoplasm – the last category not being inheritable with the DNA, but can be inherited through mitosis in a number of generations of the cell involved. Changes

then take place in a manner different from the processes of change in DNA which are of long-term consequence. Methylation and acetylation (Wesson,1991)³, for example, especially di-and trimethylation works on specific amino acids (Behe,1996), notably lysine, and thus suppress or activate particular proteins (esp. enzymes) histone modification is involved in repression of proteins. Methylation and histone modification together act to regulate the expression of the cell's DNA. Methylation can give rise to development, but also to disease, depending on the case. These processes take place molecule by molecule and exactly where it is functional, not haphazard as in inorganic circumstances.

Selective inlet through variable permeability of the outer membrane for external chemicals by choice of the cell itself enables the cell to perceive its external environment and thus it partly chooses its own future. For this purpose, cells have to selectively allow specific external information to enter its outer membrane – and just this is taking place continuously for tens of thousand of different kinds of information.

Bruce Lipton, a cell-biologist who studied epigenetics in recent years, concluded from his research on membrane processes in cells that it is not DNA-determinism that is the first responsible agent for the future course of life and heredity, but external factors perceived consciously by the cell. It is the membrane which carries receptors, like antennas, for external stimuli, including human thought. According to Lipton (2005), research into the manner in which cells receive and process information shows that the life of a cell is not controlled by its DNA alone – which merely contains blueprints for the synthesis of proteins. Rather it should be emphasized that impulses from outside the cell play a very important and determining role, and that the cell has the mechanism to perceive and interpret external information. Environmental signals can be all kinds of chemicals, and include hormones (e.g. adrenalin (epinephrine) that are released in the bloodstream as a direct result of conscious mental or emotional impulses. Could not the same apply to the 'superconscious' information from the jîva – even though unconscious to our personal mind and senses?

The physical and the energetic environment can directly influence or control the binding of regulatory proteins (which make out about half of the biomass of the

^{3.} Also quoted in R. Jansma: Global Philosophical and Ecological Concepts, Motilal Banarsidass, Delhi & Prakrit Bharati Academy Jaipur, 2010, Vol II, pp. 668-670.

chromosomes – the other half being the DNA itself). "Regulatory genes direct the activity of protein-encoding genes, but environmental signals control how regulatory proteins bind to DNA," says Lipton. The science which is concerned with these surface-proteins is called epigenetics. Lipton states that the external influences on the activities of DNA can also be, for example, the human mind. They can also be sensual impressions or perceptions. The cells as conscious beings make choices which do not only influence their present life, but also influence the activity and reproduction of DNA. Contrary to the predominating assumptions of biologists, DNA and its predetermined code (modified by chance) is not the most important organ of the cell. The outer membrane is the location where decisions are implemented by either allowing or inhibiting external influences to enter the cell. Thus conscious cell, it seems, is making choices influencing its own life and that of future generation.

4. Karma

Conscious choice and its influence on occurring events is what the Jains call karma. Lipton explains that functions of cells are directly derived from the movement of their protein suppressors or accelerators. "While proteins are the physical building blocks , complementary environmental signals are required to animate their movement. The interface between environmental signals and behavior-producing cytoplasmic proteins is the cell membrane. The membrane receives stimuli and then engages the appropriate life-sustaining cellular responses. The cell membrane operates as the cell's 'brain.' ... These protein complexes are 'perception switches' that link reception of environmental stimuli to response-generating protein pathways." And: "The simultaneous interactions of tens of thousands of reflexive perception switches in the membrane, each directly reading an environmental signal, collectively create the complex behavior of a living cell." (Lipton, 2005, pp. 98-99).

Apart from epigenetic processes, true genetic changes within the DNA strands – mutations, i.e. changes in the sequences of purine and pyrimidine bases – sometimes lead to mistakes or failures – thus providing geneticists food for the belief that when, by chance, a beneficial mutation takes place this leads to a fitter phenotype (organism) that after some generations will compete out all weaker ones. This proves that karma works in different ways on different physiological levels: on the epigenetic and the genetic level. The first level is induced by thought,

emotion and physiology, the second by interference in the cells gametogenetic and meiotic processes. Karma also works in the emotional, mental and spiritual-intuitive (*darshana*) levels, even independent of the (physical or etheric) body. 'Survival of the fittest', whether on the level of individuals, species or of the genome itself, is unacceptable for a Jain who – philosophically – regards nonviolence as a quality of the essence of beings, and who moreover supports the idea that changes in living beings can only be brought about through life and consciousness through karma, i.e. causes and effects. Though relative weakness and fitness of course occurs in nature even on the individual level and is a useful provision in nature, it is not the motor of change and evolution. These are a product of 'imperfect' karmic choices by a partly obscured or inhibited soul (*j va*) – what itself is the result of earlier produced karmas. The motor of evolution is the life-consciousness substance or *j va*. As said this conscious substance is just as eternal as the unconscious substance known as pudgala or matter.

Cause and effect in the sense of karma does not work in the realm of physical matter alone, but to all that happens in the universe through all types of matter. The finer pudgalas that build up the finer (invisible) bodies: k rmana, taijasa, vaikriyika, aud rika and h raka sharîra have their own natural laws according to their own nature, but different from the 'laws' of physical matter. For example 'time' and 'speed' behave different in other *pudgalas* than in physical matter. Each of these is subject to the workings of karma – and this is why karma often seems inexplicable or 'magic' to those who have only studied the laws of physical matter. In ignorance many western scientists attribute unexplained causes to the field of quantum physics, where functions can collapse and reappear randomly, i.e. causeless though one of the leading quantum physicists of the 20th century, David Bohm, maintains that within or behind every external order exists an implicate (deeper) order. These implicate orders invite our future research. If one asks a Jain or an occultist how to study these, they would answer: by self-purification through restraint of the restlessly wavering mind and an utter ethical life based on one's inner intuition of what is right. Ethics is nothing else than living in attunement to the spiritual dharmas of the universe. This will lead to utter refinement of inner vision and clarity of mind; by studying the (ancient) scriptures of many cultures we can learn to understand much about the properties and habits of unseen worlds and beings. All these beings and worlds are connected with us, and all are ourselves, around us filling the universe as well as within ourselves, because all living beings

have the substance of pure Jîva with its infinite potencies in common.

J va is present throughout all types of *pudgala* and therefore the karmic activity (not karma as a law, of course) itself is 'supervised' or ensouled by *jîvic* wisdom and *jîvic* intelligence. The workings of karma are therefore not 'blind' and are not a non-conscious automatism. It is therefore of the highest interest that science takes on the study of the existence, properties and workings of grades of matter that are more subtle and of another character than physical matter, and which so far can only be perceived vaguely, distorted and with often unreliable results by rare clairvoyants. That such knowledge is possible in an exact way has been proven by occultism (if genuine) within many religions in the past.

All changes, without exception, including mistakes and failures, are born from consciousness and brought about by karma. Note that even mistakes and failures have a cause in the soul and therefore are karmas – in this case leading to death and/or suffering.

A big difference between inorganic chemical processes resulting from the properties of matter or *pudgala* alone on the one hand and organic processes within living bodies on the other, is that in the first case combinations and dissociations are based on the inherent (non-conscious) properties of matter such as electrical charge (+ or -) and electrovalent and covalent tendencies, or *snigdha* (smoothness, viscosity) and *r ksha* (dryness, roughness). In the latter case, every single organic molecule is carried or transported to its proper location in the cell – indeed a process of high sophistication. Because every situation is 'privately' handled, the extra-physical factors of conscious interference as well as unconscious intelligence (for 'regular' processes) would have ample opportunity to regulate every single organic process individually.

It should be emphasized that processes in living beings always come from within and therefore can adjust several cooperating factors at the same time. An example is the development of an extremely complex organ of the eye and the parallel development of the nervous system and again the very complex chemical processes of transporting the impulse of a light photon to the vision center in the brain. Michael Behe in his *Darwin's Black Box*, describing the structure of a complex organ, the cilium, and the chemical processes of vision from the eye to the brain, followed by chemical restoration of all involved factors (chemicals and cells) (Behe, 1996, pp. 18-21).

This indicates that the inherent and internal soul-substance or livingconscious *jîva* and paramount intelligence are fully involved in the development of living organisms. This is in contrast with mechanical products such as computers, where the consciousness is external (i.e. the consciousness and intelligence or *jîva* of the engineers and program designers). Jains could accept the concept of design by intelligence and wisdom by the soul-substance in all life, but can never accept an external God or Creator or 'engineer' who constructed the universe as a nonconscious mechanism outside 'Him' self.

4.1 Body determining karma

Karma (as a theory) is the sound alternative for genetic heredity in the western vision. It also is the explanation for coming into existence of many classes and millions of species of animals, plants, minerals as well as human characters. The mechanism of karma is chemical, in the Jain view, though on a subtler level than the chemistry of physical matter, and must be extremely complex. Karma does not only apply to the physical level, as the DNA code does, it also applies to the mental and emotional levels, as well as to the individual power to have right intuitive vision. It also applies to psychic powers like clairvoyance (*avadhi*) and thought reading (*manahparyaya*). The Jains have made an exclusive classification of karma, more elaborate than any known system. To give all details here would make this article too long. It can be found on many places in printed or online literature. Here we give only a general outline in relation to the development of physical forms.

Because western biology classifies nature on the basis of physiological physical and genetic features, it is interesting to discuss here the various kinds of body-determining karma (*n ma-karma*) and, as a result of this, species-determining karma. There are 93 types of body-determining karma defined in Jain literature. The first four types of karmic results determine the conditions of existence and the realm of nature (*gati*) into which the soul is born. These four *gatis* are the subhuman, human, hellish and celestial realms. All circumstances and features which appertain to the physical (*aud rika*) or fluidic (*vaikriyika*) body apply to all these realms, if relevant. (For example "gracious flight through the air" is irrelevant for earthworms). Of course the physical and the fluidic bodies have their own unique features. The fluidic body consists of molecules of the corresponding degree of matter and belongs only to hellish and celestial beings. We don't have this fluid body during our existence on earth. The invisible model body (the *linga sharira* of

Hinduism) determining the fine shape of the physical body of each living being on earth seems, in the Jain system, to be tacitly included in the karmic with the electric body. The soul takes the karmic and the electric body with it when we "die," i.e. leave – as a soul – either our physical or fluidic body and when we are born again.

The second group of karmas determines in which kingdom of nature the soul will embody itself, and also on which biological level of classification. The visible kingdoms include what we call the elemental, the mineral, the unicellular, the vegetable, the various groups of the animals, and the human kingdom. The highest level of classification appertains to the number of sense-organs which come to expression and the power of consciousness to gain experience by means of touch, taste, smell, vision and hearing.

As regards body-determining karma, its activity seems akin to that of DNA, but needs not be on the physical level, and every karma has a cause in the thought vibrations of the jîva and is therefore related to universal or transcendental ethics. One category of karmas determines the organs and limbs and their correct growth in relation to their bodily location. So, for example, whether the brain functions properly as an organ or whether our immune system is in its proper condition is the result of the workings of karma. Physical impediments therefore develop during the fetal stages. Of course external factors during life can also change the situation, for example due to accident or disease. Next we go to the molecular level. The Jains distinguish five types of molecules in relation to the five types of bodies. Five types of karma must be involved with the mixing of the molecules of the five types of bodies. They are intertwined with the soul, and must cooperate in the right way to form an organic whole. This Jain teaching is a very important idea for modern physiology, because science is, despite its impressive knowledge about intracellular chemical processes and ways of transformation transfer between cells, especially in the nervous system, still far too little aware of the refined relations between organs, chemistry, the information contained in magnetic and electric fields produced in the organs in the body, the influence of thoughts and feelings on these fields, and the influence these fields have on and undergo from others that make up the environment. Western science is now becoming aware of such things. For example, the measurable field around the human heart stretches towards about 2 feet before him and can perceive direct information from the inner beings of plants. Read for example the chapters on the heart as perceptive organ in The Secret Teachings of Plants by S.H. Buhner. But what western science has not yet done, is to trace the

transfer of the subtler energies from incarnation to incarnation, when a physical body with all its specific characteristics is temporarily nonexistent. Here again, ancient knowledge is a step ahead of modern science.

Further there are karmas which determine the general physiognomy of the body: general perfection, or aberrations in symmetry or proportions. The next category is especially concerned with the six types of joints which occur in animals. In addition there is a category which describes all external features which do not belong to the basic form, structure and physiology of the body. These are the secondary characteristics which can be perceived by the senses (excluding hearing); in other words, how the body feels when touched, or tastes, smells or sees. This is how the colors of the bodies are determined: white, black, blue, red and yellow with their various shades; and also the surface structure of the body: to the touch it may be hot (for example the sun) or cold, soft, rough, hard, or be light or heavy. Tastes can be bitter, sharp, sour, and sweet. There are only two smells in the Jain system: pleasant and foul. Here occidental science is far more refined: the different chemical smells that humans and animals can distinguish is enormous, and independent of the subjective attributes of pleasant and foul.

Then there is a category of karmas which is of special importance for invisible beings, and which the Tattv rtha S tra describes as "the ability to maintain (after death) the form of the body in its most recent incarnation during the passage of the soul from one condition of existence towards the next" (i.e. the hellish, subhuman, human or celestial condition).

There are karmas which determine whether the body is too heavy to move, or too light to be stable, or whether an organ grows in such a way that it becomes the cause of the body's death. There are also karmas which result in the growth of fatal weapons in the animal kingdom, such as the sting of a scorpion or the poison of a snake.

In addition there is a type of karmas which again shows that many objects which westerners usually regard as inorganic are for the Jains expressions of life. An example is the "radiating heat" an object can possess which is bearable for the owner, but unbearable for others (glowing iron, for example). A separate karma applies to phosphorescence, as seen in fireflies. Then there are karmas in relation to respiration, or connected with gracious or clumsy flight in the air. And there is a type of karma which determines whether the soul will live in an immobile (fixed) body, such as that of plants and minerals, or in a mobile body.

The following eight karmas determine whether a body looks attractive or repulsive to others, and whether it brings forth pleasant sounds or unpleasant, harsh sounds (compare a nightingale to a donkey), or whether the body will look beautiful or ugly and is of refined or coarse physiognomy.

Then two types of karma are mentioned which determine whether an individual and its organs will grow into adulthood or whether it will die before it has reached adulthood. These karmas determine whether the soul will appear to be able to bring the features and powers of the body in which it is born to full expression. The actual process of growing towards and into adulthood is the process of transformation of subtle and chemical elements in agreement with the pattern laid out by the karmic molecules, which are drawn to the location where the respective organs are to be formed. For example the molecules which determine the power of inhalation and exhalation transform themselves into the respiratory system. So breathing is not a function derived from the respiratory system, but it is the other way round: the karmic desire and the energy to breath are the cause of the development of the organs involved in respiration. So for the sense organs and the brain.

The next group determines the stability or instability of the body and its substances, such as bodily fluids, muscular tissue, fat, bone, marrow, veins, digestive juices, blood, etc.

Finally the Tattv rtha S tra mentions four karmas which determine whether a body will look dull and sluggish, and whether someone will have a good or a bad name as a result. Too often people or even animals are despised because of their physical appearance, whereas he, she or it may have done nothing but good during the present life.

Whether or not we agree with all the details from the viewpoint of modern science is not the most important thing. The modern world with its ever refining measuring techniques will find its own way to describe the interplay between all these energies, fields and states of matter in relation to consciousness and its free choice. In any case it is remarkable – to say the least – that in the days of Aristotle and Archimedes, when occidental science had only just started, the Jains, already had a detailed view of the principles of ecology, biology, evolution, physiology, atoms and

molecules, and above all, the logic behind them. If the detailed knowledge gained in recent centuries by means of refined instruments is combined with the Jain background, science will become more philosophical, more universal, more ethical, and more holistic. The biological teachings of the Jains include not only the physical, but also the invisible worlds of beings and forces – a field of science which in the west is still associated with superstition and the barely recognized science of parapsychology. Without a vision which includes the whole universe with all its phenomena, modern man can never reach satisfactory and final solutions. There is a fundamentally different point of departure between the spiritual and occult religions on one side, and occidental thinking on the other. Jainism and other systems state very permanently that Life and Consciousness were there before anything else. In fact, life and consciousness are eternal, without beginning and end. The other dravyas are also eternal, including matter itself in whatever form, but it is life and consciousness which takes the initiative for change. Life and consciousness can never be emergent properties of matter, which in its own is lifeless. However complex material structures, like the human brain, may be, it is a matter of principle that life enters into matter and regulates it, but can never be a product or result of matter. No life can come out of it. Matter is the passive substance - of coarse with its own inherent properties - which is used by the soul as material to build its bodies, its vehicles to peregrinate through the universe.

5. Conclusions

An implicit doctrine of evolution is found to be present in the Jain teaching if one reads the meaning of the concepts of *parin ma*, *bhavatva* and *yath -pravrttikarana*. The true guide of evolution is jîva, i.e. inner life-consciousness-wisdom, and NOT external selective factors, chance (i.e. spiritually unguided) mutations and 'struggle for continued existence' or 'survival of the fittest' – though all such factors must naturally play a role, but only secondary and superficially. How diversification and speciation take place on the various taxonomical levels can be explained by the law of karma, i.e. cause-and-effect according to Nature's laws and habits. The basis of consciousness and choice is always in karma, and therefore, indirectly, in the external transformations.

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Appendix 1: Plant Life

There are many articles dealing with plant life and we quote a few here ("Plant-Talk" in The Scientist: (http://www.the-scientist.com/ ?articles. view/articleNo/38727/title/Plant-Talk/ (2014) by Dan Cossins, January 1, 2014) or the classic by Peter Tomkins and Christopher Bird: The Secret Life of Plants, Harper and Row (1973); or Daniel Chamovitz: What a Plant Knows: A Field Guide to the Senses, *Scientific American* /Farrar, Strauss and Giroux, New York (2012). Plants so far have been shown to communicate 'by taste' through root systems and underground fungi (Mycorrhiza) and through the air by pheromones ('smell'). New research (also quoted in "Plant Talk)" is done to plants which communicate through any of these ways; sound is one of the options. In that case plants would be 'hearing'.

From the first we quote here one example: In the fall of 2009, in a Victorian greenhouse at the Cruickshank Botanic Garden at the University of Aberdeen in

Scotland, Zdenka Babikova sprinkled vegetation-devouring aphids on eight broad bean plants and sealed each plant's leaves and stems inside a clear plastic bag. This was no act of malice, though; it was all in the name of science. Babikova, a Ph.D. student at the University of Aberdeen, knew that aphid-infested bean plants release odorous chemicals known as volatile organic compounds (VOCs) into the air to warn their neighbors, which respond by emitting different VOCs that repel aphids and attract aphid-hunting wasps. What she didn't know was whether the plants were also sounding the alarm beneath the soil surface.

Five weeks earlier, Babikova filled eight 30 cm-diameter pots with soil containing Glomus intraradices, a mycorrhizal fungus that connects the roots of plants with its hyphae, the branching filaments that make up the fungal mycelium. Like a subterranean swap meet, these hyphal networks facilitate the trade of nutrients between fungi and plants. In each pot, Babikova planted five broad bean plants: a "donor" plant surrounded by four "receiver" plants. One of the receivers was allowed to form root and mycorrhizal contact with the donor; another formed mycorrhizal contact only, and two more had neither root nor mycorrhizal contact. Once the mycorrhizal networks were well established, Babikova infested the donor plants with aphids and sealed each plant in a separate plastic bag that allowed for the passage of carbon dioxide, water, and water vapor but blocked larger molecules, such as the VOCs used for airborne communication.

Four days later, Babikova placed individual aphids or parasitoid wasps in spherical choice chambers to see how they reacted to the VOC bouquets collected from receiver plants. Sure enough, only plants that had mycorrhizal connections to the infested plant were repellent to aphids and attractive to wasps, an indication that the plants were in fact using their fungal symbionts to send warnings.

"When Zdenka first showed us those results it was quite a eureka moment," says David Johnson, a soil ecologist at Aberdeen who co-led the research. "There was a really striking difference between the insects' responses to plants with and without hyphal connections. We had more samples to test, but even at that point, it was pretty clear that this is an effective signaling system."

The remarkable conclusions from this study are the latest shoots in a growing thicket of data revealing the unexpectedly complex ways that plants exchange information with one another. Researchers are unearthing evidence that, far from being unresponsive and uncommunicative organisms, plants engage in regular

conversation. In addition to warning neighbors of herbivore attacks, they alert each other to threatening pathogens and impending droughts, and even recognize kin, continually adapting to the information they receive from plants growing around them. Moreover, plants can "talk" in several different ways: via airborne chemicals, soluble compounds exchanged by roots and networks of threadlike fungi, and perhaps even ultrasonic sounds. Plants, it seems, have a social life that scientists are just beginning to understand.

"In the last 15 years the idea that plants are communicating has become much more accepted," says Richard Karban, an evolutionary ecologist at the University of California, Davis. "The evidence for that is now substantial, and it's exciting to unravel all these different realms of plant communication."

17. Fixing Milestones of Evolution

Rajmal Jain

Abstract

An attempt is made to construct a consistent picture of the chronology of human evolution on the Earth based on the information given in Jain scriptures and modern astronomical, geochronological, archeological, fossil, climatic and cultural records. The climate cycle variations over the Earth during the past few million years enables us to narrow down the initiation of the human life of intellectual type around about 12 thousand years before present. This synthesis indicates that a rational revision of traditional interpretation of Jain scriptures is required.

Key Words: Climatic cycles, Period of Rishabh Dev, LGM, Glaciation, Climate forcing factors

1. Human Evolution

According to Jain scriptures, Bhagawan Rishabhdev or Adinath, i.e the first Tirthankar of the present Aara cycle, developed the concepts of a well organised civilized society. He invented the principles of defense (aasi), literature and art (masi) and agriculture (krishi) and taught the techniques to the people living in his kingdom. After setting up a well disciplined society, Rishabhdev became a monk, did penance at Ashtapad Mountain in Kailash, Tibet area and attained salvation there. In this context, Jain (2013) reviewed the period of Adinath. The period of his reign described in scriptures is koda-kodi years ago before the present. According to Jain scholars, Acharyas, Munis, Sadhus and Sadhvis, the unit koda-kodi is traditionally equal to $10^7 \times 10^7$ (= 10^{14}), one hundred thousand billions) years i.e. 10 times the age of the Earth. It is impossible that any human being existed before the formation of the earth and therefore Jain (2013) synthesised the geological evolutionary history of the earth and that of the Himalaya where Rishabhdev was

probably born. The major temporal evolutionry milestones of the earth are shown in Figure 1. For detailed description related to period of Rishabhdev and his life, the readers are referred to Jain (2013) and references therein. The unit koda-kodi has been rationalised and approximated to be equal to 10000. Thus it may be speculated that well developed human beings might have existed about 10000 years ago. However, life on the earth could have begun much earlier when oceans came into existence.

The word "homo", the name of the biological genus to which humans belongs to is Latin for "human". The Latin "homo" derives from the Indo-European root, dhghem, or "earth".

Fixing the Milestones - 1	
The Age of the Earth: 4.54 Ga B. P.	
Evolution of Himalaya Range:	
Current Farchconfiguration attained: 2010 Ma B. P.	
Monsoon started: 10 Ma B P	
Life of Mountain Dange: 100, 1000 Ma	
Life of Wourtain Range. Too - Tooo Ma	

Ga = Giga or billion years; Ma = Million years; B.P. = Before present Fig. 1 : The geological parameters to estimate the period of human evolution

The first serious debate about the nature of human evolution arose between Thomas Huxley and Richard Owen. Huxley argued in favour of human evolution from apes by illustrating many of similarities and differences between them. These arguments are summarised by him in his 1863 book "Evidence as to Man's Place in Nature". However, many of Darwin's early supporters (such as Alfred Russel Wallace and Charles Lyell) did not agree that the origin of the mental capacities and the moral sensibilities of humans could be explained by the law of natural selection. Darwin applied the theory of evolution and sexual selection to humans when he published "The Descent of Man" in 1871. A major problem was the lack of fossil intermediaries between ape and man. It was only in the 1920's that such fossils were discovered in Africa. In 1925, Raymond Dart described Australopithecus africanus. The type specimen was the Taung Child, an Australopithecine infant discovered in a cave. The child's remains, i.e. tiny skull and an endocrinal cast of the brain were remarkably well-preserved. Although the brain was small (volume: 410 cm³), its shape was rounded, unlike that of chimpanzees and gorillas, and was more like a modern human brain. Also, the specimen showed short canine teeth, and the position of the foramen magnum was evidence of bipedal locomotion. All these traits convinced Dart that the Taung baby was a bipedal human ancestor, a transitional form between apes and humans.

The classification of humans and their relatives has changed considerably over time. The gracile Australopithecines are now thought to be ancestors of the genus Homo, the group to which modern humans belong. Both Australopithecines and Homo sapiens are part of the tribe Hominini. Recent data suggests Australopithecines were a diverse group and that Australopithecines africanus may not be a direct ancestor of modern humans. Reclassification of Australopithecines that originally were split into either gracile or robust varieties has put the latter into a family of its own, Paranthropus. Taxonomists place humans, Australopithecines and related species in the same family as other great apes, in the Hominidae group.

Some people commonly assume that our species has evolved very little since prehistoric times. Yet, new studies using genetic information from population around the globe suggest that the pace of human evolution has increased with the advent of agriculture and development of cities. If we are still evolving, what might our species look like in a millennium from now? Will we survive whatever environmental and social surprises are there for us? Speculation ranges from the hopeful to the dystopian. On the other hand, some people believe in the old science fiction vision of a big-brained human with a high forehead and higher intellect (features and concepts like Bhagwan Rishabhdev). Others say humans are no longer evolving physically—that technology has put an end to the brutal logic of natural selection and that evolution is now purely cultural.

However, according to a few scientists, the big-brain vision has no real scientific basis. The fossil record of skull sizes over the past several thousand generations shows that days of rapid increase in brain size are long over. Accordingly, most scientists, a few years ago would have taken the view that human

physical evolution has ceased. But DNA techniques, which probe genomes both present and past, have unleashed a revolution in studying evolution. Not only has Homo sapiens been doing some major genetic reshuffling since our species formed, but the rate of human evolution may, if anything, have increased. In common with other organisms, we underwent the most dramatic changes to our body shape when our species first appeared, but we continue to show genetically induced changes to our physiology and perhaps to our behavior as well. Until fairly recently in our history, human races in various parts of the world were becoming more rather than less distinct. Even today the conditions of modern life could be driving changes to genes for certain behavioral traits. My foregoing discussion may lead you to ask many questions such as mentioned here. If giant brains are not in store for us, then what is? Will we become larger or smaller, smarter or dumber? How will the emergence of new diseases and the rise in global temperature shape us? Will a new human species arise one day? Or does the future evolution of humanity lie not within our genes but within our technology, as we augment our brains and bodies with silicon and steel? Are we but the builders of the next dominant intelligence on the earth—the machines?

Tracking human evolution used to be the province solely of paleontologists, those of us who study fossil bones from the ancient past. The human family, called the Hominidae, goes back at least seven million years- to the appearance of a small proto-human called Sahelanthropustchadensis. Since then, our family has had a still disputed, but rather diverse, number of new species in it—as many as nine that we know of and others surely still hidden in the notoriously poor hominid fossil record. Because early human skeletons rarely made it into sedimentary rocks before they were scavenged, this estimate changes from year to year as new discoveries and new interpretations of past bones make their way into print (see "Once We Were Not Alone," by Ian Tattersall; Scientific American, January 2000, and "An Ancestor to Call Our Own," by Kate Wong; ScientificAmerican, January 2003).

The world's most famous fossil is of Lucy. At the time of her discovery, Lucy was the oldest (3.2 million years) known and best preserved early human ancestor (Johanson and Edey, 1984). In Figure 2, the real fossilized remains of Lucy are shown. However, there is evidence of the famed fossil Ida (an animal of Lizard type) who at 47 million-years-old is unbelievably well-preserved and provides a view into our primate past.

Nevertheless, the exploration of 6 million years of human evolution and the



Fig. 2. The fossilized remains of Lucy (right). On left brief summary of human evolution along with structure details of Lucy and the reason of increase in brain size are presented.

investigation of the 1974 unearthing of Lucy shook the scientific community and altered our understanding of human origins. The examination of the stunning 78 foot mural that depicts 6 million years of human evolution, over 100 cultural artifacts from Ethiopia, and Lucy's homeland suggest why Ethiopia is called the Cradle of Mankind.

However, the fossil record tells us that the oldest member of our own species lived 195,000 years ago in what is now Ethiopia. From there, it spread out across the globe. By 10,000 years ago modern humans had successfully colonized each of the continents, save Antarctica, and adaptations to these many locales (among other evolutionary forces) led to what we loosely call races. Groups living in different places evidently retained just enough connections with one another to avoid evolving into separate species. With the globe fairly well covered, one might expect that the time for evolution is pretty much finished.

Nevertheless, recent investigations reveal that the brain size of hominids has increased approximately threefold during the evolution of the hominids from Australopithecus to Homo sapiens. It is proposed that the principal reason for this increase is that larger brains confer greater intelligence, and greater intelligence confers a selection advantage. A number of anthropologists have difficulty accepting this thesis because they believe that brain size is not associated with intelligence in man. Evidence is reviewed, and new evidence from two studies further confirms that brain size as measured by head size is positively correlated with intelligence as measured by intelligence tests. It is concluded that brain size is related to intelligence in man and that this is the major reason for the increase in brain size of the hominids during the last 3.2 million years. Considering the trend of increasing brain size and intellect continuing over time we may address the question 'how during the period of Bhagwan Rishabhdev the man evolved with larger forehead (brain size) and the higher intellect, sometimes around 10-20 thousand years before present'.

2. Forces Influencing Earth's Climate and Evolution of Life

The climatic cycles on the Earth are governed mainly by five major forces viz. (1) Earth, (2) Geodynamics of Earth's Inner core and mantle, (3) Solar, (4) Cosmic Rays and (5) Greenhouse gases. The Earth Force reveals: a) 41 kyr axial tilt cycle, b) 100 kyr eccentricity cycle, c) 100 kyr equatorial plane oscillation with respect to the ecliptic, and d) 23 kyr cycle of the precession of the equinoxes. Among all the five forces, the Earth's force is the strongest and has influenced the earth's geology, geophysics and environment, and hence the climate. The climatic periodicities, affect the rise and decline of human civilization, and perhaps of all life forms. Some of these aspects are discussed in an accompanying article by Jain et al (2015).



Fig. 3 Five million years of climatic change decoded from sediment core. The O¹⁶ treatment on the Vostok, Antarctic ice core reveals Benthic Carbonate (left y-axis) and equivalent global air temperature (right y-axis) variations over the Earth.

Shown in Figure 3, are the fluctuating sequences of glacial and Inter-glacials during the last five million years as revealed from the sediment records in Vostok ice core taken from Antractica ice shield. The O¹⁸ data in Vostok Ice core sediments, {ice or sediments} when observed in high time resolution, unambiguously revealed a periodicity of 100 thousand years of catastrophe cycles on the Earth in terms of maximum glaciation on earth, the last one being the Last Glacier Maximum (LGM). We present in Figure 4, the time series of about 425 thousand years. The mean global air temperature (15° C) referred as 0 on the y-axis reaches to about -8° C (on an average) every 100 thousand years. Similarly, on the same time scale of 100 thousand years the mean temperature rises up to 3°C, which has misleadingly been interpreted as global warming by some climate scientists. Thus, in fact, between LGM and warm phase, the time difference is about 50 thousand years. The last LGM occurred about 22 thousand years before present. Recent investigations of quaternary glaciation of Muztag Ata and Kongur Shan region have provided the evidence for glacier response to rapid climate changes throughout the Late Glacial and Holocene in westernmost Tibet (Seong et al., 2009). Under the severe cold and arid conditions of the LGM, vegetation seriously degraded and forests retreated to the south and east margin of the Tibetan Plateau (Tang et al., 1998). According to Yafeng Shi (2002), glaciers fed by monsoonal precipitation are mainly located on the Tibetan Plateau and the eastern most Asia. These are characterized by simultaneous accumulation and ablation in summer season. The southeast part of the Tibetan Plateau experiences monsoonal precipitation in excess of 1000 mm/yr resulting in maritime temperate glaciers. In contrast, precipitation in the middle and northwest part of the Tibet Plateau decreases from 1000 to 200 mm/yr, resulting in the formation of continental cold glaciers. During the last glacial, the regions of heavy monsoonal precipitation were restricted to the southeast corner of the Plateau. The westerly weak precipitation zone shifted southward, and occupied the major northwest part of the Plateau, where the extreme continental type glaciers greatly expanded. In the eastern margin of Asia including Taiwan, Central Japan, Hokkaido and probably Mount Changbai, maritime type glaciers were more extensive because of higher monsoonal precipitation, especially heavy snowfall in northwest Japan owing to the rich moisture content of the winter monsoon over the Japan Sea. The millennial scale monsoon intensity and glacial cycle in the Tibetan Plateau are strongly affected by the Earth's precession cycle and the orbitinclination cycle which dominates the solar irradiance variation at low latitudes, as



Fig. 4. Climate change over the Earth during Four hundred fifty thousand years in the past. dust and CO_2 variations are shown in ppm (pasts per million).



Fig. 5. The sunspot cycle variation since 1700AD to present (left-side). On the top right-side predictions for the future sunspot maximum year and amplitude are presented.

the high radiation and strong monsoon caused the warmer and wetter climate during 40–30 thousand years before present. The low radiation produced a weak monsoon and large depression of temperature and precipitation around 21 thousand years before today. This climatic pattern differs from that in the high latitudes where the eccentricity cycle is prominent. The temperature during the last glacial maximum (LGM) was 6-9°C lower than today on the Tibetan Plateau and the snow equilibrium line¹ altitude was depressed by about 1000 m in the southeast part, and in the east, south and west margins of the Plateau where precipitation was high. The equilibrium line depression was 500-300 m in the inner and especially the west part of the Plateau. This variation in equilibrium line might be caused by the combined effect of decrease in precipitation, the expansion of extreme continental glaciers and the active uplift of glaciated mountains. The estimation of a glaciated area of about 350,000 km² in the Tibetan Plateau and roughly 500,000 km² in High Asia based on observations of prominent features of LGM glacier extension, may be the direct evidence that shows that there was no Quaternary unified ice sheet developed in the Tibetan Plateau. The actual extent of the glaciated area during LGM in the Tibetan Plateau was calculated from the Quaternary glacial distribution map of Qinghai-Xizang (Tibet) Plateau at a scale of 1:3,000,000 (Li et al., 1991). However, it has been found that shortly after 19 ka (thousand years) BP, drought was exacerbated, pollen content decreased and was dominated by Chenopodiaceae, and the lake water turned brackish. Around 17 ka BP the lake shrank and separated into some small lakes, resembling the present state (Li., 1998). Under the severe cold and arid conditions of the LGM, vegetation seriously degraded and forest retreated to the south and east margin of the Tibetan Plateau (Tang et al., 1998). In summary, five shorter cold and warm stadial and inter-stadial cycles occurred during the last glacial and interglacial cycle in the low-latitude regions, due to the tremendous influence of precessional and obliquity variables. According to the Guliya ice core records and the data from lacustrine deposits and pollen records from the major part of the Tibetan Plateau, the summer monsoon was stronger, air temperature was higher and precipitation was abundant in the inter-stadial times. The winter monsoon was stronger, air temperature was low and precipitation was less in the past glacial stadials.

Thus current human civilization appears to have started less than 22

¹ Snow Equilibrium line below which Snow does not accumulate.

thousand years from present. The greenhouse gas (CO_2) emission (green color in Figure 4) also reveals similar results. The records also reveal that the period from 850 to 630 Million year B. P. was the most severe Ice Age in the Earth's history. The greenhouse gas CO_2 emission is a consequence of large volcano eruptions after the LGM.

The O^{16} treatment on the Vostok ice core reveals CO_2 greenhouse gas emission (right y-axis), and equivalent global air temperature (left y-axis) variations over the Earth. The increase in CO_2 emission and hence enhancement in global air temperature is the consequence of volcanic eruptions that often take place during long lasting glaciation periods.

On the other hand Geodynamics of Earth's Inner Core and Mantle forcing generates: a) super-rotation and inner-core mutation, b) super-plumes, c) Subducting and d) plates and volcanoes. In view of this force the Earth has been observing significant variation in its super-rotation and mutation in the last few million years, which results in several earthquakes and volcanoes in addition to wide climatic changes. One of the major forces affecting the Earth's climate in a variety of ways is the Solar Force, which has been well studied by Jain (2012). The most striking and remarkable property of the Sun is the differential rotation, which along with its convection property produce sunspots. These sunspots have 11-year periodicity and are the major form of solar activity. The 80-year and 200-year periodicity of the solar activity is related to climate change over the Earth (Bhatt, Jain and Aggarwal, 2009). The 11-year, 80-year and 200-year periodicities may be clearly noted in Figure 5 as small fluctuations in long period time series. Nevertheless, in Figure 5, the sunspot cycle variation since 1700 CE to present is shown along with predictions for the future sunspot maximum year and amplitude. However, it must be noted that sunspot activity periods may affect the climate cycle to a significant extent but not to the extent of producing a catastrophe on the Earth. The other climate affecting forces are the Cosmic Ray Forcing (which is related to heliosphere and magnetosphere shielding and only the high energy cosmic rays play a role), Greenhouse gases: (a) CO₂, (b) Methane, (c) Water vapor) and TPW (true-polar-wander).

Throughout history, the changing fortunes of human societies in Asia have been linked to variations in the precipitation resulting from seasonal monsoons. The variations in monsoon climate over longer time scales also influenced the
evolution of the world's highest mountain chain, the Himalayas. The climate over much of Asia is dominated by seasonal winds that carry moist air over the Pacific Ocean into East Asia and over the Indian Ocean into South Asia. The East and South Asian monsoons are responsible for most of the rainfall in these regions. Although the time when these monsoon patterns were first established is unknown, many lines of evidence suggest that they first came about at least 24 Ma ago. While it makes sense intuitively that heavy rainfall should be correlated with more aggressive erosion, it is important to see such direct evidence of the coupling between the processes that define the evolution of mountain ranges and climatic processes. It implies, once again, that Earth is a complex system, and we cannot begin to fully understand mountain building without appreciating the roles of the hydrosphere and atmosphere in the evolution of mountain ranges.

For ninety percent of the last million years, the normal state of the Earth's climate has been an ice age. Ice ages last about 100,000 years, and are punctuated by short periods of warm climate, or inter-glacials (cf. Figures 3 and 4). The last ice age started about 114,000 years ago. It began rapidly. For a hundred-thousand years, temperatures fell and sheets of ice of more than a kilometer thick grew to envelop much of North America, Europe and Asia. The ice age ended nearly as abruptly as it began. Between about 12,000 and 10,000 years ago, the temperature in Greenland rose more than 10°C. The climate of the ice ages is documented in the ice layers of Greenland and Antarctica. Ice-cores of these layers have been extracted, and studied in the laboratory. Not only were ice ages colder than today, but the climates were considerably more variable. Compared to the norm of the last million years, our current climate is remarkably warm, stable and benign. The cold temperatures are detrimental for human welfare and warm temperatures are beneficial. From about 1500 to 1800 AD, the climate cooled slightly during a period known as the Little Ice Age. The oscillation between ice ages and interglacial periods is the dominant feature of Earth's climate for the last million years. Earth's climate is also controlled by the Sun. In comparison, every other factor is trivial. The coldest part of the Little Ice Age during the latter half of the seventeenth century was marked by the nearly complete absence of sunspots.

We, therefore, in the context of climate variation over the Earth in the last few millions of years to the recent past, may narrow down the evolution of human life of intellectual type to have started between 12 and 10 thousand years before present.

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18. Modern Physics and Jainism

Narendra Bhandari

Abstract

All natural processes seem to be governed by certain laws and follow certain principles. Most of these laws, particularly those governing the physical universe, and principles, the nature follows in these processes, are well understood. The reproducibility of all processes and scientific experiments conducted under controlled conditions, at any place and at any time, show that the laws are universal and eternal. These observations have led to the Law of Causality, defining that every cause and its effect are precisely related, and one can not exist without the other. There can not be an effect without a cause and vice versa. This is the underlying law governing all phenomena in nature. Many laws governing the biological processes are also well understood but there is certain 'mystery' about the causative factors involved in biological phenomena, and they still remain to be scientifically understood and proven. Although the laws have always remained the same, as far as we can determine, they have an inherent, hidden component of evolution, latent in them, which provides a direction of change in both the physical as well as the living universe.

Jain philosophy has enunciated certain laws which govern both the *j* va and a*j* va. These laws are eternal, applicable everywhere, at all times, cannot be violated and are non-subjective. The "apparent" subjectivity in the domain of living beings arises because of the theory of karma, which deludes perception, knowledge and response of individuals, depending on their karmas. When one has eradicated all karmas and attained omniscience, the subjectivity vanishes. Both Jainism and science do not subscribe to miracles. Thus Jainism is basically scientific and law abiding in its approach. It may, therefore, be appropriate to look for similarities between physics and Jainism. The purpose of this article is to critically examine if

any common ground exists between them. The basic principles mentioned in scriptures and those forming the backbone of modern physics are compared in this article.

Key Words: causality, entanglement, quantum physics, Karma

1. Introduction

Science is truly universal, because it is based on certain laws which are objective, applicable everywhere, at all times, and govern all the processes involving material and biological processes. It is independent of the observer and in this sense it is not subjective. Therefore the theories of physics are acceptable to everyone. Science thus allows us to understand how things happen and gives us the power of prediction and planning. Jainism is also universal because it asserts that both, the living and non-living, are governed by certain laws. In addition, as far as the laws governing *jivas* are concerned, they tell us why things happen the way they happen and give us the power of modulating these processes. We first discuss Jain concepts related to physics and then compare them with the scientific understanding.

Jainism divides the universe into two independent entities, *jiva* and *ajiva*, the latter falls in the domain of science. Everything in the universe is governed by two basic doctrines: *Karmavada*, which governs various processes and events and *Anekantavada* which describes true nature of everything that exists. The true nature of both *jiva* and *ajiva* is multifacetedness, with infinite attributes correctly described by *Anek ntav da*, in contextual relation (*Sy dav da*) and can be expressed by sevenfolded modes of existence termed as *Saptabhangi*. These laws are mentioned in various Jain scriptures (e.g. Bhagavati Sutra) but the physical concepts are best summarized in Tattvartha sutra of Umaswati, written some 1800 years ago. In particular, Chapter-5 of Tattvartha Sutra is devoted to physics. We refer to this chapter for a comparison of science with Jainism. In several accompanying articles e.g. Laws of nature (Samani Chaitanya Prajna), Karmavada (Kachhara, Tater and Unnat Prajna) and *Anek ntav da* and *Syadvada* (Bhandari and Pokharna) have been discussed in detail; these will be only briefly covered in this article and we confine here to a comparative discussion on some basic concepts of physics and Jainism.

Observations of the universe and scientific studies, both theoretical and experiments conducted in the laboratory, have resulted in formulation of certain general laws which govern various processes of physics, chemistry and biology etc.

Physics recognizes matter (energy and matter being inter-convertible), space-time (3 dimensions of space and one of time) as the elements constituting the physical universe and three types of forces, viz. gravitation, electroweak (which includes electricity, magnetism and weak nuclear forces), and strong nuclear forces and their fields, which operate everywhere. Electricity, magnetism and weak nuclear forces, which were earlier considered to be independent, are manifestations of a single force called 'electroweak' force. Similarly, it may be possible that electroweak, gravity and strong nuclear forces may eventually arise from a single force, but so far it has not been possible to unite them. Thus the physical universe, as we understand now, is made of six components: space, time, matter (and energy), and three forces (and their fields). In comparison, Jainism states that the material universe is composed of five components (dravyas): akash (space), Kala (time), Pudgal (matter), dharm stik ya, and adharm stik ya. Thus there is agreement between modern cosmology and Jainism (see for more details the accompanying article by Jain, Bhandari and Jain; Kachhara and Jain) on the three constituents of the universe, i.e. matter, space and time. It must be emphasised that, in spite of this apparent agreement, the scientific concepts of matter, space and time are different from Jain concepts of *pudgal, kash* and *k la* respectively. For one thing, in Jain philosophy, from the definitive view point or Nischaya Naya all dravyas are independent, not influenced by the mere presence of the other. Pudgala, i.e. all matter is made of finest, dimensionless paramanus and all matter, except paramanu, is an aggregate. Similarly,

kash is not distorted by the presence of *pudgal*, unlike space which is distorted by matter, as indicated by scientific theories, e.g. General Theory of Relativity. As far as *K la* is concerned, like space, Jainism propounds many varieties. From *Nischaya Naya* (definite or absolute) point of view *kash*, *pudgal*, and *K la*, are eternal passive, and unaffected by the other, but from *Vyavahar Naya* (practical) point of view, each one of them is subject to the law of causality, as discussed in the concept of *Panchasamvaya* in the accompanying article by Samani Chaitanya Prajna. These five (*K la* (time), *niyati* (determinism), *svabh va* (innate nature), *purush rtha* (effort) and karma (causation), are the governing factors for any event to occur. Purush rtha (past and present) constitute *karma*. In this way *j va* and *aj va* have been integrated and play a definitive role in every event and are necessary for occurrence of an event.

According to the experiments conducted by Michelson and Morley, in late 19th century, no evidence was found for existence of the medium of motion (postulated as the all pervading, stationary luminiferous aether, traditionally considered to be equivalent to *dharm stik ya*). We do not have much idea of what adharm stik ya (interpreted as a medium of rest) is, in terms of modern concepts, although some candidates e.g. inertia have been proposed. At this stage, both, dharmastikaya and adharmastikaya, remain a subject of further investigation. Even so, conservation of basic 'essence (sat)' of some dravyas e.g. pudgal, Jiva (as they are going through origination), sustenance (change of modes or form) and destruction ("Utpada Vyaya-Dhrauvyayuktam Sat" Tattvartha Sutra, 5.29) is essentials. The law of conservation of various *dravyas* is the corner stone of Jain cosmology since nothing can cease to exist i.e. can be destroyed; it can only change its form. Thus law of conservation was well known to Jains for thousands of years and was widely used for estimating several parameters of the universe which was therefore considered to be eternal. Thus Jainism asserts that quantity of basic constituents (dravyas) of the universe, mentioned above, is constant and cannot be changed under any condition, whereas science considers that matter (energy), momentum (linear and angular) and several other attributes of matter are conserved in all processes/reactions.

2. Laws of nature

There has been tremendous scientific progress in the last four hundred years, especially since the time of Galileo, who experimentally determined the laws of motion. These experiments were found to be reproducible, leading to the conclusion that these laws are universal and eternal and can not be violated. The findings of Galileo were formally integrated by Newton in the three laws of motion. Dynamics of everything in the physical universe is governed by these laws. Similarly laws involving other processes have been formulated and it has been established that all the processes in nature are governed by these laws and, all the laws are valid everywhere in space and at all times. This leaves no scope for miracles or coincidences or favour or fear of God. Nothing which happens in nature is arbitrary or random and every event is a consequence of some causative factor, operated upon by these laws. The whole edifice of science is based on this premise.

The most important law of nature is the law of causality. Colloquially speaking, it implies that nothing happens without a cause i.e. every effect has an underlying cause and there is no action or cause without its accompanying effect. This has led to determinism, implying that the future is a product of the present conditions operated under these laws of nature. Thus knowing the present state, the past can be precisely determined and the future can be precisely predicted.

3. Laws Governing Gross and Fine Matter

The universe is made up of matter which ranges in size from the smallest invisible elementary particles to the biggest structures like galaxies and their clusters. The behavior of matter under different conditions is rather well understood. Physically, the matter is divided in two parts, the macro (gross) and the micro (subtle), for which classical physics and quantum physics respectively are applicable. To appreciate this division into macro and micro, it may be desirable to briefly recapitulate the historical background which led to the development of quantum physics and some of the basic principles of physics.

The biggest entity is, by definition, the universe, because it contains everything there is, but presently scientists are talking of multiverses, or a group of universes. Astronomical observations suggest that our universe was formed about 14 billion years ago in the aftermath of the Big Bang episode. It consists of about 200 billion or more galaxies, each of which, typically, comprises some100 billion stars and even more planetary (rocky or gaseous) objects (Figure 1). The smallest entity known at present is quark although search for even smaller entities is continuing.

Our vast universe, with its innumerable variety of objects, representing the large diversity of matter and life, is made up of only 118 elements. These elements combine, in multitude of ways, to form several thousand chemical compounds and several hundred rocky minerals which form the building blocks of all the living species as well as the material objects. Among these elements, 92 elements (and their isotopes) are either stable or are radioactive, with life times long enough to have survived for billions of years since they were formed in the cosmos, i.e. in stars, galaxies and in space by nuclear reactions. These elements constitute the Earth. About 26 elements (and their isotopes) with short life time, not found on Earth now, are being synthesized in the belly of various stars. This observation of only a few elements giving rise to a large variety of things in the universe led philosophers to speculate that there may be just one basic particle, out of which all the elements are formed. This principle was at the heart of Dalton's atomic theory and the basis of Ekantavad, according to which 'one' can give rise to all. As the search for the ultimate constituent of matter continued, three particles, viz. proton, electron and neutron, were discovered from which everything we see around, i.e. all the 118



The carrier of matter

Figure 1: The components of the universe from gross to subtle. Gross structures starting with galaxy, stars, planets, rocks to minerals going to the subtlest atomic and subatomic, elementary particles. Sixty elementary particles (quarks, leptons and force carriers, together with their antiparticles), known to be the building blocks of matter are arranged in the box on lower right according to their attributes (quarks, leptons and force carriers). Higgs boson, a carrier particle for mass, discovered recently may be added to this list. Graviton has not yet been discovered (Source : wikipedia).

(See colour image on page 659)

elements and more than 2000 isotopes of these elements could be formed. For a while scientists thought that this 'trinity' could be used in different proportions to build the whole physical universe. As further research continued, some serious problems arose. By the nineteen sixties, using high energy accelerators and cosmic rays coming to Earth from various stars, scientists were able to discover many elementary particles. It appeared unlikely that a large number of elementary particles would combine in a variety of ways and result in fewer, just 118 elements. Therefore it was postulated that the so called elementary particles should themselves be made up of a small number of fundamental entities. The search for smaller and more fundamental constituents is an ever continuing quest. Study of these elementary particles, which form the gross universe, showed that the rules that govern the gross matter (mentioned here as macro-world) and those governing the elementary particles (identified as belonging to the micro-world) are fundamentally different. The gross or visible matter follows the rules of deterministic classical mechanics whereas sub-atomic particles follow the probabilistic quantum mechanics.

The visible universe (minerals, rocks, planets, stars, galaxies etc. or the gross matter) follows classical physics. Basically, the state of the gross structures in the universe can be determined by summing up the state of all its components. If mass (m), velocity (v) and position (x) of all the components are known, the state of the system can be determined by the proposition that the whole is the sum of parts.

Whole = sum of parts (m,v,x)

The gross physical objects have only a few gross physical attributes, like mass (and energy), form (shape) and motion. As we go down to the level of molecules and elementary particles, the classical physics fails to describe its properties completely and quantum physics has to be invoked and some new principles come into play. Thus there is a division between laws of classical physics, applicable to the gross universe, and the quantum physics applicable to the subtle world, consisting of subatomic elementary particles. In classical physics, a proposition that " a particle is at position x" is either true or false. In contrast, in quantum physics, the best statement that can be made is probabilistic, i.e. if a measurement at a particular position is made, the probability that the particle will be at the position x would lie between 0 to 1. It means that particle may not be there (probability=0), or may be there (probability=1), and its presence at that point may have all the in between values. This concept has some similarity to the principle of

Sydavada, discussed in an accompanying paper (Bhandari and Pokharna, 2016). Most concepts arising from common sense based on observation of gross matter, are not valid in the quantum world. More importantly, quantum world is not just an objective, classical, mechanical, Newtonian world where processes follow the laws of mechanics but there are qualities which are influenced by the very act of observation. Thus, one comes to the conclusion that behavior of particles changes when they are observed and also the way they are observed. This is the first step towards understanding the interaction between *jiva* and *ajiva* as explained below.

4. Quantum Mechanics

Quantum mechanics puts stringent constraints on certainty of our knowledge. Two tenets of quantum mechanics that are relevant to this discussion may be mentioned here. One of the propositions is that the universe does not exist if you don't observe it, equivalent to the paradox of the Schrödinger's cat (for popular exposition see e.g. Gribbin, 1993). This implies that the universe and the observer exist as pairs and neither can exist without the other. The other concept is that a particle behaves in different ways at different times. This is clear from the famous double-slit experiment (Figure 2) which is the backbone of quantum mechanics and particle-wave duality.

4.1 Quantum numbers

Besides the properties like mass, electrical charge, motion etc., the elementary particles have several other attributes which are denoted by quantum numbers that do not change continuously but in steps, conventionally in multiples of 1 or 1/2, a concept of the quantum theory. There are quantum numbers like positional (e.g. orbital) quantum numbers, isospin, strangeness etc. In the unknown territory of quantum physics, names have been given at the fancy of the discoverer and should not be interpreted in terms of their literal meaning.

Quarks, leptons and force carriers are currently considered to be the basic building blocks from which all the matter of the physical universe is made (see Kachhara and Jain, this volume, for more details). Based on these particles, a model has been developed which is called the "Standard Model of particle physics". According to this model, protons and neutrons are thought to be made up of quarks. A total of six quarks are known and there are six leptons. According to Murray Gell-Mann, Nobel Laureate in physics, three generations of quarks and leptons exist. Leptons include particles, called mesons and the associated massless or low mass neutrinos. In addition there are six carrier particles for various fields. Photon (light), for example, is the carrier particle for the electromagnetic field. These 18 elementary particles, together with their anti-particles, constitute the building blocks of the material universe. To these we may add the recently discovered Higgs Boson and the proposed graviton, the carrier particle of gravity.

The main point to emphsise here is that as we go to finer (more subtle) and finer constituents of matter, new attributes come into play and the number of attributes describing a particle increases. This seemingly agrees with the doctrine of *Anek ntavad*, or multiplicity of attributes discussed in an accompanying paper (Bhandari and Pokharna).

Some of the quantum phenomena cannot be comprehended by common logic, nor can be described by words in any language. They appear "crazy and illogical". Generally, all we can say is that perhaps it is like that, a concept similar to *Sy dv da*. Some of these states cannot even be described and thus seemingly agree with the concept of indescribability, as in the seven modes of existence (*Saptabhangi*).

5. Some basic Principles of Physics

Some new principles were developed to understand the quantum mechanical behavior of elementary particles. The principle of symmetry and complementarity seem to play a role in the macro world too. In addition, in the micro world, we have, the Heisenberg's Uncertainty principle, Pauli's Exclusion principle, Entanglement and some other principles. Before we discuss the quantum behavior, we briefly introduce some of these principles, listed below, which have helped us to understand the nature of the universe.

- 1. Wave-particle duality
- 2. Principle of complementarity
- 3. Principle of symmetry
- 4. Uncertainty principle
- 5. Exclusion principle
- 6. Entanglement

6. Wave-Particle duality

The basic concept of physics is that matter, at elementary level, exists either as a particle or a wave. Wave and particle are the two modes of existence of reality. This dual nature was established by a simple observation in a church in England. A fine hole developed in the roof of a church. The sunlight entered the hole and formed a spot on the floor. This clearly indicated that light consists of particles, which like bullets travelled in a straight line from the sun and formed the bright spot on the floor. In course of time, another fine hole developed nearby and to the amazement of many, the bright spot on the floor disappeared and instead appeared linear, snake-like, white and black wavy pattern. This pattern is indicative of the wave nature. For a long time this behavior was debated because it was believed that a particle, which is like a grain of sand, can not be a wave, and a wave, which is like ripples on the surface of a pond cannot be a particle. In the 17th century Newton proposed the corpuscular theory of light supporting its particle nature whereas Christian Huygens argued in favour of wave nature of light. Thomas Young in 1802 performed an experiment in the laboratory to prove the wave nature of light and Einstein proposed photoelectric theory establishing particle nature, which earned him the Nobe prize for physics. While this debate was going on, De Broglie proposed that every elementary particle has a wave associated with it, and Schrodinger developed its mathematical formulation. The quantum theory developed by Neils Bohr is based on the particle-wave duality.

6.1 Principle of Complementarity

The principle of complementarity implies that opposite characteristics of an entity are actually complementary and together they describe it more completely. Neils Bohr, who propounded the basic principles of quantum mechanics explained it through the principle of complementarity, considered to be one of the most revolutionary concepts of modern physics. For example, some experiments showed that light photon (or electron, or any other particle) sometimes behaves like a compact object, i.e. a particle (like a solid ball) and sometimes like a wave, similar to ripples seen in a pond. These contradictory results made it difficult to understand the real nature of photon. The western philosophers and scientists could not reconcile this dual, and rather contradictory, behavior for a long time which was ultimately understood on the basis of complementarity, that both together explain the real nature of photon.

In the famous double-slit experiment (Figure 2), a beam of photons incident on two slits, after passing through them, hits upon a photographic plate kept behind the slits. The experiment can be conducted in two different ways: one with photon detectors placed right beside each slit so that the photons can be observed as they pass through the slits and/or without the detectors so that the photons can travel undetected. When the detectors are used, every photon is observed to pass through one or the other slit and essentially photons behave like particles (Figure 2, left). However, when the photon detectors are removed, a pattern of alternating light and dark spots, produced by interference of light, is observed indicating that the photons behave like waves, with an individual photon spreading out and surging against both the slits at the same instant of time (Figure 2, right). The outcome of the experiment then depends on whether one wants to measure the particle nature of photons or its wave nature. This experiment is taken as an evidence that behavior of an inanimate particle, like a photon, changes when it is being observed. But, the questions arises, "how do photons "know" or realize that they are being observed". In the real world, change of behavior of a person when being watched is a well known psychic phenomena but such a change of behavior in the material world is quite puzzling. Does it mean that even inanimate particles possess a psyche? Scientists do not agree with this interpretation but have explained it on the basis of plurality of attributes.

This phenomenon is easily understood in the framework of Anek ntav da (see Bhandari and Pokharna, this volume) which propounds that opposites and



Fig. 2: The double slit experiment showing that photons (or electrons) act as particles when observed by particle detectors (D), giving characteristic spots on the photographic plate (left), and manifesting as waves when they go unobserved (right) giving rise to the well known interference pattern that is characteristic of waves, proving the dual behavior of elementary particles.

extremes allow us to learn the true nature of reality. As propounded by Jainism, reality can manifest different attributes at different times. It may be noted that, in contrast, Buddhism avoided extremes and Gautam Buddha advocated the path of the "Golden Mean" to reconcile mutually contradictory views. This is the basic difference between Jainism, which advocates the extremes, and Buddhism which lays emphasis on the middle path.

6.2 Principle of Symmetry

Nature loves symmetry and, therefore, symmetry has played a key role in understanding nature. The formation of universe is the greatest mystery of all and it has been proposed that it formed by super-symmetry. All the living species, galaxies, planets, trees, minerals, molecules, atoms etc. are symmetrical in many respects. There are many forms of symmetry, such as left-right symmetry, mirror symmetry, time symmetry and so on. The conservation laws, on which both classical and quantum physics are based, are an outcome of the symmetry principle. In the Mendeleeve's Periodic Table, elements are arranged in eight- fold symmetry. The 118 elements in this table can be arranged in the form of octets, their properties repeat after every eighth member. The elementary particles also behave in a similar manner. In fact, symmetry principle has been used as a powerful tool to predict the existence of many unknown particles by many scientists, specially particle physicists like Gell-Mann. He arranged the elementary particles in the "eightfoldway" and was eventually able to predict and discover quark, the smallest constituent of matter known today. It is now known that elementary particles, called hadrons, can be organized in octets (8) and decuplets (10) whereas leptons are organized in nonets (9).

Sometimes symmetry is also violated. Parity, an attribute of the nucleus of an atom, for example, is a mirror symmetry which is found to be violated in certain nuclear reactions. Thus existence of symmetry as well as its violation are of fundamental importance in understanding the nature of the basic processes governing the behavior of fundamental particles and seem to be consistent with *Sy dv da* which denies a universal law to explain a particular type of phenomena under all conditions.

6.3 Uncertainty Principle

Measurements to quantify the state of a particle shows that, at any given instant of time, all the parameters cannot be measured precisely, i.e. without errors. If

measurement of some physical quantity is made, then according to quantum physics, the state of the particle changes instantaneously into a different state. It is not because one cannot measure the parameters accurately because of the limitation of precision of the instruments or the technique employed but that the measurement cannot be made without changing the the state of the particle. This principle is known as Heisenberg's Uncertainty principle . For example, both the parameters in the coupled pairs, known as conjugate variables, of energy (E) and time (t), or position (x) and momentum (p) or angular momentum and angle, expressed as $\{E,t\}$; $\{x,p\}$; $\{j,theta\}$ respectively, can only be known within some minimum uncertainty related to Planck's constant, which is very small (6.625x10⁻³⁴ joule.sec). The magnitude of uncertainty, therefore, is also quite small, but none the less, has a finite value.

6.4 Exclusion Principle

The Exclusion Principle, first enunciated by Wolfgang Pauli states that two elementary particles, identical in all respects, i.e. in the same "state" cannot exist at the same place, at the same instant of time. This principle has been used extensively in understanding the behavior and properties of elementary particles.

6.5 Entanglement

Entanglement implies that behavior of particles, produced by the same process, is inter-related. Briefly stated, when two independent systems of particles undergo temporary physical interaction due to known forces between them and then separate again, their quantum states become entangled by their mutual interaction, and they can no longer be described as independent, as they were before their interaction. Measurement on one of the particles, automatically defines the properties of the other particle, no matter how far they are. Entanglement has been demonstrated experimentally for a large separation distance of hundreds of kilometers, in case of two particles but theory can hopefully be extended for a larger number of particles. Since all the particles in the universe were produced simultaneously at the time of Big Bang episode, it follows that they may all be entangled in one way or the other.

Greenstein and Zanjoc in the their article "on quantum challenge" exemplify another aspect of quantum mechanics. In the macro world, if we throw a ball to strike a wall within a room with two windows, the ball can go out of the room only through one of the two windows. In the quantum world, when a particle (e.g.

electron, proton or neutron) hits a barrier which has two or more holes, they can go out through all the holes simultaneously. Notions of causality and impossibility of being at multiple locations simultaneously are demolished by the quantum theory. It invalidates our perception of spatial separation and is called the phenomenon of superposition of being at two places simultaneously at the same instant of time, which is related to the phenomenon of entanglement. The quantum mechanics enables us to create the whole universe out of nothing because virtual particle pairs are created out of nothing (vacuum energy).

7. Conclusions

According to our present understanding, the basic constituents of the physical universe are Mass (and Energy), Space and time and the three forces (Electro-weak, Gravitation and Strong) together with their fields. There is no mention of these forces and fields in Jain scriptures except that *Dharmastikaya* and *Adharmastikaya* have been mentioned as two additional constituents of the universe. It is pertinent to ask if the known forces and their fields can emerge from these two entities.

Based on the various points discussed above, we find that there is some common ground between modern science and Jainism. Some of these aspects are compared in Table- 1.

Table 1: Comparison of some concepts in Jainism and Science

Jainism	Science
Karmav da	Principle of Causality
Kramabaddha Pary ya	Determinism
Anek ntav da	Principle of Complementarity
Sydav da	Principle of Uncertainty
Saptabha?g	Indescribability
Parasparopagraho Jiv n m	Principle of Entanglement
Eternal existence	Law of conservation

We have seen above that laws ennunciated in Jain scriptures have much wider scope because Jainism covers both *jiva* and *ajiva* in comparison to the narrower scope of physics which deals only with material world. In spite of this, we

may compare Jainism and science. For this purpose, we consider various aspects separately: concepts, Laws, theories and descriptions. The Jain concepts related to several aspects of physics are appealing and some agree with the current scientific concepts. Many laws and principles, as listed in Table 1 show reasonable conceptual agreement between Jain philosophy and science. However, there are disagreements in many theories currently accepted by science and the traditional interpretations of Jain texts. The disagreements are much wider and stronger when we consider various descriptions such as in geography, astronomy, and cosmology. It may be mentioned that Jainism lacks details and quantitative treatment in many areas of physics; Many aspects of the universe are not mentioned in Jainism whereas science appears complete, quantitative and thorough. As an example of frontier areas of research, we may take the case of origin of the universe. Jainism propounds that the universe is eternal, unchanging on a gross scale, that is similar to the Steady State model of the universe, whereas science asserts that it originated in a Big Bang event, about 14 billion years ago. Whether the universe is a Big Bang universe, Steady State universe, oscillating or cyclic universe is a matter of continuing research and surely more comprehensive theories will emerge in times to come. As far as jiva is concerned, the working hypothesis being followed in science is that life can arise from matter but Jainism considers both as independent reals; one cannot be produced from the other and both are eternal.

It should, however, be emphasized that scientific concepts are essentially correct since they are based on experiments. Not withstanding that some of the scientific theories may be partly incomplete and subject to modifications as more observations are made and theories are perfected, in some cases, it may be fruitful to consider both, the Jain and scientific concepts and synthesise them for better understanding of the phenomena.

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19. Concepts of Matter in Jain Philosophy and Modern Science

N.L. Kachhara and Rajmal Jain

Abstract

Pudgalastikaya is one of the six constituent *dravyas* of *loka* in Jainism and is the only substance that is sense perceptible. The sense attributes of *pudgala* are colour, taste, smell and touch properties which become the basis of its diversity of forms and structures. The smallest constituent of *pudgala* is *param* ?*u*, the other forms are its aggregates. The combination of these *parm* ?*us* forms various forms of the matter.

According to modern cosmology, the universe is composed of visible (luminous) matter, dark matter and dark energy in the proportion of about 4%, 21% and 75% respectively. However, the dark matter and dark energy have been only indirectly inferred and are not fully understood. On the other hand, the fundamental particles detected so far form the two families: Fermions and Bosons. They are 24 in all and an equal number of particles has been hypothesised. Efforts to detect them is currently going on.

This article describes the properties and dynamics of the *parm ?us*, different types of combinations and modes, rules for their combinations and properties of aggregates, known as *varga? s.* Based on the four fundamental properties, we suggest the possibility of more than 100 fundamental particles and thus there is a huge scope of discovering many more fundamental particles. Moreover, based on their electrical and temperature sensitivity, *pudgalas* proposed in Jainism may be of much help to understand the 'Fifth state' of matter, recently proposed but not yet established. We briefly discuss this new aspect here.

Matter has been studied in detail at micro to macro scales using modern scientific techniques and classical and quantum theories and the principles

describing their behavior and interactions have been established. The paper briefly describes the scientific developments, their strengths and limitations. Different forms of matter and their properties are also discussed.

The Jaina concepts are compared with the scientific concepts and the way Jaina concepts can help further development of our understanding is explored.

Key Words: Pudgala, param ?u, varga? , fundmental particles

Scriptures Quoted: Sthanang Sutra, Bhagwai, Tattvartha Sutra, Gommatsara Jivakanda.

1. Introduction

Conventionally, everything around us is considered to be matter, made of atoms and molecules. However, modern science refers to matter as occupying space and having mass at rest. This suggests that subatomic particles viz. protons, neutrons and electrons are the building blocks of the matter because they have both volume and rest mass. However, by contrast, radiation formed of massless photons is not considered matter, because they have neither rest mass nor volume. On the other hand, it is not necessary that all particles with rest mass have a classical volume, since fundamental particles such as quarks and leptons (sometimes equated with matter) are considered 'point particles', with no effective size or volume. Nevertheless, quarks and leptons together make up "ordinary matter", and their interactions contribute to the effective volume of the composite particles that make up ordinary matter.

However, according to the Theory of Relativity, mass is not an additive quantity, in the sense that one can add the rest masses of all the particles in a system to get the total rest mass of the system. Thus, in relativity usually a more general view is that it is not the sum of rest masses but the energy–momentum tensor that quantifies the amount of matter. This tensor gives the rest mass of the entire system. 'Matter' therefore is sometimes considered as anything that contributes to the energy–momentum of a system, however, except the pure gravity. This view is commonly employed in cosmology. In this view, sometimes, modern science also considers the light photons and other massless particles and fields as part of matter. The reason for this is that electromagnetic radiation (such as light) as well as the energy of electromagnetic fields contributes to the mass of systems, and therefore appears to add matter to them. For example, light radiation (or thermal radiation) trapped inside a box would add to the mass of the box. Nevertheless, in modern science isolated individual photons and isolated kinetic energy of massive particles are normally not considered to be matter.

On the contrary, the matter in Jainism, *Pudgalastikaya*, one of the six constituents of *loka*, integrally comprised of four important attributes viz. colour, taste, smell and touch, reveal that it is sense perceptible. It is further emphasized that all attributes in general and touch property in particular are sensitive to thermal and electromagnetic forces i.e. energy-momentum transfer similar to that described in the modern science. Though we find a few similarities but when we compare the two schools of thoughts we find many differences and therefore it is necessary to improve our understanding of matter by considering both, scientific as well as Jaina concepts.

2. Scientific Concept of Matter

Based on physical and chemical structure, the 'matter' is considered to be made up of atoms. This definition has been extended to include charged atoms and molecules, so as to include plasmas (ionized gas) and electrolytes (ionic solutions), which are not obviously included in the definition of atoms. Therefore, the definition of matter is extended further to include protons, neutrons and electrons, and other fundamental particles forming the atom. So a definition of 'matter' at finer-scale goes beyond atoms and molecules and includes anything that is made of positively charged protons, neutral neutrons, and negatively charged electrons. However, at a microscopic level, the building blocks and constituent 'particles' of matter such as protons, neutrons, and electrons obey the laws of quantum mechanics and exhibit wave-particle duality. At an even deeper level, protons and neutrons are made up of quarks and the force fields (gluons) that bind them together. Therefore, with the advent of new technology and thereby discovery of new fundamental particles, the definition of matter is being modified. Accordingly, the elementary and composite particles made of quarks (cf. Figure 1) and leptons would be matter - while the gauge bosons would not be matter. However, interaction energy inherent to composite particles (for example, gluons involved in neutrons and protons) contribute to the mass of ordinary matter.

3. Fundamental Particles

As discussed in the previous section, the ordinary matter is everything that is composed of elementary particles viz. quarks and leptons.We briefly describe these fundamental elementary particles in this section.



Fig. 1: Pictorial description of fundamental particles, and the fields, that makes up the elementary and composite particles{wikipedia}.

Leptons are the most famous and include electrons, whereas quarks form baryons such as protons and neutrons. The leptons and quarks combine to form atoms, which in turn form molecules. Because atoms and molecules are said to be matter, it is natural to redefine matter as anything that is made of the same things that atoms and molecules are made of, which in turn leads to further define the matter as being quarks and leptons. The leptons and quarks are the two types of elementary fermions so we may say that the ordinary matter is composed entirely of first-generation particles, namely the [up] and [down] quarks, plus the electron and its neutrino (Carithers and Grannis,1995; cf. Figure 1)[1]. However, the higher generation's particles quickly decay into first-generation particles, and thus are not commonly encountered (Green, 2005) [2]. Thus all the particles that make up ordinary matter (leptons and quarks) are elementary fermions, while all the force carriers are elementary bosons (Smolin, 2007) [3]. The W and Z bosons that mediate the weak force are not made of quarks or leptons, and so are not ordinary matter, even though they have mass (Amsler et al., 2008) [4]. Therefore we conclude that mass is not something that is exclusive property of ordinary matter.

The quark–lepton definition of ordinary matter, however, identifies not only the elementary building blocks of matter, but also includes composites made from the constituents (e.g. atoms and molecules). Such composites contain an interaction energy that holds the constituents together, and may constitute the bulk of the mass of the composite. As an example, to a great extent, the mass of an atom is simply the sum of the masses of its constituent protons, neutrons and electrons. However, digging deeper, the protons and neutrons are made up of quarks bound together by gluon fields and these gluons fields contribute significantly to the mass of hadrons (Aitchison and Hey, 2004) [5]. In other words, most of what composes the "mass" of ordinary matter is due to the binding energy of quarks within protons and neutrons (Povh et al., 2004) [6]. For example, the sum of the mass of the three quarks in a nucleon is approximately 12.5 MeV/c(2), which is lower compared to the mass of a nucleon (approximately 938 MeV/c(2). The bottom line is that most of the mass of everyday objects comes from the interaction energy of its elementary components.

3.1 Structural properties of fundamental particles

The Standard Model groups matter particles into three generations as shown in Figure 1, where each generation consists of two quarks and two leptons. The first generation is the 'up' and 'down' quarks, the electron and the electron neutrino; the second includes the 'charm' and 'strange' quarks, the muon and the muon neutrino; the third generation consists of the 'top' and 'bottom' quarks and the tau and tau neutrino (Staley, 2004) [7]. It may be noted from the Figure 1 that the quarks and leptons of higher (2nd and 3rd) generations are excited states of the first generation particles. If this turns out to be the case, it would imply that quarks and leptons are composite particles, rather than elementary particles, and hence the search for the fundamental particles must go on.

According to Fermi–Dirac statistics the fermions can be elementary, like the electron or composite, like the proton and neutron. In the Standard Model, there are two types of elementary fermions: quarks and leptons.

The quarks are particles of spin- ${}^{1}D_{2}$ implying that they are fermions. They carry an electric charge of " ${}^{1}D_{3}$ e (down-type quarks) or + ${}^{2}D_{3}$ e (up-type quarks). For comparison, conventionally, an electron has a charge of '1e'. They also carry colour charge, which is equivalent of the electric charge for the strong interaction. Quarks also undergo radioactive decay, meaning that they are subject to 'weak' interactions. Quarks are massive particles, and therefore are also subject to gravity. In Table 1, we present structural and electrical properties of quarks.

The Leptons are particles of spin- ${}^{1}D_{2}$, meaning that they are fermions. They

Name	Symbol	spin	electric charge	mass $(\underline{\text{MeV}/c}^2)$	mass comparable to	antiparticle	antiparticle symbol
up-typ	e quarks						
<u>up</u>	U	¹ / ₂	+ ² / ₃	1.5 to 3.3	~ 5 electrons	antiup	u
<u>charm</u>	С	¹ / ₂	+ ² / ₃	1160 to 1340	~1 proton	anticharm	с
<u>top</u>	Т	¹ / ₂	+ ² / ₃	169,100 173,300	~180 protons or ~1 tungsten atom	antitop	t
down-	type qua	rks					
<u>down</u>	D	¹ / ₂	- 1/3	3.5 to 6.0	~10 electrons	antidown	d
strange	S	¹ / ₂	- 1/3	70 to 130	~ 200 electrons	antistrange	S
bottom	В	¹ / ₂	- ¹ / ₃	4130 to 4370	~ 5 protons	antibottom	b

Table 1Properties of Quarks

carry an electric charge of "1e" (charged leptons) or "0e" (neutrinos). Unlike quarks, leptons do not carry colour charge, meaning that they do not experience the strong interaction. Leptons also undergo radioactive decay, meaning that they are subject to the weak interaction. Leptons are massive particles, therefore are subject to gravity. Properties of leptons are presented in Table 2.

Table 2Lepton Properties

Name charged leg	symbol ptons	spin	electric charge (<u>e</u>)	mass $(\underline{MeV}/\underline{c}^2)$	mass comparable to	antiparticle	antiparticle symbol
electron	e-	¹ / ₂	- 1	0.5110	1 electron	antielectron	e+
<u>muon</u>	μ-	¹ / ₂	- 1	105.7	~ 200 electrons	antimuon	μ+
<u>tau</u>	-	¹ / ₂	- 1	1,777	~ 2 protons	Antitau	+
Neutrinos							
<u>electron</u> neutrino	e	¹ / ₂	0	< 0.000460	< ¹ / ₁₀₀₀ electron	electron antineutrino	e
<u>muon</u> neutrino	μ	¹ / ₂	0	< 0.19	$< 1/_2$ electron	muon antineutrino	μ
tau neutrino		¹ / ₂	0	< 18.2	< 40 electrons	tau antineutrino	

(420)

3.2 Matter in the Universe

The universe is composed of baryonic-luminous matter, dark matter, dark energy, black holes and various forms of degenerate matter. Amongst the baryons are the protons and neutrons, but many other unstable baryons exist as well. The term baryon usually refers to tri-quarks i.e. particles made of three quarks. Baryons are strongly interacting fermions, and therefore are subject to Fermi–Dirac statistics. "Exotic" baryons made of four quarks and one anti-quark is known as `pentaquarks, but their existence is not generally accepted.

Microwave light seen by Wilkinson Microwave Anisotropy Probe (Bennett et al. 2003)[8] suggests that only about 4.6% of the universe is visible and this part is made of baryonic matter. "Five year results on the oldest light in the universe" (NASA, 2008) reveal that larger fraction of the universe, about 23%, is invisible, i.e matter is dark, and about 72% is dark energy. The reason behind the philosophy proposing the existence of dark matter and dark energy is Baryon asymmetry i.e. there is far more matter than antimatter in the observable universe instead of the expected equal amount of matter and antimatter. This is fiurther discussed in an accompanying paper by Rangarajan.

In particle physics and quantum chemistry, antimatter is matter that is composed of antiparticles of those that constitute the ordinary matter. If a particle and its antiparticle come into contact with each other, the two annihilate completely; that is, they may both be converted into other particles with equal energy in accordance with $E = mc^2$. These new particles may be high-energy photons (gamma rays) or other particle-antiparticle pairs. The resulting particles are endowed with an amount of kinetic energy equal to the difference between the rest mass of the products of the annihilation and the rest mass of the original particle-antiparticle pair, which is often quite large. Antimatter is not found naturally on Earth. The philosophy behind this is that the antimatter that came to exist on Earth during solar system formation would almost instantly have met the ordinary matter that Earth is made of, and be annihilated. Therefore, in the early universe, it is thought that matter and antimatter were equally represented, but the disappearance of antimatter, however, requires an asymmetry in physical laws called the charge parity (or CP symmetry) violation. The observed asymmetry of matter and antimatter in the visible universe is one of the great unsolved problems in physics. However, such outstanding problems, may perhaps be resolved by considering various attributes of particles, known or proposed, as discussed below.

3.3 Dark Matter and Dark Energy

In order to resolve the anomaly of matter-antimatter asymmetry, dark matter and dark energy have been proposed as major fraction of matter in the universe. Thus current cosmological models propose that the ordinary matter formed by the quarks and leptons, constitutes about 4% of matter of the observable universe, and the remaining matter is in the form of exotic forms, of which 23% is dark matter (Pretzl, 2004 [9]; Freeman and McNamara, 2006 [10]) and 73% is dark energy (Wheeler, 2007 [11]; Gribbin, 2007 [12]). The dark matter is matter of unknown composition that does not emit or reflect enough electromagnetic radiation to be observed directly, but whose presence can be inferred from gravitational effects on visible matter (Majumdar, 2007) [13]. On the other hand, observational evidence of the early universe and the big bang theory require that this dark matter has energy and mass, but is not composed of either elementary fermions or gauge bosons (cf. Figure 1). The commonly accepted view is that most of the dark matter is non-baryonic in nature (Majumdar, 2007). On the other hand, dark energy is the name given to the anti-gravitating influence which accelerates the rate of expansion of the universe. However, dark energy is proposed not to be composed of known particles like protons, neutrons and electrons, nor of the particles of dark matter, because they all gravitate (Wheeler, 2007; Smolin, 2007).

So less than 1 part in 25 is made out of matter observed experimentally or described in the standard model of particle physics. Of the other 96%, apart from the properties just mentioned, we know absolutely nothing (for more details, see Rangarajan, Jain et al, this volume). In order to demonstrate the existence of the proposed dark matter and dark energy in the universe, search for particles like axions and chameleons is going on in laboratories around the globe. Employing the data from the various space missions Jain et al., (2015) [14] are planning to demonstrate the existence of axions and chameleons using gravitational lensing techniques.

4. Matter in Jainism

Much thought has been given to 'matter' in every system of Indian philosophy. According to Jain metaphysics, one form of *Ajivadravya* (Non-living substance) is *pudgalastikaya or pudgala* (matter substance) which exists in the Universe in various forms such as earth, water, fire, air, shadow, objects with four senses (colour, smell, taste, and touch), physical mind, speech, bodies, etc. up to karmic matter and *Param ?u* (ultimate smallest particle). *Pudgala* is tangible reality within the sensuous and super sensuous experiences in perceptible and imperceptible conditions. *Pudgala* is permanent, non-living, extensive, physical, corporeal and concrete, active, disintegrating and integrating, and changeable substance [15]. It is characterized by origination, decay and permanence without giving up its essential nature of existence.

Pudgala is the only substance which is *murta* (corporeal) and perceivable. *Rupatva* (form) /*murtatva* (corporeality) or sensory perceptibility is the sum total of the four sensuous qualities as follows [16].

Colour-five types of primary colour : black, blue, red, yellow, white

Taste- five types of taste: sweet, bitter, pungent, sour, astringent

Smell- two types of odour: good smell and bad smell.

Touch- eight types of touch: cold, hot, smooth (or positive charge), rough (or negative charge), light, heavy, soft and hard.

All colours, tastes and smells can vary in magnitude and range.

Based on the above qualities, the matter (substance) in nature is of three types [17].

- (i) Matter substance having one colour, one smell, one taste and two touches.
- (ii) Matter substance having five colours, two smells, five tastes and four touches.
- (iii) Matter substance having five colours, two smells, five tastes and eight touches.

Param ?u is the two-touch matter substance (*pudgala*); it has only one colour, one smell and one taste [18]. The four-touch pudgala comprise the subtle (*suksama*) class of matter substance, as aggregates (*skandha*), which has substantial energy. This matter has five colours, two smells and five tastes. On the other hand the eight-touch matter constitutes the gross (*badar*) class of aggregates comprising of energy and matter. These aggregates have five colours, two smells and five tastes. Thus according to Jain philosophy, all aggregates, containing a large number of

param ?us, necessarily possess all colours, smells and tastes. Generally only one or a few of the colours, smells and tastes manifest in gross state at a time, the others remain un-manifested. The manifestation of colours etc. is dependent on the mode of the substance. Some attributes manifest in the natural mode while some other attributes manifest in the alienated modes. The manifestations are both intrinsic and extrinsic. For example, some colours, smells and tastes manifest in the ripened state.

Cold, hot, smooth and rough are primary touch qualities of pudgala. The smooth touch is also regarded as positive charge and the rough touch is regarded as negative charge. The other four touch qualities viz. light, heavy, soft and hard are secondary touch qualities. These touch qualities are supposed to develop when bonding between infinite param ?us produces a gross aggregate. If number of negative param ?us is more in the bonding process, the aggregate contains light touch quality and if positive param ?us are more, than heavy touch is produced in the aggregate. When positive param ?us are in majority and they bond in cold condition, soft touch is produced and when a majority of negative param ?us bond in hot condition, hard touch is produced in the aggregate [19]. The weight (or mass) of the aggregate is said to relate to the light and heavy touch qualities. The four touch aggregates and paramanu are weight less. The weight is a property of gross aggregates having eight- touch [20]. This aspect is further discussed below.

In the true sense the *Param ?u* and aggregates as a class have no beginning; they have always been in existence. But a particular aggregate or *Param ?u* has a beginning and a survival time. The minimum period of survival of a Param ?u as free Param ?u and that of an aggregate can be one *'samaya'*¹ and maximum period can be innumerable *'samayas'* [21]. Thereafter they undergo change. The *pudgala* are of two types, subtle and gross, as mentioned earlier. The subtle does not remain subtle and gross does not remain gross for ever. These are transient qualities. After innumerable *'samaya'* the subtle changes to gross and gross splits into subtle forms [22]. Similarly, the colour and other attributes of *pudgala* also change with time. A black colour of one degree can stay in the same condition for a minimum time of one *'samaya'* and a maximum time of innumerable *'samaya'*. Thereafter, one degree black

1. Samaya is the smallest indivisible unit of time and is the time taken by a paramanu moving at slowest speed to move from its present pradesa location to the next adjoining pradesa.

shall change to finite or innumerable degree black by the internal process of *'sadguna – hani – vridhhi'*. Intrinsic modification occurs in every substance every moment. Extrinsic modification of gross aggregates is also certain after innumerable *'samaya'*.

4.1 Integration (Bandh)

All physical matter is produced either by integration (*bandh*) or by disintegration (*bheda*) process. The integration is of two types– (i) natural (*vaisrasika*) and (ii) by animate organisms (*prayogika*) [23]. The natural kind is again of two types – (i) with a definite beginning and (ii) without a beginning. Some instances of natural integration, which have a beginning, are clouds, lightning, rainbow etc.

Integration made by living organisms necessarily has a definite beginning and can be divided into two kinds [24].

- (i) Integration (combination) of one kind of matter with another, e.g., production of chemical compounds.
- (ii) Combination of matter with soul in worldly living beings.

The last one is again of two types – (i) *karma-bandha*, bondage of karma*vargana* (with soul), and (ii) *nokarma-bandha*, combination of other groups of *pudgala* with soul in vital functions and formation of gross body.

Jain philosophy provides elaborate rules for bonding among *param* ?*us*. Here we summarise some rules. which need to be reinterpreted in terms of modern chemistry. The Jain texts mention that the bonding takes place due to positive and negative charge of *param* ?*us* [25]. The charge of a *param* ?*u* varies in a limited range. Let q be the minimum indivisible unit charge, positive (q+) or negative (q-), and that the charge increases in integral multiples of 1, 2 or 3 etc. units. The *param* ?*u* can have a charge q, 2q, 3q, 4q, etc., q being positive or negative. The rules for bonding between *param* ?*us* are given in Table 3 [26, 27]. A *param* ?*u* having a minimum charge does not bond with other *param* ?*u*. If charge is more than the minimum value and differs by two units or more then the two *param* ?*u* can bond. These rules are also applicable to bonding between an aggregate and a *param* ?*u* or between two aggregates. There is some variation in the rules of bonding given in Svetambara and Digambara traditions.

	Value of charge of two	Svetambara T	radition	Digambara Tradition	
	paramanus bonding	Similar	Dissimilar	Similar	Dissimilar
	$q_1 + q_2$	charge paramanu	charge paramanu	charge paramanu	charge paramanu
1	$\mathbf{q} + \mathbf{q}$	No	No	No	No
2	q+ 2q	No	No	No	No
3	q+ 3q	No	No	No	No
4	q+ 4q and up to nq	No	No	No	No
5	2q + 2q	No	Yes	No	No
6	2q + 3q	No	Yes	No	No
7	2q + 4q	Yes	Yes	Yes	Yes
8	2q+5q and up to nq	Yes	Yes	Yes	Yes

Table 3: Rules for Bonding of param ?us

The qualities of the aggregate produced by bonding depend on the qualities of the constituent *param ?us* or aggregates. For instance one unit black *param ?u* on combining with higher degree white *param ?u* becomes white. When one degree black *param ?us* combines with one degree white *param ?us*, an aggregate of a grey colour is produced.

4.2 Param ?u

The canonical literature in general and the Bhagwati Sutra in particular defines *Param ?u* in various ways from different perspectives. It is the ultimate constituent of the physical universe. It is indivisible, indestructible, impenetrable, incombustible and imperceptible to sense organs [28]. It cannot be split or destroyed by any means whatsoever. It has no half-portion, no middle portion and no *pradesa*. It has no length, no breadth and no depth. It is dimensionless. It is truly infinitesimal.

Param ?u is the pure form of *pudgala* and possesses the intrinsic qualities of touch, taste, smell and colour. These qualities are attributed to a *Param ?u* for a fundamental reason. It is the basic assumption in Jain philosophy that the fundamental properties of a substance are also eternal; they are neither created nor destroyed. Hence only those properties which exist in *param ?us* will manifest in aggregates. A *param ?u* has one of the five primary colours, one of the two smells, one of the five tastes, two of the four primary touches i.e. one either hot or cold and

two either smooth (positive charge) or rough (negative charge) [29]. Although the four qualities are permanently possessed by a *param* ?*u*, the intensity of the qualities does not remain constant. A *param* ?*u* possessing one unit of blackness at any moment may sometimes later possess two, three or many units of blackness [30]. In the free-state, mutation occurs only in the intensities of colour etc., i.e. x unit black changes to y unit black but black does not become white or red; however during and after union with other *param* ? us change in colour etc. may also take place. It follows from this that at any given moment there would be *param* ?*us* with different intensities of blackness etc. In the same way, there would be *param* ?*us* with various degrees of other qualities.

A single free *param* ?*u* is invisible not only to the naked eyes but also to other physical instruments. Its existence is to be inferred by the collective action and reaction of aggregates of infinite *param* ?*us.* Only the omniscient (*kevalajnani*) and those possessing superlative visual intuition (*paramavadhi jnani*) can perceive and cognize the nature of a free *paramanu.*

The *param* ?*u* is the direct unit of physical substance (*pudgala*) and also the indirect unit of space, time and quality magnitude of attributes [31].The quantitative and qualitative difference in the various forms of matter (aggregates/*pudgala*) in space and time domain ultimately depends on the action/reaction of attributes of *param* ?*u*. Thus, being the fundamental constituent of the physical composite bodies, it may be considered to be the determinant of the difference of aggregates, and for the same reason it is also their substantial cause. By its own motion it becomes the measure of time unit 'samaya'.

The *param* ?*us* have the innate capacity of uniting with one another to form composite bodies. The composite bodies are liable to the process of disintegration and the united *param* ?*us* may become *free param* ?*us* and thus the process of association and dissociation goes on eternally [32]. *Param* ?*u* is capable of being dynamically active (*kriyavan*). When dynamic, it may have spin, vibratory and migratory motions [33]. The activity of a *param* ?*u* is not continuous, rather it is quantaised. The dynamics of *param* ?*u* in some respect follow certain rules but it also follows some rules of uncertainty. *Param* ?*u* generally cannot be stopped or hindered by any object (*apratighati*) and at the same time it does not cause hindrance to the motion of others [34].

A param ?u in a given space-time domain has many energy states: potential,

electro-thermal, kinetic etc. in view of their inherent attributes and their variation as a consequence of change in energy states. These qualities reveal that a *param* ?*u* is a vibrating and moving charge. It has also been said that infinite number of *param* ?*us* can occupy one space point (*pradesha*) [35]. This means that *param* ?*u* is bosonic in character. Since a *param* ?*u* is indivisible, the energy of a *param* ?*u* is the smallest amount of energy that can exist in 'free state' and therefore it can be regarded as an energy quanta.

It should be mentioned that the atom described by modern science is not the same as *param ?u*. The *param ?u* is weightless (it has quantum energy) and has one colour, one taste, one smell and two touches whereas an atom has mass and belongs to the class (iii) matter; it has five colours, five tastes, two smells and eight-touches. According to Jainism an atom, rather each of its elementary particles, contains infinite number of param ?us as described below. These param ?us may have positive or negative charge and bond together according to the prescribed rules. That is, there is bonding between positive and positive, positive and negative, and negative and negative param ?us. The particle formed in this manner has a net charge depending on the majority population of a particularly charged parm ?us. For example an electron has majority population of negative param ?us and a proton has a majority population of positive param ?us. The total negative charge of electrons is equal to the total positive charge of protons for a stable structure. Jainism does not rule out formation of particles having fractional or multiple charge of electron or proton, but such particles are not known to form a stable structure and have no practical value.

5. Varga? (Energy Fields)

Varga? is an important concept to understand nature, particularly at subtle level. *Varga*? has been defined as *pudgala* aggregate made up of similar *param* ?us or as a cluster of *param* ?us [36]. There are infinite numbers and types of *varga*? *s* according to Bhagwati Sutra but eight types are important from the point of view of their association with the soul [37]. Gommatsara Jivakanda provides another type of classification of *varga*? *s* on the basis of number of *paramanus* present in the cluster [38]. According to this classification, there are 23 types of main *varga*? *s* found all over *loka*. The *varga*? *s* fall into two broad categories, one has four- touch and the other having eight-touch. The 2nd to 14th order *varga*? *s* are four-touch type and weight less. The 16th to 23rd order varga? *s* are eight- touch type and have

weight. The 15th order *varga?* falls in between the two categories and its nature is uncertain [39].

The lower order weight-less *varga?* s can be divided into two groups.

- 1. Associable *varga? s varga? s* that associate with the soul and form various kinds of subtle bodies and other structures that assist the soul in its worldly form.
- 2. Non-associable varganas *varga?* s that do not associate with the soul.

The following are the associable varganas.

- 1) *Aharavarga?* . This *varga?* constitutes the gross, protean (*vaikriya*) and migratory (*aharaka*) bodies of organisms.
- 2) Fiery (*Tejas*) *Varga*? . These varga? constitute the fiery body of organisms.
- 3) Sound (*Bhasha*) *varga?* . The sound *varga?* is suitable for producing all kinds of sounds including the sound produced by inanimate objects like musical instruments and natural phenomena like thundering of clouds and sound produced by living organisms including speech by humans.
- 4) Mind (*Mano*) *Varga?* . This *varga?* constitutes the physical mind (*dravya manah*) of organisms.
- 5) *Karman Varga?* . This *varga?* constitutes the karma bodies of organisms.

The higher order *varga? s* can be divided in three groups.

- 1) *Varga? s* that is helpful in formation of gross bodies of plants and small microorganisms (*nigodas*), belonging to category of immobile (*Sthavara jivas*). These *varganas* assist in the formation of plant bodies and bodies of small micro-organisms. The *varga?* that assists in formation of plant body compares with sun light (photons).
- 2) Permanent Nil (*Sunya*) *Varga? s*: Detailed information about these *varganas* is not available in scriptures.
- 3) Gross Matter (*Mahaskandha*) *varga?* (GMV): This *varga?* is supposed to constitute all ordinary matter, visible and invisible, in the universe including bodies of mobile beings.

The charge in *varga?* produces an electric field. A moving electric charge in

varga? also produces a magnetic field. According to scientific concept, an electric field is nothing but a charge in the space-time continuum. All fields, magnetic, electrical and gravitational, are physical realities. A *varga*? contains a bundle or packet of energy. The energy density or energy intensity increases with the order of *varga*? . As mentioned above, *varga*? *s* of 15th and higher order are supposed to have eight- touch quality. That is, in addition to four basic touches, namely cold, hot, positive and negative charge, other four secondary touches - light, heavy, soft and hard are also present. These additional touch properties are supposed to come into existence due to bonding between *paramanus*. The light and heavy touches are supposed to produce the property of weight. In the lower order *varga*? *s* of four touch types the *paramanus* cluster but do not bond.

The act of bonding between *param* ?*us*, i.e. their interaction, requires energy. When two *pram* ?*us* bond, a part of their energy (potential energy) is used up in bonding, reducing the free energy of the *varga*? that exists as kinetic energy of motion and vibration. Therefore the maximum velocity of a two-*param* ?*u* bonded *varga*? will be less than the maximum velocity of a single *param* ?*u* or a two *param* ?*u* unbound *varga*? . We thus see that lower order *varganas* having fourtouch must have higher maximum velocity than the eight touch *varganas* of higher order. The *param* ?*u* having two- touch has the highest maximum velocity. The lower order *vargana* are weightless and must be free of gravitational effect. The higher order *vargana* have gravitational property.

5.1 Gross Matter Vargan (GMV) and Matter

All ordinary matter (visible or invisible) is made up of GMV according to Jain view, as mentioned above. We now examine how the sub atomic particles may be produced from GMV [40]. Let us first consider the case of leptons. The neutrino is the smallest lepton having negligible mass and no charge. If neutrino is made of GMV then it must be a combination of at least two GMV, one having positive charge and the other a negative charge. This will be the case when the two GMV have equal and opposite charge. As *varga ?s* exist with differing charges, it is likely that more than two GMV combine to produce a neutral charge in neutrino. So a neutrino of negligible mass should be made up of many GMV. There are three types of neutrinos. The mass of all three types is negligible but still there is a minor difference between them. Such minor variation in mass is obtained by variation in number of GMV in the three types of neutrinos. It may be noted that when the mass of a neutrino is considered to be negligible, the mass of GMV is even lesser.

Now consider another lepton, the electron. The mass of electron is 0.511 MeV, which is millions of times greater than the mass of a neutrino. This means that an electron is made of millions of GMV. In an electron, the number of negative charge GMV exceeds the positive charge GMVs, giving a net negative charge of - 1.6022 x 10⁻⁹ coulomb. This also shows that the charge of one GMV is millions of times smaller than the charge of an electron. And since a GMV contains infinite *paramanus*, the quantum charge of a *paramanu* is really unimaginably small. The lepton muon is more than 200 times heavier, and tau is about 3500 times heavier than electron and therefore, they must contain more GMV in the same proportion.

Next consider the stable baryon particles proton and neutron. These particles are supposed to be made up of quarks. The mass of a proton is 1836. 12 times greater than that of the electron and neutron is only slightly heavier than proton. The mass of a quark is uncertain but it is many times more than that of the electron. So a quark is made from that many times more GMV than an electron. There are six types of quarks having fractional charges, both positive and negative, and masses ranging from 2 MeV to 18000 MeV. According to Jain view the fractional charges of quarks are possible by appropriate combination of positive and negative GMV. Another thing we observe is that the charges of up quark, charm quark and top quark are the same but their masses vary considerably. Similar is the case with down quark, strange quark and bottom quark. Formation of these quarks is clearly possible with suitable combination of GMV. So, in Jain view, quarks and leptons are composite particles and subject to gravity. Many more types of particles can be formed, including those not discovered so far.

Mass of matter is nothing but transformation of energy, that is, both matter and energy are but two modifications of a single entity or substance. This has been only recently realized in science. Jain physics has identified all forms of matter and energy as modification of the same substance *pudgala*. Intra-convertibility of various forms of energy - mechanical into electrical, electrical into heat, light, sound etc., - which is the basis of modern technology - has been recognized by Jain philosophers as the basic attributes of *pudgala*, since all forms of energy are fundamentally the modification of the same substance, *paramanu pudgala*.

6. Dark Energy and Dark Matter

There is no direct mention of dark energy and dark matter in Jain scriptures. The existence of dark energy in science has been postulated to satisfy the condition

of expanding and accelerating universe and it is supposed to have antigravity property. The non associable *varga? s* described above are weightless and gravity free. These *varga? s* may comprise a good fraction of the total mass present in the *loka* that is gravity free but do not possess anti gravity property as postulated by modern science. The Permanent Nil *Varga? s* may be considered to constitute the dark matter as they are not detectable by ordinary means. These *varga? s* may constitute a significant portion of mass present in the *loka*. The matter formed by these *varga? s* could be non-baryonic as the baryonic matter is formed by higher Gross Matter *Vargana* (GMV). Jainism supports the scientific view that mass is not the exclusive property of ordinary matter. According to Jainism even photons have mass.

Jain scriptures mention about bodies on which even beings having great powers e.g. heavenly beings fear to go. Jain canon Bhagwati Sutra describes existence of dark structures in space comparable to black holes. These structures are of two types :(i) *Tamaskaya* (body of darkness), and (ii) *Krisnaraji* 'Black Streaks' [41]. Both are pitch dark structures containing no parts like stars, sun, moon, planet etc. and no life. Both have rains meaning thereby that they attract neighbouring matter that appears as showers on their surfaces. The light of other stars and moons becomes dim as they approach these structures. *Tamaskaya* is a huge structure extending from a location far away from Jambudvipa, supposed to be our Earth, and going up to fifth heaven in the upper *loka*. This is said to have been formed by transformation of water bodies of organisms and other matter. The *Krisnaraji*, eight in number, in a closed loop structure located in fifth heaven in upper *loka*, is said to have been formed by transformation of earth (bodied beings) and other matter. This indicates that dark holes (or dark matter) can be formed in two ways one from fluidic matter and the other from solid matter.

7. The Laws of Subtle Cosmos

It is now scientifically established that as we go down from the macro to the micro state of matter, new attributes of matter come into play and the number of attributes increase. The macro world is deterministic and follows the laws of classical mechanics. The micro world follows the laws of quantum mechanics. Some laws of classical mechanics are not valid in the micro world. On comparing it with Jain concepts, we find that macro and micro worlds are comprised of 8-touch gross aggregates containing mass, which consist of higher-order *varganas* in bonded form. The weightless four-touch *vargana's* subtle aggregates which exist only in
energy form is a different class of matter. The weightless, four-touch *varganas* do not carry the fundamental forces as their *param ?us* are supposed to be in unbound state. Their behavior, therefore, must not be governed by known laws of science. On extrapolating, we expect that at subtle level of the physical world e.g. weightless four-touch *vargana*, there may be yet another set of operating principles, which still remains to be discovered.

8. Motion

8.1 Motion of a param nu

A *param* ?*u* is *apratigati*, implying that when it is in an independent state, it does not interact with any other object. Hence there is no external influence of any kind on the motion of a *param* ?*u*. It's motion is *asparshad gati* type [42]. A *param* ?*u* moves due to its intrinsic characteristic of dynamic action. Its motion is hindered only when it collides with another *param* ?*u*, a very rare possibility. Thus, in Jain view, the Newtons laws of motion and the limit imposed by Special Theory of Relativity do not apply to *param* ?*us* as the forces on which these laws and theories are based are not applicable in this case. The dynamic activity of a *param* ?*u* is uncertain as described before and it may move with low, medium or high velocity as determined by the property of *sadgun-hani-vridhi*. In the extreme case, *param* ?*u* with highest velocity can travel from one end of *loka* to another end in one *samaya* if not hindered by another *param* ?*u*.

8.1.1 Motion of four-touch vargan

A four-touch *varga*? may contain two to infinite number of *param* ?*us*. The fundamental forces are still absent in this type of *varga*? and its motion is not governed by known laws and the Special Theory of Relativity. However, there is affinity between *param* ?*us* in a *varga*? and therefore the maximum velocity of this *varga*? can attain would be less than the maximum velocity of a *param* ?*u*, as explained above. Due to large number of *param* ?*us* the chances of their colliding with other *varga*? are significant. On collision, the two *varga*? *s* may merge and form a bigger *varga*? of the same kind or a *varga*? of another kind.

8.1.2 Motion of eight-touch vargan

Eight-touch *varga*? contains *param* ?*us* in the bound state and all the fundamental forces must be operating there. All electromagnetic radiations fall in this category. This eight-touch type of *varganas*, therefore, are expected to obey the

known laws of science and the limit on speed imposed by the Special Theory of Relativity may apply. On account of their small mass, the gravitational force must be negligible and the motion is largely governed by electromagnetic force e.g. in the case of a photon.

8.1.3 Motion of Particles (made of Mahaskandh Vargan)

In the case of matter formed of GMV, at the level of subatomic particles and atoms, the gravitational force is still very small and other forces determine the motion. As the aggregates grow in size the gravitational force increases and the effect of electromagnetic force diminishes because the number of *parmanus* having positive and negative charge in the aggregate is likely to be of the same order canceling the charge of each other. Thus the motion of large particles and objects is governed mainly by the gravitational force.

9. Conclusions

It appears that spatial, spectral and temporal energy states are major differences between the two smallest size of matters known so far: fermions and parmanus in science and Jainism respectively. The param ?u of Jain philosophy is the smallest indivisible quantum of energy. It is the real energy quanta, far too smaller than the quantum of energy, photon, so far determined by scientific studies. Particles like quark have been discovered but 'what makes the quark' still remains a mystery. The journey of science has been from gross to fine and it has gone to the level of quark. Jain philosophy starts from the ultimate particle param ?u and proceeds up to the gross form of matter. Jain physics propounds that the fundamental constituent of nature is energy and *param ?u* is its ultimate unit. param ?u makes up varga? and varga? make up photon and the gross particles like quark, electron, etc. Jain philosophy presents the subtler forms of matter which have not yet been discovered by scientific studies, although the aggregation of matter from quark and electron onward is well understood. Jain philosophy also offers some plausible explanation to puzzling questions like what is the nature of matter other than the ordinary matter. Thus synthesis of Jain philosophy and science can together reveal more complete picture of the physical reality.

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20. Contemporary Views of Cosmology

Subhendra Mohanty

Abstract

Earlier concepts of earth-centric view of cosmology, accepted for several millenia, were abondoned and new concepts have evolved significantly over the past 5 centuries, since Copernicus presented his heliocentric theory of revolution of planets. The evolutionary history of these concepts from Copernicus, Tycho Brahe, Kepler, Galileo, Newton to Einstein are traced in this article and contemporary views are described. Kepler's and Galilieo's reliance on observations as the fundamental principle for discovery of truth must be the basis for any acceptable cosmology and not philosophical or religious conjectures.

Key Words: Cosmology, Planetary motion, Kepler's laws, heliocentric theory

1. Introduction

Modern cosmology started with the publication of the treatise. On the Revolutions of the Celestial Spheres by Nicolai Copernicus (1473-1543 CE) in 1543 CE. In this treatise Copernicus challenged the long held ideas of Aristotle and Ptolemy that the Sun and other planets move in circular orbits with the Earth at their center. One peculiar feature of the observed motion of planets was that they sometime unexpectedly reversed their directions. This retrograde motion of the planets had been explained in the Earth-centric framework of Aristotle by Ptolemy's theory of epicycles- the idea that planets sometimes wandered into small circular orbits, in the overall circular orbit around the Earth, shown in Fig. 1.

Copernicus had studied astronomy (in addition to theology and medicine) in Bologna (Italy) and had made observations of the planetary positions first hand. From the observations of Mercury and other planets which had this seemingly irregular orbits, Copernicus developed the idea that if the Sun and not the Earth was



Fig. 1. Ptolemy's picture of the Earth centric solar system where the planets and the Sun orbited around the Earth in circles and epicycles (little circles).

to be made the center of the planetary orbits, the irregularities like retrograde motion could be explained. Copernicus circulated a hand-written manuscript containing these ideas in 1514 but his fear of going against the tenets of the orthodox Church (which supported the Earth-centric cosmology of Aristotle and Ptolemy) prevented him from publishing his full thesis till the year 1954. According to legend, he received the first printed copy of his life's work on his death bed. Apart from establishing the basic structure of planetary motion the Copernican principle did away with the notion that the Earth had any special status in the organization of the Universe. This principle continues to be the central tenet of modern cosmology.

The ideas of Copernicus were largely ignored by the astronomers till Johannes Kepler (1571-1630) laid down his laws of planetary motion in the books 'Epitome of Copernican Astronomy' published between 1617-1621. Kepler wanted to understand the orbital speeds of orbits of different planets. He noticed that the outer planets liked Saturn had lower speeds than the inner planets like Mercury and he also found that speeds of planets would vary over time, not all of which could be explained in the Copernican framework of circular orbits. Kepler went to work for the astronomer Tycho Brahe (1546-1601) with the intention of using Brahe's extensive observations of planetary orbits to determine if there was a mathematical pattern in the planetary motion. Brahe put him to work on studying the orbit of Mercury which had proved to be the most unpredictable. Tycho Brahe died suddenly of an illness in 1601 and Johannes Kepler usurped all his data and set



Fig. 2. The Sun-centered solar system of Nicolai Copernicus.

about the task of deriving the mathematical relations between planetary speed and distance, which he completed by 1621. In a major conceptual change compared to the Copernican system of perfect circular orbits, Kepler found from the data that the planetary orbits are elliptical and the planets speeded up as they got nearer the Sun. Kepler's Laws of planetary orbits would stand unchallenged for 300 years till a small anomaly in Mercury's orbit required Einstein's General Relativity for an explanation. Keplers's reliance on data instead of mathematical symmetry was carried on by Galilieo as the fundamental principle for discovery of scientific truth and his laws of planetary motion would prove critical in Newton's discovery of the inverse square law of gravity.

Galileo Galilei (1564-1642) used a telescope of Dutch construction to explore the solar system and discovered the four moons of Jupiter. Based on his observations of the solar system he published the treatise 'Dialogue Concerning the Two Chief World Systems' in 1632 in which he firmly supported the Copernican Sun-centric solar system over the Aristotelian Earth-centric model-which was the belief of the Catholic church. For this heresy Galileo was placed under house arrest by the church and died ten years later. His method of discovering scientific laws from observations are the foundations on which the modern scientific method is based. Any acceptable model of cosmology should likewise be based on observations and not on philosophical or religious conjectures.



Fig. 3. Kepler's solar system where planets orbit the Sun in elliptic corbits which sweep out equal areas (shaded region) for any given time period (one month shown in figure) independent of position.

Galileo's empirical method was carried forward by Isaac Newton (1642-1727) whose most important contribution was to establish the idea that the 'heavenly bodies' obeyed the same laws of physics as the terrestrial ones. Newton's law of universal gravitation stated that any two bodies had a force of gravitational attraction between them which was proportional to their masses and inversely proportional to the square of the distance between their centers. Newton's law of gravity showed that the same force which pulled an apple from a tree towards the center of the Earth also kept the Moon in orbit around the Earth, and the Earth and other planets in a Keplerian orbits around the Sun. Newton's explanation of Keplers laws of planetary orbits and the successful prediction of the return of Halley' comet in 1758 (by Edmund Halley using Newtonian gravity) firmly established Newton's laws of motion and gravity which are used in all aspects of practical science- from construction of bridges to the trajectory of rockets, to this day.

Newton also developed ideas about cosmology beyond the solar system. He believed that the universe had, on an average, uniform distribution of matter and the spatial extension of the universe was infinite. The uniform distribution of matter was based on the Copernican principle extended to the entire universe - that all regions of the Universe were the same, the Earth and the Solar System held no special position in the Universe. His law of universal gravitation then demanded that the universe had to be infinite and unchanging in time in order that it does not collapse under gravity towards the 'center' if a center of gravity of matter were to be present.



Fig. 4 . Newton's discovery that the same gravity which attracts objects towards the Earth also keeps the Moon in orbit around the Earth and the Earth in orbit around the Sun. Objects thrown from V with increasing velocities will have trajectories ending at D, E and F.

This idea of an infinite unchanging universe stood till the beginning of 20th century when Einstein's theory of Relativity and the observations of Vesto Slipher and Edwin Hubble established that the Universe is actually expanding. In 1887 an experiment performed by Michelson and Morley had shown that the speed of light from the Sun was independent of the motion of the Earth which was at odds with the Newtonian mechanics. Albert Einstein (1879-1955) was led to the idea that the laws of electromagnetism laid down by Maxwell were incompatible with Newtonian mechanics. He set about reconciling the two systems with his focus on light which was viewed as an electromagnetic wave in one system and a motion of particle in the other. Taking the constancy of the speed of light (about 3x10⁸ meters/second) for all observers as the central axiom. Einstein was led to the conclusion that the lengths of objects and the time duration between events depended on the relative speed of the observer. Einstein's Special Theory of Relativity published in 1905 changed the Newtonian idea of a universal time and constancy of length scales for all observers. Einstein went a step further and showed in his General Theory of Relativity in 1916 that an accelerated observer was identical to an observer in a gravitational field thereby changing the idea of gravity from an external field like magnetism to a manifestation of the space-time grid around the observer.

Einstein's General Theory of Relativity correctly predicted the amount of the bending of light by the Sun - which was measured in an experiment in 1919. It also explained a long standing anomaly in the orbit of Mercury which had remained unexplained in Newtonian gravity. The most profound effect of Einstein's theory was to be in cosmology. In 1922 the Russian mathematician Alexander Friedmann (1888-1925) found that using Einsteins theory as a model of the universe with uniform matter distribution led to the conclusion that the universe must be expanding. Friedmann communicated his findings to Einstein who was very disturbed by the idea. An expanding universe implied that there was a time in the past when all the distant parts of the universe were at one point in space and there was no concept of time prior to that event. The notion that the universe and time itself had to have a beginning was anathema to Einstein who belied in an unchanging infinite universe like Newton. To correct the situation Einstein introduced an extra term "the cosmological constant" in his equations to obtain a steady state solution for the universe. However astronomical observations proved subsequently that the universe was expanding. Indeed in 1998 it was shown from the observations of distant supernovae that the universe is actually expanding at an accelerated pace which implies that a 'cosmological constant' or a vacuum energy is present in the universe, but with an opposite sign, and having the opposite effect compared to what Einstein had intended.

The idea of an expanding universe based on both observation and Einstein's theory was propounded independently by Georges Lemaitre (1894-1966) who was a Roman Catholic priest, well trained in mathematics and astronomy. Lemaitre observed the red-shift in the colour of distant galaxies and proposed the expanding universe solution of the Einstein equations in 1927 (which he discovered independently) as an explanation. He was the first to put theory and observations together and proposed that the universe started from a 'primeval atom' prior to which space-time had no meaning. His ideas found favour in the Catholic church which had long held the notion of a universe created from nothing. Lemaitre however rejected the idea that his findings in cosmology confirmed the theological ideas of the Catholic church. In his view science was based on logical deductions from empirical facts whereas religion was based on spiritual belief and religion did not have to depend on science for validations of its tenets. According to Lemaitre "Omnipresent divine activity is everywhere essentially hidden. It never had to be a question of reducing the supreme Being to the rank of a scientific hypothesis."



Fig. 5. According to Einstein's theory of General Relativity, gravity is due to curvature of spacetime (shown of grid) around massive bodies and correctly predicted the bending of light in Sun's gravitational field.

Edwin Hubble (1989-1953) using the largest telescope at that time at the Mt. Wilson Observatory in USA, systematically studied the nebulae in galaxies outside our own Milky Way and found that distant galaxies receded from our own with speeds proportional to their distance. This Hubble's Law published in 1929 was conclusive evidence of Lemaitre's and Friedmann's expanding universe predictions based on Einstein's General Relativity.



Fig. 6. According to Einstein's theory of General Relativity, galaxies are seen to recede away from each other as the space between them expands -like the surface of a balloon. The figure shows expanding balloon with time (X-axis).



Fig. 7. Hubble's inference of the linear relation between velocity and distance of galaxies.

There was still an influential section of astronomers, among them Fred Hoyle, who did not accept the idea of a beginning of the universe which was a necessary inference of the expanding universe idea. Fred Hoyle coined the phrase "The Big Bang" in a derisory fashion to describe the beginning of the universe. Fred Hoyle's alternate theories of Steady State universe have not stood the test of time but the name Big Bang for the expanding universe idea stuck. The accidental discovery in 1964 by Arno Penzias and Robert Wilson of the 2.75 degree Kelvin temperature of photons in space which were predicted to be there as remnants of the hot Big Bang an early phase of the universe, has firmly established this theory.



Fig. 8. Anistroipy of the 3 degree kelvin microwave background measured by PLANCK experiment shown by non-uniform and non-isotropic distribution of orange and blue colours.

Working with the hot Big Bang idea, cosmologists were able to correctly predict the abundances of light elements like Helium and Lithium which were formed in fusion reactions in the early universe. By the second half of 20th century the Hot Big Bang theory was firmly established with a few unanswered problems left like an explanation of the origin of galaxies. In a homogenous expanding universe a perturbation was needed to seed the formation of galaxies and other large structures seen in the universe. The formation of large scale structure like galaxies and galactic clusters could be finally explained on the basis of a theory called Cosmological Inflation. In this theory, prior to the hot expanding phase, the universe went through a phase of cold exponential expansion driven by a large "cosmological constant". During this rapid expansion, small perturbations in the density were amplified and grew in time to become galaxies and other large scale structures. One of the predictions of Inflation is that the 2.75 degrees Kelvin background temperature would have perturbations of the order of a few hundred micro-Kelvins, and this prediction has been confirmed in satellite based observations of the temperature of space. The quest for the fundamental theory of what caused Inflation is what currently occupies the cosmologists.



Fig. 9. Modern view of cosmological evolution of the Universe. A period of rapid expansion called Inflation was followed by a radiation and matter dominated era.

In 2012 the Higgs boson was discovered with the Large Hadron Collider in CERN. The Higgs field which is omnipresent and gives masses to the other elementary particles is considered as the prime candidate for the source of the cosmological constant which was responsible for driving the inflation. It is possible that there are many different universes characterized by different values of the Higgs mass and other fundamental constants of nature.



Fig. 10. Multiverse where the different parts of the universe have different fundamental particles and interactions.

This view of the Universe where different parts are connected only by passages in space-time called wormholes and where the different parts have entirely different laws of fundamental interactions and elementary particles is called the multiverse. Experimentally accessing the Multiverse seems like a task beyond the reach of modern science.

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21. Cosmology - The Story of Our Universe

R. Rangarajan

Abstract

Over the last few centuries our understanding of the composition and history of the Universe has increased dramatically. This has been aided by the development of various Earth and space based instruments to look at the sky, as well as by theoretical developments, most notably Einstein's proposition of the Theory of General Relativity. We now understand that the early Universe was very hot and dense, and filled with relativistic particles. As the Universe expanded and cooled, it went through various epochs such as the formation of nuclei, atoms, the Cosmic Microwave Background and finally stars, galaxies and other structures. Today the visible part of our Universe is composed of galaxies, clusters, superclusters and voids but overall the current Universe is dominated by nonvisible matter, or Dark Matter, and an unknown form of energy referred to as Dark Energy. While we now have a fairly elaborate understanding of our past, there still remain questions about the nature of dark matter and dark energy, and about the future of our Universe.

Key Words: Cosmology, Universe, General Relativity, Big Bang.

1. Introduction

Cosmology is the study of our Universe as it is today, and of its past history and future evolution. Since time immemorial humans have asked "How old is the Universe? Has it existed forever, or did it have a beginning? Will it exist forever, or will it end? What governs the motion of the stars that we see in the night sky?" This curiosity led to the development of science, in particular astronomy and mathematics, in all societies. Astronomy found many applications. For example, knowing the position of stars and planets in the sky was essential for creating a calendar that could indicate when to plant crops, when rivers would flood, etc. It was also essential for navigation for those who travelled across both land and sea. Over centuries, the study of the motion of stars and planets further developed in many societies. In parallel, each society came up with its own story of the creation and evolution of the Universe, often based on a mix of philosophical and mythological motivations.

Philosophically and mythologically, there have been notions of an evolving or changing Universe, of a static Universe in which the gross features do not change, and of a cyclic Universe in which the Universe evolves with the gross features changing in a periodic manner. These ideas have appeared in modern cosmology too. When Einstein first proposed the Theory of General Relativity described below, he presumed that the Universe was static. But subsequent observations indicated that the Universe is evolving and this idea was quickly abandoned. According to the generally accepted Big Bang model of the Universe, the Universe was very hot, dense and structureless at early times but it subsequently cooled and evolved into stars and galaxies and other structures. More recently there have been theories describing a cyclic Universe in which the Universe goes through eras of expansion and (brief) contraction. More research is needed to understand all the details of these models. The original notion of a static Universe may have had philosophical underpinnings but subsequent notions of the Universe have been largely driven by observations and possibilities suggested by the mathematical formulation of the physics of the Universe.

Historically, a major milestone in our understanding of our Universe came with the invention of the telescope and its use by Galileo (1564-1642) to look at the planets in our solar system. While all motion is relative, Galileo's observations (of the phases of Venus) could confirm the Copernican thesis that placing the Sun at the centre of our solar system, with the planets including the Earth going around it, made for a far simpler description of our solar system. This indicated that perhaps the Earth was not the most important object in our Universe. Galileo's discovery of four moons around Jupiter further indicated that our Earth with a moon was not special. These discoveries had major philosophical and religious implications. Since religions tend to be Earth-centric with prophets and Gods identified with the Earth, the notion that the Earth was not special could be in conflict with most religious doctrines. It is no wonder then that Galileo was persecuted by the church for his beliefs. But today the cosmological principle that there is no special position in the Universe, including the Earth's location, is a cornerstone of modern cosmology.

Galileo's contemporary, Kepler, using the observations of Tycho Brahe, gave us the Laws of Planetary Motion. Newton subsequently proposed the Law of Gravitation which explained Kepler's laws. The next major development in this field was Einstein's proposition of the Theory of General Relativity in the early 20th century. General Relativity is a theory of gravity which supersedes Newton's Theory of Gravity. For precise calculations of the motion of objects very close to a massive object (for example, for satellites orbiting the Earth), and for objects moving close to or equal to the speed of light, Newton's Theory of Gravity fails and Einstein's Theory of General Relativity prevails. (General Relativity does reproduce the results of Newtonian gravity in the regime of validity of the latter). In addition, to understand the dynamics of the Universe one needs to invoke General Relativity.

Modern cosmology involves the observation of astronomical objects – galaxies, clusters of galaxies, superclusters, filaments – with the help of Earth based telescopes and satellite based instruments, and using these observations of the present state of the Universe and the equations of General Relativity to understand the past history and future evolution of our Universe. Just as Newton's Laws of Motion can predict the future motion of an object given an initial position and initial velocity, or the past motion from the final position and final velocity, one can use the equations of General Relativity, referred to as Einstein's equations, to study the past and future of our Universe given values of certain parameters of our Universe today.

Below we will first discuss Einstein's equations for our Universe, then discuss the present structure and composition of our Universe and then finally describe the past history and possible future of our Universe.

1. The Theory of General Relativity

We now provide a brief introduction to the Theory of General Relativity and its application to understanding the evolution of our Universe. General Relativity is a theory of gravity which was developed between 1907 and 1915 by Einstein. In Newtonian gravity the attraction between objects of non-zero mass is due to a gravitational force. In General Relativity the gravitational force is replaced by a modification of space. In theories prior to General Relativity, space was treated as a static region in which all matter exists and physical phenomena occur. Up to the beginning of the 20th century it was believed that space was unaffected by the

matter in it. The Theory of General Relativity modified this notion radically – space was now dynamical and affected by matter present in it. Furthermore the motion of objects in space was affected because of any modification of space due to other objects. For example, consider a star and an object moving past it. The mass of the star modifies the space around it and the motion of the object moving in this modified space is affected such that it moves as if attracted to the star (effectively reproducing the gravitational attraction of Newtonian gravity). The modification of space is referred to as the curving of space and the modified space is referred to as curved space. The curvature of space at a point affects the motion of all bodies at that point equally (just as the acceleration due to gravity on the Earth is the same for all bodies with mass, irrespective of their mass).

When one wants to apply General Relativity to the Universe one has to consider the matter content of the Universe. One finds in that case that space is evolving in time, and observations indeed indicate that the Universe is expanding. By expansion we mean that the volume of any finite region of space is increasing with time because of the dynamical nature of space. More precisely, one should refer to a dynamical spacetime but for this article we shall only refer to dynamical space.

Another feature of Einsteinian gravity is that it affects all bodies including massless objects, unlike in Newtonian gravity where the gravitational force between two objects is proportional to the masses of both the objects. The gravitational bending of light, which consists of massless particles called photons, as light passes by a star has been observed and this was one of the early vindications of the Theory of General Relativity.

We now present a few equations that describe the dynamics of the Universe. On very large scales (larger than supercluster scales) the Universe appears uniform and can be treated as isotropic and homogeneous (i.e. the Universe appears the same in all directions from a given point, and appears the same at all points). For such a Universe the distance $d_{AB}(t_2)$ between distant galaxies A and B at time t_2 is related to the distance at time t_1 by a mathematical function R(t) called the scale factor.

(1) $d_{AB}(t_2) = d_{AB}(t_1) R(t_2) / R(t_1)$.

In an expanding Universe R increases with time and so does the distance d_{AB} . A set of equations, which are the Einstein's equations, describes how R changes with

time. The dynamics of the Universe depends on the details of the material constituents of the Universe. Einstein's equations for an isotropic and homogeneous Universe are

(2)
$$\left\{\frac{\dot{R}^2}{R}\right\} = \frac{8pG}{3} \rho \frac{\Lambda c^2}{3} \frac{kc^2}{R^2}$$

(3) $\frac{\ddot{R}}{R} = -\frac{4pG}{3} \left\{\rho + \frac{3p}{c^2}\right\} + \frac{\Lambda c^2}{3}$

where the dot represents a derivative with respect to time t, rho (ρ) and p are the energy density and pressure of the material in our Universe, c is the speed of light and k =1,0,-1 is a constant (taken as 0 hereafter). G is Newton's gravitational constant. Lambda (Λ) is a constant and is called the cosmological constant and it was introduced in these equations to explain a static Universe as initially presumed by Einstein. While we now know our Universe is not static, Lambda can still play a role as the Dark Energy responsible for the current accelerated expansion of the Universe as mentioned in Section 2b(iv). When the energy density of the Universe is dominated by that of relativistic particles, ρ and p vary as $1/R^4$ and Einstein's equations above imply that R increases as $t^{1/2}$. When the energy density of the Universe is dominated by that of non-relativistic particles, ρ varies as $1/R^3$ and p is approximately 0, and then R varies as $t^{2/3}$. If the constant Lambda dominates on the right hand side of the above equations for R(t) are called the Friedmann-Lemaitre-Robertson-Walker solutions and the de Sitter solution.

Thus the evolution and rate of expansion of our Universe depend on the average mass and energy density of the Universe, and on the composition of the Universe (i.e. whether its energy density is dominated by relativistic or non-relativistic particles or some other form of matter).

2. Present State of our Universe

a. Present Structure of our Universe

As we go from smaller length scales to larger length scales we find that our Universe is made up of stars with planets, galaxies composed of stars, conglomerations of galaxies called clusters, groups of clusters in the form of superclusters, and supercluster complexes or filaments with large voids in between. Galaxies can have a few thousand to a 100 trillion stars like the Sun in

them. These stars too can have planets - so far 1800 Exoplanets (i.e. planets outside our solar system) have been discovered around other stars. One way of discovering planets is to look for a periodic decrease in the brightness of a star as a planet passes in front of it, or for an increase and decrease in the frequency of starlight as a star moves towards and away from us as part of its motion about the centre of mass of a star-planet system. Stars are grouped in galaxies of spherical, elliptical, spiral or irregular shapes. In the early 20th century it was not clear if the Milky Way constituted the entire Universe or was one of several 'island universes' (the old name of galaxies). However this issue was resolved in the 1920s by Edwin Hubble whose observations indicated that certain astronomical objects are too distant to be within our galaxy (Hubble, 1926). Galaxies group together in clusters and the clusters come together to form superclusters, which in turn are arranged as filaments or supercluster complexes and large voids. All these structures have been detected through various observations, and similar structures have also been produced in computer simulations. The basic physics behind structure formation is that overdense regions corresponding to initial inhomogeneities attract additional matter from surrounding regions due to gravity and subsequently these overdense regions collapse into structures such as galaxies and stars and then clusters and superclusters and finally into filaments with voids in between. We will briefly mention a possible source of the initial inhomogeneities later.

b. Present Composition of our Universe

The Universe consists of many components as discussed below.

i. Relativistic particles

In addition to the electromagnetic radiation (light, heat, etc.) emitted by stars and galaxies, the Universe is filled with electromagnetic radiation with an associated temperature of 2.725K. This is referred to as the Cosmic Microwave Background and its prediction and subsequent discovery was a major milestone in cosmological research. In addition there is a Cosmic Neutrino Background which so far remains undetected. Neutrinos are light neutral particles with a mass less than one millionth of the electron mass.

Though both photons and neutrinos are produced in stars, the backgrounds mentioned here are left over from processes in the very early Universe, much before galaxies and stars were formed.

ii. Non-relativistic luminous matter

This consists of protons, neutrons and electrons (the particles which constitute atoms and molecules and hence matter which we are familiar with). The interactions of protons, neutrons and electrons, such as those occurring in stars, leads to the emission of light and other electromagnetic radiation which can be detected.

iii. Non relativistic non-luminous matter / Dark matter

It has been known since the early 1930s that a large fraction of the matter of our Universe consists of non-luminous matter which we cannot see. This matter, which does not emit light or scatter light, is called Dark Matter (PDG 2014). When one considers the motion of stars in the arms of a spiral galaxy as they go around the galaxy and equates the centripetal force with the gravitational force of the galactic matter, one concludes that there is far more matter in the galaxy than what may be deduced from measurements of the luminosity of the galaxy. In fact one finds that 90% of the matter of a galaxy is dark. We still do not know what particles constitute Dark Matter.

Some scientists have argued that the Dark Matter may not exist and that the current observations that are explained by postulating Dark Matter can instead be explained by modifying Newton's Law of Gravitation or General Relativity (Milgrom 2015).

iv. Dark Energy

Observations indicate that the rate of expansion of our Universe has been increasing for the last 5 billion years while it was decreasing prior to that (except during a very brief period of Inflation in the very early Universe to be discussed later) (Perlmutter, 2003). While the earlier period of deceleration is understood within the framework of models of the Universe, we do not know what is causing the current acceleration. This acceleration can be explained by the presence of a cosmological constant in Einstein's equations, or by presuming the existence of some new material that permeates the Universe and causes space to expand faster with time. This material is called Quintessence and both the cosmological constant and Quintessence are referred to as Dark Energy.

Thus, the Universe today consists of:

- 1) Background photons and neutrinos
- 2) Protons, neutrons and electrons

- 3) Dark Matter and
- 4) Dark Energy

Observations indicate that if one averages over any large region of the Universe the contribution to the energy density (kinetic energy + potential energy + mass energy) of these four components, then the contribution of photons and neutrinos is negligible, that of protons, neutrons and electrons is about 5%, of Dark Matter is about 27% and of Dark Energy is about 68% (Planck, 2015). (Though the ratio of the Dark Matter contribution to the standard luminous matter contribution is about 5 overall, in galaxies the ratio is about 10.)

c. Dynamics of our Universe

The next issue we would like to address is whether our Universe is static, i.e. has it, broadly speaking, been like the present in the past and will it continue to be so in the future as well, or is it changing in time. When Einstein first applied his Theory of General Relativity to understanding our Universe he presumed that our Universe was static. However observations by Slipher (Slipher, 1913), and Hubble and Humason (Hubble, 1929) implied respectively that distant galaxies are moving away from us, and at a speed proportional to their distance. The relation, $v = H_o d$, where v is the velocity at which a distant galaxy at a distance d moves away from us and H_o is a constant, is called Hubble's law. This is best explained in the context of an expanding Universe in which space itself is expanding. We stress that this means that distant objects are moving away from each other not because of their intrinsic velocities but because the space between them itself is increasing. As discussed above, in General Relativity space is dynamical and can evolve in time.

One may note that we have used the term "distant galaxies" in the paragraph above. For bound systems such as our solar system or our galaxy the local gravity that keeps the system bound is much larger than the background gravity that causes objects to move away from each other. Hence the net result is that objects within these systems are not moving apart according to Hubble's law. In contrast, distant galaxies which are not part of a gravitationally bound system obey Hubble's law.

To determine the past history and possible future of our Universe one solves Einstein's equations given that currently 1) our Universe is expanding, 2) the energy density in relativistic matter is extremely small, with the associated background photon temperature of 2.725K, 3) the energy density in non-relativistic matter is about 32% of the total, 4) the equivalent energy density associated with Lambda is about 68%. In different stages of the evolution of our Universe the solution of Einstein's equations reduces to those mentioned in Section 1 as the Friedmann-Lemaitre-Robertson-Walker solutions and the de Sitter solution.

3. Past History of our Universe

As we have mentioned earlier our Universe is expanding and on very large distance scales all galaxies are moving away from each other. This implies if we go back in time all the material that is in the galaxies around us was in a smaller and smaller region. At the earliest instance that we can study using our equations, the density was very high, all matter broke down to elementary particles, and all these particles were moving away from each other very fast. This initial state, 13.8 billion years ago (Planck, 2015), is referred to as the Big Bang. It should be noted that this does not describe an explosion of highly concentrated matter in space. It actually describes a very rapid expansion of space (filled with matter) everywhere. It also does not imply that the volume of our Universe was concentrated at a point. The entire Universe could have been infinite at the time of the Big Bang. But any finite volume of space today would correspond to a very small region at the time of the Big Bang.

a) After the Big Bang

For the first microsecond after the Big Bang the Universe was filled with a hot primordial gas of fundamental particles like electrons, quarks, photons, neutrinos and unknown particles such as the Dark Matter particles. After the first microsecond, quarks condensed to form protons and neutrons. Between 1 second and 3 minutes, light nuclei such as that of deuterium, helium and lithium were formed. The first atoms formed when the Universe was about 380,000 years old and the photons of that epoch have been streaming since then through the Universe and constitute the Cosmic Microwave Background today. Stars formed in protogalaxies (precursors to galaxies) when the Universe was about 300 million years old. The first galaxies formed when the Universe was 1 billion years old. The solar system was formed when the Universe was 9 billion years old. Around this time the Universe's expansion started accelerating. Today the Universe is 13.8 billion years old from the time of the Big Bang.

In the first 9 billion years after the Big Bang the Universe was expanding but decelerating except for a brief period sometime between 10-34 seconds and 10-12 seconds after the Big Bang when the Universe went through a period of accelerated

expansion called 'Inflation'. Such a phase can explain certain observations of the Universe today. Due to Inflation the volume of any inflating patch of our Universe increased quickly by a factor of at least 10^{45-90} , and has then continued to increase till today. Since this entire region was in casual contact at one time (the time when Inflation commenced) one can expect that regions within this volume will show similarities. This then explains why the Cosmic Microwave Background coming to us from different directions in the sky has the same temperature to 4 decimal places. Inflation also explains why the curvature term in Eq. (2), (kc^2/R^2) , is observed to be negligible, as $1/R^2$ goes to 0 during Inflation when R increases by several orders of magnitude. In addition, Inflation also explains why the Cosmic Microwave Background can have slight variations in the temperature, which have been observed at 1 part in 10^5 , and predicts the form of correlations in this temperature anisotropy. These have been confirmed by observations. Furthermore, spatial fluctuations in the energy density or distribution of matter in the Universe during Inflation could be the initial inhomogeneities mentioned in Section 2(a) as the seeds for the formation of structure later in the history of the Universe.

The above description is referred to as the Big Bang model of the Universe. This model is widely accepted because it seems to provide a plausible explanation for current observations and because its predictions, such as the abundances of light elements (such as hydrogen, deuterium and helium) and the existence of the Cosmic Microwave Background, have been verified by observations. However note that there is still uncertainty as to what are Dark Matter and Dark Energy and in the details of Inflation.

One may ask what happened prior to the Big Bang, or in other words, what is the origin of our Universe. To understand this question one would need a quantum theory of gravity valid at energies and densities higher than at the time of the Big Bang. However Einstein's Theory of General Relativity is a classical theory and becomes invalid beyond the Big Bang. There have been attempts to quantize gravity in which gravitational interactions are associated with particles called gravitons just as electromagnetic interactions are associated with photons. The simplest attempts to quantize gravity give absurd theoretical results in which the probability of certain gravitational processes to occur is infinite and hence ill defined. String Theory and Loop Quantum Gravity are two theories that attempt to resolve this issue.

In String Theory the fundamental physical entities are not point-like

particles but one dimensional string-like objects. At the energies at which we currently do experiments in accelerators such objects will effectively appear as point-like particles. To probe the string-like structure we would have to do experiments at energies that are 10^{15} times higher than in current experiments. In string theory space has 6 additional dimensions other than the 3 dimensions we are familiar with and very high energy experiments would see effects of these extra dimensions too. In Loop Quantum Gravity one quantizes spacetime which implies space itself has a discrete structure. The smallest measurable length scale is then the Planck length of 10^{-35} m. This provides a natural cutoff in the divergent integrals that were generating infinite probabilities of events, thereby rendering the probabilities finite. Both these theories require further development before they can answer all questions about the origin of our Universe.

4. Future of our Universe

We are uncertain about the future of our Universe because we do not understand the material that dominates the energy density of our Universe today, namely, Dark Energy. Even if the Universe continues to expand it is not clear whether its expansion will continue to accelerate. In some accelerating scenarios all distant galaxies will move away while galaxies will retain their structure for a long time (100 trillion years) at which point the stars will run out of nuclear fuel and stop shining. In other scenarios galaxies move apart, then stars within galaxies move apart, then stars breakup and the Universe after 50 billion years is filled with a dilute gas and is dark and cold. Note that our solar system has a future lifetime of about 6 billion years.

There are other models in which our Universe goes through cycles of expansion and contraction. In such models our 3 dimensional Universe is embedded in a larger space of more than 3 dimensions. The dynamics associated with the relative motion of our 3 dimensional space and that of another 3 dimensional space (namely, regularly repeated collisions and then moving apart) causes our 3 dimensional space to go through contracting and expanding phases. Dark Energy is associated with the attractive force between the two spaces that causes them to collide, perhaps once every trillion years or so. Each collision leads to the creation of new matter in our Universe in the contracting phase while the subsequent expansion cools and ultimately completely dilutes the matter. Such a model is called the Cyclic Universe, and is an alternative to the inflationary model of

the Universe (Steinhardt). It attempts to explain many cosmological observations such as the large scale homogeneity, isotropy and negligible curvature of our Universe, as well as the smaller scale inhomogeneities, from phenomena occurring during the last contracting phase. Currently research is going on to understand this scenario better.

5. Conclusions

To summarize, we live in an expanding Universe and the equations of General Relativity imply that the earliest state of the Universe describable by the equations of General Relativity consisted of a very dense and highly energetic distribution of particles moving apart at a very high speed. Subsequent to this initial state called the Big Bang, the Universe evolved through many stages ultimately giving us a Universe today consisting of stars, galaxies, clusters, superclusters, filaments and voids. In the absence of a Quantum Theory of Gravity we do not have a complete picture of the origin of our Universe. We also do not understand the source of our accelerated expansion today, i.e. Dark Energy, and hence we are unsure about the future evolution of the Universe. Furthermore scientists continue to search for the particle that constitutes the Dark Matter and it is hoped that experiments at the Large Hadron Collider (LHC) at CERN in Europe will detect the elusive Dark Matter particle. In spite of all these uncertainties there is much evidence that indicates that our understanding of the Universe is broadly correct. It is hoped that in the coming years efforts by scientists will provide certain key missing pieces in our understanding.

It should be emphasized that our current understanding of the Universe has evolved over centuries and is based on matching theories with observations. Theoretical models of the Universe need to be well defined and based on certain principles or axioms. They must make definite predictions which can be verified. Merely propounding an idea without detailing its basis and implications in a logical manner would be seen as speculation without much depth. Thus the measure of any new (or old) theory of the Universe would be its ability to justify or at least explain the principles underlying the theory, its ability to provide unambiguous explanations of current observations, and its ability to make definite predictions that can be verified or falsified by experiments and observations.

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Big Bang: The state of the Universe at the earliest instant of time at which we can apply the Theory of General Relativity. The Universe then was very hot and dense, and expanding very rapidly.

Cosmic Microwave Background: The all pervading background of electromagnetic radiation in the Universe at a temperature of 2.725K.

Cosmological constant: A constant included in Einstein's equations which can lead to accelerated expansion. Denoted as Lambda.

Cyclic Universe: A higher dimensional model of the Universe in which our 3

dimensional Universe goes through phases of expansion and contraction.

Dark Energy: The cause of the current acceleration of the Universe.

Dark Matter: Matter that does not emit light or scatter light and hence can not be seen.

Einstein Equations: The principal equations of Einstein's theory of General Relativity. Their solution indicates how space is modified due to the presence of matter.

Inflation: A phase of accelarated expansion in the very early Universe.

Loop Quantum Gravity: A theory that attempts to provide a quantum description of gravity

Scale factor: In an expanding Universe, it is a measure of how distances between distant objects increase with time. It is denoted as R(t) and is obtained by solving Einstein's equations.

String Theory: A theory in which the fundamental physical entities are one dimensional string-like objects and not point-like particles.

22. Modern and Jain Cosmology: A Comparison

Raj Mal Jain, Jeo Raj Jain and Narendra Bhandari

Abstract

Cosmology or *Lokav da* is an integral part of Jain philosophy. Jainism subscribes to Steady State cosmology and is probably a multiverse theory. Several aspects like structure, shape, constituents of the universe and time cycles are described in detail. Law of conservation forms the back bone of all processes described in *Lokavada*, and it is not confined only to material aspects but is dominated by living (*j va*) processes. In comparison, modern cosmolgy has a solid theoretical as well as observational foundation but it is still an evolving subject. Although Jain cosmology is conceptually very appealing, it differs in many respects from modern ideas ingrained in theories of origin (Big Bang Theory) and evolution (expanding phase) of the Universe. In this article we make an attempt to point out similarities and differences between some aspects of modern cosmology and Jain concepts.

Key Words: Cosmology, *Lokakash*, Steady State theory, Big Bang, Conservation Law, Structure of the Universe, String theory, *k 1 chakra*, cosmic cycles

Scriptures Quoted: Tilloya Pa??atti, Bhagavat S tra

1. Introduction

Origin of life, origin of universe, origin of earth etc. are fundamental questions of enquiry in philosophy, religion as they are in science. The Nasadiya Sukta¹ in Rig-Veda (ca. 3000 BCE) ponders over the mystery of origins and illustrates the philosophic depth of thinking, contradictions, uncertainties and complementarity, which are the basic tenets of Jain philosophy as also of quantum mechanics to describe the true nature of the universe. The Jain principle of *Syadvada* puts a limit on knowledge, similar to quantum mechanics as discussed in an

accompanying article by Bhandari and Pokharna (This volume).

Tremendous progress has been made in the field of cosmology, both observational as well as theoretical, during the past century. Even so, we are still far from a complete understanding of the origin, evolution and fate of the universe, as discussed in the preceding article by Rangarajan (2016). Hubble's observational evidence of galaxies speeding away from each other, indicated that the universe has been expanding. Extrapolating this expansion back in time led to the formation of the universe in the "Big Bang" event about 13.7 billion years ago. The universe has been expanding and cooling ever since, but whether this expansion will continue forever or not is highly debated. Various stages of physical and dynamical evolution since Big Bang have been quantitatively defined. In this scenario most of the matter was formed in a very short episode, starting at a tiny fraction of a second (10⁻³⁵ seconds) to 3 minutes since the Big Bang and then slowly evolved into stars and galaxies, i.e. visible matter under the influence of various forces operating in nature. According to the current ideas, the strongly interacting, visible, luminous matter in the Universe, in the form of stars, is only 4%. The rest of the matter, ~ 26% is weaklyinteracting, invisible or dark matter, inferred by its gravitational effects, and ~70% is dark energy, exerting a kind of repulsive force, resulting in expansion of the universe.

In spite of the success of the Big Bang model, what caused it and what was happening before Big Bang remains an enigmatic point. In this context other theories like Steady State, cyclic and oscillating universe are appealing and philosophically satisfying. Hoyle, Bondi, and Narlikar proposed the Steady State cosmology but later, to make it consistent with Hubble's observation of expanding universe, Narlikar tried to accommodate the Big Bang event in the Steady State model and modified it to a "Quasi Steady State" theory, in which the universe is oscillating between contraction and expansion. One of the most discussed theories at present is the string theory, not yet fully established, but considered to be a good

1. The Nasadiya Sukta ponders over the question of "what was there in the beginning, before water, air, light and Earth, universe and God came into existence" and describes the conditions "there was neither non-existence nor existence then; no death, no immortality; no day, no night; no above, no below etc.; Who really knows, it asks? Perhaps it created itself, perhaps it did not. May be it was the Hiranyagarbha, the primal nucleus. Perhaps He who looks from the highest heavens knows or even he knows not, it says"

candidate for unifying all the forces in nature (electromagnetic-weak nuclear, gravity, and strong nuclear) and can possibly lead to Theory of Everything (TOE). Efforts are underway to develop a model of the universe based on Quantum theory and General theory of Relativity.

Jainism subscribes to Steady State theory, in which the universe is eternal, without beginning and end. The Jain scriptures have discussed constituents, structure, size and time cycles (*K l Chakra*) operative in the universe in great detail. Jain cosmology, formulated about 2600 years ago, divides the universe in two parts - *Loka* and *Aloka*. *Loka*, the visible part of the universe, is finite, defined by the presence of six basic constituents (*dravya*), *j va* (soul), *pudgal* (matter), *kash* (space), *k l* (time), *dharm stik ya* (considered to be responsible for motion) and *adharmastikaya* (responsible for the state of rest). *Loka* is immersed in the infinite *Aloka*, which is pure space, devoid of all other five constituents and is invisible. So far as material i.e. non-living (*aj va, pudgal dravya*) and living-beings (*jiva*) are concerned, they are always in a dynamic state, continuously interacting with each other and changing their forms and modes.

The geometrical shape of the Jain universe i.e. *Loka* (pictorially described as a man in a standing pose with elbows stretched out), is quite peculiar. No such structure is found in nature and such a structure is unstable according to the laws of physics. We therefore take the view that the diagrams in the scriptures do not represent physical aspect (structure, shape etc.) of the universe and are symbolic and illustrative pictograms, like an artist's conception, representing something else, which needs to be decoded properly. One likely explanation is that this structure represents a multiverse, i.e. three universes side by side.

In Jain Steady State cosmology, the universe has always been, in a gross sense, like as it exists now. To circumvent the problems of formation and destruction of the universe within the framework of the Steady State Theory, Jainism postulates cycles of various types within the steady State. The Jain concept of time cycle (kal chakra) within a steady-state universe is as follows. One complete cycle is divided in two parts, *Utsarpini* and *Avasarpini* and each of these half cycles are further divided in six "*Aaras*". Recent observations suggest that several time cycles, ranging from diurnal, monthly, to hundreds of millions of years are operative on earth. These include solar, lunar, climatic, geological, astronomical, galactic and cosmological cycles in the order of increasing time periods. These cycles (*k l*

chakras) regulate creation, evolution, sustenance and destruction. Following earlier suggestions by Jain (2010) and Bhandari (2010), Jain et al and Jain, Bhandari and Surana, (2017), in accompanying articles, argue that these *K l chakras* (periodic cycles) are climatic in origin and govern the earth and not the whole universe. There may well be other cycles of cosmic nature, which govern the solar system, galactic phenomena and the universe.

In spite of incomplete and imprecise description of subatomic particles, enunciated by the Heisenberg's Uncertainty principle, scientific observations show that every physical process in the universe is governed by certain laws, which are well defined and can be mathematically formulated with precision. Origin of everything that exists in the universe must follow these laws which are inviolable. These laws should have existed before anything came into being, so that they operate on every phenomena and all the constituents responsible for formation of the Universe. Observationally, we find that the universe has evolved over the ages but the laws of physics, which govern it, have remained invariant. Various attempts to find even the slightest variation in these laws with time have so far not been successful. Thus these laws are universal i.e. applicable at all places, at all times. This possibility envisages that either the universe has not been created and has been as it is since eternity. This forms the basis of the "Steady State theory" of the universe. Alternatively, the universe has come into existence spontaneously, swayambhu, i.e. self created. This is akin to the spontaneous breaking of super symmetry, a mechanism considered to be responsible for formation of the universe. At the present state of our knowledge, it is not possible to make a correct choice between various models mentioned above, some of which appear contradictory.

The questions that naturally arise are: How did these laws come into being and why are the laws in the form as they exist at present and not different? Are there other universes where the governing laws are different from those applicable to our universe? What makes these laws to be mathematically formulated with precision? These questions are not easy to answer, except to say that they are inherent in the very nature of the universe.

Jainism propounds that certain "entities" (*j va*, and *aj va* and the other *dravyas*, mentioned above) are eternal and the universe follows the steady state model according to which *jîva* and *ajîva* have always existed as they exist now. There is no origination or creation, causal or spontaneous. But the scientific evidence

suggests that the universe, the Earth and life on Earth have originated at some point of time and gradually evolved to the present state and eventually they will be destroyed. It has also been observed that all the stars, galaxies, galactic clusters, molecular clouds, planets and other constituents of the universe are evolving, disintegrating and new stars and galaxies etc. are being formed. According to the fundamental Jain law, *Tripadi*, everything (living or non-living) which is created, continuously changes its form and is ultimately destroyed but its basic 'essence' (*dravya*) is indestructible and permanent even though the cycles of changes continue *ad infinitum*. The quality of permanence is akin to the basic law of conservation in physics.

Even so, it is difficult to visualize the cause or the motive force responsible for creation of the universe. In this context, a Buddhist concept of Karma as the driving force, is appealing. According to this proposition, karmas of sentient beings are the motivating force for origination of the material universe, or at least various habitable planets including the earth (as well as hell-like or heaven-like habitats). Appropriate habitats and their environments are spontaneously created by nature where the sentient beings are reborn to expiate the consequences of their accumulated karmas of their past lives. Thus karma (or causality) is the prime force driving the universe.

Although many features of Jain cosmology do not agree with the modern observations, it is quite amazing that the precision with which such calculations have been given in the scriptures, documented several millennia ago, are comparable to the precision obtainable presently. Unfortunately there is enormous confusion regarding the values of units of space and time appearing in various texts so that a comparison of jain cosmology with contemporary cosmology is difficult. In an accompanying article (*Jain and Jain*, this volume) an attempt has been made to rationalize the values of various units given in the scriptures. It is possible that these inconsistencies have crept in the undocumented records that were transmitted orally from one generation of Acharyas to the next over the intervening period of several centuries or due to the influence of other philosophies in vogue in India, by the time the Jain texts were formally documented. Nonetheless, it appears that the basic concepts and approaches may have survived without much distortion. We

¹Beginningless and Endless Universe: Bhagavati Sutra, 1-6-1, Q-9. "There is no sequence of beginning and end of the constituents of the universe, because it is eternal".

now make an attempt to compare some features of modern concepts with the corresponding Jain concepts.

2. Modern Cosmology

One of the core assumptions on which some of the current theories of cosmology have been developed is that the universe is isotropic and homogeneous and is time-invariant (in its gross characteristics), an assumption known as the Perfect Cosmological Principle. Theoretical considerations imply that a static universe is not stable and therefore dynamic models (expanding, cyclic, oscillating universe etc.) have been proposed. Before we make an attempt to understand the way the universe originated, it is necessary to define what is meant by universe. One way of defining the universe is that it is the totality of space, time, matter and energy, i.e. universe includes everything that exists. The *j* va (soul) has been given no role in the modern cosmology, although it is considered to be an important element of universe in Jain cosmology. In this respect Jain cosmology is much wider in scope.

2.1 Big Bang Origin of the Universe

The currently acceptable theory of origin of the universe, well supported by observations and theoretical calculations is the "Big Bang" theory but other models are also plausible. According to the Big Bang model, the universe originated as a singularity, which 'exploded' about 13.7 billion years ago. There was nothing before this event; no matter, not even time existed before this event, and since space and time occur together in the 4 dimensional space-time continuum, even space may not have existed then. It is not clear what actually 'exploded', but according to the models, the seed universe consisting of energy, space and progenitor of matter or only quantum vacuum underwent rapid expansion, cooled and evolved at progressively slower rates with time, and was sequentially controlled by quantum gravity, electroweak and subsequently by strong nuclear forces. The initial 10⁻⁴³ seconds, called the Planck time, was the phase of quantum gravity when temperature of the nascent universe was higher than 10³² Kelvin. After this it entered the Grand Unification epoch which lasted till 10⁻³⁴ second. Electroweak forces dominated its evolution up to 10⁻¹⁰ second and were followed by the radiation dominated phase. Thus in the beginning events happened quickly, within a small fraction of a second.

To start with, there was only radiation which got quickly converted into matter as space expanded, time progressed and the temperature of the universe reduced. It took about 100 seconds after the Big Bang episode for the universe to enter the matter-dominated phase when fundamental particles were formed from radiation. The first to form was quark-gluon plasma and leptons (e.g. electrons). They quickly combined to form protons and neutrons, which in turn fused and subsequently interacted with electrons to form atoms of elements such as hydrogen, helium and lithium. These atoms combined in definite proportions to form matter as it exists today. As the universe expanded in space with time, the reduction in its temperature enabled the formation of cluster-like structures. The matter thus formed was dominantly Baryonic (nuclear) which is what one sees around today. As matter-dominated phase started, the cooling process became faster and the radiation got decoupled from matter. During this stage, the matter in the universe became optically transparent. Inside the clusters, formation of individual stars took place due to gravitational contraction of molecular clouds of hydrogen, which by the process of thermonuclear fusion produced various other heavier elements. As the universe evolved further, various generations of stars formed, evolved and disintegrated, resulting in the formation of a variety of objects including our solar system containing the earth and eventually life began to evolve. The radiation which decoupled from matter around 300,000 years after the Big Bang episode cooled and reached the present temperature of around 2.7 K as a nearly isotropic background radiation in the infrared wavelength region, as discovered about half a century ago.

In this way, starting with nothing (quantum vacuum), the whole universe with its galaxies, stars, planets etc. were created. One of the major problems with this scenario is that matter and antimatter should have been formed in equal proportions but what we actually see around today is only matter and there is no trace of antimatter. The question that is still unanswered is: where has all the antimatter gone? It may have formed another isolated universe, because matter and antimatter cannot coexist since they annihilate each other instantaneously, producing intense radiation.An accompanying article by Kachhara and Jain discusses this problem in some detail.

Thus we have seen that the universe has been expanding and cooling ever since it came into existence. In this theory most of the matter was formed in a very short episode, starting at a tiny fraction of a second (10^{-35} seconds) that lasted up to 3 minutes. Thereafter the changes in its composition and structure were very slow. It took a billion years for galaxies to start forming. The theory of expanding universe is

primarily based on the observations of Edwin Hubble (1889-1953), a pioneer in the field of extragalactic astronomy, that all the galaxies are receding, i.e. moving away, from each other. He found that, farther we go, the light emitted by a galaxy shifts progressively towards red (longer) wavelengths. According to the Doppler Effect, when a source of light moves away from an observer the wavelength of source/light becomes longer, shifting towards red wavelength. Based on the red-shift measurements, Hubble came to the conclusion that farther a galaxy, redder is the light received from it, implying that faster it is receding away from us.

2.2 Steady State and Other Theories

Whereas there is a general agreement among scientists on the expanding universe model, there have been competing theories to Big Bang. Cosmologists Fred Hoyle, Thomas Gold, Hermann Bondi, and Jayant Narlikar proposed the Steady State cosmology in 1948, although it contradicted the expanding universe model.The expanding universe model requires continuous creation of matter, to compensate for the expansion, for which no evidence has been found. To accommodate the Big Bang event in the Steady State framework, Narlikar subsequently modified it to a "Quasi Steady State" theory, in which the universe is oscillating. The expanding universe is just the current phase which is ultimately going to enter a contraction phase. In this theory, the Big Bang is the current expanding phase of this cyclic Quasi-Steady State universe. Other proposed theories include cyclic universe, which repeats itself, between formation and destruction with a certain time period.

3. Visible Universe

We first look at the modern concepts describing the nature of the universe. After the Big Bang episode, the universe underwent a short phase of rapid expansion early in its history, called 'inflation' and has been slowly expanding ever since (Rangarajan, this volume). But, since we are located within it, we can only see or observe only a part of the universe, because farthest we can see is the point wherefrom the light can come to us over the age of the universe, i.e. 13.7 billion years. What lies beyond this region (13.7 billion years × velocity of light = 3×10^{23} km) is and will never be visible to us. This is due to the fact that light originating from a source beyond this distance would take more than 13.7 billion years, i.e. more than the age of the universe to travel to us, and therefore can never reach us. In an expanding universe we can see earlier phases of the universe and this distance of
observable universal becomes 93 billion light years all around the Earth (R. M. Jain and A. Jain this volume. Therefore, there is an observable part of the universe and an unobservable part.

Secondly, universe, by definition, contains everything and hence there could be only one universe. However, for the last few decades, it has been debated whether the universe is actually a multiverse, comprising of many universes and ours is only one of them. Can we observationally infer their existence, or is our universe completely isolated from other universes? Theoretically, we can address these questions using the General Theory of Relativity. The quantum theory of gravity combines quantum mechanics, the rules governing small, elementary particles and the General Theory of Relativity in which gravitation plays a dominant role. It is known that at the minutest level, there are elementary particles of matter (quarks, leptons and carrier particles etc., in all 18 of them, together with their anti-particles of various types (see Kachhara and Jain (2015); Bhandari, 2010) and the three forces of nature (gravitation, electroweak and strong nuclear forces), which govern the behavior of these particles. Together, these constitute the universe. Can all of these be described by a single theory, supposed to be the Theory of Everything (TOE). Attempts to integrate various theories of matter and forces into a single theory have so far not met with much success, although many propositions have been put forward.

4. Shape of the universe

Simply stated, the shape of the universe is determined by competition between the outward momentum produced by expansion and the inward pull due to gravity as a function of space and time. The rate of expansion is expressed by the "Hubble Constant" while the strength of gravity depends on the density and pressure of the matter contained in the universe. The fate of the universe is then governed by its density; if it is less than a certain value called the "critical density" which is proportional to the square of the Hubble constant, then the universe will continue to expand forever. If the density of the universe is higher than the "critical density", the gravity will eventually dominate and the universe by itself will collapse back into the so called "Big Crunch". These two conditions give rise to a closed spherical universe and a saddle like open universe respectively (Fig. 1). If the density of the universe is exactly equal to the critical density, the universe will remain flat, as shown in Fig. 1. The density of the universe also determines its

geometry; if it exceeds a certain critical density, then the geometry of space is closed and positively curved like the surface of a sphere. If it is less than the critical density, then the geometry of space is open and negatively curved like the surface of a saddle. If it exactly equals the critical density, then the geometry of the universe is flat. Thus, there is a direct link between the geometry of the universe and its fate whether it will continue to expand, eventually contract or will maintain status quo for ever.



Fig. 1. Various shapes of the universes with positively curved sphere having closed geometry with critical density \bigvee \bigvee plain geometry, flat $\bigvee \neq \bigvee$ and saddle- like negatively curved, open geometry $\bigvee \checkmark$ \bigvee If they are juxtaposed one above the other, we get a shape similar to the Jain universe according to N. L. Kachhara (2011) (Source : Wikipedia).

Results of a recent study suggest that the expansion rate of the universe is actually increasing and not slowing down (Riess et al., 1998). One way this can happen is if a certain form of matter (or energy) exists which exerts a strong negative pressure. This is sometimes referred to as "dark energy" which is responsible for the accelerated expansion of the universe, during its infancy. In a sense the dark energy, being responsible for motion, which led to inflation of the universe, may be equivalent to dharm stikaya of Jain universe, as will be discussed later. If, however, dark energy were to play a significant role in the evolution of the universe then, in all likelihood, the universe will continue to expand forever.

Recently the temperature of the universe has been measured using spacecrafts (Hinshaw et al., 2009). The density of the universe, based on the observed fluctuations of the microwave background radiation temperature, is found to be close to the critical density \lor and, therefore, it appears that the geometry of the universe is flat. It may, however, be noted that the observations have a small (about 2%) error, which can influence this conclusion.

Two things are clear from the data obtained from observational astronomy. Firstly, everything in the universe is rotating, around its own axis as well as around the centre of the system, be it planets, sun, galaxy or other celestial objects. Secondly, everything in the universe is expanding and contracting, in howsoever miniscule a manner (akin to breathing), be it the sun, earth (together with its atmosphere), or stars. While discussing the Jain cosmology these two points must be borne in mind.

5. Jain Cosmology

Jain texts have described the origin, constituents, shape and dimensions of the universe in form of short *shlokas* and in a series of questions, asked by Gautam swami and answered by Bhagawan Mahavira. At places, some inconsistencies are encountered. We therefore summarise below some of these aspects but we refrain to discuss the dimensions because they are difficult to convert in to modern space or time units (see Jain and Jain for rationalisatio of Jain units).

5.1 Constituents of Jain Universe

As has already been mentioned, Jainism has divided the universe into two parts - *Loka* and *Aloka. Loka*, the visible part of the universe, is finite, defined by the existence of six entities (called *dravyas* or reals) : *jîva* (soul), *pudgal* (matter), *k sh* (space), *k l*(Time), *dharm stikaya* and *adharm stik ya*. The equivalents of the last two entities are not understood in terms of modern cosmology, but according to the scriptures, they are related, respectively, to motion and state of rest of *jiva* or matter (*pudgal*). They have been frequently mentioned in Jain texts as medium of motion and medium of rest respectively. In the context of the above discussion we may speculate that they are related to some kind of accelerating and retarding forces, respectively. Dark energy could be a possible candidate for *Dharm stik ya*. There may be a serious objection to this statement because forces and dark energy are matter (*pudgal*) and *Dharm stik ya* is not *pudgal* (although it is *ajiva*) according to scriptures. We will continue this discussion later in this article.

The *Loka* is finite in size and its extent is defined by the presence of the six *dravyas*, mentioned above. The *Loka* is immersed in infinite *Aloka*, which is pure space and does not contain any of the other *dravyas* existing in the *Loka*.

5.2 Shape of Jain Universe

The shape of the Jain universe (*Loka*) is quite peculiar (Figure 2). According to physics, spheroids, ellipsoids, discs and annular shells or annular rings and

cylinders have a stable structure in nature. This is because of various natural forces acting on them. Trapezoidal or parallelepiped, rhomboidal and conical structures with sharp edges and corners are not stable and even if they are formed, they quickly acquire one of the above stable shapes. Astronomers have observed a large part of the visible universe. They find that only a few structures, like an ellipsoid (or its special case spheroid, such as the sun and the various planets) and a disk (such as a galaxy) are stable over long periods of time. Certainly a static, multi-cornered body like Jain *lokakash* immersed in an infinite *Aloka* is inherently an unstable configuration according to the laws of physics. Therefore, there is no way in which the universe can have this shape. We take the view that this diagram does not represent the actual shape of the universe, but some other, more fundamental, feature of the universe. Several possibilities have been invoked to get an agreement between such a structure (Figure 2) and modern cosmology. We discuss three of these propositions here.



Lokakash, 14 Raju

Middle loka

Fig. 2. Shape of the Jain Lokakash (front view) likened in shape to a man standing, with his elbows stretched. On the right is shown the top view of Middle loka, containg humans and animals.

Jain *Lokakash* is sometimes pictorially depicted as a hexagon resting on an inverted conical section with a flat base with finite thickness, as shown in Fig. 2. In some versions (e.g. in Shvetamber Jain tradition) the sides of this structure are smoothened to various degrees and are shown as rounded. Various parts, from top down, are called *Siddhashila* (space of purity, stated to be the abode of *Siddhas*), of devas, of humans (animals and other living beings), and hell respectively. Both *Urdhvaloka* and *Adholoka*, each are further subdivided into 7 distinct regions, as marked by faint lines. In addition, there is *Trasanadi* connecting the top of the loka to the bottom, half way along the depth of loka, as shown in this figure. The soul can instantaneously (in a few (1 to 4) *"samaya"*, the smallest unit of time) travel from one part of the universe to another through this *Trasnadi*.

1. Theoretically, three types of universes are possible, characterized by positive curvature, flat, and with negative curvature, with density values greater than, equal to and less than the critical density respectively (Figure 1), as discussed above. N. L. Kachhara (2011, 2013) has pointed out that if the universe is created as a triplet with all these three types of universes juxtaposed one above the other, with spherical universe being at the top, the flat one in the middle and the saddle like universe at the bottom, we may geometrically get a structure approximating the shape of Jain *Lokaksh* mentioned in Jain cosmology. The flat universe, called *Madhya loka*, containing *manushyaloka*, in which humans live, acts as an interface between the other two universes that have negative curvature (called 'hell' in Jain terminology) and the closed, spherical universe at the top (called heaven or devaloka by Jains), as shown in Figure 3. If this is true, then Jain *Loakaksh* is a multiverse theory.



Fig. 3: The three universes with positive, flat and negative geometries, produced as a triplet, juxtaposed one above the other to match the structure of the Jain Universe, as proposed by N. L. Kachhara (2011).

2. Some current theories e.g. Kaluza-Klein Theory suggests that the universe may have 11 dimensions, ten of space and one of time, instead of the four dimensional space-time universe, with which we are familiar (see Wesson, 1999). It is difficult to draw a multidimensional object on a two- dimensional paper. The sketch of the Jain Lokakash (Figure 2) may be pictorial projection of a four (or 11) dimensional object (see e.g. P. D. Ouspensky) on to a 2- dimensional sheet of paper.

3. There is another possibility that this is not a geometrical sketch representing the structure of the universe but symbolically shows some other fundamental features of the universe. J.R. Jain (2012) has pointed out that the diagrams given in the Jain texts are artist's conception or pictorial depictions (statistical pictograms), symbolically showing the total content of the universe, in terms of matter and living beings in their different phases, modes and states in a systematic method. The resultant shape is mistakenly construed to be the shape of the Universe.



Figure 4: Jain Lok k sh showing its 11 arms, as marked. Each arm may symbolically represent a dimension of the universe and may agree with the string theory (M-theory) which envisages an 11- dimensional universe, with 10 dimensions representing space and the eleventh dimension, marked by #7, representing time. The *Trasanadi*is proposed to be a wormhole that connects various parts of the universe.

*Trasanadi*¹ serves as an ultra-fast channel through which a soul can move instantaneously and spontaneously from one part of the universe to the other, say from *manushya loka* to *siddhashila* or *devaloka*. This reminds us of the characteristics of wormholes deduced on the basis of the General Theory of Relativity. The sketch in Figure 4 can therefore be understood as representing the 11 dimensions of the universe as envisaged in the string theory and *Trasanadi*, resembling a wormhole. However, it may be noted that wormholes require a special, highly dense spacetime geometry and hence may be very rare. Also many properties of worm holes are quite different from that of the *Trasnadi*, mentioned in the scriptures. Eventhough, this comparison of *Trasnadi* with wormholes is highly speculative, in support of the above proposition, we will discuss here some features of the string theory and worm holes in section 7.

Currently, one of the most debated theories is the string theory, not yet fully established, but considered to be a possible candidate for the Theory of Everything (TOE) and appears to have some relevance to the Jain view of lok k sh. We, therefore, describe the essential aspects of the String theory here.

According to Jain cosmology, the finite lok k sh is immersed in the infinite Alokakash. For stability, there are three requirements: (i) The structure should have a stable shape, like a sphere, disk or cylinder; angular shapes like Jain Lokakash (trapezoidal or parallelepiped, rhomboidal and conical structures with sharp edges and corners etc). are intrinsically unstable as pointed out earlier (ii) The Jain *Lokakash* should be rotating with respect to Alokakash. A static body is unstable and only if it rotates, it can have a stable configuration, (iii) There should be a region of interface between Lokakash and Alokakash, to allow for a smooth transition from one to the other. Such interface regions, called *vatavalayas*, have been mentioned for many celestial bodies but are not specifically proposed around Loka immersed in Aloka². Some gross features, like theories of origin, structure, constituents and time scales, etc. of the modern and Jain cosmologies are compared in Table 1.

6. Jain and Modern View of Space and Time

According to Jain concepts, space and time are the two of the six essential constituents of the universe, besides matter, living beings, *dharm stik ya* and

^{1.} Trasnadi. Tras-jeevas are not confined to Trasnadi only, but are scattered throughout the Loka. 2. An example in Agamas mentions that if somebody stretches an arm from Loka towards Aloka, it will not enter Alokakash because the six dravyas do not exist in Alokakash.

Parameter	Modern Cosmology	Jain Cosmology	Comments
Origin	Big Bang; alternative models which	Eternal, Steady state	Big Bang took place around
	are cyclic, oscillatory and Quasi		13.7 billion years before
	steady state have been proposed.		present
Size	Infinite	Finite, but immersed in	Loka has dimension of 14
		infinite Aloka.	Rajju
Constituents	1.Space	1. Akash	In modern cosmology jiva is
	2. Time	2. K la,	not considered as a separate
	3. Matter (radiation, energy)	3. Pudgal	constituent but emerges from
	4. Three forces (electroweak, strong	Dharmastikaya	matter. In Jainism there is no
	nuclear and gravitation) and their	Adharmastikaya	mention of any forces or fields.
	associated fields	Soul and jiva	
Structure	Three dimensional vast structure	Consists of loka of finite size	
	depending upon the following two	covered by Aloka of infinite	
	aspects.	size. The Loka consists of the	
	1.Its Local geometry depends on	six components, while Aloka	
	curvature produced by the observable	is vacuum. The Loka is well	
	universe, which is about 46 billion	defined in ancient units of	
	light years in radius.	Rajju/ yojans etc. which are	
		difficult to convert in modern	
	2 Its global geometry concerns the	units of space.	
	topology of the universe as a whole		
	topology of the universe as a whole.		
main objects	Sun, moon, planets, comets, asteroids,	Sun, moon, planets, comets,	In Jain cosmology there is
	stars, galaxies, interstellar dust/	siddha kshetra, Urdhva Loka,	direct connection between
	plasma, molecular clouds, nebulae etc.	Madhva lok, Narak Loka are	Madhva lok and siddha kshetra
	I ,	described.	through a channel known as
			Trasnadi
	It is highly dynamic: The whole	Static, isotropic,	
	universe is expanding in size, and is	homogeneous, and uniform	
State	filled with isothermal background of	0	
State	~2.7K.		
	Origin: 13.7 billion years ago, earth	K 1 chakra defines a full	These K lchakra cycles are
	formed 4.56 billion years ago. Life on	cvcle of kodakodi time.	probably climatic cycles, as
Time cooles	Earth appeared 3.5 billion years ago	divided into two half cycles,	argued byJain et al, 2012;
Time scales	and evolved by Darwinian evolution;	utsarpini and Avsarpint, each	2014.
	Diurnal, lunar, annual	of which are further divided	
	(solar), astronomical and cosmological	into six Aaras. The kodakodi	
	cycles operate as solar system moves	time scales have not been	
	in the galaxy with 250 million year	converted into modern units	
	period.	of time.	
	^		

Table 1: Comaprison of some features of Modern and Jain cosmology at a glance

adharm stik ya. The philosophical, historical and modern aspects of these *dravyas* have been very lucidly discussed by Muni Mahendrakumar in his book "Enigma of the universe". In comparison, according to modern cosmology, space and time, in addition to matter (particles, radiation), three basic forces (nuclear, electroweak and gravitation) and their fields constitute the universe. As far as *Jiva* is concerned, modern cosmology subscribes to chemical or abiological origin whereas Jainism considers soul to be eternal and *jiva* to be a combination of soul and matter. As far as matter is considered, there is a good agreement between Jainism and modern concepts (see Kachhara and Jain, This volume), although in Jainism, matter is eternal and in modern cosmology, it is created immediately after Big Bang. When the matter has an appropriate configuration or structure, the soul enters it and forms *jiva*. Regarding space and time there are some similarities and some

dissimilarities as we discuss below. *Dharm stikaya* and *adh rmastikaya* will be briefly mentioned later since there is no clear idea about them.

Jain scriptures consider space as just empty (void), in which all other constituents of the universe exist. Thus space gives place to everything that exists in Loka. It is eternal (without beginning and end), cannot be created or destroyed, is homogeneous and uniform in all properties, and it is static. Most importantly it is passive and non-interactive with any other coexisting constituent. Thus it permeates the whole universe, but is only a facilitator, not partaking in any process, and remains unaffected by anything present in it, such as jiva¹ (soul), matter (*pudgal*) or any forces. Ak sh fills the Loka, has the same expanse as the Loka and exists even in Aloka. It is indivisible and continuous but sometimes it is considered to be made up of infinitesimally small units of space, defined as "pradesha" or "unit space". In comparison, modern concept of space is that it is continuous, is three dimensional, and together with one dimensional time, it makes four dimensional space-time continuum. However, space is affected by matter, force and fields (i.e. by the gravitational force that the matter exerts). Gravitation curves the space around the object, to the extent governed by its gravity, and in turn, space governs the motion of matter. Thus the two types of spaces: pure, passive space or Jain-space (k sh) which is non-interactive and modern space (dynamic space) which is interactive are conceptually very different. Thus we see that according to the General Theory of Relativity, the modern concept of space is not the same as Jain concept of *k* sh. To differentiate between them we henceforth call Jain-space as kash.

Time is more difficult to define (see the accompanying article by Prasanna for concepts of time). According to Jainism, there are two types of time: Absolute and Empirical. Jainism postulates that Absolute time is eternal, without beginning and end, and is *apradeshi*, that is, it does not occupy space. It is linear and flows at a uniform rate. Empirical time (from the point of view of *vyavahar naya*), according to some scholars is a construct of mind and can be defined in different ways under different conditions. Jain scriptures, as also modern physics, invoke empirical or relative time as a measure of change i.e. the rate of change of a physical process is defined by time. Although Newton defined time as absolute, according to the Theory of Relativity, time is relative and depends on the "frame of reference", and its motion i.e. the motion of the object with respect to the observer. Time is thus contextual and physical (i.e. empirical) and can be defined in many ways. There is

¹*Jiva (living beings) is defined as embodied soul.*

astronomical or cosmic time, defined with respect to the motion of the earth around the sun; sidereal time with respect to the stars; atomic time defined by radioactive decay; and psychological time related to the mind. The psychological time is controlled by thoughts. There is also the concept of "timelessness" (k lat ta), a state of mind in which time stays "still" and does not flow. We do not discuss psychological aspects of time here and confine only to the physical time. Modern cosmology postulates that time did not exist before the birth of the universe i.e. before Big Bang; time, space and radiation (i.e. energy which later converted into matter) came into existence simultaneously with the Big Bang event. In physical processes, time is reversible at a microscopic level, i.e. every physical process can proceed forward or backward and is valid even when one changes the direction of time. Increase in entropy is sometimes defined as the direction of time. The Special theory of Relativity postulates that measure of space and time depends on relative motion of the frame of reference of the object and the observer. Length of an object contracts (Fitzgerald contraction) and time can be dilated (time dilation) if the frame of reference of the object accelerates away with respect to the frame of reference of the observer, so that relative motion of an object reduces its size and a moving clock runs slower; neither time nor length are absolute.

Thus there are basic differences in the concepts of time and space in Jainism and modern science. A basic tenet of Jainism is that everything in the universe has infinite types of paryayas (modes), which manifest at different times at different places, depending on the prevailing conditions. Thus every entity behaves in a manner determined by the perspective from which it is observed. To explain the behaviour of various entities, Jainism postulates various types of nayas, i.e standpoints or perspectives. We consider here two types of Nayas: absolute (nischaya) naya and practical or behaviorial (vyavah r) naya. To explain the differences in the properties of space and time, according to these two standpoints, we have two types of these entities. In the real sense, the *k* sh and *K* l of Jainism are absolute, according to nischaya naya and the space and time of modern science are their practical modes from the point of view of vyavahar nayas. The absolute space and absolute time are then constituents of the universe but what we observationally deal with in science are the practical space and time. Absolute time, is considered to be made of "unit time" or "k l nu", similar to the modern hypothesis of "chronon" and absolute space is made up of pradesha or unit space. In practice, from vyavahar naya point of view, both of them appear continuous.

Mahendra muni (2010) has discussed various aspects of space and time (including their units mentioned in scriptures and their equivalents in terms of modern units) and compared them with their descriptions given in the Jain texts. If the properties of modern "space" and empirical "time" used in modern cosmology can arise from k sh (absolute or pure space) and k l (absolute time) respectively, then Jain and modern concepts can be reconciled. This appears to be a good problem for further investigation. Alternatively, if *dharm stik ya* and *adharm stik ya* can make absolute space or *Loka* space behave like space of modern cosmology, which gets curved around matter and, in turn, affects the motion of matter, then Jain concepts and modern concepts can be reconciled.

6.1 Dharm stik ya and Adharm stikaya

Thus we see that there is an agreement between cosmology and Jainism on the three constituents of the universe, i.e. matter, space and time, but this is only apparantly so. In their innate characteristics, there are fundamental differences. Also, there is no clarity about *dharm stik ya* and *adharm stik ya*. According to the experiments conducted by Michelson and Morley, in late 19th century, the concept of medium of motion (postulated as the all pervading, stationary luminiferous aether, considered to be equivalent to *dharmastik ya*) has been disproved. We do not have much idea of what is *adharm stik ya* (interpreted as a medium of rest) in terms of modern scientific concepts, although some candidates, like inertia or friction, have been proposed and debated. We propose here three possibilities which may be investigated further.

- (i) We have seen that the same three constituents (space, time and matter) are mentioned in Jain and modern cosmology. The only difference is that Jain cosmology mentions *dharm stik ya* and *adharm stik ya* whereas modern cosmology contains three forces (gravitation, electroweak and strong nuclear) and their *fields*. Efforts must therefore be made to see if *dharm stik ya* and *adharm stik ya* can, in some way, produce the observed forces and their fields.
- (ii) *Dharm stik ya*, being responsible for motion, can be considered to be equivalent to dark energy, responsible for expansion of the universe, as already mentioned earlier.
- (iii) In this context, it is pertinent to recall here the Newton's first law of motion (law of Inertia), according to which everything continues to

move with a uniform velocity or remain in the state of rest, unless acted upon by an external force. The origin of continuous state of motion or rest, i.e. inertia, may have origin in *dharmastikaya* and *adharmastikaya* respectively. This also is a topic worth further exploration.

The objection with the first two alternatives is that forces, fields, and dark energy are materialistic properties and *dharma* and *adharma* can not be derived from any of the other *dravyas* (*pudgal, jiva* (soul), *k sh* or *k l*). We may ask, what is that which operates all over the universe, does not take part in any processes, is eternal and yet is not any of the other dravyas. The only thing which operates all over the universe and is not any of the *dravyas* are the laws of science. The last alternative therefore looks more plausible.

7. Relativity, Wormholes, String Theory and Dimensions of the Universe

The General Theory of Relativity predicts that extremely intense gravitational fields can warp up both space and time which can provide shortcuts from one part of our universe to another. If our "universe" is a multiverse, consisting of many universes, a route opens up from our universe to some other universe through such wormholes. A wormhole is, in principle, like a tunnel with two ends, each end being at a separate point in space-time. Thus a wormhole is an Einstein-Rosen Bridge, a hypothetical topological feature that would be fundamentally a "shortcut" through space-time and there could exist intrauniverse as well as inter-universe wormholes. Such wormholes are very rare because of the requirement of very intense gravitational fields. Some of the aspects of General theory of Relativity, wormholes and time are discussed in detail in an accompanying paper by Prasanna (2016).

In the 19th century, space was considered to be three dimensional: up-down; front-back and left-right. Subsequently, time was integrated with space as the 4th dimension by Minkowski, who introduced the concept of Space-Time continuum. In 1919, Theodor Kalutza showed that if one extra dimension exists in the universe, electromagnetism can also be incorporated with gravity. Thus universe may be five dimensional: four of space and one of time. In 1926, the Swedish physicist Oskar Klein gave a physical interpretation of the extra dimension - it is wrapped up into small circles which are too small to be seen and, therefore, this dimension is unobservable.

The string theory postulates that the fabric of space is such that at the fundamental level, the elementary particles (i.e. electrons and quarks) within an atom are not 0-dimensional point objects, but rather 1-dimensional oscillating lines ("strings") that vibrate, resonate and manifest as various particles, depending on their frequency, mutual interaction and presence of nodes. The "superstring theory" proposes that miniscule strands of energy vibrate in 11 dimensions (10 of them related to space and one to time). The extra dimensions, other than the four known dimensions of space-time, have been compressed to extremely small scales so that they are not easily observable.

After ruling out the possibility that sketch in Fig. 2 represents the shape of the universe, for reasons discussed above, we may now speculate as to what features the Jain *Lok k sh* diagram actually describes. Looking at the sketch of Jain *lok k sh*, we find that it has 11 sides (arms). May be this structure with 11 sides is a way of symbolically representing 11-dimensional world. The *Madhya Loka* is connected to *siddha shila, Urdhva Loka* (heaven), *Adholoka* (hell) through *Trasnadi*, and it is mentioned that the soul can swiftly move from *Madhya Loka* to either of these three regions, depending on its karmic balance, over time scales of the order of a few "*Samaya**". This is possible only if these regions are connected with wormhole like pathways. We thus propose that *Trasnadi* is like a wormhole, which allows instantaneous movement of souls from one part of *loka* to the other (see Prasanna. This volume).

Some points related to this suggestion, as mentioned in the agams, need to be recounted here. Firstly, soul is not a physical entity and all the souls are not confined to *Trasnadi*; most of the immobile living-beings are located outside *Trasnadi*. Although all the souls can pass through the middle (*Madhya*) *loka* (which includes *Manushya Loka*, the abode of humans), they do not necessarily do so for every rebirth and may remain in the same region of the *Loka* without passing through *Trasnadi*. Only when the soul attains *moksha*, it moves to *Siddhashila* located in the "uppermost" part of *lok k sh*. Further, it may be noted that the soul cannot move back and forth between any of the four regions but all the pathways are routed through *Madhya Loka*.

Thus many of the disagreements between modern concepts of universe and Jain *lok k sh* are resolved if the *lok k sh* diagram is not reckoned as a geometrical figure, depicting its shape, but it is assumed that each one of its arms represents a

dimension of space-time. In such a case the 11-armed *lok k sh* is consistent with the M-theory in which the universe has eleven dimensions, ten of space and one of time. Further, transit from *Madhyaloka* to *Adholoka* and *Urdhva Loka* is possible if *Trasanadi* behaves like a wormhole.

8. Jiva

According to Jainism, *tm* (soul) is an important and independent constituent of the universe. *Jiva* is often considered to be synonym of *atma* but, for this discussion here, we prefer to distinguish between soul and jiva which should be taken to be embodied soul. *Atm* in Jain philosophy is considered to be eternal, unborn, undestroyable, pure and can not be defiled, but *jiva* are born, evolve, die and are reborn. In contrast, modern cosmology considers life to be a mere product of matter and it is not given much importance. Several accompanying articles (e.g. Jain and Jain) deal with *jiva* in detail and therefore we discuss only a few aspects, like its origination here.

8.1 Origin and Evolution of Life-Jain View

As mentioned above, Jainism does not subscribe to the concept of origination of life; *Jiva*, in its varied forms, existed since eternity and will continue to exist for ever. Since all the life forms exist all the time, it is taken to imply that Jainism does not subscribe to Darwinian evolution; This concept has been taken to mean that interaction with the surrounding environment does not lead to evolution, it is the karma which is the deciding factor and Jainism is anti-Darwinian. Some of these aspects have been discussed in the accompanying articles by Jansma and others and will not be dealt with here.

We show here that the above inferences are erroneous. We present a series of arguments to show that Jainism considers interaction with surroundings as an important trait of *Jiva*, it is not anti-evolutionary and it is consistent with some modern concepts of origin and evolution of life, such as chemical (abiogenic) origin, Darwinian evolution etc.

According to Jainism, there are two reservoirs, where infinite number of souls exists: *nigoda* and *siddha*. *Nigoda* is a single sensed *jiv stik ya*, with only one sense organ of "touch", having the lowest form of consciousness and *Siddha* is the pure soul, *atma*, with highest form of consciousness.

Jainism postulates that immobile nigoda jiva are embodied by earth, air,

water, energy and plants and recognises 5 types of immobile living-beings, viz, earth-bodied (*prithvik ya*), water-bodied (*apk ya*), radiance-bodied (*Teuk ya*), airbodied (*v yuk ya*) and plant-bodied (*Vanaspati k ya*). Scientfically, plants were not considered to be living till about a century ago when J.C. Bose showed that they are alive, although Jainism always treated them as alive. Scientifically, earth, air, water and energy are considered inert, non-living but, according to Jainism, Earth, air, water, energy and plants can exist in two forms: *sachitta* (conscious) and *achitta* (inert). Jain and Jain in an accompanying article have discussed these classes of *jiva* in detail and therefore we discuss this aspect here only briefly. These concepts would be consistent with chemical or abiogenic origin in the following manner:

Earth (solid substances), water (liquid substances), air (gaseous substances) and fire (energy) are normally considered inert. Let us take the case of water. Water is made of H_2O molecules as shown in Fig. 5. The water molecules exist individually in steam but in the liquid form, water molecules do not stay as individual molecules but join with other molecules of water to form a chain of structure as shown in this Figure. In ice phase these structures become more organised. Similarly other elements present in dissolved form in water e.g. sodium, chlorine etc., as in common salt solution, form a chain of molecules.

Thus, to summarize, Jainism proposes that when chemical, non-living structures are having a configuration suitable to sustain a particular type of life, an appropriate soul descends in the molecular structure (RMSS) and makes it alive. Such structures, which have one sense of touch, can be considered as the point where life can originate. Such a scheme of structures exist for liquids, and gases, earth etc. Dr. Jack Szostak has proposed that this is the way life originated. If molecules of N, P, C and H are present in water, they form a linear or circular or other forms of chains. When the configuration is right, i.e. it acquires a helical structure, it may become a protein and eventually form a DNA like structure. This is the abiogenic or chemical origin of life. Thus life can be created chemically and Jainism provides a mechanism of integration of soul and body for this purpose whereas scientists are working on the possibility that chemical compounds can, by themselves, start reproducing and in this sense can be considered alive.

It is easy to break the structure, e.g. by boiling a liquid or by a mechanical disturbance when it will lose the sense of touch and will become *achitta*. This is illustrated in Fig. 6a which shows a number of molecules, randomly moving in the



The Physical States of water



Fig. 5. Water molecule consists of two negatively charged hydrogen atoms (blue) at an angle of 104.5°, attached to a positively charged oxygen atom (red) through a chemical divalent bond. In steam, water molecule may float individually (lower right) but in liquid form (water) they do not remain independent and many of them join by a delta bond to form structures. In ice they form large molecular structures, as shown in the lower left (courtesy, Wikipedia). Such structures form and exist in earth, air and in a group of energetic material particles any where, besides water, and can act as receptacles for soul (we can call Receptable Molecular Structures for Soul, or RMSS), called Yoni, in which souls from the infinite ocean of souls in the universe, can descend and make them alive. This stage, when suitable structures for soul (RMSS) are formed can be taken as the beginning of life. Such organised structures can be considered as *sachitta* (live) phase, but with a slight disturbance (heating) or vibration (touch), the structures break down and the matter becomes *achitta* (life-less). This *sachitta* kind of RMSS form the infinite reservoir of *Nigoda*. More details are given in an accompanying article by Jain and Jain and the book by J.R. Jain.



Fig. 6. a) random floating molecules, achitta b) chains of molecules sachitta, c) replicate chains and d) organised structures.

medium. In Fig. 6b, they start forming a chain of organized molecules. There is always a bond which is not fully satisfied and whenever a suitable molecule comes by, it joins the chain. These chains can be easily broken or divided either by mechanical or thermal disturbances, for example by vibrations, currents, waves or heating or by presence of absorbing surfaces, and the liquid becomes *achitta*, a purely chemical solution. In course of time, these chains break into two or more groups and each daughter chain, inherits the parents properties and continues to grow and replicate. A sort of competition sets in and a polymer chain which grows faster, dominates the population. At the same time, new templates are formed and the process continues. If suitable conditions prevail and supply of various molecules is adequate, and given enough time, they will continue to form long chains, vesicular and tubular structures or colonies and large, complex molecules of proteins, sugars, amino acids, polymers etc. and eventually, at a suitable time, a soul will descend and a living organism will emerge. This is the beginning of chemical synthesis, resulting in biotic molecules and origination of life and subsequently

biological, Darwinian evolution takes over (J.R. Jain, 2012). Chemical aspects of formation of large molecules, including amino acids, proteins etc. which are building blocks of life, have been experimentally demonstrated by Urey-Miller reaction, in which an energy source in form of electric spark and ultraviolet light is provided to a water solution having a mixture of simple molecules like carbon di oxide, ammonia, alcohol, methane, hydrogen etc. No living cells were produced in this reaction but this reaction established that it is easy to produce precursors of biomolecules. If life can be synthesized from chemicals, biochemists will claim that they have synthesized life whereas Jains will claim that the molecular structure that they have synthesized is suitable for a soul, from the omnipresent infinite reservoir of *Nitya Nigoda*¹ (having a single sense of touch) to enter the structure and make it alive. Thus Jain concepts are consistent with synthesis of life; only their explanation is different, since they consider soul as a *dravya*, independent of matter, which cannot be formed from matter. Recent scientific experiments have showed that DNA can be synthesized and when it is injected in a living cell, it starts taking part in the biological reactions of the cell. An accompanying paper (Jain and Jain) discusses various aspects of one-sensed living-beings and the role of nigoda. Some of these ideas are experimentally testable. If large biomolecules are stored for a long time, an infinitesimal fraction of them will acquire a soul from the nigoda and they should become alive.

Coming to the question of Darwinian evolution, we may quote the famous Jain principle of "*Parasparopagraho jivanam*", which clearly states that living beings are mutually dependent (or entangled with each other). This dependence arises by interaction with each other, directly or through matter, and results in Darwinian evolution.

9. Concluding Remarks

Modern cosmology is firmly based on observational astronomy, theoretical modeling and laws of physics. Many evolutionary aspects of the universe and their time scales are well understood. Even so, the origin of the universe remains an enigmatic topic and none of the theories, be it Big Bang, Steady state, Quasi Steady state, oscillatory or cyclic, is convincing. The ultimate fate of the universe, whether it will expand forever or eventually contract back to its initial state also cannot be

Agams claim that 608 jivas from the infinite reservoir of nigoda, in a period of six months and 8 samayas, get embodied.

predicted from the current observations of COBE (Cosmic Background Explorer) satellite or anisotropy measured by Wilkinson Microwave Anisotropy Probe (WMAP). Some basic concepts of cosmology described in Jain texts are appealing, at least aesthetically, and may be useful in this context. Jain cosmology is wider in scope because it considers *jiva* to be an important constituent of the universe and, in addition to matter, it also deals with living beings in contrast to the modern cosmology which is confined only to the material aspects. It may be mentioned that the Jain texts discuss many concepts in short, and sometimes mysterious, sutras and diagrams, which have not been properly interpreted and decoded. The discussion given in this article shows that some concepts are basically common in Jain and modern cosmology although several fundamental aspects of modern cosmology (existence of various forces, particles etc.) are not mentioned in the Jain texts. Even so it may be worthwhile to reconcile and reinterpret Jain texts in terms of modern understanding of the universe. It appears that integration of Jain and modern concepts may lead to a better understanding of the origin of the universe.

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Appendix 1 : Divisions of *Lok k sha*

The Lokakash (Figure 2) is divided in several regions (Bhagvati Sutra13-4-5):

(i) Urdhva-Loka.

The upper part is called *Urdhva-Loka*. It has a height of 7 Rajjus (unit of length). It consists of 8 regions, depicted by a horizontal bar. Each bar represents one type of heaven, (called *Deva Loka*), abode of Empyrean celestial-beings.

(ii) The Middle- Loka

The Middle loka is located around the mountain Meru. Innumerable pairs of circular landwater masses exist in the Middle- *Loka*. Its innermost circular land mass, termed Jambu dvîpa, is surrounded by a circular ring of saline ocean (*Lavana- Samudra*). *Manushya Loka*, where humans reside, is part of Middle *loka*.

(iii) Adho-Loka

The Lower- *Loka* consists of 7 regions each depicted by a bar. Each bar represents a type of land, called Hell, abode of Empyrean infernal-beings.

(iv) Siddhashila

A region of absolute purity exists above the *Urdhva Loka*. It is the eternal abode of *Siddhas*. When a soul attains enlightenment, it moves to this land of purity.

23. Enigma of Time

A.R. Prasanna

Abstract

TIME, has NO definition. It is a concept which everyone knows about but no body is able to define. It is a commonly used term yet defies description. It is no wonder that thinkers from the very early civilisations have pondered over this entity called time, be they religious seers, philosophers or scientists.

Historically, the beginnings of attempts to understand the Universe, that we are a part of, could be traced to Vedas and Puranas in India and to Plato and Aristotle in the West from very early times. The quest for understanding 'time' has lead to the concept of duration, which is defined as the 'time lapse between two events'.

While Newton needed the quantification of time for defining 'motion', for Einstein, it was a part of a structure within which the laws of the physical world was to be defined. While in the Special Theory of Relativity, he introduced the equal footing of time and space, in the General theory, he identified the most fundamental of forces, Gravity as combination of time, space and matter, which forms the Universe as we see around us.

The often raised questions about time are, is it real? Is it reversible? Can one travel back in time? Are the Physical laws eternal? In the following an attempt is made to raise the fundamental question of what Time is understood to be in Sciences, and how it is incorporated in the analysis of events in the Universe we are aware of. The subjectivity of Time endorses the observer's limitations in drawing conclusions about the laws of Nature. The arrow of Time is a reality which tells us the direction in which Nature progresses and its laws, which may or may not be eternal.

After briefly introducing the treatment of Space and Time in Special

Relativity, we discuss the Light cone and its structure, which forms the basis for analysing and understanding the solutions of Einstein's equations of General Relativity, through the Penrose diagrams. After a brief discussion on the arrow of time as understood from Thermodynamic and Cosmological points of view, the difference between a non rotating (Schwarzschild) and rotating (Kerr) black holes, is presented for illustrating the possibility of "time travel" which also leads to a picture of 'Multiverse' theories. Finally, with a picture of the history of our Universe, starting from the Big Bang to the Present, the question, how eternal are the 'Laws of Physics', is discussed.

Key Words: Concept of Time, Relativity, Time reversal, Laws of physics, Black holes, cosmology.

Scriptures quoted: Purana, Vedas.

1. Time and its Perception

TIME, the most enigmatic of all concepts perceived by the human mind is as elusive for definition, as its role is in our lives. Our perception of time depends upon the change we notice, the change that happens at the same location. What does one mean by the same location? It is well known that there is nothing fixed, except the point of location to the self. Hence it is clear that Time, the recorder of change, at a point is purely subjective. In fact, it is alluded that St'Augustine of Hippo (~ 400 BCE), a well known Christian theologian, had remarked " When no one asked about Time, I know what it is, but when someone asked, I do not know"! Perhaps this is true for most of us.

Time is associated with the events Past, Present and Future. It is just one's experience ordered sequentially as they occur, that gives one the notion of Time. This automatically, precludes any 'Objective' definition of Time independent of the one experiencing it. It is, in fact, something to wonder about, why Isaac Newton thought that Time was absolute! As he mentions in his Magnum Opus 'Principia', "Absolute, true, and mathematical time, of itself, and from its own nature, flows equably without relation to anything external, and by another name is called duration: relative, apparent and common time, is some sensible and external (whether accurate or unequable) measure of duration by the means of motion, which is commonly used instead of true time; such as an hour, a day, a month, a year".

In order to deduce his 'laws of motion', where the displacement of a body involves 'change of location', he needed the change to occur with respect to a 'measurable quantity'- the subjective time - whereas to describe the 'state of rest', he needed some independent parameter which is changing itself and that perhaps, he meant as 'absolute time'. Though the concept of relative motion is something Newton had accepted, he did not seem to have appreciated or explored the effects of relative motion on time, which later Einstein clarified in a natural manner. Though the concept of measuring time was perhaps known even before Aristotle, it was Newton who identified Time with measure of motion implying motion with all forms of change, for which he seems to have been guided by the astronomical practice, for understanding the 'uniformity', of time which he termed as 'Duration'.

The notion of absolute time that Newton conceived identifying with 'God', may be compared to that of 'Universal time' or 'Cosmic time', as perceived today. However, it is the 'Relative time' which is subjective, is the one that can be quantified and measured, with the uniformity of time as perceived by Aristotle, and which can indeed be understood as a pattern whose regularity is related to the phenomena under observation.

As Observation implies, communication of information between the observer and the observed, it is natural that the notion of Time gets intermingled with propagation of information and limitations of its measurement one can achieve. An important danger one has to reckon with at this point is the distinction between the physical measurement (using appliances) of time and the psychological perception of comprehension by the 'mind'. Let us first restrict ourselves to the discussion of the physical measurement of Time.

The main distinction between the views of Newton and Einstein, comes in the wake of the fact that Newton, who considered 'action at a distance', had no restriction on the velocity of information propagation, which allowed events to happen at varied different locations in space at the same 'time' for all observers, a notion which Einstein rejected, and restricted the propagation of information to a finite velocity, the velocity of light 'c', (electromagnetic signal) and further stated that 'NO physical ' signal can travel faster than 'c'.

Acceptance of this premise immediately implies that there is no 'simultaneity' of events for all distinct observers independent of his/her spatial location with reference to the events under observation. This is the main essence of



Fig.1. Observer O, receiving signals from P1 and P2 at a distance R1 and R2 away.

'Time being relative', a fact easily understood with a simple picture (Fig. 1) as follows: Consider two events happening at time t_1 at points p_1 and p_2 which are at unequal distances R_1 and R_2 from the observer O. Obviously, the signals from p_1 and p_2 reach O at times (t_1+R_1/c) and (t_1+R_2/c), which cannot be the same, meaning O will not see the events as being simultaneous.

It is thus, according to Einstein, also supported by repeatable experiments, 'time', becomes another coordinate, along with the spatial variables, in a four dimensional continuum of 'Space-time', with every event assigned the four numbers, identifying where and when the event occurred. If two events occur at points $P_1(x_1, t_1)$ and $P_2(x_2, t_2)$, then the distance between them is given by the function and in four dimensions expressed as.

$$ds^{2} = (x_{2} - x_{1})^{2} - c^{2} (t_{2} - t_{1})^{2}$$

and in four dimensions expressed as

$$ds^{2} = dx^{2} + dy^{2} + dz^{2} - c^{2} dt^{2}$$

with the sign difference indicating the separate nature of space variables and of time variable. This is generally known by the name 'Minkowski metric', named after the German mathematician Hermann Minkowski, who gave the geometrically intuitive picture of space-time, as a basis for defining the physical entities.

This notion of space-time structure for the underlying arena for all events automatically incorporates the concept of 'relative time' between different observers and the accompanying consequence of lack of simultaneity along with host of other physically meaningful and measurable aspects of modern physics, particularly the notion of "Time dilation", between two relatively moving observers, which is generally known by the effect that a fast moving observer's clock goes slower as compared to the clock of one at rest. This effect, a consequence of Special Relativity, was confirmed experimentally by comparing the half life of the radioactive particle, Muon from cosmic ray showers as compared to its counterpart produced in the laboratory. The success of Einstein's Special theory of Relativity as a foundational basis for almost all aspects of the twentieth century Physics, while on the one hand dethroned 'Time' from its Newtonian pedestal of being 'absolute', and made it a number attached to an event, it also provided a 'causal arrow', uniquely governed by the 'light cone' structure of the Minkowski space time manifold that reveals a meaningful definition for events, Past, Present and Future.

The distance function, defined above linking any two events, can obviously take all the three possible values, > 0, = 0, and < 0, because of its 'indefinite #nature, arising from its signature, (+,+,+,-) or equally valid (-,-,-,+).

Let us consider the case when $ds^2 = 0$. Writing it fully one gets [1]

 $ds^{2}=dx^{2}+dy^{2}+dz^{2}-c^{2}dt^{2}=0$

Asserting the fact that the velocity of the signal linking the two events is

$$(dx^{2}+dy^{2}+dz^{2}) / dt^{2} = v^{2} = c^{2})$$

which means that, it is a light signal having velocity c. For illustrating, if we restrict to two dimensions, the time and one space, we can write it using finite quantities, as $x^2 - c^2t^2 = 0$, or $x = \pm ct$.

Plotted on a (x,t) diagram, this equation gives a pair of lines which are asymptotes to a rectangular hyperbola as shown below (Fig. 2,a,b,c).



Fig. 2 (a) Asymptotes $x= \pm ct$, Rectangular Hyperbolae 4

(493)

Generalizing this to four dimensions by rotating around y and z axes, one gets, two right circular cones joined at the vertices coinciding at the origin O as shown in the figure.

As the generators of this double cone are the lines defined by ds=0, one has the generators as the paths of particles with dx/dt = c, or the photons (Blue lines), the particles of light. In other words the trajectories of light rays form a right circular double cone in the four dimensional space-time called the LIGHT CONE. or the "Null cone", as the distance between points on the cone ds = 0.



Fig. 2 (b) Light cone - Two right circular double cones joined at the origin



Fig. 2 (c) Time like (green), Space like (red) and Null -light like (blue) lines.

If one consiers the points lying inside the light cone, they are connected by the trajectories of particles with dx/dt< c , or what are called the 'Tardyons' (Green line), following lines with the distance function ds < 0. These are also called 'time like' trajectories, on which the actual physical particles move with velocity v < c. On the other hand, if one considers points outside of the light cone, they are connected by the trajectories of particles with dx/dt > c, for these points the distance function ds >0. Such particles having velocity v > c, are called 'Tachyons' (Red line), and their paths in the space-time are depicted by 'space like' trajectories residing outside the light cone. Thus all trajectories, time like, light like and the space like pass through the origin O, going from the lower cone region to the upper cone.

The point O corresponds to the 'present' while the region below represents the 'past' and the region above, the 'future'. Information from the past reach us along the past light cone as time flows in the forward direction indicating the 'causal arrow of time', which expressed in simple terms says that 'Every Effect should have a Cause in the past'. All our experiences are stored in the past light cone, from where we can often identify the reasons for some event that might follow in the future.

Deviating a little, let us briefly consider the perception of Time from the ancient Indian perspective, particularly the relativity of 'duration'. Whereas, the measures of the 'day', 'hour', and 'second' have been, as understood universally, with respect to the celestial motions of Sun, Earth and Moon, there seems to have been periods of measuring 'duration', ranging over a huge scale from micro to macro scales. The lowest being a 'Kshana' or a 'Nimisha', which is the time lapsed for twinkling an eye, and the largest being a 'Kalpa' defined as 25 years of Brahma, with one year of Brahma being equal to 311,040,000,000,000 human years while one Day of Brahma was considered equivalent to 8,640,000,000 human years [1].

There could be a little variation in the numbers expressed for the day of Brahma, depending upon the particular Purana one considers, but what is important is the concept of relative differences in measuring the duration, a concept imbibed in Einstein's Relativity, as depicted for different observers in relative motion leading to 'time dilation'. Speaking figuratively, what are few years for 'humans' would be only few kshanas for Devas. Further, the notion of cyclicity, inherent in the ancient Indian thought is expressed in the following [2];

"Hinduism's understanding of time is as grandiose as time itself. While most cultures base their cosmologies on familiar units such as few hundreds or

thousands of years, the Hindu concept of time embraces billions and trillions of years. The Puranas describe time units from the infinitesimal truti, lasting 1/1,000,0000 of a second to a mahamanvantara of 311 trillion years. Hindu sages describe time as cyclic, an endless procession of creation, preservation and dissolution".

Advanced technologies have developed aids to measure time in very minute intervals as Nano (10^{-9}), Pico (10^{-12}) and Femto (10^{-15}) seconds. How many can even picturise such short time intervals? The accuracy of measuring such Intervals in normal day to day human life is almost impossible and of little relevance. On the contrary, what about a virus or a bacteria whose entire life cycle could last only that long! Thus it is amply clear that 'Time', is purely a subjective entity and one cannot look for any objective definition of time.

The fact that the light cone structure as shown above, is symmetrical about the point O, representing the present, indicates in principle, that the laws of physics are time symmetric. Does it mean that one can go back in time to re- experience the past? Unfortunately, NOT. In practice, Time seems to move only in forward direction in everyone's experience, a fact for which, Sir Arthur Eddington in 1927, metaphorically, coined the phrase 'Arrow of Time'. There seems to be several aspects to this enigma associated with a wide variety of physical processes, and generally the time arrows are mainly classified as follows: Causal, Thermodynamic, Cosmological, Quantum, and the Psychological arrows of time.

2. Arrows of Time

Having briefly mentioned about the 'Causal arrow of time', already, let us consider the Thermodynamic arrow of Time. One of the most fundamental of physical laws attributed to Nature is the 'conservation of Energy', and associated with it are the first and second laws of thermodynamics, which say that, Energy cannot be destroyed or created and if a system is isolated, (no exchange of energy between itself and its surroundings), the potential energy of its equilibrium state will always be less than that of its initial state. The statement can be understood in the following way. Any isolated system, has to use its energy content as best as it can for its evolution from one state to another till it settles down to an equilibrium state.

If the initial state of the system is said to be in an ordered state, its evolved state would be considered as in a disordered state. For example, consider a box

containing some gas molecules in one part of the box which is separated from the other empty part with a partition; on removing the partition, the gas molecules would spread, moving around randomly till the gas reaches an equilibrium state occupying the entire volume of the box, when there will be no ordered distribution of the gas molecules! The degree of disorder thus obtained is known by the name Entropy and the transition from order to disorder evidenced in the above experiment is termed as the increase of entropy. While such a transition happens, some of the internal energy of the gas gets utilized, and thus the potential energy of the equilibrium state will be less than that of the initial state. Obviously, in such a case the system by itself can never get back to the initial state however long one waits (state before the partition was removed), when the gas molecules were confined to one corner of the box, the process is called 'irreversible'. However, there can be situations where the process can be reversible, in which case the entropy remains constant, as the entropy gained in the forward process will be lost in the backward process.

It should be noted that reversible processes can never happen in any isolated system, as the backward process requires interaction with the surroundings. The idea of irreversibility is what is closely related to the thermodynamical arrow of time, which is natural to all practical physical processes. It is often expressed as the increase of entropy, which marks the flow of time from past (gas in a corner) to future (gas occupying the entire volume of the box). Thus the thermodynamic arrow of time is identified with the increase in entropy of an isolated system.

Before moving on to the next point, it is important to realize that there could be some situations like a biological system or a self gravitating system, where the interpretation of the notion of entropy may not be as simple and straight forward as the possibility of reversibility, though being isolated, may be realizable. We shall try and discuss a little about them later.

What is Cosmological arrow of time? Cosmology deals with the history of the Universe. As all histories begin at a time t=0, the Big Bang event, associated with the birth of the Universe (Space, Time and Matter), considered as a 'singularity', the progress of time could be related only to the occurrence of forces and fields. The direction of time along the light cone indicates the progress of the Universe with matter coming from radiation and cooling to various forms under the influence of forces and fields. Closely associated with this is the expansion of the Universe,

which is revealed through the red shift of galaxies moving away from each other. As all the observational evidence seen today indicates only expansion, the time is elapsing in the forward direction as one understands 'Past' and 'Future' defined by the light cone. One may ask as to how can we decide the fate of the Universe looking at it from one small spot- the earth, which is less than a dot in the vast space of the Universe. One has to remember the continuous motion associated with all matter, and so, as the dot is moving all around the space, the point of observation at any instant is different both from the previous and the next instants, and the recorded observations of the expanding Universe is all pervading and almost the same in all directions in space. Thus the definition of the 'cosmological arrow of time' is also associated with the diverging Universe going from order to disorder, increasing its entropy. In this sense the Thermodynamic and the Cosmological arrows of Time seem to agree with each other.

Coming next to the Psychological arrow of Time, as it is associated with the perception of an individual, it is purely subjective and related to the changes and experiences of the individual. Here again the direction is from past to future for all material bodies. One may argue that an individual's mind can transgress this restriction as one can, in principle, go back in time in his/her mind to recollect the events past, but one cannot relive that experience or alter it to change the history. This again indicates that for matter in bulk 'Conscious meaning of Time' has to agree with the other two arrows of moving from 'Past to Future' through the 'Present'. In this discussion, I am restricting myself to the realm of scientific evidence only and leave the interpretations of parapsychology to other experts. In fact, this raises the question: how far can one quantify the comprehension of Time by the mind? As one believes, if the signals from the mind has NO speed limit, then what would the concept of time be? Would one then say that Time is beyond measurement but only duration is quantified as hinted by Newton?

3. Is time reversible? Is Travel to past possible?

As all laws of Physics, expressed mathematically, are the same with '-t' replacing 't', one says that the equations governing the physical systems are invariant under time reversal. But what does this mean physically? Though people have written a lot of Science fictions with reversing time as basis, so far they have been only that, Fiction!

With Einstein's General Relativity, and the subsequent discovery of Black

holes, as end product of massive stars, and the concept of the 'event horizon', the urge to look for the possibility of back tracking in time has taken a new turn. The very first solution obtained for Einstein's equations by Schwarzschild is given by the space-time metric [1]:

 $ds^{2} = (1 - 2m/r) dt^{2} - (1 - 2m/r)^{-1} dr^{2} - r^{2} dq^{2} - r^{2} Sinq dY^{2}$

which describes the gravitational field at the distance r, outside of a star of mass m =MG/ c^2 , centered at r = 0. In this geometry, the duration, dt is multiplied by a factor, which decreases continuously as the radius of the star reduces and tends to 0 as r tends to 2m. This indicates that as the star's radius is reducing, the signals from its surface, reaching the external observer, slows down and as r reaches 2m, it would take infinite time for the signal to reach an outside observer! Hence this surface of a star, when r = 2m, is called an Event Horizon, as events happening there would never reach the outside observer. This feature is well illustrated in Penrose diagrams as depicted below (Fig. 3), showing clearly the tilting of 'light cones', as they approach the Event Horizon, with light rays and time like lines all going towards the singularity r = 0 and no information is able to cross the horizon. The massive collapsing star going beyond its horizon, according to the theory, ends up as a 'Singularity'. and the star collapsed beyond the event horizon is called a 'Black hole'. As across any null surface, the notions of space and time get interchanged (as shown in the null cone picture), how does one interpret the arrow of time inside a black hole?



Fig. 3. Penrose diagram, for a collapsing star with bending light cones.

In order to understand this, one follows a geometric method of embedding the spacetime by using different sets of coordinates as depicted through Kruskal coordinates and Penrose diagrams. Though these developments happened in nineteen sixties, Einstein himself along with his Princeton colleague Nathan Rosen had obtained an embedding of the Schwarzschild metric, in 1935, showing the possibility of avoiding the singularity, by extension of space through the horizon into what is called a Hyperspace. In particular, they had shown that the Schwarzschild solution which represents a static blackhole, actually represents a bridge in hyperspace, now known as Einstein-Rosen bridge between two regions of the Flat space time. This passage between the two regions as shown (Fig 4 a,b) is popularly known as a 'Worm hole' which is the favourite of fiction writers for picturising travel backwards in time or travelling into the distant past or future. It is





(b)

Fig. 4 (a) (b) Worm hole joining the two mouths of black holes, depicting Einstein-Rosen Bridge

generally assumed that someone entering through the event horizon of a blackhole comes out through another one at some other part of the Universe or in some other Universe but completely at a different time which could be either in Future or Past. However, this possibility is improbable for a static Schwarzschild blackhole as the wormhole throat is not stable and shrinks to a point from within which no time traveller can escape outside as the ER bridge appears for a very short time [2]. Luckily, General relativity admits another important solution to Einstein's equations, discovered by Roy Kerr in 1963, which describes the field outside a rotating star which at the end becomes a rotating blackhole. Unlike in the case of Schwarzschild, where the event horizon shrinks to a point, here the blackhole, will have two ring type horizons , called the inner and outer horizons, thus making the mouths of the wormhole wider (Fig. 5).



Fig. 5. Ring like structured event horizons of a rotating black hole (Kerr)

As depicted in the Penrose diagram (Fig. 6), for a traveller the journey A is a conventional journey where he encounters no event horizon and thus avoids the singularity. Journey B takes him directly into the singularity as he crosses the boundary of Event Horizon, and gets crushed completely by tidal forces, after

which he cannot turn back. On the other hand, journey C which shows that he crosses the horizon and comes out in a different part of the Universe requires him to avoid laws of Physics by exceeding the speed of light. Though this possibility does not exist for a Schwarzschild wormhole, as pointed out above, the Kerr blackhole, having two horizons, gives the possibility of the journey D as shown in the diagram below, where the traveller will start from one part of the universe, passes through the two horizons and emerge elsewhere apparently without violating the speed limit. In this journey he may not only be at some other location when coming out, but also possibly some other time patch, which could be in distant past or distant future!!

This obviously violates 'causality', as is generally understood, if the traveller goes to his past, because then the effect seems to precede the cause, like he could witness the birth of his grandmother!! How does one avoid such a situation? What happens inside a blackhole? Discussing this possibility, in the context of traversable wormholes, Kip Thorne and co workers [3], showed that the causality violation may be overcome through the introduction of 'Exotic matter' through Quantum field theoretic effects of Casimir effect, which produces negative pressure, that can possibly give rise to negative energy and a consequent solution to any paradox that might arise with 'the arrow of time', and energy conditions of Hawking and Penrose. We shall not get into details of this physics here as it would be too technical and much beyond the scope of this article.

The Penrose diagram, depicted above, has also been interpreted in terms of a 'Multiverse' model of Spacetime, wherein the traveller D, comes out in an altogether different Universe, with the wormhole linking different Universes, and the horizons providing the doorways inwards and outwards. The solution obtained by Thorne and co-workers, for an Einstein-Rosen bridge, with exotic matter, was indeed recognised as a traversable wormhole, connecting two different Universes [5].

Very recent experimental observations [6] related to the polarisation of the cosmic microwave background radiation, seem to show the influence of the gravitational waves produced at the Big Bang, on the microwave background, giving credence to the inflation (exponential expansion of space) scenario of the very early Universe (see the accompanying article by Rangarajan,This volume). Associated with that, it has been argued by several cosmologists, that such a



Fig. 6. Penrose diagram showing the link of the inner and outer horizons of a Kerr Black hole [4].

runaway expansion could have created several bubbles, each of which could have given birth to a universe of its own and thus the initial singularity which gave birth to Time and Space could have created Multiverse-sets of Universes, among which ours is one. If this theory is right then one could conceive a picture of travelling between different universes in the 'Hyperspace', using the wormhole links!

The Multiverse theory of modern cosmology, could have parallels in ancient Indian thinking and scriptures, as mentioned in the following quotation {2a}"The similarities between Indian and modern cosmology do not seem accidental. Perhaps ideas of creation from nothing, or alternating cycles of creation and destruction are hardwired in the human psyche...... And if, as some theorists have proposed, the Big Bang is merely the prelude to the big crunch and the universe is caught in an infinite cycle of expansion and contraction, then ancient Indian cosmology is clearly cutting edge compared to the one-directional vision of the Big Bang. The infinite number of Hindu universes is currently called the many world hypotheses, which is no less undocumentable nor unthinkable". (source: Lost Discoveries: The Ancient Roots of Modern Science - By Dick Teresi p. 159 and 174 -212).

4. Are the Laws of Physics Eternal??

Let us finally look at the question whether laws of Nature, or the physical laws as they are normally called, are eternal or ever evolving? What do we really consider as a law of Nature? Nature, as we understand, is a product of Space, Time and Matter. The laws are nothing but the status and evolution of Matter in Space and Time, expressed in terms of observations that our minds comprehend. In this one sentence, I have used several terms, which all need clarification.

If you ask a 'passerby', the question What is Time?, most probably she/he will shake the head with a wry smile, indicating what a silly question it is? Because people in general feel and think that the concepts like Space and Time are self explanatory. But is it true? As discussed earlier, for many thinkers Time is an enigma. In our present understanding of the Universe as we see today, it all seemed to have had a beginning called the Big Bang, when all of Space ,Time and Matter (Energy) came into existence.

As pictorially represented below (Fig. 7), at t = 0, which is referred to as 'Initial Singularity' or Big Bang, the Universe was born. The idea of starting with zero, is for the purpose of measurement, as the physical evidences, we can gather and interpret


Fig. 7. Diagramatic representation of the History of our Universe, starting from Big Bang to the present. Time is increasing upwards.

as events, have to have durations for different 'epochs'. From zero as time elapsed, the energy got converted to matter and the matter started expanding in space.

Working backwards from the observational data, accumulated in the past hundred years or so, physicists have agreed that any understanding, that one may have is only after the time 10^{-43} seconds (generally known as Planck time) from the bang, and the time before (0 to 10^{-43} seconds) known as Planck era, still is an unknown territory.

With this proviso, all our understanding of the Universe we are a part of, from which the Physical Laws are defined, cannot be extended up to the beginning. The main difficulty for this impasse is the fact that we do not yet have a framework which can treat the fundamental interaction, gravity, in the regime of Plank era, which needs quantum treatment of Space and Time.

Thus our Laws cannot be called eternal because we have no framework to understand how matter/energy behaved between time '0' and 10-43 seconds. As we get new evidences and be able to bring the physics into mathematical structure for this period, will one be able to clarify whether the laws that we perceive today as basic laws are indeed the laws that govern for all times! As Time itself is relative, the laws expressed through the history of observations, are bound to be considered ever evolving. Again, as is well known, while Newton's laws are good in local Space and Time with low velocities and small masses, they become inadequate when we go to large masses, very high velocities and large volumes of Space-time, where it is Einstein's laws of Relativity that govern the Cosmos. So far the experiences of science practitioners have been, irrespective of the discipline, to revise the notions and concepts that govern the prescribed laws every time new observations reveal hidden and deeper secrets of Nature. Particularly in the last two hundred years the human understanding of Nature, both in microcosm and macrocosm, has undergone a continued evolution with modifications to earlier prescribed physical laws.

5. Concluding Remarks

Time, the most important of all entities, is measurable to the extent of its relative role and to one's own perception. As it involves change, its impact is important as it flows only in one direction in our experiences. One is advised not to procrastinate, as one cannot retrieve the past, often quoted as 'Lost Time'. While trying to understand the world around us, we accept several things as experience from the past, and use the knowledge in the hope of making better future. As all experiences and experiments are consequences of interactions, and pre-knowledge, the role of the past time seems to be far more significant than predictions for future. What if Time machines are real? As we know, the present technology, confined by the limit on the speed of information transmission, may not be sufficient to make time machine physically possible. However, there have been reports of teleportation, at the sub atomic level which seems to overcome the barrier of light! But, can this really cross over from the quantum regime to the classical regime of real experiences? Will it then change all our understanding of notions of space and Time drastically? As mentioned briefly in the context of having 'no knowledge of Planck era', will a superior theory of describing space and Time at all scales from the infinitesimal to infinite, give a precise, objective definition of Time? Will there be any possibility of riding on closed time like curves (achronal) visiting the past and the future and have cognisable knowledge of the ultimate reality? In the present context of physics, there are several definitions of concepts which are restricted by the preordained notions confined to a classical description of a spacetime structure and the associated concept of energy. As Time is a relative concept, how can one define it objectively for a statistical system of many constituents? Since observation itself disturbs a quantum system, how does one cross over the uncertainty to define energy and time, for all observers, which are canonical conjugates?

Will there ever be a Theory of Everything? TIME alone can answer.

At the end, I would like to clarify that in this article I have not considered the notion of time associated with the human mind! As the mental processes do not seem to have a speed limit like the physical electromagnetic signal, the notion of time and its measure may have to be completely different in this context. However, it is important to ask ourselves the question whether the process of thought formation, its assimilation and expression has any continuous time link, with finite transmission speed or is it a randomly linked connection where Time of occurrence does not matter?

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24. Jain Geography: A Reappraisal

Jeo Raj Jain, Narendra Bhandari and Jinendra Kumar Surana

Abstract

The geography of the Earth, all the planets and their satellites in our solar system and many astronomical objects outside the solar system are well documented based on high resolution photography aboard spacecrafts and observations made by modern techniques. Their shapes, sizes, orbital and rotational velocities, locations, characteristics of their surfaces and atmospheres are known with high degree of accuracy. However, when these observations are compared with the traditional interpretation of ancient Jain scriptures, serious disagreements emerge, leading to the argument that the "Jain geography" is erroneous and should be modified. In our opinion, these discrepancies arise mainly because the diagrams given in the scriptures are symbolic, heavily ornamented, artist's conceptions or pictograms, and not geographical, geological or geometrical diagrams. For example, Earth, because it is depicted as a circle, has been erroneously taken as flat, disk shaped body. Based on some diagrams given in the scriptures, two Suns and two Moons going around the earth have been postulated, Sun being nearer to Earth than the Moon. Some diagrams imply that the Jambudvipa (Earth?) and other lands (planets?) are sequentially surrounded by oceans of different compositions, each being twice the size of the previous land or water body. The problems are further compounded because neither it has been possible to rationalise the units of distance and time given in Jain scriptures nor can they be converted into modern units in a consistent manner.

We make an attempt here to reinterpret various diagrams given in Jain Texts. We take the view that, Hindi (and its related Indian roots) is the only language in the world which translates geography as *Bhoogol*, emphasizing that *Bhoo* (earth) is *Gol* (spherical), ruling out all other interpretations about shape of the Earth (like a flat disk) and setting all controversies about its shape at rest. We further show that, with some assumptions, a better agreement with the modern geography is possible. Amazingly, we also find that some information which has come to be known only recently with modern techniques, is mentioned in the scriptures. Even so, many problems remain, and it calls for further study of various aspects of the earth and other habitable planets described in Jain scriptures.

Key Words: Geography, Geology, Jambudvipa, astronomy, Meru, climatic cycles, *kaal chakra*.

Scriptures Quoted: Jambudvip Pannati, Surya Pannati, Chandra Pannati, Jivabhigam sutra, Bhagvati Sutra.

1. Introduction

Science has made tremendous progress in observational techniques as well as theoretical modeling during the last four hundred years, particularly since Galileo first looked at celestial bodies with his small telescope and Newton enunciated the three laws of motion (Mohanty, This volume). Remote sensing by space based observations has given us clear, factual, picture of geography and motion of the Earth and other planets of our solar system. All the planets of the solar system have been explored by flyby-, orbiting- or landing- missions by American, Russian, European, Japanese, Chinese and Indian spacecrafts. Samples of the moon, asteroids and comets brought back by space missions and rocks from moon, mars, asteroids, comets, meteors etc. falling on Earth as meteorites and interplanetary dust particles have been studied in the laboratory for their chemical, mineral and isotopic composition and formation ages. Thus we have a reasonably good knowledge of the constitution of various planetary bodies of the solar system and their formation as well as evolutionary and chronological histories. Thousands of planets beyond the solar system, around other stars of our galaxy, termed Exoplanets, have also been identified and some of them are located in 'habitable zone', i.e. having equitable temperature with liquid water, around their central stars. In addition we have fair knowledge of our Milky way and other galaxies. Most of these factual descriptions can not be ignored and can only be refined to a limited extent.

Jain scriptures have described the geography of the earth, motion of the sun, moon and planets in great detail in Jambudvîpa Pannati, Surya Pannati and

Chandra Pannati. The Earth's geography, descriptions of planets, their satellites and the Sun, cosmology (galaxy and Universe) and astrobiology, i.e. life beyond the Earth, are all treated together in these texts, each of which have since developed into separate subjects in their own right. The Jain Agams were documented centuries after the period of Mahavira (~600 BCE) and historical maps show that the geographical and geological features of the world were accurately known at that time. Lunar calendar was invented long time ago and solar and lunar eclipses were accurately predicted, even during Ramayana and Mahabharata times, much before the period of Mahavira.

Surely at the time of Mahavira (about 600 BC), the geography, at least of India and neighboring lands, was well known, as evidenced by maps of the Earth of that era. Mahavira walked through the length and breadth of India and Alexander with his army, came to India from Greece soon after, much before the Agams were compiled. Even a lay man would not imagine rivers flowing in straight configuration, in a symmetrical way and lands being annular in shape. We must therefore reckon these pictures merely as symbolic representations, and not as actual geographical maps, in their literal or geometric sense. It is important to first understand the style of representation prevalent at that time, before interpreting them. As pointed out by J. R. Jain (2013), the scriptures used a style or code using unnatural symmetry and emphasizing on ornamentation of geometric features in the form of decorative diagrams. We therefore conclude that the geography of the Earth and orbits of Sun, Moon and planets were well known at that time. This laid the foundation of astronomy in India, atleast two millennia ago and was followed by great scholars like Aryabhata, Bhaskaracharya, Varahmihira and others who established a rich tradition in astronomy and mathematics.

Even so, serious discrepancies exist in the traditional interpretation of Agams and observations.

To provide a frame work for comparison of Jain concepts with modern theories, we give some basic data about earth and solar system, according to the traditional, prevalent interpretation of Jain scriptures in Appendix 3, 5 and 6 at the end of this article. Some relevant aspects of the Hindu cosmology is also included for comparison. The cosmological aspects are discussed separately in an accompanying article (Jain et al.) and here we confine to a few specific issues of Jain geography to show that some concepts and data can be, at least qualitatively, reconciled with the observations.

2. Geography According to Jain Scriptures

The Jain scriptures describe earth, moon, sun and other five planets (Mercury, Venus, Mars, Jupiter and Saturn)¹ of the solar system, stars (e.g. Swati and Abhijit) and black holes (*Tamask y* and *Krisnar ji*) etc. and mention possible existence of life, in other dvîpas, beyond earth. These descriptions are accompanied with pictorial diagrams, which are difficult to understand. As a case study, we consider here three of these diagrams: Jambudvipa (Fig. 1), Meru (Fig. 2), and various habitable planets from Jambu dvipa to Nandishwar dvipa (Fig. 3). If the reinterpretation given here is found to be logical, then it can be extended to other descriptions and diagrams given in the Agams.

These figures are actually pictorial representations based on the symbolism prevalent in olden times that have been erroneously interpreted literally as geographical maps, without understanding their symbolic codes. These drawings (Figure 1, 2 and 3) are more like an artists conception, and have been mistakenly taken to imply a flat, disk-like earth, rotating around a Meru (rocky axis), alternate annular lands surrounded by annular oceans (lavan samudra), rivers flowing westward as well as eastward, two suns and two moons, etc. accompanied by many highly precise, mind boggling calculations of their dimensions and the distance of sun, moon and planets, sometimes to accuracy of up to five digits.

3. Geological and Biological Evolution of the Earth

Origin and evolutionary history of the Earth and life on earth have been well established based on isotopic analyses of various types of rocks and study of fossils found in sediment deposits. We discuss some of the relevant data below.

3.1 Geologic History of the Earth

The evolutionary chronology of the Universe, that is time of its formation and major stages in its evolution are reasonably well documented by observations of black body radiation (corresponding to temperature of 2.7K), astronomical observations as well as theoretical modeling. The Big Bang theory indicates that the Universe formed about 13.7 billion years ago and some of these aspects will be discussed in the accompanying articles (Rangarajan; Jain et al). Briefly, our solar system, i.e. the sun and planets started forming about 4.56 billion years ago and the

1. Perhaps the existence of the outer two planets, Uranus and Neptune was not known at that time since they have not been depicted in these diagrams. They were discovered only recently.



Fig. 2. Interior section of the Earth. The symbolic figure from scriptures (left) showing five divisions is compared with the currently accepted section of the earth (right) with five divisions of crust, upper mantle, lower mantle, outer liquid core and inner solid core. In the left diagram, the sky is depicted as an annular ring with two suns, two moons, stars (e.g. Abhijit), constellation (Swati) and planets (Mercury, Venus, Mars, Jupiter and Saturn). In our opinion, the conventional interpretation that there are two suns and two moons going round the flat earth, one in the northern part of the disk of the earth and the other in the southern part of the disk is erroneous. Two suns and two moons is the artists way of depicting that the same moon physically revolves around the earth and the earth physically revolves around the same sun. In contrast the planets are shown only once, since they do not revolve around the earth.



Figure 3. Eight habitable planetary bodies starting with Earth (Jambu dveep) to Nandishwar dveep are shown as annular rings. This has been literally (and erroneously) interpreted as annular geometry of various planets surrounded by annular seas whereas the main purpose of this diagram is to show that the compositions of various types of seas around different habitable planets, made up of salty water around the earth, normal water around two planets (Dhataki Khand and Pushkar dveep), alcoholic sea around Varunivar dveep, milky sea around Kshirvar dveep, oily sea around Ghritvar dveep and sugary sea around Ikshuras dveep. The largest planet is Nandishwar dveep, surrounded by sugary sweat sea. It may be noted that recently some planets with calcium-rich water (appears milky, because of the colour of calcium carbonate), planets and seas containing organic oily-tar like compounds have been discovered. Some planets or satellites (Titan, e.g.) have abundant organic matter and cold temperature so that lakes or seas of methane or ethane or alcohol exist these. Around a star Rho Ophiuchi, organic sugars (glycoaldehyde) have been detected. Comets are also known to have alcohols and sugars.

first signs of life appeared on the earth in form of primitive algae atleast 3.5 billion years ago. We know the way the universe, galaxies, various types of stars and the Sun have evolved since they were formed. Our Solar system, i.e. the sun and the planets, including the Earth, formed due to collapse of a fragment of a cold, dense, rotating Giant Molecular Cloud.

The surface and geography of the Earth is not a stable feature but a continuously changing phenomena. The continents and other land-masses were not in the present configuration, but existed as a supercontinent called Pangaea (see

Fig. 4), consisting of all the continents which exist now, in a joint single land mass, from about 300 to 180 million years ago. Pangea later broke up into two major continents due to plate tectonics: Laurasia and Gondwana. Laurasia was composed of Europe, North America and Asia, while Gondwana was composed of Africa, South America, New Zealand, Madagascar, India, Antarctica, Arabia, Iran, Australia etc. All of them are moving even now, albeit at a slow rate. By about 100 million years ago, Indian continental plate began to drift northward from its position alongside Africa, and rifts developed in Gondwanaland. The opening between India and Africa gradually became the Indian Ocean. Due to plate tectonics, the Indian Plate split from Madagascar and collided with the Eurasian Plate (China), resulting into the origin and uplifting of the Himalayas about 55 million years ago and it continues to move roughly northwards at the rate of 3 to 5 cm per year even now.



Fig. 4. Pangaea. It was a supercontinent that existed from about 300 to 180 million years ago. The outlines of the modern continents and other landmasses are indicated in this figure. Pangaea later broke-up to become two major continents; Laurasia and Gondwana. Laurasia was composed of Europe, North America and Asia, while Gondwana was composed of Africa, South America, New Zealand, Madagascar, India, Antarctica, Arabia, Iran, Australia etc.

The Earth has been going through cold and hot cycles throughout its history. Several temperature excursions occurred over the earth between 3 million and 14000 years ago, comprising 34 cold periods with intermediate warm periods (inter glacials) of around 10,000 years each (Fig. 6 b). The forests receded during the glacial times, but the climate was favourable for habitation during warm periods. The civilisations began along major river systems around 40000 years ago, classified as Paleolithic (Old Stone age). The humans colonised various parts of the continents during the past 15000 -10000 years BP (Before Present); The New Stone age, with advanced stone tools (Neolithic period) started around 8000 years BP. These dates are based on geological (mainly sedimentary), fossil and climatic records and archaeological excavations. We summarise the fossil records below.

3.2 Fossil Records

The history of life on the Earth reveals that life first appeared on the earth about a billion years after the earth was formed. The life, in form of single celled algae (sthawar), i.e. prokaryotes began only around 3.5 billion years ago and then, from this common root, all the species belonging to fungal, animal and plant kingdom evolved by Darwinian evolution. The mobile species, which could move from one place to another, originated about 540 million years ago. The period of 490-420 million years ago was the age of marine fishes, 240-200 million years ago was the age of amphibians and 200-65 million years ago was the age of reptiles. The forests evolved around 200 million years ago and the flowering plants around 100 million years ago. The mammals mainly evolved during Tertiary period (65-4 million years ago). The gorilla and chimpanzee diverged around 4-6 million years ago. The early bipeds evolved around 4 million years ago into Australopithecus and later into Hominids. The members of genus Homo successively evolved as Homo habilis (2.3 million years ago), Homo erectus (1 million year ago), Neanderthals (100,000 years ago) and Homo sapiens as modern man (35,000 years ago). The Homosapiens used stone tools, and the humans colonised various parts of the continents during 15,000 - 10,000 years B.P. The oldest record of human-like presence on the earth dates back to 3.2 million years in the form of the fossil "Lucy", with a height of 1.1 meter and weight of 29 kg, found in Ethiopia in the year 1974. Darwinian mechanism of natural selection i.e.struggle for existence and survival of the fittest, seems to have played the key role in the evolution of species from algae to humans over the past 3.5 billion years.

4. Comparison of Jain Geography with Modern Observations

Although many of the above, well established, observations are not mentioned, geography has been given much importance in Jain Agams. We discuss Figs. 1, 2 and 3 here and see if they can be reconciled with the current models based on remote sensing, geologic and fossil records. The traditional interpretation does not agree with the facts but a fair comparison is only possible if the style of representation of various features in these figures, prevalent during that era is understood. In absence of this information, we try to see if, with certain assumptions, they would agree with the observations. This discussion is bound to be speculative and subjective even so we take the following approach.

4.1 Jambu Dvip

Usually, a three dimensional sphere is schematically projected or drawn on a two dimensional sheet of paper as a circle. This diagram (Fig.1), therefore, must not be taken to mean that the Jambu dvip (earth) is a flat disk. We go by the Hindi word 'Bhoogol', a term used for geography, implying that the 'Bhoo (earth)' is 'gol (round)'.

Since it is not possible to show both the faces of the spherical earth in one diagram, it may be that the upper half of the circle represents the front face (western hemisphere) of the spherical earth and the lower half, its rear face (eastern hemisphere) is shown here from the north pole to equator, so that the whole northern hemisphere, rotating around Meru (rotational axis of the Earth) can be depicted in one diagram. Essentially this is an areal, polar view of the earth from above the north pole. The smaller circle represents the Equator and the Bharat Kshetra, presumed to be Greater India, encompasses south China, Tibet, Burma, Thailand, Indonesia, Srilanka, Afghanistan etc. The Bharat kshetra, which borders the equator of the Earth and is surrounded by a salty sea (outer circle), validates this interpretation. The diagram represents six major rivers of the eastern hemisphere and six of the western hemisphere and several mountain ranges. Except for westward flowing Sindhu and eastward flowing Ganga, whose names have survived, the names of other rivers have changed over the millennia with the passage of time. Appendix-1 gives the modern names of rivers corresponding to those given in this diagram. It may be noted that these are all major (longest) and culturally important river groups, although some may have changed their courses during the past few millennia. We can proceed in a similar way and identify the

mountain ranges, where except the Indian mountain ranges (Vijayavardh i.e. Vindhyachal) and Himvan (Himalayas), other ranges have to be identified in terms of modern names. If this interpretation is correct, then we can conclude that Sumeru or Meru represents the rotation axis of the earth. Most calculations (e.g. durations of day and night, seasons) in Surya Pannati and Chandra Pannati have been based on observations over high northern latitudes. Thus the Jambu dvip could be the earth itself or just the northern hemisphere.

4.2 Rotation axis (Meru) and Interior Section of the Earth

We now try to understand Fig. 2, in the light of the above discussion, again ignoring the decorative and religious icons. A ring of planets and stars are shown going round the Meru Parvat. As discussed above, Meru may be taken as the rotation axis of the earth. The cross section along the axis is divided in 5 parts. We compare this figure with the currently established internal structure of the earth. It has five sections: crust, upper mantle, lower mantle, outer core and inner core. These divisions seem to be qualitatively consistent with the sections given in Fig. 2, although the depths or thicknesses of various sections do not agree with their actual thicknesses and location within the Earth. This is partly because linear and areal dimensions are not distinguished in these descriptions. Even so, it is clear that the rotation of the earth was well known in ancient times.

When seen in this perspective, it can be inferred from Fig. 2, where two identical suns and two identical moons (in the same phase) are shown on the opposite sides of the earth, that these represent their apparent orbital paths, as appearing from the front and rear hemispheres of the earth. This should not be taken to mean that there are two suns and two moons. Moon and sun look identical from everywhere and it does not seem plausible that people who were intelligent enough to correctly invent lunar calendar to a high degree of accuracy, and predicted eclipses precisely, were not aware of the fact that the earth has only one sun and one moon. It may be noted that in Fig. 2, the five planets (Mercury, Venus, Mars, Jupiter and Saturn, marked by squares) are shown singly and not in pairs, like the sun or the moon are shown, to distinguish their orbital paths with respect to the earth. They are shown singly, may be because this is the artist's way of indicating that neither the earth goes around these planets nor these planets go around the earth. This is the way (by showing in pairs or singly) the motion of moon around earth, of earth around Sun, and of planets relative to the Earth has been

distinguished in this diagram. By the same logic, some stars like Abhijit and Swati are also shown singly. These diagrams are not to scale so that the distances measured from such diagrams, say between earth (Meru) and sun or earth and moon and other planets can not be used to imply that the sun is nearer to the earth than the moon is. Such measurements are therefore erroneous.

4.3 Habitable planets and their compositions

We now consider Fig. 3, which depicts different types of planets (or habitable zones) as we go away from Jambu Dvip. Each land in this figure is surrounded by an ocean (with waters having different compositions), and size of each successive outer structure is depicted as double the size of the immediately previous one. Based on the above discussion of Fig. 1 and 2, it appears unlikely that scholars who wrote the Ågams did not know the actual shapes of planets and depicted them as annular in shape. Going by the disk-like structure of Milky way Galaxy, some scholars have proposed that this figure represents our galaxy. This inference can not be true because galaxy is spiral in shape and the approximation from spiral to circles can not be ignored. If so, Fig. 3 probably describes other habitable planets in the suns neighborhood. Some scholars have chosen to consider that this figure represents other planets within the solar system, as we go away from the Earth. In our opinion, this figure represents various types of planets and oceans in the universe, which may harbour life. Be as it may, it is clear that some of these planetary bodies are surrounded by seas of oil (ghritav r), sugarcane juice (ikshu ras), sweet liquid water, milky liquid, salty water, or wine (daru) etc. Planets with these types of composition (alcohols, sugars, oils and sweet and saline waters) have been recently discovered in the outer solar system. Several spacecrafts have gone near various outer planets which are rich in carbon, hydrogen, nitrogen etc. and planets with carbonaceous, tar like oily substances have been recently discovered, which may justify the name *Ghritv* r (oily) sea. Likewise, Milky looking liquid may be oceans rich in calcium carbonate, which dissolves in water and make it appear milky. Recently some stars and planets, rich in carbon have been discovered where under high pressure, carbon has been converted into diamond. In Agams such diamond earths, besides, sandy, dark and other types of planets also find a mention.

In this context, we mention some recent results obtained by space missions sent to explore outer planets of our solar system. The Galilean satellites of Jupiter, i.e. Callisto, Ganymede and Europa, have been found to have undersurface oceans, some with saline water and Io has abundant sulfur and sulfur compounds. Cassini-Huygens mission of NASA explored Saturn and it's satellite Titan (Lorenz and Mitton, 2002). It found that Titan has lakes of hydrocarbons i.e. liquid ethane, methane, and propane and possibly alcohol (Mitri et al., 2007), which may match with the oceans of liquor i.e. 'daru' mentioned in Agams; Cassini spacecraft also made flyby's of Enceledus, the large icy moon of Saturn, and found evidence for undersurface ocean and active water geysers or fountains (Spencer and Nimmo, 2013). Organic matter, found on the outer planets and satellites synthesises into sugars and give rise to sweet sugary oceans, akin to *ikshuras* oceans. NASA's Widefield Infrared Explorer (WISE) found glycolaldehyde molecules ($C_2H_4O_2$, sugar) around a sun-like star in Rho Ophiuchi, a star-forming region. It is a young star, called IRAS 16293-2422, and is part of a binary (or two-star) system. It has a mass similar to the sun and is located about 400 light-years away in the constellation of Ophiuchus.

We can not justify many numbers mentioned in these diagrams, till we understand what they actually represent, but some attempt has been made by Jeoraj Jain in his book. In this context, it may be noted that the ratio of land area of the Jambudvîp to the area of its surrounding salty ocean, mentioned as 1:2, seemingly agrees with the earth where the land to sea surface area is 1:2.

5. Chronology of the Universe and Jain *K l*-chakra (The Wheel of time)

Modern chronology of origin and evolution of the Universe, solar system including various planets, earth and meteorites coming from distant objects of the solar system are well documented based on astronmical observations and precise methods of radioactive dating. Some of these data, going back to 13.7 billion years when our universe originated from the Big Bang, will be discussed below. In comparison the Jain chronology, based on conventional interpretation, is said to be going back to 10¹⁴ years, about 10,000 times too large compared to the age of the Universe. Jain cosmology is a Steady State cosmology as discussed in more detail in an accompanying article (Jain et al., 2015). It assumes that the universe is eternal, without beginning or end, and has always been, in a gross sense, like as it exists now. However, even in the Steady State scenario, there are many cycles of change. One possibility is that the Universe is eternal, as Jainism postulates, and the birth of the

universe in Big Bang, is but the last cyclic phases, which repeats itself, within the frame work of Steady State model. However, based on a number of evidences, we argue below that the age of the universe, mentioned in Jain scriptures, is unacceptable and, when the units of time and distance are rationalized, it will turn out that the Jain k lchakra (Fig. 5) is related to the earth and not to the cosmos; the word cosmic in k lchakra relates to the external (mainly solar) influence on the earth's climatic cycles, and not to the Cosmic cycles of the galaxy or Universe.

5.1 Jain Kal Chakra

The concept of cycles within a Steady- State universe is traditionally termed as the cyclic nature of the universe (Fig. 5) as depicted by Jain wheel of time (kal *chakra*). It postulates the existence of several cycles operating within a large cycle. One complete cycle is divided into two half cycles, Utsarpinî (ascending) and Avasarpinî (descending). Each of these half cycles has a period of 10 kodakodi (KK), the exact equivalent of which in years is uncertain¹, but it is generally (and erroneously) assumed to be very large, and sometimes estimated that 1 KK equals to 10¹⁴ years. The cosmic cycle keeps on repeating ad infinitum and will continue forever. Each of the half cycles is further divided into six sub-divisions (called "Aara"). According to Jain scriptures, we, on the planet earth are presently living in the 5th Aara of the Avsarpini kal which is said to have begun 3 years and 8½ months after the Nirvan of Bhagawan Mahavira (524 BCE). According to the Jain texts, this Kalchakra is said to be applicable only to the Aryakhand of Bharat and Airavat regions of the Loka, implying that it is not a cycle operating on the universe (cosmic cycle) but only related to some part of the Earth. The six sub-divisions (Aaras) have been named according to a "happiness index" (Appendix 3), ranging, during Avasarpini, from Happy-happy to Unhappy-unhappy, implying a gradual change and are probably related to climate (from comfortable to harsh). This sequence reverses in Utsarpini cycle, as shown in Fig. 5. The periods of the various cycles, i.e. Aaras are: 1st cycle - 4 KK, 2nd cycle - 3 KK, 3rd cycle - 2 KK, the sum of the periods of 4th, 5th and 6th cycles is 1 KK. The periods of 5th and 6th cycles are 21000 years each. The traditional explanation of Jain K lchakra is given in Appendix 3 and also compared with Hindu cycles of Yuga and Mahayuga.

^{1.} For units of space and time, See for example books by Nath Mal Tatia, Muni Kanak Nandi ji, and R.M.Jain and A.Jain (This volume).



Fig. 5. Jain Kal Chakra depicting ascending and descending cycles, each divided in 6 r 's.

5.2 Climatic Cycles on the Earth

Modern cosmology finds that cycles with several periodicities are operative on earth. These include climatic cycles, geological cycles, astronomical cycles and cosmological cycles in the order of increasing periodicity. Many of these cycles have been established by study of chemical, isotopic and fossil records preserved in sediments collected from sea-beds or ice cores taken from Greenland and Antarctica, which can be used as a proxy for climatic (e.g. temperature) and geological (e.g. volcanic, and impact) events on the earth. Considering only the important ones, there is diurnal cycle, monthly lunar cycle and annual solar cycle. The climate of the Earth depends on solar irradiance received by the Earth. Milankovitch, a Russian scientist, showed that the solar irradiance received on earth (solar insolation) depends on three cycles, the precession of equinoxes (which changes inclination of the spin axis of the earth) with a period of about 21000 years (being the average of 19 thousand and 24 thousand years when at the aphelion and the perihelion, the northern hemisphere is tilted away from the sun and towards the sun respectively), obliquity of the earth, which also depends on the inclination of earth's axis to the ecliptic plane (the plane in which earth moves around the sun in its orbit) which changes with a period of 41000 years and change in the eccentricity of the earth's orbit (which changes the distance of earth from the sun) varies with a





(b) The Milantsovitch Cyles.

Fig. 6a and b: The earth's orbital geometry around the sun and the periodicities due to precession (~19000, 22000 and 24000 years), obliquity (41000 years) and eccentricity (100000 years). The time axis is shown at the top in kilo years. All cycles operate simultaneously, giving rise to a cumulative or composite curve shown at the bottom with 100000 years periodicity. This curve represents glacial and interglacial stages in the ~100000 year cycle. The temperatures are highest at the peak (interglacial) and lowest at the trough (glacial) epochs. The maximum change in temperature is -3 to $+3^{\circ}$ C. Currently we are at the peak of interglacial epoch (Reproduced from Wikipedia). (See colour image on page 660)

period between 95 and 400,000 years. The orbital geometry of the earth is shown in Fig 6a and Milankovitch periodicities are shown in Fig. 6 b. Although the solar insolation changes slightly with the orbital geometry, the earth's atmosphere amplifies the effect and the extreme change in temperature ranges between -3 to +3°C, enough to drive the earth into glaciation and warmer periods, called "interglacials". These data have been discussed in some detail by Bhandari (2010) and www.jainscholars.com. The sun moves in the galaxy, up and down from the plane of the galactic disk like a carousel, around the galactic nucleus. The astronomical cycles, i.e. the motion of sun (and the earth) in and out of the galactic plane is about 60 million years and one rotation period of sun around the galaxy is about 250 million years. The sun itself has a life expectancy of about 10 billion years and we are about half way through in its life cycle. Effects of some of these cycles on the earth, particularly their biological effects, have been debated and the 60 million year cycle, mentioned above, has been linked to mass mortality on earth due to impact of material from the galaxy, as the sun moves in and out of the galactic plane. Superimposed on these periods are random events like impact of comets and large asteroids, which can create havoc on life on earth and wipe out a large fraction of the civilisation and most of the species. The impact of about 10 km size planetary body, 65 million year ago, linked to extinction of dinosaurs is one such established event (Bhandari et al., 1994).

The temperature cycles have been experimentally verified by climate markers (isotope ratio of oxygen (Oxygen-16/Oxygen-18, a proxy for temperature). Oxygen has three isotopes, weighing 16,17 and 18, with respect to hydrogen =1. Oxygen-16 is most abundant and 17 is least abundant. The ratio of various isotopes in a compound, e.g. water depends on temperature of formation. Therefore the rain water has oxygen isotopic ratio which depends on cloud or atmospheric temperature. In the polar regions, precipitated rain deposits as snow and forms ice sheets on Greenland and Antarctica, preserving the time sequence, from year to year and season to season. The deeper layers are older, having deposited in the remote past and the surface regions represent contemporary snow/rains. By determining oxygen isotope ratio in layers of ice in Arctic or Antarctic ice or sediments, one can obtain temperature of the earth at the time of their deposition. These data in such ice or sediment cores show a 100000 year cycle, going through

cold glacial and warmer interglacial epochs, as shown in Fig. 6 b. It is possible that the Jain kalchakra cycles are also climatic cycles, because their names are related to "degree of happiness and unhappiness" (see Appendix 3, Table 1). Happiness may be reflecting comfortable, warm, equitable climate when food productivity increases and "unhappy" epoch may be denoting unfavourable or cold, harsh climate. The sequential degree of changes from happy to Unhappy mentioned in the Jain texts implies that the earth climate changes slowly. It cannot be a mere coincidence that two of the Milankovitch cycles (~21000years) agree with the period of 5th and 6th àarà. The 100, 000 year climatic cycle, however, does not match with the traditional value of period of 3rd àrà. N. Bhandari (nbhandari.com) and R. M. Jain (2010) have argued that the period of third àarà is actually 100000 years and the time unit kodàkodi used in Jain texts means 100,000 years (see the accompanying article by R. M. Jain and A. Jain). A larger, important geological cycle (of probably volcanic periodicities on Earth) is 33 million years.

6. Concluding Remarks

Although the reinterpretation of the three sketches (Fig. 1, 2 and 3) and Kal chakra taken from the Agams helps us to reconcile them with the current views of the earth' geography, climatic periodicities and possible compositions of habitable planets beyond earth, as described above, it should be considered only as one of the possibilities. There may be other ways of looking at them since some important discrepancies still remain. Alternative possibilities, therefore, need to be explored. We would like to point out some discrepancies in our explanation given above, when compared with Jain texts. Firstly, there is no mention in Agams that Jambudvipa is rotating around Meru (rotation axis of the Earth). Also, only the Jyotishka Loka is mentioned to be rotating around Meru. Hence, this presumption may not be in line with the scriptures. The Mahavideh Kshetra, a region considered to be abode of some enlightened Arhats, is traditionally not considered as part of the Jambu Dvipa. Further the Agams mention some geographical boundaries which humans cannot trespass, whereas our interpretation does not include any such limits. Lastly, the relative positions/heights (distances) of stars, Sun and planets above the Earth (Jambudvîpa) in the texts do not match with the modern findings and ought to be corrected. In spite of these limitations, the current analysis has provided some scientific basis for understanding a few concepts mentioned in Jain Agams.

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Appendix -1: River Systems Mentioned in Jambu Dvip

Table 1. Major Group of Rivers of the world, from equatorial regions (#1) to poleward (#7), corresponding to the diagram of Jambu dvip (Fig. 1). These rivers are shown in the world map below (Fig. 7).

	Eastern hemisphere		Western Hemisphere	
	Fig.1	Modern name	Fig.1	Modern name
1	Sindhu	Indus	Narikanta	Riogrande
2	Ganga	Ganges	Narkanta	Mississippi
3	Rohitasha	Volga	Rupyakala	Niger
4	Rohita	Huang, Yangtze	Suvarna kala	Nile
5	Harikanta	Amur		Raktoda Amazon
6	Haritkanta	Rhine, Danube	Rakta	Congo
7	Sitoda	Mckenzie	Sita	Ob



Figure 7. Major river systems of the world.

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Appendix 2: Sun-Earth-Moon System

Some Jain scholars have tried to justify existence of two suns and two moons in the following manner:

A theory of formation of planets postulates that solar system came in to existence when two stars (one of them being our sun) had a close encounter and pulled out material from each other, by their gravitational force, in a cigar shaped mass, which subsequently coalesced into planets. The other star then moved away on its course and it is not possible to identify it now. This theory is no longer in vogue and has been replaced by the theory of solar nebula in which Sun and planets formed from a cold, rotating, dense molecular cloud.

The two moon theory is explained on the basis that the Earth, at times, temporarily captures another satellite as asteroids (or near-earth objects) accidently comes too close to it. At present, earth has another companion moon (called object SO16) moving around the earth in a horse-shoe shaped orbit. Such events are plausible and have occasionally occurred in the past. A recent (2011) computer simulation by Jutzi and Asphaug (2011) has shown that the earth indeed had two moons in the beginning, soon after the infant Earth was struck by a large asteroid, which then merged into one Moon in a slow-motion collision. These explanations are meant to achieve an agreement between Jainism and modern observations and were probably not in the mind of scholars who compiled Agams.

Appendix 3: Jain Kal-chakra and Vedic Cycles

This Jain *Kal-chakra* is the cosmic cycle consisting of two parts, an ascending and a descending half cycle, called Utsarpini and *Avsarpini*. The *Utsarpini* follows the *Avsarpini* and the *Avsarpini* follows the *Utsarpini*. Thus the cycle keeps on repeating ad infinitum and will continue forever. Each of the half cycles is further divided into six sub-divisions (called "*Aara*"). These cycles are applicable only to the Aryakhand of Bharat and Airavat regions of the *Loka* and currently we are in 5th *A* ra of *Avasarpini Kal*.

The six sub-divisions (*A ras*) have been named according to a "happiness index", ranging, during *Avasarpini*, from Happy-happy to Unhappy-unhappy, implying a gradual change probably related to climate (from comfortable to harsh). The time duration of each sub-division as well as the life span, height and number of bones of human beings progressively decrease (Table 1). This sequence reverses in

Utsarpini cycle and the *Utsarpini k l* also has six sub-divisions in reverse order (trending from Unhappiness to Happiness).

 Table 1. Traditional concept of Jain Kal-chakra (Avsarpini-kal)

Average for Humans

Aara	Name	Period	Height	Age	No. of back bones
Ι	Happy-happy	4 KK Sagaropam	6000 dhanush	3 palyopam	256
II	Нарру	3 KK Sagaropam	4000 dhanush	2 palyopam	128
III	Happy-unhappy	2 KK Sagaropam	2000 dhanush	1 palyopam	64
IV	Unhappy-happy	1 KK Sagaropam -42,000 yrs	500 dhanush	1 crore purva	48
V.	Unhappy	21,000 yrs.	7 hath	130 yrs.	28
VI	Unhappy-unhappy	21,000 yrs.	1 hath	20 yrs.	12

KK= *Koda-kodi sagaropam* (very large time unit), *palyopam* = medium time unit, *dhanush* = length of bow, *hath* = length of human hand (see Appendix 3 and the paper by R.M.Jain and A. Jain, this volume).

Vedic Cycles

According to Vedic religion, the life in the universe is created and destroyed once every 4.1 to 8.2 billion years which is one full day (day and night) of Brahma. The cycles are repeated *ad infinitum*. A complete *Yuga* cycle comprising of Four *Yugas: Satya yuga, Treta yuga, Dwapar yuga* and *Kali yuga* follow a periodic ratio of 4:3:2:1 (Table 2). The ages see a gradual decline of dharma, wisdom, life span, stature and physical strength. Kali Yuga, the present period, is estimated to have begun from 20th February, 3102 B.C.

A complete *Yuga* or *Maha yuga* is equal to 4.32 million years. One thousand *Maha yuga* make a *Kalpa* of 4.32 billion years, which is close to the current scientific estimate of the age of the Earth =4.56 billion years based on radioactive dating.

Yuga	Characteristics	Duration (years)	Stature (height)	Age (years)
1. Satya	Virtuous (No sin)	4 x 432,000	21 cubits	100,000
2. Treta	Virtue/Sin(3:1)	3 x 432,000	14 cubits	10,000
3. Dwapar	Virtue/Sin(1:1)	2 x 432,000	7 cubits	1,000
4. Kali	Virtue/Sin(1:3)	1 x 432,000	3.5 cubits	100
One <i>Maha Yuga</i> = 4.32 million years One <i>Kalpa</i> = 4.32 billion years				

Table 2. Hindu cycles of Yuga and Mahayuga- Four Age Cycle.

Appendix 4: Estimation of time and distance units used in Jain texts (following Rajmal Jain, 2011)

The traditional historic units mentioned in Jain scriptures have been redefined based on modern scientific data.

In this approach: *Koda* = 1000, *Kode* = 100, *Kodi* = 10. Time/ *Muhurt*: 1 Day = 8 *Prahar*, 1 *Prahar* = 4 *Purva* / *Ghadi*. Length: *Dhanushya* = (i) Cross-section of the vessel (bio. scale) =/< 5mm. (ii) Length of '*Dhan*' (grain) = 4 - 5 mm.

Appendix 5. Time Cycle Based on Forest Eco-system

We give here an alternative thine cycle system based on forest eco-system. In pre-historic times the "*Kalpvriksas*" (the benevolent trees) were capable of giving all that is required in fulfilling the needs of all human beings, animals and other life forms. This period may be considered as the 1st *Aara* (Happy-happy) of the planet earth.

In natural forest areas all life forms live in harmony and are symbiotic with mutually cooperative relationship. The carnivorous animals, birds, insects etc. mainly work as scavengers in nature, the waste converted into manure directly. In forest eco-system, the population of all life forms remain optimum matching the availability of food.

When the greedy man started over-exploitation of nature beyond its capacity, the damage and degradation of mutually sustained eco-systems began. That's how the regression i.e. the good to bad trend begins. It represents various *Aaras* of the *Avsarpini-kal* as described in Jain scriptures. This downward trend continues with the degradation of forest eco-system, increase in pollution and decrease in the moral values of human beings.

The period of perfect symbiotic conditions on the earth can be considered to be the beginning of 1st *Aara* of the *Avsarpini-k* 1 on the earth. Similarly, the period and duration of subsequent *Aaras* have also been computed and given in Appendix 3, Table 1.

Aara	Appx. Period B.P. (duration) in years	Brief description
Ι	4 – 1 million (3 million)	People very-very happy. Perfect symbiotic conditions. All needs fulfilled by "Kalptarus". Plants and animals cause no harm to each other. Even carnivorous animals act as scavengers. Air, water and soil in purest form.
II	1 million to 200,000 (800,000)	People by and large happy. Slightly degraded stage. Increase in population. Pressure on natural resources. Early Old Stone Age.
III	200,000 – 15,000 (185,000)	People partially happy. Decreasing natural resources. Rapid evolution of modern human culture (50,000 years B.P.) Beginning of farming culture (15,000 B.P.). Period of Bhagwan Rishabhdev around 14,000-15,000 years B.P.
IV	15,000 – 2,500 (12,500)	People more unhappy. Forests suffer onslaught because of expanding agriculture, Period of 23 Thirthankars.
V	2,500 to Present	People by and large unhappy. Regular decrease in Moral values. Advances in Science and Technology but regular decrease in natural resources and increase in Pollution.
VI	??	People very-very unhappy. Worst living conditions. Exhaustion of natural resources, destruction of Forests and trees. Highly polluted environment, acidic rains etc.

Appendix 6. Table: 1. Trend of Avsarpini-kal in relation to the Planet Earth

The beginning of 1st *Aara*, also somewhat corresponds with the beginning of *Satya yuga* of Vedic religion (Appendix 3, Table: 2). The later part of *Dwapar yuga* may be condidered to be the period of the first 23 Thirthankars and the beginning of *Kali yuga* to be the period of Bhagwan Mahavira.

25. Ecological Considerations in Jainism and Modern Views

Rudi Jansma, Christopher Key Chapple and T.M.Dak

Abstract

Ancient Jain ideas relating to 'ecology' are discussed and compared with some modern scientific models. The key concept of Jainism is *jîva*-soul-life-consciousness – which are inherently immortal and pure. It is the guiding factor in evolution as well as in ecology. Why and how consciousness carries out this role is discussed in this article. All processes in living Nature are due to *jîva*. From a Jain point of view every individual and its evolution has a purpose; ecology being a specific and necessary karmic manifestation. The purpose of the soul of every individual is to become free of illusion, delusion and the multiplicity of forms and become omniscient and divine. The classification of living beings is, in the first place, according to their state of expression of inner development, not on their outer forms or ecological purposes. Jainism recognizes a living-conscious essence in every manifested living being which includes minerals, invisible beings, subhuman and super-human beings, and in the forces of Nature. All are interconnected and influence/help each other.

This article discusses some ideas which have become popular in modern science, viz. the Gaia-theory proposed by James Lovelock (the earth behaves in many respects like a living being); intricate symbiosis (living and working together) between and within living beings, which has gained great momentum due to the work of biologist Lynn Margulis, and the ethical philosophy, first formulated by Arne Naess, known as 'Deep Ecology'. Finally Jain pluralism and sense of connectivity and its ethical impact are discussed.

Key Words: Ecology; *jîva*; ethics; Jaina ecological behavior; non-organic consciousness; Gaia Theory; symbiosis; ecological cooperation, Deep Ecology

1. Introduction

In writing this article comparing Jain and contemporary occidental views, the authors are aware that Jainism - and other Eastern and ancient scientific teachings - are derived from the vast heritage of human thought and effort throughout long ages. Modern science of western origin is relatively new - often thought to have started with the Greeks Aristotle (theoretical science) and Archimedes (practical science), but its explosive expansion has only taken place in the last few centuries. The true expansion of western science came only after one had done away with spirituality or 'God' and embraced a matter-only view to explain the universe around and within us.

However from an oriental point of view physical matter and all its manifestations are but a very thin surface layer - and the grossest layer - of the whole universe. It is generally accepted that there are vast fields of knowledge which have not but touched or even surmised by modern science. Science will therefore have to learn many things outside or beyond its present field of attention.

It has therefore more appeal to logic that the modern scientific world should learn from the ancient and in general more spiritual traditions rather than the other way round. On the other hand occidental science has developed unique precision in perceiving the processes of physical matter, and has revealed details in the small as in the large, about which even great yogis of the past might have been astounded. Such great yogis would however have argued that all such things as modern science finds out today through external means, can also be understood on deeper levels through internal means by meditation. The yogi would approach the universe from the noumenal rather than from the phenomenal side, but would not shun external knowledge: it is remarkable that thousands of years ago, even before Plato and the other great Greeks, the Jains and other oriental searchers already talked about atoms¹ and compound molecules, and were also aware of the vastness of our universe. It is evident from the scriptures that one knew about speeds in the order of, and probably faster than that of light and which were possible for bodies built of types of matter which are more subtle than 'our' coarse physical matter.

Modern and ancient thought and effort together will form the basis for a global mental future in which coming generations will live and develop. We as humanity, not just as scientists or Jains, are co-responsible.

¹ The Greek word a-tomos, means non-divisible – with which Demokritos meant the really indivisible 'Parama?u' of Eastern philosophies rather than 'atom' in the modern scientific sense, which is divisible.

In no way are we motivated by an effort to promote or superpose one particular thought system on top of another; nor are we motivated to show that "we also have something to say, and that modern science proves in many cases that we were right all the time." Also we should be very careful not to force ideas of different cultures into congruence. Truth itself is always beyond human speculation, and therefore no human concept or theory can be absolute, nor can two different human truths be completely identical. Truth can not be reached by the human mind - it can only be desired by the mind, and the mind, within its self-created limitation, can only read relative, not absolute truth. For this to reach, the discursive, speculative mind should ultimately be transcended, left behind as the guiding principle - as indeed the enlightened beings have done. Science is and will be an ever expanding effort towards human omniscience, until we know everything that can possibly be known about the universe including ourselves. Jainism teaches that the soul, on its pilgrimage through the universe, has to come in contact with every aspect of it. Only then we will transcend the mind and enter the infinitely greater realm called nirvana or *moksha* - in which all thought and form is seen to be but an illusionary reflection into one particular finite possibility. Only then the soul is truly liberated, i.e. free of illusions, bondage and impurity, and does no longer have to peregrinate through this our universe.

The first two sections of this chapter will discuss the relevant teachings of Jainism for understanding ecology in a philosophical approach, and compare these briefly with the predominant western views.

The remaining sections (3-8) will briefly discuss: the Jain classification of living beings as relevant for our purpose; some modern developments in the occidental science of ecology and discuss these in the light of Jainism; the impact of a practical application of the Jain ethics to modern ecology in our world.

2. Life

J va, Soul, is the core principle of all Jain doctrines.

J va means Life, Consciousness, Spirit, Monad, and is eternal. It has no beginning and has no end; it always existed and will always exist.

All processes and forms in living Nature are due to *jîva*. The *jîva* is characterized by absolute purity and omniscience and intelligence and is faultless: it can commit no evil. The characteristics of the pure soul are: *jñ na*, knowledge; *darshana*, spiritual vision; *sukha*, bliss; *v rya*, power; *samyagdarshana*, right belief;

samyakc ritra, right conduct; *avy b dha*, undisturbability; and freedom from all limitations due to the various karmas (Tattv rtha S tra IV. 2). J va is in all living beings, and all body forms and behaviors of all living beings are based in *jîva. Jîva* itself is the only living and conscious '*tattva*' in the Universe (*loka*).

J va is one of the six *tattvas* or *dravyas* – usually translated as 'substances' – of Jainism. The other five are: space, time, motion, non-motion, and matter (*pudgala*). These last five have no life or consciousness. The *dravyas* have no characteristics in common: for example *jîva*, life, has no material characteristic, whereas matter has no consciousness characteristic. Space provides the emptiness for all things to move in, but in itself has no time, matter or consciousness; likewise time is a substance. Motion and its opposite – non-motion or inertia, is a *dravya* which works on matter and soul within space and time, but in itself contains none of the characteristics of the others. All these together, and no others besides these, make up the Universe.

The only thing they have in common is their '*dravya*-ness'. This is the essence of all things and beings in the universe (*loka*), of all phenomena. Logically they all 'recognize' each other because of this commonness – though this recognition does not have to be conscious (e.g. a hydrogen and an oxygen atom have, according to Jainism, their non-conscious recognition in the nature of lifeless matter itself). Soul can attract and influence subtle matter, and does so in time and space by motion or by bringing it to a standstill. Space and time are recognized by consciousness (=soul) and all life exists in space and time, and either moves (and accelerates or decelerates) or remains stationary.

Soul is the nucleus of every living being. Every living being has a soul, i.e. life and consciousness and eternal bliss at its core.

Perhaps the earliest mention of the Jain interpretation of soul can be found in the Acârânga Sûtra (I:2:3). This is a text that has been dated to the 4th century BCE. In this passage, one can almost hear the cries of all living beings:

All beings are fond of life.

They like pleasure, they hate pain,

They shun destruction.

They like life and long to live.

To all, life is dear.

The soul, being by nature fully conscious and intelligent, has the ability to recognize multiplicity, distinguish between joy and suffering, to know and experience the external world, to desire, to generate energy, and to make contact and bond with matter in its various types (gross and subtle). In other words, all forms of limitation and personal consciousness are due to the impurity of the soul or life or *jîva*. Once the soul has entered a body, it is said to take the shape of that body, and is all-pervading. It means that all physical structures in our body, including our brain besides all other gross and subtle organs, each cell and its organelles and molecules is pervaded by soul, i.e. life, consciousness and intelligence. Thus it takes a form. So, in spite of its absolute purity and unlimited consciousness, it is ultimately responsible for all life-forms, adventure and misery in the universe. Only we ourselves, every living being itself, and nobody else, is responsible for our external as well as internal suffering and of those which whom we are connected.

Jainism states, together with Buddhism, that all living things are connected and influencing each other – *parasparopagraho j vanam* – Tattv rtha S tra [5.21], not on a one-to-one basis, but multidimensionally; all living beings continuously and uninterruptedly influence all other beings. No soul can vibrate without affecting all other souls. Independence does not exist.

The soul has the ability to interact with matter (*pudgala*) and exude energy, *pr na*; either *pr na* is related to substance or *pr na* is related to mental activity. It is able to vibrate (yoga) [1]. The essence of *j va* ever remains pure and unstained, but the individual consciousness is limited due to this bondage. The soul has, 'since beginning less time' an invisible vehicle or body around itself, called the karma body or *k rmana shar ra*. It is due to karma or conscious action throughout eternity that the almost infinite variety of phenomena is brought about and through which all phenomena in the universe perish again when their karmic energy is exhausted. All phenomena are therefore connected with the initiative and energy of the conscious and living soul or *j va*. The most primitive organic beings, which have only one sense, the *nigodas*, have a soul that, due to its karma, is encapsulated in the lowest form of existence in our universe.

All beings on whatever ecological or cosmological scale, except the fully liberated or accomplished ones (*siddhas*) have, due to the karmic 'dust' or matter (karma-pudgala) clinging to them, a limited ability to be consciously at one with the essence of *j* va. They all are alive and conscious, but limited by the properties of lifeless matter clinging to them, obstructing them or obscuring them. At the same

time they are all connected with each other in larger units, like ecosystems, continents, etc.

In summary, the concepts *jîva* encompasses: the Absolute (Absolute Consciousness; Purity beyond Mind); Conscious Distinction and Intelligence; Desire (leading to vibration); Energy (*prâna*); Form (*rûpa*); and Bondage (*bandha*) with life-less Matter (*pudgala*). Except the Absolute, all other terms refer to ever changing temporary manifestations, all of which will ultimately cease when liberation is attained by the peregrinating individuals.

Lifeless matter is attracted from outside to form a temporary body for the soul. It exists either in atomic¹ or in geometric compounds of atoms (*anus*). It can be said that the only thing in our constitution that does not truly belong to ourselves, is *pudgala*. The only way in which matter, when it is attached to the soul can influence the soul, is by hampering it – thus limiting, but also diversifying its expressions. This hampering can be done in innumerable ways. The soul can only shine forth in its pristine purity when it liberates itself by self-conscious (human) effort from all forms of *pudgala*.

In the Tattv rtha S tra it is said that *hins* is the disturbance of *pr nas* or vitalities. It means that every *pr nic* movement is a form of violence as compared to the inherent absolute nonviolence of the pure soul. The Tattv rtha S tra has defined hins as injury or hurting of the vitalities by passion vibrations that are carried out through *pramattayoga*¹ which agitate mind, body or speech. On the same lines, another classic Jaina Text, the Purus rtha Siddhi-Up ya asserts that passion is the moving cause which leads to *hins* "... any injury whatsoever to the material or conscious vitalities caused through passionate activity of mind, body or speech is assuredly (definitely) *hins* .

The ultimate purpose of a human is to become self-consciously absolutely non-violent. Then the *j* va remains in its own pure essence; mental, emotional and physical attachment and desire are destroyed and liberation is attained. No *pr nas* relating to the world (*loka*) will ensue anymore. In conclusion we can say that lifeconsciousness is responsible for all that happens in and around us and in every living beings: *J* va, with its many degrees of consciousness, has the ability to perceive and establish bondage, while, at the same time, it maintains its absolute

^{1.} Here yoga implies union or bondage and is not to be confused with its common use as a method of spiritual practice.

purity. Life and consciousness are the core of Nature.

From a Jain point of view it is unacceptable that life, consciousness, intelligence and mind, energy and free will are products or emergent properties of physical matter alone. Nonetheless all these are substance (*dravya*). From a Jain and general oriental, or from an occult point of view, modern philosophy and science err when they surmise that life and consciousness are 'later products' of evolution. The pilgrimage of each soul is a journey through the whole universe, in which all beings are interconnected and who have a common purpose. Jainism is therefore teleological – a concept firmly shunned by modern science.

Ecology is thus the interaction of souls, of living beings, each of which has an inner purpose to consciously become one with the inherent purity, each has within him-, her- or itself. Thus ecology is related to karma. Karma reflects the circumstances and environment in which an ensouled entity is born: Karma determines the type of body and its internal and external properties. The soul goes there where it finds the right circumstances to make evolutionary progress from its own standpoint. In the case of humans, this type of karma is called *gotra-karma*, which determines whether the environmental circumstances in which one is born, and usually refers to the family, caste or social circumstances. Extending the concept of *gotra-karma* further, it implies all ecological circumstances in which a soul takes embodiment. An ecosystem then becomes a conglomerate of individual karmas. A human community or an ecosystem brings those entities together who have particular karmas in common, where old karmas can be exhausted and where progress can be made. No entity exists in a particular space, time, form or motion without previous conscious cause.

Purity, Non-violence, Intelligence, Omniscience and Liberation form the essential nature of Soul. Having inherent perfection and omniscience and its urge for liberation, the soul chooses its own path. So in a Jain based ecology, every component, living and nonliving, has a purpose and direction. Every being is a soul, and therefore all are entangled in the directions they have chosen for themselves. Consequently, every existing being, be it a mineral or deity in a high heaven, is equally respectful.

The explanation of diversification and speciation (i.e. arising of new species in the course of evolution) in the totality of expressions of life in the universe is due to intelligence, knowledge and omniscience, due to which the soul vibrates, attracts karmic matter and gets entangled with it in myriads of ways. It is due to Soul and Karma, which is the inerrable law of the Universe, and which interacts with the initiatives of the inherently perfect *jîva* to which belong all conscious existence.

It is true that we see struggle and the awful fact of a division into predator and prey in Nature, but this can not be the motor and cause of evolution and ecological coexistence. As the innate nature of the *jîva* is non-violence and peacefulness, such developments are rather seen as aberrations in our present lower, avasarpini part of the cycle from the normal cause of nature, which is cooperation. It has also been observed in former cycles as we witness, for example, during the dinosaur period on our Earth and may not necessarily be in the same form on the other dvîpas. By far, the majority of living beings are helpful even today: minerals support our physical being, plants provide oxygen, purified air and food, and imbibe solar energy and integrate it into physical existence. Most insects work for pollination (bees, butterflies, etc.), spreading seeds or cleaning (such as ants), and innumerable microscopic beings play an indispensable role in the recycling processes of nature and even the predators form a necessary part of keeping or restoring balance in Nature. Numerous invisible beings are recognized by us in their working upon physical matter as the forces of nature, and are responsible for meteorological, geological and interplanetary phenomena. No being exists by and for itself alone.

So competition, killing and harming, parasitism, the causing of suffering and misuse of resources are products of the darkened egoic minds of the lower parts of the time-cycles (*k l chakra*), and not expressions of the true and free soul inherent in every living being.

3. Living beings: the Jain Classification

Living beings include all ensouled beings in the universe, and they have bodies that are either invisible and otherwise imperceptible for our sense organs and instruments, or are (partly) visible and perceptible for our senses and their technical extensions.

The basis of the Jain classification of living beings is their stage of inner unfoldment of perception on basis of the number of sense organs they have developed and through which the soul can perceive the outer world. Elemental beings, minerals, *nigodas*, and plants have but one sense: touch or feeling (including psychic feeling). Animals have 2-5 senses, progressively in this order: (1) touch, (2)

taste, (3) smell, (4) color, (5) sound. The highest five-sensed animals and humans have mind also.

Of course even within the one-sensed beings, there are many degrees of development – compare a grain of sand with an orchid. The same applies to the other classes of beings. It is due to the characteristic vibration of each individual lifeessence (*jîva*) that a particular karmic environment and a body fit to express the soul in that stage is created. As described in Jain philosophy each soul has an innate tendency towards liberation, so naturally strives to progressive development (see chapter 16). So after the one-sensed stage, beings will abide for uncountable embodiments in the state of two-sensed beings, i.e. the lowest animals. And so on until five senses and a formation of mind is reached. As liberation can only be attained by means of a developed human mind and only from *Madhyaloka*, the natural tendency of beings is upwards, towards humanity, and from humanity stepwise up by conscious effort along a ladder of spiritual stages up to *Siddhahood* (liberated state of being).

The practical consequence of this doctrine is that human consciousness can experience 'joy' or 'suffering' by means of their senses. These are part of compassion and violence towards others should be avoided as much as possible, if not entirely.

Now we briefly discuss the elements and minerals, and celestial beings as a part of living ecology. It is not within the scope of this article to discuss detailed classification of plants, animals and humans.

3.1 Elements and minerals

Earth-bodied beings or earth-lives may be expressing specific karmas to manifest in bodies which we know as pure earth, silica pebbles, sand, salt, iron, copper, gold or other metals, and also precious minerals such as diamond, emerald, sapphire, and so on. The body forms which the water-lives can take are pure water, dew, moisture, white frost, ice, fog, etc. Fire-lives manifest as, for example, glow, pure fire, flames, rays of light, lightning, or sparks: the spark emitted by the tusks of two fighting elephants show that fire-souls reside in those tusks to suddenly manifest themselves as sparks. The air-bodied entities have the karma to present themselves to us as various types of wind, such as a steady breeze, a whirlwind, a cyclone, a hurricane and many other meteorological phenomena which take place in the air. Some of them we do not usually recognize, such as winds which only occur in the heavens or in the hells, or the final hurricane which will destroy the
earth in distant future. So among them there are souls which come to us as rest or silence, beauty, desire, or silent forces, whereas others manifest as violent forces of nature beyond the power of man to control them – unless a person has developed such a strong will that he has become master of the elements, such as the emotional storms within him. The soil, volcanism, earthquakes, the atmosphere, wind, lightning and the behavior of water are ecological factors of major importance. They offer to others the opportunity to experience their environment, and sometimes to work as karmic adjusters. Natural disasters are not haphazard, but are brought about by conscious, but for us invisible living beings, who act according to the causal karma created by intelligent beings. The forces of nature can only perform their tasks in agreement with their natural character without karmic responsibility of their own. All such beings have the inherent possibility to evolve that which is already within them, and to become a human, a god, or a liberated soul in the distant future.

3.2 Nigodas

The world of one-sensed organisms transcends our scientific imagination. One droplet of water contains – apart from numerous water-souls, the essence of water itself – numberless *nigodas*, and such droplets rain all over the earth including its rivers and oceans. Earth, forests, fields, and also the inside of the bodies of all creatures (except those of the enlightened ones) are packed with *nigodas*. They may include bacteria, viruses, Rickettsia species, phages, etc., but also entities which have not been recognized by modern science. They occur everywhere in loka, including all the invisible realms (so not only on our gross-physical planet). Apart from the visible world, all space in physically imperceptible worlds and in heavens and hells is full of them. Apart from those *nitya-nigodas* that never make progress, all of them as souls will at some point go through all human stages of development and consciousness, and also through all other levels of consciousness within the universe, and will finally become enlightened, omniscient, liberated divine souls.

3.3 Celestial beings

The intelligent self-conscious beings of the upper and nether worlds – 'above' and 'below' the Middle World – have recently lived in physical bodies on Earth and have to and will return to Earth (or elsewhere to *Madhyaloka*) in the future in order to continue their path of expression and ultimate liberation. The highest of them, residing in the highest heavens may incarnate on Earth as remarkably great souls in

particular fields of high culture, or may attend special initiatory events, such as the consecration of a Tîrthankara.

4. Developments in the Science of Ecology

4.1 Gaia

Gaia hypothesis or theory was mainly developed by the biochemist James Lovelock (born 1919) and postulates that the biosphere is a self-regulating entity with the capacity to keep our planet healthy by controlling the chemical and physical environment.

If we look at the situation in which we find the living earth today, we can hardly conclude that life has adjusted itself to the circumstances of the lifeless planet before the beginning of evolution. Rather life has adjusted earth to its requirements. And this was done in an incredibly precise and complex way. It is, for example, remarkable that the average temperature on earth - now about 14 degrees - has remained constant within the limits of relatively small variations during a long period, while other periods have seen long permafrosts or tropical circumstances.

The theory was named after the Greek goddess of primordial matter or earth, the nourisher of all things, and to whom all must return (in their physical aspect) at death. The idea was conceived in the mind of chemist James Lovelock and first published in book form in 1979: *Gaia, A New Look of Life on Earth*. Lovelock states that the physical and chemical condition of the earth, the atmosphere and the oceans is made and kept suitable and comfortable for life by the presence of life itself.

The earth's atmosphere, for example, is very unstable chemically, contrary to the atmospheres of for example Mars and Venus. A great number of chemical reactions take place continuously in our atmosphere. If, for example, the carbon dioxide content of the atmosphere from the present 0,03% were to increase to 1% (and that is almost nothing compared to the 98% of a dead planet) temperature might rise to boiling-point, and all life in its present material form would cease to exist. If plant, animal and human life were to cease to exist, the earth's atmosphere would return to a condition of stability much like that on Mars or Venus.

The mechanism of building and sustaining the balance of the biosphere is life itself. The idea that the biosphere is a self-regulating entity with the capacity to keep our planet healthy in contradistinction to the usual view which holds that life has adjusted itself to the given circumstances on our planet, but "Lovelock boldly asserts that rocks, soil and atmosphere of the earth are either produced or directly modified by the planet's living organisms, observing that virtually all mineral samples that man has studied, even those dating back two billion years or more, bear life's unmistakable mark.." The Gaia theory was co-evolved with the knowledge and ideas of the American Microbiologist Lynn Margulis (see the paragraph on symbiosis and cooperation).

One example brought forth by Lovelock is that one particular microorganism living on continental flats along the world's coasts, is largely responsible for the ozone balance of the upper atmosphere, the absence of which would make life on earth impossible. How does that minute creature in the sea 'know' that it has to function responsibly for all other life on earth, including humanity? No scientist would even think for a split second that this micro-organism itself could have such knowledge, intelligence and compassion. Still the fact that it (unawares) fulfills its specific function for the whole planet can not be denied.

To what extend can the earth be compared to a living organism? The earth shows in its functioning great resemblance to the human, animal or vegetable body. In our body all organs, and within the organs the cells, and within the cells the organelles, perform their own function while serving the whole. By subtle balances in hormone regulation, temperature, blood pressure, blood sugar, etc., are kept within defined limits from the moment our physical life began until the moment we die. Living planets have their own balances. Balances are kept by means of cybernetic processes, i.e. processes comparable to the operation of a thermostat. A thermostat has the ability to perform measurements, and has a memory containing the desired stable situation it is to maintain. The bodies of organic beings as well as the earth work in principle in the same way.

Not all factors have remained constant since the beginning of the earth. There have been extreme changes in the atmosphere, otherwise the atmosphere would still be akin to the present Martian atmosphere. The remarkable thing is however that life as a whole has obviously been able to keep these changes under control and at the same time keep other parameters constant.

A number of essential ideas are echoed in the Gaia theory. In the first place that life is a concept that stretches beyond the physical limits of plants, humans and the primitive forms of life. The atmosphere belongs to life, it is not merely life's

environment. A second essential idea is that all organisms and processes taking place outside the boundaries of the organisms themselves are connected. No single atmospheric condition, no drop of water or even a stone is excluded. Matter and life everywhere show a tight unity and close cooperation. This seems a reflection in the material world of the Eastern philosophy saying that nothing can come into existence and exist in independence of other things. A third very essential idea is that cooperation and service of a larger whole are inherent in nature. This raises nature above mere selfishness of the individual.

Gaia theory demands a worldwide symbiosis of living organisms. "We realized that it was not life or the biosphere that did the regulating but the whole system. We now have Gaia theory, which sees the evolution of organisms as so closely coupled with the evolution of their physical and chemical environment that together they constitute a single evolutionary process, which is self-regulating. ... Through the ceaseless activity of living organisms, conditions have been kept favorable for life's occupancy for the past 3.6 billion years" (*Healing Gaia 24-5*).

Gaia was interpreted as an idea that the Earth is alive. For example, Lovelock (2000) stated in the first paragraph of his book *Gaia: A New Look at Life on Earth*: "The quest for Gaia is an attempt to find the largest living creature on Earth."

Lovelock, however, defines life in a occidental scientific way: mechanistically and independent of consciousness – as a self-preserving, self-similar system of feedback loops, like Humberto Maturana's autopeiosis (Maturana, 1973) as a selfsimilar system. An autopoiesis is a mechanism organized as a network of processes of production (transformation and destruction) of components which through their interactions and transformations continuously regenerate and realize the network of processes (relations) that produced them.

However, in a mechanical approach like this, there seems no place for a guiding, intelligent substance or 'soul,' unless as a secondary arising property of the system. Jains see it the other way round: The eternal soul substance of any system (which is finite), including the components, ways of working and transformations within that system, and whatsoever complex, is the conscious guiding force within that system. The system itself would be lifeless, until and unless an individual soul enters it.

Lynn Margulis (1938-2011), who in important aspects supports Lovelock's theory, is famous as the great propagator of co-operation of micro-organisms

through co-evolution in Nature. She discovered that some organs within living cells most probably were independent living beings in a past phase of evolution of life on Earth – a theory which now find wide acceptation among biologists. According to her, the Earth is a kind of community that can exist at many discrete levels of integration. In multicellular organisms cells do not live or die instantaneously, nor are homeostatic "set points" constant through the life of an organism. The same is true for the cooperation units (organisms and inorganic entities) which together build up the earth.

In 2001, the International Humanist and Ethical Union signed the Amsterdam Declaration, starting with the statement that "The Earth System behaves as a single, self-regulating system with physical, chemical, biological, and human components." This definition avoids the question whether the planet itself should be regarded as a living organism or an entity highly comparable to a living organism. But it includes life in the 'Earth System' and apparently does no longer regard the Earth as a lifeless clump of minerals on which life developed as a result of chemical possibility and chance.

Jainism regards the elements and minerals in all phases of solidity as ensouled beings. Natural forces and events are related to invisible conscious beings. Does it follow that Jainism automatically subscribes to relevant aspects of Gaia theory, and does it teach that the Earth itself is a living being or divinity?

For Gaia to work it seems to need an organizing principle of a higher order. Where do we find such an organizing principle within the Earth? Jainism does not see the totality of souls in the universe as part of a larger over soul, and also does not explicitly teach that the planet or any *dvîpa* or *bhûmi* has a soul of its own – unless we treat the Earth as one of the *Jyotiska*, the heavenly bodies including the planets. But then, nothing is said in literature about the complexity of such souls. Jains therefore may deny or doubt the existence of a supervising intelligence, an individual soul to the Earth itself. Still, the question then remains: how ('by whom') are all these individual souls coordinated into a system that remains stable and suitable for ages. The answer may be found is that the *jîva* itself, being omniscient in its essence, is far more intelligent and conscious than any individual conscious being. Therefore communication between souls on a higher level, beyond the individual level, could explain super-cooperation in nature. As repeated many times, all *jîvas* are there to help each other.

Did the Earth go through a process of re-embodiment? Certainly it did according to Hindus and Theosophists who define one life-time on the planet (together with its *dvîpas*) as a Day of Brahmâ, while Brahmâ 'him'self lives a hundred years. Theosophy very explicitly states: "The earth actually is an animate being, as are all the celestial globes"; and: " each of the planets, ... being ruled by the highest regents or gods, . . . is a septenary, as also is the chain of *dvipas* to which the Earth belongs, etc.

Elsewhere in Theosophical literature, in letters written by the Mahâtmas, the 'founders' behind the Theosophical movement we find that the correspondence between a mother globe (the Earth or any of the other man-bearing $dv\hat{i}pas$) and her child – man – may be thus worked out. Both have their seven constituting principles or elements. In the globe, the elementals (of which there are in all seven species (the four of Jainism + three higher types) form (a) a gross body, (b) her fluidic double or model body, (c) her life principle, (d) her fourth principle $k\hat{a}mar\hat{u}pa$ (desire body) is formed by her creative impulse working from centre to circumference; (e) her fifth principle (her animal soul or *manas*, physical intelligence) is embodied in the vegetable (in germ) and animal kingdoms; (f) her sixth principle (or spiritual soul, *buddhi*) is man; and (g) her seventh principle ($\hat{a}tma$) is in a film of spiritualized k sa that surrounds her (cf. Barker, 94).

According to Theosophy, Earth definitely has her own *jîva* or life principle. Living beings do not live on the earth, but are part of it. Moreover we see that the planet has its own force working from within outwards, and it is clearly stated that a physical intelligence is inherent in the planetary organism. Man too is one of the factors of which the earth is composed, namely its spiritual soul. From this point of view, humankind is an indispensable, and the most responsible part of Gaia.

Jains as individual thinkers and *anekântavâdins* may or may not accept the cooperation and intelligence that keeps the planet balanced and proper for life, while most of them probably deny the concept of Earth as an individually ensouled being, goddess or god, though when regarded as one of the *Jyotiska*, they may stand closes to the Theosophical viewpoint.

4.2 Deep Ecology

The term deep ecology, coined by the Norwegian philosopher Arne Naess (1912-2009) in his paper "The Shallow and the Deep, Long-Range Ecology Movement (1972)." Naess recognized the inherent value of living beings regardless

of their instrumental utility to human needs. Deep ecology argues that the natural world is a subtle balance of complex inter-relationships in which the existence of organisms is dependent on the existence of others within ecosystems. Human interference with, or destruction of the natural world poses a threat therefore not only to humans but to all organisms constituting the natural order. "Man must give up his privileged position as the lord of the earth and seek a new accommodation with nature, at once harmonious, modest, and subordinate." Naess was one of the first modern scientists to recognize, like Jainism, ethical and metaphysical values which supersede the common mind and its mere brain-mind reasoning.

Jainism has traditionally related all aspects of life with a religion that reaches the very core of existence. Religion in its true meaning is deep understanding and has always been taught by those who have a very much deeper insight in the nature of reality than average people.

Arne Naess recognized the inherent value of each living being. For a Jain this would be just 'normal thinking,' because in Jainism there is no fundamental distinction in value between humans and other ensouled beings. Naturally no Jain would want to create an obstacle for the chosen path of any soul. If particular organisms have an active value for people, like cows, fruit trees, medicine or objects of beauty, they may be used and gazed at with gratitude and respect, but never be misused with force and against their inherent nature.

Jains will not object to Naess's statement that "the existence of organisms are dependent on the existence of others". An ecosystem is the togetherness and living together of beings in a particular environment. It includes the mineral circumstances of soil, water, air and fire.

Most westerners, except mystics, would not subscribe to the idea of life, soul, feeling or consciousness in all the components of an ecosystem. An occidental ecologist might in principle decide to kill living beings for the sake of saving the system. Philosophy in the West has often ignored the natural world, since most studies in ethics have focused on human values. The mission of ecophilosophy is to explore a diversity of perspectives in interrelationships among all that is involved. It fosters deeper and more harmonious relationships between the self and the natural world. It does not subscribe to anthropocentric environmentalism – which is concerned with conservation of the environment only for exploitation by man for human purposes – since it is grounded in a quite different set of philosophical

assumptions. Deep Ecology takes a more holistic view of the world human beings live in, together and of equal value with the totality of life. It seeks to apply to life the understanding that the separate parts of the ecosystem (including humans) function as a whole.

The Deep Ecology movement has also propagated a drastic reduction of the world population; but this can not be realized practically and ethically. From a Jain point of view the solution of many world problems, economically as well as ecologically, would rather be sought in simple living. The concepts of *aparigraha*, i.e. non-grasping or non-hoarding is one of the very fundamental concepts of Jainism, ancient and modern. It simply means: not to take more than is needed. Quite a few people world-wide have an awakening awareness to such ideas nowadays.

Principles of Deep Ecology

Proponents of deep ecology believe that the world does not exist as a resource to be freely exploited by humans. The ethics of deep ecology hold that a whole system is superior to the interests of any of its parts (e.g. human individuals).

Proponents of deep ecology summarized their view in a number of points as phrased by Arne Naess and George Sessions in 1984, the most important of which are useful in our context: a) The well-being and flourishing of human and nonhuman life on Earth have values in themselves. These values are independent of the usefulness of the nonhuman world for human purposes. b) Richness and diversity of life forms contribute to the realization of these values and are also values in themselves. c) Humans have no right to reduce this richness and diversity except to satisfy vital human needs. d) The ideological change is mainly that of appreciating life quality ... rather than adhering to an increasingly higher standard of living.

The aim of ecophilosophy is a total or comprehensive view of our human and individual situation. 'Comprehensive' includes the whole global context with humanity in it, sharing a world with diverse cultures and beings. We move toward a total view via deep questioning.

Adherents to Deep Ecology come from all walks of life and from a wide variety of cultures and places. The thinking of the heart I see at least as important as the thinking of the mind. Each person has something unique to contribute by living their own ecosophies. Ecosophy is not one rigid system or viewpoint and is a living and developing philosophy. This harmonizes with the Jain concept of anekântavâda: the doctrine that many different viewpoints are possible and respectable. No one philosophy or technology (if such is needed) is applicable to the whole planet. There will be diversity on every level.

4.3 Symbiosis and Cooperation

Lynn Margulis was the great propagator of co-operation of micro-organisms through co-evolution in Nature, and she discovered that some organs within living cells most probably were independent living beings in a past phase of evolution of life on Earth. According to her, the Earth is a kind of 'community of trust' (a remarkable term for a scientist, 'trust', because only conscious beings can trust (or distrust) each other) that can exist at many discrete levels of integration.

The most definite form of cooperation has been proposed as a theory by Margulis. It is now widely accepted among biologists that complex eukaryotic cells we know them today were formed by symbiosis between primitive cells and certain prokaryotes, which became cell organelles such as mitochondria and plasmids, or spirochetes which became flagellae. For example cyanobacteria became mitochondria, the energy factories of the cell in eukaryotes. Up to today, mitochondria have their own DNA, and reproduce independently, and at different times than the rest of the cell. It is believed that the present forms of life could not have developed without this complex cooperation between early forms of life which at first developed independently.

An intimate relation exists between some 25,000 species of fungi (among others of genus Cladonia) and algae (e.g. Trebouxia) or cyanobacteria, together known as lichens. The algae or cyanobacteria act as photosynthesizers for the fungus. The symbiosis is so intimate that we tend to treat lichens as species, and have their taxonomy based on their habitus as a whole. The way lichens multiply is through pieces breaking off that continue their growth elsewhere when they get the opportunity. This holds the mold and the alga together forever. But the mold may also procreate through spores, from which grows a new thallus. It has to reach for and find its alga. What the benefit is for the alga as an individual I cannot say, except that it finds protection. But the cooperation leads to "remarkable examples of innovation emerging from partnership: (the lichens) possess many morphological, chemical, and physiological attributes that are absent from any partner grown independently. The association is far more than the sum of its parts" (Margulis, 1967).

Many organisms cooperate with nature in a still wider sense.

As a general tendency we may quote Augros & Stanciu (1987): "*Nature is not at war ... Nature is an alliance founded on cooperation*" (p. 129).

Some authors are of opinion that the cosmos including all its properties and constants is uniquely fit for life as it is. Michael Denton, in his *Nature's Destiny*, even goes so far as to say that "the cosmos is uniquely fit for only one type of biology – that which exists on earth – and that the phenomenon of life cannot be instantiated in any exotic chemistry or class of material forms" (p. xiii). Such a statement is very extreme, and would be falsified as soon as any form of life were encountered elsewhere in the universe. It is also contrary to Buddhism, which declares, in the Avatamsaka Sûtra and elsewhere, that there are many planets and universes with different forms and entirely different 'life-styles'.

Most thought systems accept life as something universal, and not limited to physical matter. But if we leave out earth-centered and anthropocentric restrictions, and leave open the possibility of the universal presence of life, we might still ask whether the universe, regarded as a wholeness, is one coherent logical phenomenon of which life is an inherent part.

Traditional western science would say that life itself, the planet and all its ecosystems are the result of the properties of matter combined with personal desire, even inherent selfishness – a metaphysical factor. Jainism would add mutual benefit, service for the benefit of others, altruistic service to a larger whole (Gaia hypothesis) and all-encompassing wisdom and compassion as metaphysical factors.

5. Jain Impact on Practical Ecology

Traditionally Jains have been very nonviolent and kind to living beings and nature, not taking more from nature than was necessary. This is illustrated in many Digambara temples by wall paintings of the so-called *kalpa* trees originally present in nature that fulfilled all human needs. There are ten types of *kalpa* trees, and they provided drinks, food, clothing, ornaments for the women, garlands, light, housing, utensils and musical instruments. (for details see *Ecology Religion* by the present writer, recently published at Prakrit Bharati Academy, Jaipur.

Another type of tree often seen in temples symbolizes six human attitudes or 'thought colors' (*leshyas*), depicted as men and there attitude towards a fruit tree.

We could as well call these 'ecological attitudes'. These are: Uprooting the trees, black (destructive, violent, uprooting the future). Cutting main branches, blue (haughtiness) Cutting smaller branches, grey or brown (depressive, lazy) Cutting twigs, red or yellow (distinction and care) Picking ripe fruits from twigs, yellow (benevolent) Taking fruits fallen on the ground, white (enlightened).

Again a tree that is often found painted in temples depicts a man hanging down from a branch, sticking out his tongue, on which sweet honey drops. He happily and carelessly enjoys life. But he is not aware that below his feet is a pit with deadly poisonous snakes that will kill him when he falls in the pit. He is also not aware that the stem of the tree is violent shaken by an elephant: his emotions. Third, he does not see that two mice - a white and a black, for day and night - are constantly gnawing at the basis of the branch from which he hangs, because in his careless way of living he ignores the fact that he is undermining his own support which symbolizes the inevitability of death. This is what present day humanity is doing, and there is only one way out of the cycle of misery: to adopt a wise spiritual, unselfish attitude. This is symbolized by a divine being in a heavenly vehicle (vimâna) floating above the tree, raining flowers on him: at any time, before it is too late, humanity can turn away from the dull sweet life that will ultimately kill all that is natural including man himself, towards a spiritual life of wisdom and consideration. Humanity will save itself, live in eternity, and in harmony with Nature and the Divine within himself.

These three tree symbols beautifully present us the core of Jain ecology: take what is given at the right time, control and ennoble your own mental and emotional life or your character in general, and remember the choice one has at any time to choose the easy path of self-destruction or the path towards eternal blissful life.

6. The Practice of Jain Ethics

From earliest times, datable at least to Parshvanâtha, who is supposed to have lived about 900 BCE, Jains have advocated the practice of nonviolence or ahinsâ, for the purpose of purifying one's soul. By observing an ethical life, one actively restructures one's karma, expelling dark materiality and cultivating light. By the time of Mahâvîra, five foundational vows were to be observed by all Jains

appropriate to their status, lay or monastic: *ahinsâ* (nonviolence), *satya* (truthfulness), *asteya* (not stealing), *brahmâcârya* (sexual restraint), and *aparigraha* (non-possession). For lay people, these vows have prescribed expected norms of behavior in the Jain community: vegetarian diet, honesty, faithfulness in marriage, and donations to religious persons (monks and nuns) and organizations such as temples and Jain organizations. Additionally, several occupations are not suitable for Jains, such as the manufacture or sale of weapons or meat.

For monks and nuns, these vows become increasingly rigorous. These individuals are forbidden from preparing food, because of the potential harm caused in the process of collecting, chopping, and cooking of grains and vegetables. Food must be freely given by lay supporters, and ideally one is given food in small amounts by many different families in order not to cause a disproportionate burden to only a few households. This guards the purity of the monk or nun, and also benefits the families who, by donating food, cleanse their own karma. As a practice of truthfulness, monks and nuns regularly confess their shortcomings, asking forgiveness for even the smallest of infractions. Touching between genders is strictly forbidden. Monks and nuns possess only a change of clothing and own no shoes. When they take their final vows, they forgo all motorized or mechanical forms of transit, even bicycles. They periodically remove the hair from their heads to discourage lice, and bathe infrequently, and then only with very meager amounts of water, if they use any water at all. In the Digambara tradition, the most advanced monks give up all clothing and remain naked until death. In this state, they avoid harming the insects who could be trapped in their robes, they avoid harm to the cotton that would need to be woven for their garments, they take nothing at all from the environment to clothe themselves, have no shame about their sexual organs, and do not even possess a bowl for eating food, taking donations of food directly into their palms.

These vows bring the mendicant closer to the purified soul, dispelling karma and revealing increasing energy, consciousness, and bliss.

In addition to the five great vows, monks and nuns also adopt five rules of conduct (*samiti*) that heighten mindfulness of the soul in one's life and the life of others minute by minute. These five are care in walking, care in speaking, care in accepting things from others, care in picking up and putting down things, and care in the performance of excretory functions. The adoption of these observances makes nearly every movement an occasion for reflection on the status of one's soul.

7. Engaging the Jain Soul in Environmental Ethics

The Jain tradition challenges many traditional categories and conceptions regarding the human person and ethics. First, it exhibits a radical pluralism. Innumerable souls take seemingly countless forms. Second, it suggests a radical egalitarianism. Each soul has endured countless births in a variety of different forms of life. Each human knows innately how it feels to be an animal, how to be a member of the other gender, how to feel empathy even with the earth itself. Third, this tradition evokes images of the solitary hero. Each of the Tîrthankaras forged a life of privation through which they gained great spiritual strength, serving as a model for later practitioners. Their spiritual liberation was achieved without the help of others, and, once liberated, they are able to inspire others but are not able to directly provide aid or succor to others.

If we examine the three soul qualities of Jainism: pluralism, egalitarianism, and individualism, we confront a religious system quite markedly different from those that emphasize monism (such as Brahmanical Hinduism) or monotheism (Judaism and Islam) or trinitarianism (Christianity) or even harmony (Confucianism and Taoism). How then, might Jainism contribute to the conversation of environmental ethics?

A renewed sense of connectivity with others arises as one enters into the Jaina spiritual journey. For Jains, this journey requires care in all inter-personal and animal relationships, to be enacted through adherence to the vows of nonviolence, truthfulness, not stealing, sexual restraint, and non-possession. The sense of community and personal responsibility in this tradition leads to the development of not only a normative ethics that may be universally applied, but is also leads in many cases to the cultivation of a personal ethics in keeping with one's individual tastes and inclinations. In Jainism, this concept of 'others' extends beyond the human realm to animals and to plants and insects. Non-violence requires a careful consideration of how one's actions affect not only the human order. In traditional Jainism, vegetarianism, periodic fasting, vows of stability (limiting the extent of one's travel), and in some instances the donning of a face mask and the use of a broom to sweep one's path constitute adaptive ethical responses that exceed what would normally be expected under the general requirements of normative ethics. Particularly for laypersons, the application of the Jain ethical code requires imagination and creativity. Jains in the pharmaceutical industry, for instance, have

developed animal-friendly testing to minimize harm and suffering. Many Jains in America, aware of the peril to the well-being of animals caused by factory farming, have eschewed dairy products that otherwise would be consumed in more cowfriendly India. The list of ethical issues to be considered in Jainism includes topics not generally taken into account when thinking about the 'good life' in Europe and America.

Jainism's unique cosmology gives cause for Jains to think deeply about their role in such environmental issues as industrial pollution and global warming. Jains state that the waters and the air contain life, in addition to the living creatures that dwell therein. Hence, pollution deemed harmful in either element must be mitigated, not only for the sake of human health, but also for the sake of the life that thrives in air and water. Similarly, global warming will not only cause great disruption for humans but will displace and perhaps decimate countless species, the most famous at present being the polar bear. Given human complicity and causality in regard to climate change, Jains would have a double incentive for taking action: protection of humans and protection of other life forms.

The Jain definition of soul puts life in the recesses of the earth, in the waters of lakes and oceans, in the very air itself. In order to preserve the well-being of our own soul, Jainism suggests that steps must be taken to protect the lives of all beings. With disregard and perhaps intentional harm, karma accrues that deprives the human being of energy, of happiness, even consciousness itself. By respecting life in its human and non-human forms, the soul embarks on a steady course of self-purification that benefits all beings.

8. Conclusions

The Jain idea of omnipresence and eternity of life, consciousness and purpose in Nature is still far away from the predominant western ideas of the secondariness of consciousness and life. Also the axiom of an inherent spiritual, guiding and nonphysical and ethical essence and useful coexistence as leading factors in ecology is unacceptable to most scientists in the Western tradition. In the Jain vision, life, mind and responsibility, not dead matter, are the cause of all phenomena in the universe. All beings in an ecosystem, either on a smaller scale or that of the Earth or the Universe, are there 'to help each other', i.e. have the possibility to influence each other's evolutionary path and well-being positively. However in practical ecological ethics, modern science and Jainism seem to approach each other more closely. Both are concerned about the well-being of individual lives as well as about the total health of all who live together on our planet. In modern society, though usually not in the context of official science, ideas like a living ('ensouled') Earth have gained popular momentum, thanks to the work of Lovelock, Margulis and others, even though they themselves deny any mechanism superior to Darwinist blind and chance processes. Due to the pressure of overpopulation and environmental degradation as well as the contact with non-western and non-Christian cultures a new, previously almost unknown ethics – though in the modern world partly no more than a fear-based opportunistic morality towards life – has arisen worldwide.

In the human sense, the impact of Jain ideas greatly challenges traditional occidental categories and conceptions regarding the human person and ethics. A renewed sense of connectivity with others – humans and all organic as well as non-organic manifestations of Nature as being consciousness and spiritual throughout – comes to the surface of our awareness if one enters into the Jain joint pilgrimage of living souls towards ever greater nobility.

9. Suggestion for Research

- 1. Thorough study of the Jain scriptures with regard to statement about cooperation, (mutual) helpfulness, non-violent solutions, examples (and stories) expressing the attitude of humans towards other living beings and the environment in general.
- 2. Research to examples of cooperation in Nature.
- 3. Studies of the Scriptures with regard to living and conscious natural forces, such as the Kumâras.
- 4. Examples of non-violence in the workings of Nature.
- 5. Seeking examples of beings working for the benefit of others or of a larger whole (altruism versus inherent selfishness).
- 6. Brainstorming (discussion, study groups and research) about possible nonviolent human attitudes world-wide and actions which are ecologically beneficial.
- 7. Proposing expert realistic juridical laws for India (and elsewhere) which support non-violent attitudes towards animals and other entities, including ecosystems. Many countries already have laws that protect nature and the situation for living beings better than India does, and from the Jain background

India can seek to create comprehensive laws that outdo laws of many other countries and create examples that could inspire others to follow suit.

8. Human islands in nature instead of other way round.

So far, at least in the last few centuries, the human species has sought to dominate other species and nature. Instead of a *parigrahic* attitude humanity should develop a respectful *aparigrahic* attitude towards nature.

Instead of reducing nature to islands (reserves, etc.) between cultivation and civilization, Humanity should take on the more humble attitude of striving to limit herself to 'islands' or regions of cultural activity in the midst of nature – reducing destruction of nature to an absolute minimum and leaving the largest possible part to pristine nature. This involves curtailing of unlimited expansion and of uncontrolled and unsupervised exploitation.

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26. Jain Contribution to Mathematics

Anupam Jain, S.C. Agrawal and R.S. Shah

Abstract

Mathematics forms an integral part of ancient Jaina texts, some going back to 1000 to 2000 years. Mathematical concepts are used to define, besides, cosmlogical and geological parameters, karma and its consequences and religious and philosophic discourses. Mathematics forms main thrust of Ganitanuyoga and Karunanuyoga. It consists of *laukika ganit*, useful in dailylife and *alukika ganit* for understanding para-worldly consequences and includes the Number theory, Karma system theory, Fundamental Operations, Set Theory, Fractions, Simple, quadratic, cubic and higher order Equations, combination and permutation (combinatorics) etc. Work of Shridhar and Mahaviracharya are some of the prominent mathematical treatises. Important contribution of Jaina scholars to mathematics is summarised in this article.

A survey of various libraries and Bhandaras reveal a large number of manuscripts dealing with mathematics and astronomy; only a few of them have been translated so far and whereabouts of many are not known. We provide the results of our search in this article and group them in different categories, depending on their availability.

Key words: *Laukika Ganit, Alaukika Ganit,* Mathematics, Set theory, fractions, combinatorics, Mahviracharya, Shridharacharya

Scriptures Quoted: Ganitanuyoga, Karananuyoga, Bhagvatisutra, Tiloyapannatti, Lokavibhaga, Dhavala, Jayadhavala, Gommatasara-Jivakanda, Karmakanda, Labdhisara, Anuyogadvara.

1. Introduction

India has a glorious past and Indian scholars have contributed significantly

to the development of knowledge. Religion and philosophy have been their major fields of interest but our ancestors have made important contributions in the field of science and technology, especially in Mathematics and Astronomy. '*Sramana*' (ascetic) and 'Vedic' (ritualistic) are two main cultures of India. References to '*Sramana*' culture in Vedas indicate its presence during Vedic and pre-Vedic era. The Jaina tradition is one of the two streams of '*Sramana*' culture.

In the *mangalacharana* (invocation) of his famous Indian mathematical text of Jaina tradition, Ganita Sara Sangraha (GSS), the great saint-scholar Mahaviracharya (814-877 CE) says "I bow to Lord Mahavira who is unsurpassable in all the three worlds and who has acquired four infinite attributes. I bow to that highly glorious Lord Jina (the conqueror of passions) with whose shining lamp of the knowledge of numbers, the whole of the Universe has been made to shine [1]." In this *mangalacharana* Mahaviracharya refers to Lord Mahavira as an illuminator of knowledge of numbers.

Another great mathematician Acharya Shridhara (799 A.D.) writes in the invocation of Trishatika that- 'Sridharacharya bowing to Lord Jina tells the substance of mathematics as extracted from the Pati composed by him for the use of people [2].' This indicates the purpose of compiling mathematical texts by Jainacharyas. A great number of Jain saints, however, contributed to the development of mathematics for religious and metaphysical purposes. In Jain literature, we find not only elementary but quite advanced mathematics like set theory, karma quantum system theory, theory of series and sequences, combinatorics, logarithms, number theory results, fascination with large numbers, crude ideas about multitude of infinities etc. Jain acharyas used mathematics as a tool to explain:

- * Cosmological data and description of the three-fold universe. It is used in giving length, area and volume of different sections of the universe and dimensions of mountains, rivers and parts of our earth (Jambudvipa).
- * Different types and sub-types of karmas and their operations of uprising, binding and shedding and the net effect of their infinitude of combinations on living beings.
- * To get auspicious place and time for various religious ceremonies like *dîksha* (initiation) and *Pratistha* (consecration) etc.
- * To train followers (householders) in basic mathematics (Laukika Ganita)

required in daily life.

* Jain logic system, which is used for establishing facts and reconcilation with others' views. Modern mathematical logic is available in the texts of Jain *Nyaya* (Logic).

In light of the above, it is clear that mathematics is an integral part of Jain literature. According to subject-wise classification scheme, the Jaina literature can be classified in four sections that are known as anuyoga [3].

1. Dharmakathanuyoga		Prathamanuyoga
2. Karana- Carananuyoga	OR	Karananuyoga
3. Ganîtanuyoga		Carananuyoga
4. Dravyanuyoga		Dravyanuyog

Out of these four anuyogas, text of Ganitanuyoga and Karananuyoga are full of mathematics. The canonical work Sutrakrtanga, Sthananga, Bhagavati, Jivabhigama, Prajñapana, Suryaprajñapti, Candraprajñapti, Jambudvipaprajñapti, Anuyogadvarasutra, Tattavarthadhigamasutrabhasya, Visesavasyaka-bhasya, and Karmaprakrti of Svetambara tradition and Kasayaprabhrta, Satkhandagama, Panchastikaya, Tiloyapannatti, Dhavala, Jayadhavala, Gommatasara, Trilokasara, Jambudvipapannattisangaho etc. of Digambara tradition are full of mathematical content. We will discuss the salient features of these canonical texts from mathematical point of view in the present article.

A primary survey of Jaina literature yields that the following mathematical topics are discussed in detail:

- * Place value system with zero having a place value, measurement systems, fractions, geometry, solid geometry, series, sequences, logarithms, theory of indices, rule of three, algebraic equations, Binomial co-effecient, Exponentiation, Combinatorics, Partition theory, Figurate numbers, miscellaneous problems on interest, wood cutting, shadows, Movement of person etc.
- * Astronomy, Cosmology.
- * Set Theory, System Theory, Number Theory, Theory of infinity, Partition Theory, Transfinite numbers, Theory of Matter etc.

Texts of Patiganita written by Shridharacharya, Mahaviracharya, Rajaditya, Simhatilaka Suri, Thakkura Pheru and others were composed to train the pupils in

mathematics for better understanding of canonical texts and for solving the problems of daily life. Broadly we can classify the entire mathematical content found in Jaina Literature in two parts-

Worldly Mathematics (Laukika Ganita):

The Mathematics which is useful in daily life or understanding the philosophical details related to conducts of laity comes under this category. The content of Patiganita texts composed by Shridhara, Mahavira etc. and a part of mathematics found in canonical texts come in this category.

Para-Worldly Mathematics (Lokottara Ganita or Alaukika Ganita):

The Number theory, Karma system theory, Mathematics related to Palyopama, Sagaropama, Rajju etc. come under this category. Mathematics found in Tiloyapannatti, Lokavibhaga, Dhavala, Jayadhavala, Gommatasara - Jivakanda and Karmakanda, Labdhisara and other Karmagranthas come under this category. The Arthasamdristi Adhikara of Samyakjnanachandrika commentary is mostly mathematical.

In respect of 72 arts, it is said that all the arts are full of Mathematics [4]. Mathematics plays a great role in Jainism. The technical word used for mathematics in Jaina tradition is *Samkhyana*. In Thanam, we find an important verse related to the topics of *Samkhyana* [5].

The types of mathematics as per Jaina Canons are following:

Ancient Term - Present Subjects

- 1. Parikarma Fundamental Operations
- 2. Vyavahara Applications of fundamental Operations
- 3. Rajju Para worldly mathematics, related to Simile Measure etc.
- 4. Rasi-Set Theory
- 5. Kalasavarna Mathematics of Fractions.
- 6. Javata Tavata Simple Equations
- 7. Varga Quadratic Equations
- 8. Ghana Cubic Equations
- 9. Vargavarga Higher Order Equations
- 10. Kalpa/Vikalpa Combination and Permutation (Combinatorics)

In the light of above, we made a survey of history of mathematics to find out the reason why Jaina school of mathematics was ignored by academicians and as to when it came to light. Modern mathematical world was completely unaware with this school before the publication of Ganita-sara-Samgraha in 1912 with its English translation by M. Rangacarya [6]. After this, a detailed survey article under the title 'The Jaina School of Mathematics' appeared in Bulletin of Calcutta Mathematical Society (1929) written by B.B. Datta. It indicated that the Jaina school of Mathematics has origin in ancient times. Later, A.N. Singh, K.S. Shukla, R.C. Gupta, L.C. Jain, S.S. Lishk and Anupam Jain produced many articles and books. Seven volumes of L.C. Jain's work and 'The Enigma of Universe' by Muni Mahendra Kumar-II are very important. After completing a minor research project 'Mathematics in Ardhamagadhi Jain Canon (2006)', Anupam Jain recently completed a major research project 'Development of Mathematical Thoughts in Jain Literature (2016)'.

A careful survey of Jaina Canonical and non-canonical literature shows that list of the saints and scholars who contributed in the development of Mathematics directly or indirectly is very long. We give the list of some prominent scholars with the name of the texts of mathematical interest, in Appendix-1 since many of these are still unpublished or unknown to the scientific world.

This list indicates the richness of Jain literature from mathematical point of view, even though it is not complete. Many other names like Gunabhadra, Yallacharya (Yalla), Nemicandra, Siddhasuri, Lalacanda, Anandakavi, Bhudharadasa etc. can be added. Garga Risi is a renowned Jaina astronomer responsible for the development of Jain Nakshatra system. According to Saraswati (1979), Maskari, Purana, Putana also may be Jain scholars. The verse used in Baksrali Manuscript, use of the word *Kala Savarna* and other internal references indicate that this may be a part of a Jaina work.

During the past three decades we have tried to collect information about the vast Jain mathematical literature, but we could pull out only a small part of it. Many mathematical manuscripts written by different Jain scholars still remain unexplored, unidentified and we are still unaware about their mathematical content. Even so, the available information is very vast and deserves attention. The list of Jain authors (Appendix-1) and their mathematical works exhibits the importance given by Jainas to Mathematics.

We can classify all the available non-philosophical, non-canonical mathematical texts (Laukika Ganita) of Jaina School in the following 6 groups.

Group I:

In this category, we include those mathematical texts, which are well known and their critical editions have been published.

1. Trishatika of Shridharacharya (8th century CE)

Acharya Shridhara was initially Shaiva (Hindu) and at that time he composed his first book Patiganita. After some time he adopted Jain religion and composed Trisatika (Patiganitasara or Ganitasara). Trishatika was very popular, even for several centuries afterwards. The area of segment of circle and volume of sphere were exactly calculated by Acharya Shridhara for the first time. The authenticity and popularity of Shridhara can be evaluated by the proverb 'Ganite Shridharacharyah'. There is a lot ofinfluence of Sridhara on later mathematicians like Aryabhata-II, Sripati, Bhaskaracarya, Simhatilkasuri and Thakkura Pheru. Trishatika was first published by Dvivedi in 1899 and later by Rastriya Sanskrita Samsthana, New Delhi with its Hindi translation and commentary by Sudyumna Acharya (2004). Its invocational verse (*mangalacara*) was changed. later. The original invocation was- '*Natva Jinam svaviracita patya ganitasya sara muddhratya*' in which the word *Jinam* was later changed to *Sivam*. We have internal references in support of it [7]. Such attempt was also made in the commentary of Ganita-Sara-Samgraha, by Pavalurimall (Telugu) [8].

2. Ganita-Sara-Samgraha of Mahaviracharya (850 CE)

Ganita-sara-Samgraha is the first Indian mathematical work, written in text book form and free from the effect of Astronomy. It was composed by Digambara Jaina Saint Acharya Mahavira during (814-877 CE) in Rastrakuta dynasty. It was so popular that it has been translated in Kannada, Telugu, Tamil and other languages and used for many centuries. Since its English translation and notes by M. Rangacharya was first published by Madras Government in 1912, it has been translated in Hindi by L.C. Jain (1963), in Kannada by Padmavathamma (2000) and in Telugu by Tennetti (2003).

The rule for adding fractions of unequal denominator - *Niruddha*, General formula for Combinations see- it is ${}^{n}c_{r}$, area of ellipse, solution of higher order algebraic equations, longest list of 24 decimal place value system (upto that time) is given by him.

3. Vyavahara Ganita and Lilavati of Rajaditya (1120 CE)

Out of six or more books written by Rajaditya in Kannada, Vyavahara Ganita was first published by M. Mariyappa Bhatt (1955) with Kannada translation. This text in Kannada and English translation and notes were again published by Padmavathamma in 2013. In its appendix, another small book of Rajaditya, Lilavati was published with Kannada and English Translation.

The special feature of Vyavahara Ganita has the longest list of place value (upto 40 places), published for the first time. Another beauty is its simplicity of treatment.

4. Ganitatilaka, commentary on Patiganita of Sripati, written by Simhatilaka Suri (1275 CE)

The Patiganita of Sripati was first commented by Simhatilaka Suri. It was first published by Gaikwada Oriental Series, Baroda with English translation by H.R. Kapadia. It does not contain any new formula but the text is very useful to understand the development process of mathematics and distinct features of Jaina School of Mathematics.

5. Ganita-sara-kaumudi of Thakkura Pheru (13th Century CE)

Thakkura Pheru was very versatile scientist of the 13th Century. Ganitasarakaumudi is his famous book which was recently translated with critical notes by Sakhya. It is not only the first full-fledged mathematical text composed in Apbhramsa, but it also extends the range of mathematics beyond the traditional framework of the earlier Samskrita text and includes diverse topics from the daily life where numbers play a role. He borrowed some material from the work of Shridhara and Mahavira.

6. Istankapancavisatika by Tejasimha Suri (1686 CE), Astronomy

This small book of 25 verses was first translated in English with critical notes by T. Hayashi and published in a reputed Journal Ganita Bharati (28, 1-2, 2006).

Group II:

In this category, we include only those texts which are in *Prakrita* or Samskrita and their original texts have been published but their critical editions have not been published so far.

1. Amgula Saptati of Municandra Suri [9].

- 2. Lilavati of poet Lalachandra [10].
- 3. Amkaprastara of poet Lalachandra [11].
- 4. Jyotrijñanavidhi by Shridhara (799 CE), Astronomy [12].
- 5. Ganitasara by Hemaraja (1673 CE) [13].

Group III:

In this group we include those texts which are under publication and copies are lying with the first author.

- 1. Sattrinsika by Madhavachandra Traividya (11th Century CE) [14].
- 2. Lokanuyoga by Jinasena (I) (783 CE.) [15].
- 3. Trailokya Dipaka by Pt. Vamadeva (14th Century CE) [16].
- 4. Trilokadarpana by Kavi Khadagasena (1656 CE) [17].
- 5. Commentary on Ganita-Sara-Samgraha by Bhattaraka Sumatikirti (17th Century CE) [18].

Group IV:

This group contains the texts which are still preserved in different libraries of India. In the catalogues of different *bhandaras* we have the information about these texts but we do not know the present state of these manuscripts. Need less to emphasize that there is an urgent need to preserve these manuscripts properly.

- 1. Ganitasathasau by Mahimodaya [19].
- 2. Ganitasara by Ananda Kavi [20].
- 3. Ganividyapannatti [21].
- 4. Ganitasamgraha by Yallacharya [22].
- 5. Kshetraganita by Nemichanda [23].
- 6. Kshetrasamasa by Somatilaka Suri [24].
- 7. Kshetrasamasa Prakarana by Sricandra Suri [25].
- 8. Brhatkshetrashamasa Vrtti by Siddha Suri [26].
- 9. Laghukhetrashamasa Vrtti by Haribhadra Suri [27].
- 10. Kshetrasamasa by Ratnasekhara Suri [28].
- 11. Kshetrasamasa by Simhatilaka Suri [29].

- 12. Uttarachattisi Tika by Shridhara and Sumatikirti [30].
- 13. Ganita Shastra by Rajaditya [31].
- 14. Ganita Shastra by Gunabhadra [32].
- 15. Ganitavilasa by Chandrama [33].
- 16. Ganitasamgraha by Rajaditya [34].
- 17. Ganitavilasa by Rajaditya [35].
- 18. Pudgala Bhanga Vrtti [36].

This list may be extended by making extensive search and survey of various Bhandaras. More detailed information about these manuscripts are available in the article "Jaina Mathematical Literature" (1988) by Anupam Jain [37]. The present state of these manuscripts requires further verification.

Group V:

We list those texts in this group whose names are mentioned in other texts but there is no information about their availability. Further search is therefore required.

- 1. Brhada Dhara Parikarma [38].
- 2. Siddhabhupaddhati Tika by Virasena [39].
- 3. Karana Sutra by Yativrsabha [40].
- 4. Karana Bhavana by Anantapala [41].
- 5. Patiganita by Anantapala [42].
- 6. Chattisa Purva Prati Uttara Pratisaha by Mahaviracharya [43].
- 7. Kshetra Ganita by Mahaviracharya [44].
- 8. Alaukika Ganita by Ratnashekhara Suri [45].
- 9. Ganita Sutra by Ratnashekhara Suri [46].
- 10. Trisati by Ratnashekhara Suri [47].
- 11. Kshetra Vicarana (Ratnashekhara Suri [48].
- 12. Kshetra Samasa Balavabodha [49].
- 13. Lilavati Bhasha Caupai [50].

Group VI:

There are a large number of old mathematical works which were composed in Souraseni or/and Ardhamagadhi Prakrta, either in prose or/and poetic form. The quotations from these works are found in later works but the original texts are not available. The names of the texts where such quotations are available are as follows:

- 1. Tattvarthadhigamasutra bhasya of Umasvati [51].
- 2. Commentary on Aryabhatiya by Bhaskara (I) [52].
- 3. Dhavala Commentary by Virasena [53].
- 4. Commentary on Anuyogadvara Sutra by Silamka[54].
- 5. Bijaganita by Bhaskara (II) [55].

The well known method of solving quadratic equations given by Sridhara (799 CE) is available in Bhaskara (II)'s Bijaganita.

Caturahta Vargasamairupai Paksadvayam gunayeta Newl

Avyakta Vargarrupairyukto Pakso tato Mulam.

In modern symbolism, this is equivalent to:

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ax^{2} + bx = c
4a (ax^{2} + bx) = 4a.c
4a^{2}x^{2} + 4abx + b^{2} = 4ac + b^{2}
(2ax + b)^{2} = 4ac + b^{2}
2ax + b = \pm \ddot{O}(4ac + b^{2})
x = -b \pm \ddot{O}(b^{2} + 4ac) / 2a
```

A detailed study of the Mathematical content available in Arddhamagadhi Jain canon is made by Anupam Jain (first author) under a minor research project of J.V.B.I. Ladnun [56]. It includes the mathematical content of Anuyogadvara, Sutrakrtanga, Thanam, Bhagavai, Uttaradhyayana, Visesevasyaka-bhasya, Brhatkshetrasamasa etc. A more detailed and deeper study has been made by the first author under a major research project 'Development of mathematical thoughts in Jaina literature' which will to be published shortly.

Now, we quote below a few rules/concepts from canonical literature which were earlier discovered by Jainacharyas but do not find any mention in the existing books on history of mathematics: 1. The theory of combination and permutation is available in many Jaina texts by the name bhanga or Vikalpa. Anuyogadvara Sutra and Bhagavati Sutra (see accompanying article by Samani Vinay Prajna) are replete with its examples [57]. It contains the formulas for ${}^{n}C_{1}$, ${}^{n}C_{2}$, ${}^{n}C_{3}$, etc. Dhavala commentary and Gommatasara are also very important for the study of Combinations and Permutations.

2. The general formula for Permutation nPr = n! / (n-r)! is given in the commentary of Anuyogadvara sutra by Hemcandra [58], while according to D. E. Smith it is invented in Europe in 14th -15th Century [59].

In the Visesavasyaka bhasya of Jinbhadragani (609 CE) two verses are quoted from the Avasyakaniryukti of Bhadrabahu (5th Century CE) giving the formula $nPn = n! = n (n - 1) (n - 1) \dots 3.2.1 [60]$.

3. The concept and formula for logarithms with base 2 is available in the Tiloyapannatti (2-7 Century CE) under the name arddhaccheda (literally, halves) etc. [61] and in Dhavala commentary of Satkhandagama by Vîrasena (816 CE) [62]. The formulae which are available in Dhavala and Gommatasara are:

log m.n = log m + log nlog m/n = log m - log n $log m^{n} = n log m$ $log log m^{n} = log n + log log m, etc.$

Not only this, but the concepts of log2log2 (vargasalaka) and log2log2log2log2 (vargasalaka of vargasalaka) is available in the Dhavala commentary. Furthermore, Virasena even talks about log3 (trikccheda), log4 (catuhccheda) etc. More details are available in the article of Prof. L.C. Jain, 'On Some Mathematical Topics of Dhavala text or in the book 'Exact Sciences from Jaina Sources, Vol.-1, Basic Mathematics' [63] or in the article 'Jaina Mathematics: A Precursor of Calculus' by R. S. Shah [64]. But the credit for the invention of logarithm is given to John Napier (1550-1617 A.D.) and Just Burgi (1552-1632 A.D.) which, in the light of above discussion, requires reconsideration [65]. Of course it is true that in Dhavala or Gommatasara, all the rules are discussed with base 2,3,4 but in the modern mathematics base '10' and 'e' are more popular. The concepts of anti-ardhaccheda and anti-vargasalaka are also available in the commentaries written by Madhvacandra Traividya [66].

4. In Satkhandagama, we find use of the word 'Ogha' or 'Rasi' for set [67].

There exist concepts and illustrations of set theory. Other synonymous words used in Dhavala commentary are *Ogha, Punja, Sampata, Bhavya Jiva Rasi, Mithyadristi Jiva Rasi, Vanaspati Kayika Jiva Rasi* etc., all of them being well defined as sets. The concept of finite and infinite sets, Singleton set, Null set, Sub-set, Super set, etc. are available in Dhavala in detail but the credit for invention and development of set theory goes to George Cantor (19th Century CE). Satkhandagama mentions about Asamkhyata (innumerable), *Asamkhyata-samkhyata, Ananta* (infinite) and *Anantananta* as different orders of innumerables and infinities.

Anuyogadvarasutra and later opuses on karma theory even speak about 3 types of innumerables and 3 types of infinities in the manner very similar to arguments of Cantor, although they very much lack the rigorous treatment of Cantor [68]. Of course, it may be true that concept of set was developed by Cantor independently and with far more rigor but on this ground we cannot neglect the contributions of Dharsena or Virasena or his predecessors.

5. The concept and examples of continued fractions are available in Dhavala, Vol-3, in 9th century, while credit goes to Antonio Cataldi (1540-1620 CE)[69].

6. Concept of Probability is available in the Pancastikaya of Kundakunda (1st Century CE) and Aptamimamsa, commentary written by Samantabhadra (2nd Century CE) [70] while credit goes to Galileo (1564-1642), Fermat (1601-1625), Pascal (1623-1662) and Bernouli (1654-1705) [71]. In Jainology it is available in the name of *Avaktavya*. Some Jain concepts of indescribable (*Avyaktavya*), paradoxes, probability and statistics are discussed in an accompanying article by Bhandari and Pokharna.

7. The important formula for approximation of surds is available in Jambudvipa prajnapti [72], as mentioned below:

$$\sqrt{a}^2 + E = a + \frac{E}{2a}$$

It is given in process of finding the value The same rule was also discussed independently by Heron of Alexandria (2nd century) [73]. In Anuyogadvara Sutra (Sutra 234), the circumference of the pit of diameter 100000 yojana is given 316227 *yojana*, 3 *kosa*, 128 *dhanusa*, and slightly over 13 1/2 *angula*. If we convert it in modern notation it is equivalent to 316227.766017578125. Hence the value of p(Jaina value) is 3.1622776601757.. and correct value is 3.16227766016737. Here it is important to note that by saying slightly over, Aryaraksita hinted about irrationality, though in a

rough form.

8. The formulas of indices are available in Anuyogadvara Sutra [74].

 $a^m x a^n = a^{m+n}$ $(a^m)^n = a^{m.n}$

The first formula used in the following illustration regarding a particular Jivarasi i.e.

 $2^{2^6} x 2^{2^5} = 2^{64} x 2^{32} = 2^{96}$

Anuyogadvara also contains some examples of operations with fractional indices [75], viz. $\sqrt{a} x \sqrt{\sqrt{a}} = (\sqrt{a})^3$

9. A more detailed classification of countable numbers is available in Thanam [76], Bhagavati and Dhavala. They form residue classes of 4.

Krta Yugma 4 n + 4 = 4, 8, 12, 16,.....

Trayoja $4 n + 3 = 3, 7, 11, 15, \dots$

Dvapara Yugma $4 n + 2 = 2, 6, 10, 14, \dots$

Kalyoja 4 n + 1 = 1, 5, 9, 13,....

Bhagavati [77] also classifies number field in 16 classes as-

16 n, 16 n + 1, 16 n + 2, ... , 16 n + 15 or as n = 0, 1, 2, ... , 15 mod (16) in terms of moderm mathematics.

It is also remarkable that in Jain literature unity is not treated as a number. The least countable number (Jaghanya Samkhyata) is 2 and not 1 [78]. The Jain way of classification of numbers in countable (3), uncountable (9) and Infinite (9) is unique.

There are several other ways of classification of infinity in Thanam, Tiloyapannatti, Anuyogadvarasutra, Dhavala etc.

10. Satkhandagama (1st Century CE) and Virasena in Dhavala [79] give what is equivalent of the modern formula:

 $\overset{64}{\overset{}{a}}_{r=1} \ ^{64}C_r = 2^{64} \text{-}1 = 18 \ 446 \ 744 \ 073 \ 709 \ 551 \ 615$

It indicates that Virasena knew the modern formula. The same formula is used in Bhagavatî sutra as $a_{r=1}^{64} {}^{6}C_{r} = 2^{6}-1 = 63$

11. Regarding the measurement of time, we get a detailed list in Anuyogadvara (2nd or 3rd Century CE), Jyotisakarandaka (3rd or 4th Century CE), Tiloyapannatti (2 to 7th Century CE), Rajvartika (7th Century CE), etc. [80].

These lists go up to very big numbers: (in years): According to Anuyogadvara: Shirshaprahelika = 1 Shirsha Prahelika = $84^{31}x \ 10^{140} \sim 7.58 \ x \ 10^{193}$ According to Jyotisakarandaka: Shirshaprahelika = 1 Shirsha rahelika = $84^{36}x \ 10^{180} \sim 1.88 \ x \ 10^{249}$ According to Tiloyapannatti: 1 Acalatma = $84^{31}x \ 10^{90} \sim 4.49 \ x \ 10^{149}$ According to Rajvartika: 1 Acalatma: =

 $84^{31}x \ 10^{155}$ ~ 4.49 x 10^{214}

12. The concept of Binomial Co-efficient and the expansion of $(1+1/x)^{Y}$ where x is very large. Virasena [81] obtained $(1+1/56)^{41} = 2$ which is very close to the modern value 2.066.

Very interesting and useful material is available in the treatment of 14 Sequences made by Åcarya Nemîcandra in Trilokasara.

 $(84)^{_{31}} \times (10)^{_{90}} \quad 4.49 \times (10)^{_{149}}.$

13. Occupancy problem is very famous in Probability theory. It is related to finding the number of ways r balls can occupy n cells. The formula for total number of ways is

 $^{n+r-1}C_{r} = ^{n+r-1}C_{r-1}$

In Bhagavatî sutra we find a problem of finding r ways [r = 1,2,3,---Numerable, Innumerable, --- Infinite] souls can enter 7 hells. The calculation upto 10 souls are given precisely-

1 Soul in 7 Hells =	$^{7+1-1}C_1 = ^7C_1 = 7$
2 Souls in 7 Hells=	$^{7+2-1}C_2 = {}^{8}C_2 = 28$
3 Souls in 7 Hells=	$^{7+3-1}C_3 = {}^9C_3 = 84$
10 Souls in 7 Hells=	$7+10-1_{C_{10}} = {16 \choose C_{10}} = 8008$
	(570)

These perfect calculations show the great expertise in the field [82]. The famous pigeon hole problem also exists in Bhagavatî under a different name and is discussed in an accompanying article by Samani Vinay Prajna.

14. Figurate Number is a unique contribution of Bhagavatî sutra. A detailed description of the minimum number of points (Pradesa) required to construct any two dimensional (Pratara) or three dimensional figure (Ghan) line, Isosceles Triangle, Square, Rectangle, Circle, Cube, Cuboids, Sphere etc. is given in Bhagavati. A detailed study of this topic was carried out by Dipak Jadhav [83].

Now we would like to give a glimpse of mathematical achievements in the non-canonical literature.

15. The proces^{§4} of finding perpendiculars and base or hypotenuse is available in GSS [84] but its credit is given to Fibonacci (1202 CE) and Vieta (1508 CE) [85] whereas actually the credit should go to Mahaviracharya (850 CE.).

16. The general formula for combination $n_{C_r} = n! / r!(n-r)!$ is available in Patîganita of Shridhara (799 CE), GSS of Mahavira (850 CE) [86], and commentary on Thanam by Abhayadeva (11th Century CE), but credit is given to Herigon (1634 CE) [87].

17. Patiganita and Trishatika of Shridhara (799 CE) Ganita Sara Samgraha of Mahaviracharya (850 CE) contains the rule of adding fractions of unequal denominators by the name Sadrischedikarana 'niruddha' [88]. This rule was invented in Europe in the 15th century and came in use around 17th century [89].

18. Treatment of unit fraction is another unique contribution of Mahaviracharya [90]. No other Indian mathematician discussed it before Narayana Pandita (14th century). Seven different types of cases are mentioned in GSS, chapter 3 [91].

19. The rule for finding the area and circumference of ellipse is available in GSS [92]. Here the ellipse is called Ayatavrtta (literally, rectangular circle) but in Trishatika of Shridhara, it is discussed under the name Yavakara (literally, barley shaped or shaped like a convex lens). Both names are not used in any other earlier or contemporary books. Many other unique geometrical figures are discussed in the 7th chapter of GSS.

20. The development of different rules related to A.P., G.P. and mixed progressions are found in the Yativrsabha's Tiloyapannattî, Nemicandra's

Trilorasara and GSS of Mahaviracharya and they all are illustrated in the book ''Mahaviracharya: A Critical Study' by Anupam Jain and S.C. Agrawal [93].

21. In Vedic tradition, we get the list of place value up to 12th place. We get similar value in some other texts like Vajasneyi Samhita, while, in Jain tradition, Shridharacharya (799 CE) gives a list upto 18th places, Mahaviracharya (850 CE) gives up to 24th place and Rajaditya (1120 CE) gives up to 40th places.

Not only this, but in ancient texts like Bhagavati Sutra, we find Partition Theory, Concept of Separation under Pathakatva etc. A more detailed study would yield many new facts and jewels of mathematical ideas from the Jaina scriptures.

At the end, we would like to summarise that there are two type of models available in Jaina Literature:

1. Karmic Model

Jains have a unique concept of Karmic particle (matter) which, being associated with soul, affects a lot and determine all our activities. The life of any man, woman or living being is the function of the Karmas associated with his/her soul (see the accompanying article by Kachhara, Tater and Samani U. Prajna). This field is totally ignored and not scientifically studied by mathematicians. If it is studied well, it may have more far reaching consequences compared to the study of genes.

2. Cosmological Model

Cosmology is a very complicated field (see the accompanying article by Rangarajan). To explain the cosmic structure, Jainas have developed their own number system which is not perfect yet, surprisingly, gives the hint of many concepts of modern number theory. The modern number theory itself has many paradoxes. May be there is some way by which the present paradoxes and controversies can be resolved by using Jaina concepts given in Jaina literature?

To assist these two types of models, some basic mathematics, known as Laukika Ganita, was also developed by Jainas. The unique achievement made in the field of Laukika Ganita motivates us to make a deeper study of Jain Literature covered in Ganitanuyoga.

્વા लहा इसालकालः १ वमीलं स 20 48 18 2.0 228 anu 25 a, £ े। तो नतानधानवापाचालनास ार्भ सः वासः किंचतस्त्रीवदव व्यान्। 1.2 Ċ, ξt 15/10/ तिमारमध्यन वित्यामि जिसम्बद्धारसमातः । श्रीगात उट्ट 13 8 13 निस्तन्तर सिन्दर सिन्द्र सिन्द्र सिन्द्र सिन्द्र भाषि दे ह -61 二年 法法法 医 नाभु गचार्गतापलर गणितवन्त्र माधवच 438.112 रासियिविदिगणि जाधामार संयदाम मिसिकि खिद वियस कलिता त्यमस - याई वेतलाधिकार 1,3,11 1 25

Fig. 1. An important page bearing the name of Madhavachandra Traividya.

वतेष्वदिशनिष्ठन्यव अनुमनाज्व न्येमसाईद्रसात्र्यं तन्त्रध्येया अनतराष्ट्रणः प्र्यंप्रात सरीसेदयप्रमालंगविण छि GRANI. 18 તા માલિવ ਟਿਡਟੋਲਰੋਲ (ਟੈ*?* जन्मतः सिद्धाः विताः ग 3 ाजानइतिइस्राता।**इ**श्वक उन्ध्र जारी राष्ट्र रवात्मा नः सि हानवद्यन दसतताननण्यय 130205 विं एविस गः राष्ट्रत धमधानधवलसहतमाज्ञदिउति 1:10 48 य न न न न न म शरी की म न त की **उतिविचय** मस्रान्धनामदाकाताः सङ्ख्यभारतन 000विम्नारापनिधिय इण्डांताला दायाग जनाचनाचारमा सतदाख 3028एमासिकः हलाकवसानानामृत्र हानकामातक

Fig. 2. Last page of Lokanuyoga by Jinasena (I), bearing the name of the manuscript and the author.

to the Walter ँईः नमोवीतरागायः ॥वन्देदेवेन्द्र इंदार्च्याः नाभेयं जिनमास्त ग्रंथेनन्नाना सुभिन्नित्यालोका ठोको प्रकाशितीश १॥ संस्तवीयिकमद्वद्वं श्रेषाणांतुर्जिनेश्विन ाधिमध्यस्ट।विलोक्यपद्मसंनिभेगव्या विद्धातुममप्रसागजनशास्त्राव्वाधनीग्रश्रीमस्तिन्सुखाभोज्यानिर्ग्रताञ्चतदेवता। ३॥ सिद्धान्त्वारिधेव हस्तस्छामलकोणमा ४॥ विभातिविरादाकीतिं।यस्यत्रेलोक्यवर्त्तिनी।नमस्तस्मेसुनीन्द्रायात्री वरशत्वादसनस्य मिस्मात्वास गदिवाकर। यम्मोकरइति रज्याता समिनिः स्तर्थत मया। ३॥ ॥ ६॥ ग्रयपंचगुरुन्तन्ता। वस्पसंस्कृतभाषया।विलोवपसारमालोका। ग्रंथवेलोक्यकीएक मिदेवस्यान्य्राययनगरसो॥प्रधायभव्यवीधायाः २०॥ अपनदेशमाकाशः मनंतस्व र तन्मध्यणरिवाभाति लोकासरवय प्रदेशकः । ९ लाकात्यत्रमधाता द्व्याणा श नोक्तान विदावदे १० अन्तरिनिधनआसे। स्प्रित्यार्थात्वयात्मन्त्र विचित्राक्त लाकःकव्यनसाद्र ग्रह्यामध्यादेभेदेना साण्डलाका तागला तस्यान्से धार्वसंख्याच सस्याना। नकनाण विनि २। तत्मानलाकिक मति लोकात्रा मतिहिधा तावन्मानानग 6 440 भग्रात १०० चाया सहस्य १००० मयत यया। १६ एका १८मा ताराय। जातव्यक्रकतायय 10000000 GELE SITTE मानंलोकोत्तरत्वे व्यन्भेदनिगवते। १३ । प्रयम् द्रव्यमानस्यात् स्विमानद्वितीयकात्त्रतीयकालमा 3 350 3

Fig. 3. First Page of the Manuscript Trailokya Dipaka by Pt. Vamadeva.



Fig. 4. First Page of the manuscript "Trilokadarpana by Kavi Khadagasena.

उर्द नमः ॥श्री जिनायनमः ॥श्री गुरुभ्योनमः ॥श्रो लक्षयेनमः । ग्रंथ प्रारम्भः ॥ प्रविषत्य महावीरं विद्यानंदं विद्युद्ध गुणनिलयं ॥ स्रिच महावीरं कुवेत-द्वषित झारू स द्वृत्तिं ॥ १॥ अलंघ्य त्रि जगत्सारं यस्यानंत चलुष्टयं ॥ न मस्तर्से जिनें द्वाय महावीराय तायिने ॥ २ ॥ यस्य त्रिजगत्सारं निराव-रणत्वा दनन्य साधारणत्वा च्व लेकित्रय सारं त्रिजगद्भव्या राध्य मि त्यर्ध ॥ अतंत चलुष्टयं अनंत दर्शन ज्ञान सुरव वीर्यणि ॥ अत्मंध्ये ज्याप्ता मासा गम्यं अतल्लम्य मस्ति तायिने धर्मी पदिश कल्वेन मन्य त्राणाय तस्मे महावीराय वर्द्धमानसाहिन जिनेंद्वाय स्वर्देशेन क-मीरा तीन् जयंतीति ॥ जिना असंयत सम्य ग्दब्सा दयस्तेषा मिंद्रस्व मी तस्मेनमः ॥ संख्या ज्ञान प्रदीयनजेनेंद्रेण महालिषा प्रकाशितं

Fig. 5. First page of the Commentary on Ganita-Sara-Samgraha by Bhattaraka Sumatikirti.

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Egadeguttaraya chaggacchagaya paroppabsmatya

purimatema dugahioa parimaoamaoupuvioam.

Its samskrita version is also available in the commentary of Sutrakrtanga by Shilanka.

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Appendix-1 :List of prominent Jain scholars and their texts.

- 1. Gunadhara (1st century BCE): Kasayapahuda
- 2. Dharasena, Puspadanta and Bhutabali: (1st century CE): Satkhandagama and Mahabandha.
- 3. Kundakunda: (Ist century CE): Panchastikaya, Pravachanasara etc.
- 4. Aryarakshita: (05 B.C.E 70 CE): Anuyogadvarasutra.
- 5. Umasvami (Graddhapiccha): (2nd century CE.): Tattvarthasutra (Mokhasastra).
- 6. Shivasharma: (2nd century CE): Karmaprakrti.
- 7. Samantabhadra: (2nd -3rd century CE): Aptamimamsa.
- 8. Umasvati: (4th century CE): Tattvarthadhigamasutrabhasya & Jambudvipasamasa.
- 9. Yativrsabha: (176-609 CE): Tiloyapannatti, Churni Sutra Karanasutra.
- 10. Sarvanandi (458 CE): Lokavibhaga (Prakrta)
- 11. Bhadrabahu (II): (5th century CE): Niryukti on Suryaprajñapti and Avasyakasutra.
- 12. Padaliptasuri: (5th Ccentury CE): Commentary on Jyotisakarandaka.
- 13. Devanandi (Pujyapada): (539 CE): Sarvarthasiddhi.
- 14. Jinabhadragani Ksamasramana: (609 CE): Vishesavashyaka Bhasya and Brhatksetrasamasa
- 15. Akalanka: (620-680 CE): Tattvartharajavartika.
- 16. Jinadasagani Mahattara (7th century CE): Curnis on Anuyogadvara & Sutrakrtanga.
- 17. Candrarsî Mahattara (8th century CE): Pañcasamagraha.
- 18. Haribhadra (Yakini-mahattara-Sunu): (8th century CE): Jambudiva Samgahani; Commentaries on Anuyogadvara, Javabhigama, Prajñapana.
- 19. Jinasena-I: (738 CE): Harivamshapurana.
- 20. Vidyananda: (775-840 CE): Tattvarthaslokavartika.
- 21. Sridharacharya: (8th century CE): Patiganita, Trisatika, Jyotirjñanavidhi, Bijagaiita (not available), etc.

- 22. Virasena: (816 CE): Dhavala, Jayadhavala (Commentaries), Siddhabhupaddhati Tîka.
- 23. Jinasena-II: (9th century CE): Jayadhavala (Commentary).
- 24. Mahaviracharya: (850 CE): Ganitasarasamgraha etc.
- 25. Kumudendu: (860-880 CE): Siribhuvalaya.
- 26. Silamka: (9th century CE): Commentaries on Sutrakrtanga and Jivasamasa etc.
- 27. Nemicandra Siddhantacakravarti: (10-11th century CE): Gommatasara, Trilokasara, Labdhisara, Ksapanasara.
- 28. Madhavachandra Traividya: (10-11th century CE): Sattrinsika, Commentaries of Gommatasara, Trilokasara etc.
- 29. Padmanandi- I: (977-1043CE): Jambudivapannattisamgaho
- Amitagati (2): (11th century CE): Chandraprajnapti, Sardhadvayaprajnapti, Vyakhyaprajñapti;
- 31. Abhayadevasuri: (1015-1078 CE): Commentaries on Thanam, Vyakhyaprajñapti etc.
- 32. Simhasuri: (11th century CE): Lokavibhaga (Samskta)
- 33. Hemacandrasuri: (1107 CE): Anuyogadvara Vrtti, Vishesavasyaka Bhasyavrtti.
- 34. Malayagiri: (1080-1172 CE): Commentaries of surya/ chandra/ Jambudvipaprajnapti, Bhagavati, Pañcasamgraha, Brhataksetrasamasa, Brhatasamgrahani.
- 35. Rajaditya: (1120 CE): Vyavahara Ganita, Kshetra Ganita, Vyavahara Ratna, Jaina Ganita Sutrodaharana, Citrahasuge, Lilavati.
- 36. Chandrama (-): Ganita Villsa (Kannada).
- 37. Chandrasuri (12th century CE): Brhatasamgrahani, Angulsaptati or Angulavicarasaptatika (Prakrta).
- 38. Devananda (12th century CE): Khsetrasamasa
- 39. Srichandra (disciple of Silabhadrasuri): (12th century CE): Khettasamasa, Sricandiyasamgrahani, Samkhitta-samgrahani.
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- 41. Anantapala (13th century CE): Patiganita and Karanabhavana.
- 42. Padmaprabhasuri: (1237 CE): Bhuvana Dipaka.
- 43. Simhatilakasuri: (13th century CE): Commentary on Patiganita of Sripati Ganitatilaka.
- 44. Thakkura Pheru: (1265-1330 CE): Ganitasarakaumudi.
- 45. Devendrasuri: (13th century CE): Navya Karma Grantha (with self-commentary).
- 46. Narachandrasuri: (13th century CE): Jyotisara.
- 47. Pt. Vamadeva (14th century CE): Trailokyadipaka.
- 48. Mahendrasuri: (1370 CE): Yantraraja.
- 49. Malayendusuri: (1378 CE): Commentary on Yantraraja.
- 50. Keshava Varni: (14th century CE): Commentary on Gommatasara.
- 51. Somatilakasuri: (14th century CE): Brhatkshetrasamasa.

- 52. Ratnasekharasuri: (1440 CE): Laghukshetrasamasa.
- 53. Harskula-gani (16th century CE): Commentary on Sutrakrtanga.
- 54. Megharatna muni: (16th century CE): Ustaralava yantra (with self-commentary).
- 55. Prabhacandra: (16th century CE): Commentary on Pancasamgraha.
- 56. Kavi Khadagasena: (1656 CE): Trilokadarpana.
- 57. Mahimodaya: (1665 CE): Ganitasathasau.
- 58. Hemaraja: (1673 CE): Ganitasara.
- 59. Bulakhichandra: (1680 CE): Vacanakosa.
- 60. Tejasimha suri: (17th century CE): Istankapancavisatika.
- 61. Bhattaraka Sumatikirti: (17th century CE): Commentary on Ganitasarasamgraha named Uttarchattisitika.
- 62. Todaramala: (1720-1767 CE): Samyakjnanachandrika (Commentary onGommatasara, Trilokasara etc.)
- 63. Vinayavijaya (gani): (18th century CE): Lokaprakasha.
- 64. Yasovijaya: (18th century CE): Commentary on Karmaprakrti.

Many other names like Gunabhadra, Yallacharya (Yalla), Nemichandra, Siddhasuri, Lalachanda, Anandakavi, Bhudharadasa etc. can be added to this list. Garga Risi is renowned Jaina astronomer responsible for the development of Jaina Nakshatra system. According to Saraswati (1979), Maskari, Purana and Putana may be Jaina scholars. The verse used in Bakshali manuscript, use of the word Kala Savarna and other internal references indicate that this may be a part of Jaina work.

27. Mathematics in Bhagawati Sutra

Samani Vinay Prajna

Abstract

In Jain literature mathematics is widely used to explain the metaphysical concepts, to explore the theory of soul and knowledge, the concept of Jain geography, astronomy, cosmography and cosmology, the units of space and time etc. We find many mathematical concepts like theory of numbers, algebra, geometry, partition theory, set theory, indices, permutation & combination and many other concepts to precisely explain the details of various metaphysical principles which deal with the process of the physical as well as non-physical substances. Thus, Jain mathematics holds a significant place in the philosophical world. These mathematical concepts and their philosophical implications, ascribed to Bhagaw n Mah v ra (~ 600 BCE), are mentioned in the various Jain canons (gama) documented about 1500 to 2100 years ago. Some of these concepts, as described in Bhagawat S tra, are described in this article.

Key words: Number theory, time units, pigeon hole principle

Scriptures Quoted: Bhagawat S tra, Jain Sidhh nta D pik

1. Introduction

Jain canonical literature, known as Agamas, are the treasure of the preaching of Bhagaw n Mahavira. Out of 12 Angas, Bhagavat S tra (BS), also known as Vyakhya Prajñapti, holds the fifth place. Being the largest Agama which elucidates various aspects of Jainism, it describes several topics like culture, ontology, metaphysics, ethics, and cosmology, along with matter, atoms, mathematical concepts, biological ideas and many more. This S tra is in the form of dialogues between Bhagwan Mah v ra and his chief disciple Indrabh t Gautam. It consists of 36,000 questions and answers. Along with the philosophical ideas, the latent scientific aspects are truly amazing and enhances the value of this gama. In short, it is an encyclopaedic work.

Jain mathematicians, in ancient times, contributed a lot to the development of mathematics and applied it to cosmology. Jainism propounds that the universe is infinite, beginning-less and end-less, and Jain scholars did lot of research in the concepts of space, time and matter. Their necessity of making large calculations helped in development of Jain mathematical system. We describe the mathematical concepts given in Bhagawati S train this article.

A Birds Eye-view of Mathematical Content

This gama describes mathematical measures to explain the philosophical aspects. We find the use of decimal place value system in this gama at various places. Though we do not find the word "zero", the concept is used in describing various numbers. The largest number calculated in this S tra is Shirshaprahelika which is equivalent to 8400000^{28} or 7.58×10^{193} . It then states that arithmetic ends here and the calculations moves further in the form of simile as *palyopama* and *sagaropama*.

In this gama permutations *(bhanga)* and combinations *(vikalp)* are widely used.

Modern partition theory developed by Euler, Hardy and Ramanujan etc. are found in its elementary form.

The positive numbers are classified in 4 categories. For example: 4n, 4n+1, 4n+3.... for n=0, 1, 2, 3...Later the same are classified in 16 categories: 16n, 16n+1, 16n+2...16n+15 for n=1, 2, 3,

3. Number Theory

3.1 Decimal Place Value

We find the use of decimal place value system at various places in BS for defining the age and height of various living beings and while describing the various entities of the universe. The units used for time, and length are listed below to show the large scales, from minutest to the largest, covered by these units. Some of these units have been discussed and rationalised in an accompanying paper by Jain and Jain.

3.1.1 Time Units

The time units are explained in BS 6.7.132 which defines samaya as the smallest unit of time and proceeds to define higher units of time as follows:

```
1 \operatorname{samaya} = 1 \operatorname{param sukshma} k la
asankhya samaya = 1 avalika
Sa?khyeya avalika = 1 ucchwasa (inhalation) = 1 niswasa (exhalation)
1 ucchwasa + 1 niswasa = 1 prana
7 prana = 1 stoka
7 stoka = 1 lava
77 lava = 1 muh rta
30 muhûrta = 1 ahoratra
15 ahoratra = 1 paksha
2 paksha = 1 masa
2 \text{ masa} = 1 \text{ ritu}
3 ritu = 1 ayana
2 ayana = 1 samvatsara
5 samvatsara = 1 yuga
20 yuga = 1 saya
10 saya = 1 sahassa
10 \text{ sahassa} = 1 \text{ dasasahassa}
10 dasas ahassa = 1 saya sahassa
84 saya sahassa = 1 p rvanga
84 saya sahassa p rvanga = 1 p rva
84 saya sahassa p rva = 1 trutitaga
84 saya sahassa trtitanga = 1 trumita
84 saya sahassa trutita = 1 adad nnga
84 saya sahassa adad nga = 1 adada
84 saya sahassa adada = 1 avavanga
84 saya sahassaav avavanga = 1 avava
84 saya sahassa avava = 1 h h kanga
84 saya sahassa h h kahga = 1 h h ka
```

84 saya sahassa h h ka = 1 utpalahga 84 saya sahassa utpalanga = 1 utpal 84 saya sahassa utpal = 1 padmanga 84 saya sahassa padmahga = 1 padma 84 saya sahassa padma = 1 nalinanga 84 saya sahassa nalinanga = 1 nalina 84 saya sahassa nalina= 1 arthanipuranga 84 saya sahassa arthanipuranga = 1 arthanipura 84 saya sahassaarthanipura= 1 ayutanga 84 saya sahassa ayutahga = 1 ayuta 84 saya sahassa ayuta = 1 prayutanga 84 saya sahassa prayutanga = 1 prayuta 84 saya sahassa prayuta= 1 nayutanga 84 saya sahassa nayutanga = 1 nayuta 84 saya sahassa nayuta = 1 c likanga 84 saya sahassa c \hat{u} likanga = 1 c lika 84 saya sahassa cûlika = 1 shirshaprahelikanga 84 saya sahassa shirshaprahelikanga = 1 Shirshaprahelika

Shirshaprahelika, in terms of modern notations can be calculated as $(84 \times 10^5)^{28}$ = $(84)^{28} \times 10^{140}$. There is some dispute about the exact value of Shirshaprahelika. According to Mathur council, *Shirshaprahelika* is a number accurately calculated up to 54 digits and is followed by 140 zeros (approximately ~10¹⁹⁴), while according to vallabh council, it is calculated up to 70 digits followed by 180 zeros (approximately ~10²⁵⁰). It is stated that measurement of time up to *Shirshaprahelika* is only physically meaningful and is subject of mathematics or cosmology and beyond this value, time is measured with simile with *palyopama* and *s garopama*. *Shirshaprahelika* was being used to count the lifespan of hellish beings and Bhavanpati and Vayantar deities. Muni Mahendra kumar (2010) has discussed the meaning and importance of *Shirshaprahelika* is, however, not defined.

The decimal scale used in the gama is eka (1), *dasa* (10), *saya* (100), *sahassa* (1000), *dasa sahassa* (10,000), *saya sahassa/ laksha* (100,000), *dasa laksha* (10, 00,000), *kodi*

 (10^7) , *dasa kodi* (10^8) etc. We can say that this system was prevalent in the era of Bhagaw n Mah v ra, dating back to about 600 BCE.

3.1.2 Units of Length

In BS we find another measuring scale to measure the height and distance. BS (6.7.134)

```
Infinite param nu = 1 utslaksanaslaksanika
8 utslaksanaslaksanika = 1 slaksanaslaksanika
8 slaksanaslaksanika = 1 urdhva renu
8 urdhva renu = 1 trasrenu
8 trasrenu = 1 ratharenu
8 ratharenu =1 balagra
8 balagra = 1 liksa
8 liksa = 1 yuka
8 yuka=1 yavamadhya
8 yavamadhya = 1 angula
6 angula =1 pada
12 angula = 1 vitasti
24 angula = 1 ratni
48 angula = 1 kuksi
96 angula = 1 danda (dhanusa, yuga, nalika, akcaormusal)
2000 \, danda = 1 \, gavy ta (kosha)
4 gavyûta = 1 yojana
```

This measure was being used to explain the height of human beings and was also used to define the measure of *palya* used in the simile-measure of *palyopama* and *sagaropama*.

3.2 Concept of Zero

Some scholars argue that the oldest reference to Zero is in a Jain work 'Lokvibhag' which was written by a Jain ascetic Acharya Sarvanandi in 458 CE. In BS we do not find clear use of zero for counting. In shataka 1 (BS,1.2.104- 111) explaining the *samsthana k la* (the life-duration of a living beings in that realm), the word *sunya* is used. *Samsthana k la* of hellish beings, deities, human beings and

animals are explained. It is classified as *sunyakaal, asunyakaal, misra kaal. Sunyakaal* is the period when there is no being in the realm. In other words, if the particular realm is devoid of living beings, then that period would be known as *sunyakaal* of that realm. From this we can infer that it is the period when there are zero or *sunya* beings in the realm.

3.3 Concept of P?thaktava

In Agamic literature the word *P?thakatva* is used many times which means separation. It is a range between two successive powers of 10. For example, this word *P?thakatva* is used to denote any digit between 2 to 9. *Saya P?thakatva* means any number between 101 to 999. *Sahasra P?thakatva* means any number between 101 to 9999.

3.4 Number System- Sa? khyeya, Asa? khyeya and Ananta

It is interesting that Jain calculations do not end at *s* garopama. Jain literature talks about another form of counting as *Sa?khyeya*, *Asa?khyeya* and *ananta*. These are used very frequently in gama. This is the unique contribution of Jain philosophy.

A living being can continue to take birth in the same realm *(gati)* many times and therefore, the same soul stays in that realm for long. The time-span of a living being in the same realm in many lives is known as *samsthana k la*.

In this context it is mentioned that *samsthanakala* of hellish beings is *Asa?khyeya* times more than that of human beings. *samsthanakala* of deities is *Asa?khyeya* times more than that of hellish beings and *samsthanakala* of animal kingdom (*tiryanca*) is *ananta* times more than that of deities. This does not seem to be true because animals are known to have short life span of years, comparable to life span of humans.

In BS 6.7.132 explaining the time it is mentioned, *asa?khya samaya* = 1 *Avalika*. Ganadhara Gautam asked Bhagaw n Mah v ra, 'How long an atom stays in the same state?'Mahavira answered, 'minimum one *samaya* and maximum Asa?khyeya (innumerable) *k la*.' It means an atom stays as an atom for a maximum period of *Asa?khyeya* time before changing its form. An aggregate of *ananta* (infinite) atoms can also stay maximum for *Asa?khyeya k la* in the form of the same aggregate. (BS 5.7.169,170).

The same chapter in verse 176 tells that an atom takes the state of an aggregate and after that it may take maximum *Asa?khyeya k la* to come back in its

original form as the atom. Similarly, a *dvi-pradeshi skandha* may take maximum *ananta k la* in becoming the same *dvi-pradeshi skandha* again from an aggregate. *Asa?khyeya* is an innumerable or incalculable number which is beyond *palyopama* and *sagaropama* but finite. *Ananta* is beyond that which means infinite. Defining the Universe Bhagaw n Mah v ra says "From spatial viewpoint, *loka* (cosmos) is *Asa?khyeya kotakoti yojana* in length and width and the same is the circumference but from temporal viewpoint it is *ananta* (infinite). This can be interpreted to mean that the size of the universe is finite but immeasurable and it is eternal.

Explaining the state of *j* va it is mentioned that a soul has infinite modes of knowledge, intuition, conduct, *gurulaghu* and *agurulaghu*. Sa?khyeya, Asa?khyeya and ananta are used frequently at many places to describe its characteristics.

3.5 Fractions and Extractions

In Sataka (chapter) 8, the effect of heat of the sun is mentioned. It says that the heat of the sun goes up to 47263 plus 21 out of 60 parts of yojana. It can be written as $47263^{21/_{60}}$ Yojana. In this way we find the use of fraction at many places.

3.6 Classification of Numbers

The 18th Sataka talks about numbers. It introduces the classification of numbers like *k*?*ta-yugma*, *tryoja*, *dwapara* and *kalyoja*.

- 1. *K*?*ta* is a set of such positive integer numbers where, after dividing by 4 or multiples of 4, the remainder is 4 or 0. It can be expressed in mathematical form as *k*?*ta-yugma* = 4n+4, i.e. 8,12,16,20,.....where n = 1, 2, 3......
- 2. *tryoja*: 4n+3 i.e. 7, 11, 15, 19,..... where n = 1, 2, 3..... (the remain der is 3 after dividing by 4 or multiples of 4)
- 3. *dwapara:* 4n+2, i.e. 6, 10, 14,.... where n = 1, 2, 3...... (remainder is 2 after dividing by 4 or multiples of 4)
- 4. *kalyoja:* 4n+1 i.e. 5, 9, 13.... where n = 1, 2, 3..... (remainder is 1 after dividing by 4 or multiples of 4)

 \swarrow This classification is used to determine the number of hellish beings. It explains that the minimum number of hellish beings can be *k*?*ta-yugma*, maximum *tryoja* and intermediate numbers can be any of the four aforementioned categories.

The minimum number of living beings from 2 senses to 4 senses can be *krtayugma*, the maximum can be *dwapara* and intermediate can be any of the above categories.

4. Bhanga Samutkirtana (Combination)

Jain philosophy explains various concepts on the foundation of *anekanta*. It becomes the basis for permutations and combinations in mathematics. Bhagawan Mahavira always answered various questions using this pattern. For example," in how many ways a *paramanu* can be accommodated in space or occupy the spacepoints?" is answered using permutations and combinations.

In Sataka 8 also we find *abhanga* for defining the possible combinations of pratikramana. It can be done with multiple options of using *karana* and *yoga*.

There are 3 *karana* – To not to do, to not suggest others to do, to not approve of others doing it. 3 *yogas* are mind, body and speech. It is explained that there can be 49 possible ways of *pratikramana* using 3 *karana* and 3 *yoga*. Similarly, 49 *bhangas* are mentioned for restraint of the present and renunciation of the future activity in the next verse. Sataka one elucidates multiple possible combinations of passions and heights of hellish beings.

4.1 Pigeon-hole Principle

This is a popular principle in modern mathematics. It shows that if you have N pigeons in K holes, and (N/K) is not an integer, then at least one hole must strictly have more than (N/K) pigeons. For example 16 pigeons occupying 5 holes, implies that at least one hole has a minimum of 4 pigeons.

If there are infinitely many pigeons in finitely many holes, then at least one hole must have infinitely many pigeons! If there are an uncountable number of pigeons in a countable number of holes, then at least one hole has an uncountable number of pigeons!

A probabilistic generalization of the pigeonhole principle states that if n pigeons are randomly put into m pigeonholes with uniform probability 1/m, then at least one pigeonhole will hold more than one pigeon with probability

In BS the same concept is very beautifully explained by Bhagaw n Mah v ra. Sataka 9 talks about the possible ways of entry of hellish beings in hell. There are 7 hells. How many are the possible ways of one, two, three or more beings to get into hell? In which hell the living beings will go? Such questions are explained very

beautifully. First of all, the answers of these questions following the pigeon-hole principle is as follows:

Number of ways 1 soul can enter 7 hells = (7+1-1) = (7) = 71 1 Number of ways 2 souls can enter 7 hells = (7+2-1)=(8)=282 2 Number of ways 3 souls can enter 7 hells = (7+3-1)=(9)=843 Number of ways 4 souls can enter 7 hells = (7+4-1) = (10) = 210Number of ways 5 souls can enter 7 hells = (7+5-1) = (11) = 462Number of ways 6 souls can enter 7 hell = (7+6-1) = (12) = 9246 6 Number of ways 7 souls can enter 7 hells = (7+7-1) = (13) = 17167 7 Number of ways 8 souls can enter 7 hells = (7 + 8 - 1) = (14) = 3003Number of ways 9 souls can enter 7 hells = (7+9-1) = (15) = 50059 9 Number of ways 10 souls can enter 7 hells = (7 + 10 - 1) = (16) = 800810 10

It is really surprising that the way BS has explained also gives the same results accurately.

One living being can go in any one of the 7 hells. It means there are 7 possibilities for him. If there are two living beings, then the options are more. Both can go to the same hell or to different hells. It gives 28 possibilities. For 3 living beings there are 84 possible combinations.

If there are 3 souls then possible ways for all the three souls going in one hell are 7. If 2 souls go together and one separately, then there are 42 possible ways. If all three go separately then possible ways are 35. In this way, collectively there are 84 ways. This result exactly matches with the result of pigeon-hole calculations mentioned above.

Similarly, at several places we find philosophical explanations through permutations and combinations.

5. Partition Theory

In number theory and combinatory, a partition of a positive integer n, also called an integer partition, is a way of writing n as a sum of positive integers.

For example, 4 can be partitioned in five distinct ways:

 $\begin{array}{r}
4 \\
3+1 \\
2+2 \\
2+1+1 \\
1+1+1+1 \\
\end{array}$

5.1 Ferrer's diagram

The diagrams for the 5 partitions of the number 4 are listed below:

4	3+1	2+2	2+1+1	1+1+1+1
0	00	00	000	0000
0	\circ	00	0	
0	0			
\circ				

In Sataka 12 (4.69-80) the possible combinations of fission of aggregates are explained. In how many ways an aggregate can be disintegrated? An aggregate having two atoms can be disintegrated in one way that is two atoms. An aggregate having 3 atoms can be disintegrated in two ways as presented below.

Aggregates	Possible combinations	No. of atoms
Having 2 atoms	1	1, 1
3 atoms	2	1, 2
		1, 1, 1
4 atoms	4	1, 3
		2, 2
		1, 1, 2
		1, 1, 1, 1

An aggregate having numerable *(sanakhyeya),* innumerable *(asanakhyeya)* and *ananta* atoms can be disintegrated in *sanakhyeya, Asa?khyeya* and *ananta* ways (BS 12.4.80).

The difference we find is, in partition theory the number itself is always counted. Therefore, for number 4 the number of partitions is 5. In BS the numbers of partitions is one less excluding the number itself. A molecule with 4 atoms can be disintegrated in four different ways: 3+1 or 2+2 or 2+1+1 or 1+1+1+1.

6. Geometrical Figures

BS explains several types of geometrical figures. In BS 6.5.70-88 we find the concept of Tamaskaya (mass of darkness). It is very dense and dark, deep and terrifying. It is water bodied being. While explaining its rising place it is said that from the rim of the platform on the outskirts of Jamb dv pa Island 42,000 yojan towards Arunodaka Ocean there rises a linear structure of the width of one spacepoint from above the surface of water. At the bottom the shape is like earthen bowl and at the top its like cage of a hook. There are two types of *Tamaskaya*: 1) numerable thousand *yojan* in diameter and perimeter, 2) innumerable thousand yojan in diameter and perimeter. Heavy clouds can rain there. The light of sun and moon become dim when it reaches there.

In Bhagava we also find the concept of *krsnaraji*. In BS 6.5.90, while explaining *krsnaraji*, it is said that the shape of two external *krsnaraji* (black streak) in east and west are hexagon, in north and south are triangular (*trayasra*), inner *krsnaraji* in east and west are square (*caturasra*) and inner *krsnaraji* in north and south are square. Further, it is mentioned that the size length, width and height of *krsnaraji* are *Asa?khyeya*, innumerable thousand yojana. *Krsnaraji* are the earth-bodied beings, and are transformation of the earth-bodied beings', and also matter and are located in the upper cosmos. It is dark black and no light can pass through it. There is no light. Even the light of sun and moon is absent. There is no life. It is eternal. Astronomical studies have since discovered black holes and described them in detail. But they appear to be different from *krsnaraji* described in Bhagvati. Black hole is a large dense object which pulls in it everything from its surroundings due to its gravity. According to physics, it is a kind of dense star from which even light can not escape and that is the reason why it can not be seen. It is non-eternal, while according to Jainism *krsnaraji* is eternal.

At a few places ayata (rectangle) and valayavratta (annular shell) etc. are also

found. This text also states the minimum number of points required to draw a geometrical figure or shape. For example, a circle needs minimum five points and the least number of points to form a triangle are three. Beyond these concepts many more concepts and principles like alpa-bahutva (minima & maxima), one-to-one correspondence, one- to-many correspondence are also mentioned in BS.

7. Conclusion

BS carries rich heritage of Jain philosophy. In fact the philosophy was explained scientifically, since it was the necessity to use the scientific approach to explain the ideas logically. We can say that the principles used around 2500 years ago are still in vogue today under different names and for different purposes and with refinement and observational and theoretical foundation.

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28. Dh r s (Sequences and Sub-sequences) of Trilokas ra

R.S. Shah

Abstract

Nemicandra Siddhāntacakravarti (10/11 century of Christian era) was a great saint, scholar, philosopher and an expert 'karma' theorist of Jaina religion. His works contain many mathematical jewels. In his '*Trilokasāra*' he deals with 14 sequences- in fact one mother sequence N of all positive integers (excluding zero) and 13 sub-sequences emanating from it. In that process he develops interesting number theory results, concepts of very large numbers, not so rigorous ideas on infinity and their hierarchy, and above all a fully developed treatment of logarithms with base 2. He was able to tackle *log*₂ (*ardhacheda*) and *log*₂ *log*₂ (*vargaśalākā*) operations with great ease. Jaina philosophy and karma theory have some special numbers which can pale into insignificance very large numbers of modern number theory like Skewes' Numbers, googleplex etc. and are comparable with modern Graham's Number and like. Nemicandra gives a very systematic treatment of these numbers and is able to arrive at some interesting number theory results.

1. Introduction

Nemicandra Siddhānta-cakravarti was a great scholar-saint of Digambara sect of Jainism and belonged to 10th C. A.D. He is popularly renowned as the Guru (master) of Camundarāya, the Chief of army of kings of Gańga dynasty ruling over major part of areas around modern Mysore, and is more famous for installing mammoth 57-feet idol of Bāhubalī, regarded as one of the wonders of the world. Nemicandra was a mathematician of great prowess as can be revealed from his works: Trilokasāra (a tome on Cosmology and Cosmography), Gommaasāra- Jivakāņa and Karmakāņāa (a treatise on Karma theory of Jainism), and Labdhisāra including Kşapaņāsāra (other volumes

relating to Karma theory with emphasis on riddance from bondage of karmas). Interestingly, these works throw light on the state of mathematical development of Jaina school of mathematics in particular and Indian mathematics in general.

All the results contained in his works were known earlier, at least to *Vīrasena* (8th C. A.D.). *Nemicandra* compiled and systematized the mathematical development by his predecessors as was done by Euclid to Greek mathematics. His works contain very interesting results in number theory, logarithms, exponentiation, binomials, bounded and unbounded sequences, sets and sub-sets, transfinite numbers etc. In this article we are mainly dealing with his detailed enunciation of 14 sequences and sub-sequences involving very interesting results in logarithms and other areas which were developed about more than 500 years later by European mathematicians.

2. Notation

In this section we have used certain notations to explain some technical terms and processes dealt in with by Nemicandra.

- (i) Ardhaccheda (half-sections): If a number N can be successively halved *n* times to ultimately get 1, then N = 2^n , and *n* is called ardhaccheda of N or symbolically the same can be written as ac (N) = *n*. Thus it can be clearly seen that operator $ac \equiv log_2$ of modern mathematics. I.e. $ac(4) = log_2(4) = 2$, ac(8) = 3, ac(65536) = 16 etc.
- (ii) Vargaśalākā (successive squaring units): If starting with number 2, we go on squaring it m times we get the sequence 2, $2^2 = 4$, $4^2 = 2^{2^2} = 16$, $16^2 = 2^{2^3} = 256$, ..., $2^{2^n} = N$, say. Then m is called vargaśalākā of N and is symbolically represented as m = vs (N). Thus it can be immediately seen that the operator $vs \equiv log_2 log_2$ of modern algebra. E.g. vs (16) = $log_2 log_2$ (16) = $log_2 (2^4) = log_2 (2^2) = 2$. Similarly, vs (256) = 3, vs (65536) = 4, etc.
- (iii) Anyanyobhyāsa (raising a number to its own power): When X is raised to the power of X, i.e. X^{X} , it is called raising X to its own power. This is explained by Nemicandra as writing units (1s) X times and then multiplying them together (to get X^{X}). This process is called 'viralana' (discretization). Nemicandra describes and utilizes processes of successive and recursive exponentiations, for which we will adopt following notation to explain the same. We will denote $X^{X} = X]^{1}$, $X]^{1 \times |1|} = X]^{2}$, $X]^{2 \times |2|} = X]^{3}$, etc. Thus, this obeys the recursion relation $X]^{n-1 \times |n-1|} = X]^{n}$. This process is carried forward in Jaina karma theory further for which we will adopt following notation. As per above notation, let us denote $X]^{X} = X]_{1}$, $X]_{1}^{X|1} = X]_{1}^{1}$, $X]_{1}^{1|X|1} = X]_{2}$. In the same manner $X]_{2}^{|X|^{2}} = X]_{3}$, and so on. This process of raising a number successively for its own times, subjecting this resultant number successively for that number of times, and this resultant number is again subjected to same process. This process for three times is called *śalākā-traya-niṣțhāpana* (*STN*).
- (iv) Knuth's up-arrow notation: As it will not be possible to write very large numbers, even as powers of 2 or 10 or any other number, Donald Knuth has invented a notation of recursive nature, which we are going to use for capturing some very large quantities of Jaina

cosmography and karma theory. In this we denote a^b as $a\uparrow b$, $10\uparrow 10$, 10^{10} as $10\uparrow \uparrow 2$, $10^{10^{10}}$ as $10\uparrow \uparrow 3$, etc. and in general $10^{10^{10^{10}}}$ where height of tower of 10 is *n* as $10\uparrow \uparrow n$.

3. Number System

3. NUMBER FIELD.

About over 6 centuries before *Nemicandra*, decimal place value system with zero having place value was in place and Jaina saint-scholars had contributed a lot towards the same.[6; p. 416, 425, 426], [3; p. 81-100], [4; p. 4-14]. Decimal numeration of Jainas begins with 2 (as 1 was not regarded as a number for counting purposes. [5; p. 225]. The positive number field is divided in 3 main divisions: *Sańkhyāta* (enumerable), *Asańkhyāta* (innumerable) and *Ananta* (literally meaning infinite). *Sańkhyāta* is further subdivided in 3 parts: *Jaghanya* (minimum), *Madhyama* (intermediate) and *Utkṛṣṭa* (maximum). *Asańkhyāta* and *Ananta* are first divided into 3 categories each: *Paritāsańkhyāta*, *Yuktāsańkhyāta* and *Asańkhyātāsańkhyāta*, and *Paritānanta*, *Yuktānanta* and *Anantānanta*, which we may loosely translate as lower, middle and higher order innumerables and infinities respectively. Each of these 6 divisions is further divided into 3 subcategories: *Jaghanya* (minimum), *Madhyama* (intermediate) and *utkṛṣṭa* (maximum). These 7 sets of numbers can be schematically represented in following manner:

(1) *Sańkhyāta* (enumerable) set: $\{\sigma\} \equiv \{2 \text{ (min.)}, 3, 4, ..., A - 2, A - 1 \text{ (max.}\}.$

(2) Paritāsańkhyatā (lower level innumerable) set:

 $A = \{A \text{ (min.), } A = 1, A + 2, ..., B - 2, B - 1 \text{ (max.)} \}.$

(3) Yuktāsańkhyāta (middle level innumerable) set:

 ${\bf B} \equiv {\bf B} = {\bf A}^{A} \text{ (min.), B + 1, B + 2, ..., C - 2, C - 1 (max.)}.$

(4) Asańkhyātāsańkhyāta (higher level innumerable) set:

{C}: = {C = B^2 (min.), B +1, B + 2, ..., C - 2, C - 1 (max.)}.

(5) Paritānanta (lower level infinity) set:

 ${\bf D} = {\bf D} = {\bf C}_{3} \text{ (min.), } {\bf D} + 1, {\bf D} + 2, \dots, {\bf E} - 2, {\bf E} - 1 \text{ (max.)}.$

(6) Yuktānanta (middle level infinity) set:

 ${\bf E} = {\bf E} = {\bf D}^{\bf D}$ (min.), ${\bf E} + 1$, ${\bf E} + 2$, ..., ${\bf F} - 2$, ${\bf F} - 1$ (max.)}.

(7) Anantānanta (higher level infinity) set:

 ${\bf F} \equiv {\bf F} = {\bf F}^2$ (min.), ${\bf F} + 1$, ${\bf F} + 2$, ..., ${\bf G} - 1$, ${\bf G} = {\bf F}]_3$ (max.) <<< K}, where K is defined as *Kevalajñāna* or omniscience or infinite knowledge far greater than higher level infinity.

This reminds us of Cantor's infinities of ordinal numbers, viz. 1, 2, ..., $\omega - 1 \mid \omega, \omega + 1, ..., \omega^{\omega} - 1 \mid \omega^{\omega}, \omega^{\omega} + 1, ..., \omega^{\omega} - 1 \mid \omega^{\omega} = \omega \uparrow \uparrow 3, \omega \uparrow \uparrow 3 + 1, ... \mid \omega \uparrow \uparrow 4, ..., \omega \uparrow \uparrow \omega = \epsilon_0$, etc., although ideas on infinity then were not very clear and rigorous about 1000 years before Cantor.

Jainas had great fascination for very large numbers. The minimum of *asańkhyātas* (innumerables) above, *A*, itself is so mind-bogglingly large that it cannot be counted by even super-computers. As per a rough estimate :

 $A \approx 10^{10^{10^{10}}} = 10 \uparrow \uparrow (N_0^3 + 4)$, where exponentiation of 10 will go up to a height of $N_0^3 + 4$ (height of tower of 10) and where $N_0 \approx 2 \times 10^{45}$.

4. The Dhārās (Sequences and Sub-sequences)

In fact, *Nemicandra* deals with one main sequence (set), our usual set of positive integers (excluding zero), e.g. $\mathbf{N} \equiv \{1,2,3, \dots, n, \dots, \infty\}$, and all remaining 13 sub-sequences (sub-sets) emanating from the mother sequence (set) \mathbf{N} . We list below these sets (sequences) and we have used bold capital letters to denote these sequences (sets) avoiding the denominations \mathbf{Q} , \mathbf{R} , \mathbf{C} , as they commonly stand for sets of rational numbers, real numbers and complex numbers respectively.

1) Sarvadhārā:
$$\mathbf{N} = \{1, 2, 3,, n, K\} = \{n\}.$$

2) Samadhārā: $\mathbf{E} = \{2, 4, 6,, 2n, K\} = \{2n\}.$
3) Vişamadhārā: $\mathbf{O} = \{1, 3, 5,, 2n-1, K-1\} = \{2n-1\}.$
4) Kŗtidhārā: $\mathbf{S} = \{1, 4, 9,, n^2, (VK)^2\} = \{n^2\}.$
5) Akŗtidhārā: $\mathbf{A} = \{2, 3, 5, 6, 7, 8, 10, K-1\} = \{a \mid a \in \mathbb{N} \sim S\}.$
6) Ghanadhārā: $\mathbf{T} = \{1, 8, 27,, n^3, (K/2)^{Y_3}\} = \{n^3\}.$
7) Aghanadhārā: $\mathbf{D} = \{2, 3, 4, 5, 6, 7, 9, K-1\} = \{d \mid d \in \mathbb{N} \sim T\}.$
8) Kŗtimatŗkadhārā: $\mathbf{G} = \{1, 2, 3,, \sqrt{n^2}, \sqrt{K}\} = \{\sqrt{n^2}\}.$
9) Akŗtimatŗkadhārā: $\mathbf{F} = \{\sqrt{K+1}, \sqrt{K+2},, K\} = \{f \mid f \in \mathbb{N} \sim G\}.$
10) Ghanamatŗkadhārā: $\mathbf{H} = \{1, 2, 3,, (n^{3})^{Y_3}, (K)^{Y_3}\} = \{(n^3)^{Y_3}\}.$
11) Aghanamatŗkadhārā: $\mathbf{U} = \{4, 16, 256,, 2^{2^n}, K\} = \{2^{2^n}\}.$
13) Dvirupa-ghanadhārā: $\mathbf{V} = \{8, 64, 4096, ..., 2^{3.2^{n-1}}, (K)^{9/16}\} = \{2^{9.2^{n-1}}\}.$

It may be noted that the Jaina equivalent of modern infinity (∞) was *Kevalajñāna* (K) or the knowledge of the omniscient which cannot be exceeded by any other quantity. However, from the above table it will be clear that rigorous treatment of ∞ was never attempted, so that we find *Nemicandra* (or his predecessors) talking of such terms as vK, (K)^{1/3}, (K)^{9/16} in the above table. Anyhow due to deep contemplation on the above sequences, they were able to derive

very interesting and advanced results in number theory, logarithms, indexation etc. This will be clear from the following paras, wherein we have dealt with each series separately.

Nemicandra, in his work Trilokasāra [1], is able to assign various sańkhyātas, asańkhyātas and anantas to appropriate subsequence. We now give a glimpse of his treatment with necessary explanations. While citing the references from this work we have adopted the following scheme: [1, G.53; p.49] shall mean the work at reference no.1 at the end of this article (i.e. Trilokasāra), its Gathā (stanza) 53 on page 49.

4 (1) Sarvadhārā (Sequence of Natural Numbers) : {N}:

This is nothing but modern (ordered) set (sequence):

 $\{\mathbf{N}\} \equiv \{1, 2, 3, 4, 5, \dots, n, \dots, K\} \equiv \{n\}.$

As the ideas about infinity were not rigorously established then, Nemicandra says that the last term of this sequence is *Kevalajñana*, the subject matter of the omniscient's knowledge. This K is even greater than *utkṛṣṭa anantānanta* described in sec. 3. In fact it may be likened to ∞ of modern mathematics. Hence he talks of the last term of the sequence as K and the number of the terms of this sequence as K. [1, G.54; p.50]. The Kannada commentator of this work, *Mādhavacandra Traividyadeva* tries to explain number of concepts by what he has called '*ańksandṛți*' which may be literally translated as 'numerical symbolism' a precursor of modern algebraic symbolism at it used digits instead of letters. He explains a number of properties of this sequence by representing it as; {1, 2, 3,, 16} by assuming K = 16 = (∞). Whenever it was not possible to explain any property by this, he has chosen K = 65536 (= 2¹⁶) and N = {1, 2, 3,, 65536}. [In fact, this method of '*ańksandṛți*' was widely used by *Virasena* some 200 years earlier in his commentary Dhavala (on *Śaţkhaņdāgama*)]. N is called *sarvadhāra* as all 13 subsequences below emanate from this mother sequence. (... *sesā samādidhārā tatthupaņņeti jāņāhi*). [1, G. 55, p.50].

4. (II) Samadhārā (Sequence of all even numbers: {E}:

This is the subsequence of *Sarvadhārā* and can be represented as:

 ${E} \equiv {2, 4, 6, 8, \dots, 2n, \dots, K} \equiv {2n}.$

Nemicandra defines this as a sequence beginning with minimum term 2, increasing with a constant common difference of 2 and with the highest term K. Interestingly, he makes two observations: the number of terms of this sequence is K/2 and K (*Kevalajñāna* = ∞) is an even number. [1, G. 55; p. 50].

It was quite natural to assume that the number of even and odd numbers is same and equal to K/2 as they are occurring with equal frequency. Times were not ripe enough to infer like Galileo that the sets of natural numbers, even numbers and odd numbers, or of their squares or roots or their multiples have equally infinite numbers. Nor could *Nemicandra* or his predecessors have been able to conclude like Cantor that in respect of infinite aggregates, the part may have the power of the whole.

But it is not clear as to why *Nemicandra* assumed K (= ∞) as an even number. It may probably due to a common bias for odd numbers. More likely explanation may lie in Jaina cosmography or Karma theory where a number of quantities go on doubling and lie in the sequence 2, 4, 8, 16, Infinite or *Kevalajñāna* is defined as equivalent to subject matter of entire universe, it was, therefore, probably treated as an even number. However, there is no clear and direct evidence for this assumption. Further as per 'ańksandṛți' commentator Mādhava represents this sequence as:

E : {2,4,6, ..., 16} or {2,4,6,, 65536} with number of terms as 8 or 32768 .

Further, it appears that K is also assumed to be of the form n^2 , $2^n \text{ or } 2^{2^n}$. Again, from the process of arriving at various sańkhyātas, asańhyātas and anantas, it can be seen that minimum of paritāsańkhyāta/ yuktāsańkhyāta/ asańkhyātāsńkhyāta/paritānanta/yuktānanta/anantānanta and utkṛṣṭa anantānanta (i.e. A, B, C, D, E and F of sec.3) are in samadhārā, i.e. are even.

4. (III) *Vişamadhārā* (Sequence of Odd numbers : {O}:

This also is a subsequence of Sarvadhārā and can be represented as:

 $\{O\} \equiv \{1, 3, 5, 7, \dots, 2 n - 1, \dots, K-1\} \equiv \{2 n - 1\}.$

Nemicandra defines this as a sequence beginning with least term 1 and subsequent terms increasing with a common difference 2, till the last term K-1 is reached. Thus total number of terms in this sequence is again K/2 as is the case with samadhārā.

To prove this, he quotes the formula in respect of Arithmetic Progression (*kevalaņāņasaddhaṁ* ţ*h*āņā*iṁ samavisamadh*ā*ray*āņ*a have /*ā*di ante suddhe vaddhide igijude* ţ*h*āņā) [1, G.57; p.52]:

Lemma 1: n = 1 + (l - a)/d, where *l* is the last term, *a*, the first term and *d*, the common difference. In case of *Vişamadhārā*, a = 1, l = K-1 and d = 2. Substituting these values in the formula, we get n = K/2. Similarly in case of *Samadhārā*, a = 2, l = K and d = 2, and thus n = K/2. [ibid].

It is also stated that the maxima of *sańkhyāta, paritāsańkhyāta, yuktāsańkhyāta, asańkhyātāsańkhyātā, paritānanta* and *yuktānata* lie in this *dhārā*. This follows from the definitions of these numbers or from the remark in 4(II) above about that minimum of these numbers lie in *Samadhārā*. *Mādhava* uses to prove all above results by representing the sequence in numeric symbolism ('ańksandṛaṣți') as:

 $\{O\} = \{1, 3, 5, 7, 9, 11, 13, 15\}$ or $\{1, 3, 5, ..., 65535\}$, so that the last term in the $dh\bar{a}r\bar{a}$ is K-1 = 16-1 = 15 or 65536-1 = 65535 and the number of terms is (by lemma 1 above): 1+(15-1)/2 = 8 or 1+(65535-1)/2 = 32768.

4. (IV) Krtidhārā (Sequence of Squares): {S}

This is the sequence of squares of natural numbers, i.e.,

 $\{{\bf S}\} \equiv \ \{ \ {\bf 1}, \ {\bf 4}, \ {\bf 9}, \ {\bf 16}, \ ..., \ n^2, \ ..., \ {\bf K} \ \} \equiv \{ \ n^2 \ \}.$

This is the famous sequence cited by Galileo to show that it can be put in one to one correspondence with sequence of natural numbers, {**N**}. But for *Nemicandra* it is a sequence with first term 1, last term K and number of terms \sqrt{K} . In fact his definition amounts to:

$$\mathbf{S} \ \equiv \ \{ \ \mathbf{1}^2, \ \mathbf{2}^2, \ \mathbf{3}^2, \ \mathbf{4}^2, \ \dots, \ n^2, \ \dots, \ (\ \sqrt{\mathsf{K}} \)^2 \ \},$$

showing that it has \sqrt{K} terms. He further states that *jaghanya* (minimum) of various *asańkhyātas* and *anantas* lie in this sequence. [1, G.58; p.52]. This follows from processes of constructing these quantities). This also follows from the fact that they lie in Dvirupavargadhārā (the 12th sequence described later), where general term is of the form $u_n = 2^{2^n}$. This then can be proved thus:

Lemma 2 : If a number of the form 2^{2^k} is in *krtidhārā* (sequence of squares) then its square root also lies in it.

For, $(2^{2^k})^{1/2} = 2^{(\frac{1}{2}) \cdot 2^k} = 2^{2^{k-1}} = [2^{2^{k-2}}]^2$, and hence lies in kṛtidhārā.

Now, as *jaghanya* (minimum) *paritāsańkhyāta* (= A) is in *kŗtidhārā*, its preceding *utkṛṣṭa sańkhyāta* (= A-1) cannot be in this sequence. *Nemicandra* then asks to find out the term in this *dhārā* just preceding *utkṛṣṭa sańkhyāta*. He then provides the answer: it is:

 $[\sqrt{(jaghanya paritāsańkhyāta)} -1]^2 = (\sqrt{A} - 1)^2 (igihīņatappadakadī heţţhimamukkassa savvattha). [1, G. 58, p. 52]. In fact he generalizes this by stating that the term in krtidhārā just before utkrṣţa (maximum) of sańkhyata and utkrsta of any of 3 asańkhyātas or 2 anantas (excluding utkrsta anantanant) is:$

 $[\sqrt{(jaghanya of any of 3 asańkhyātas or any of 3 anantas) -1]^2}$.

4.(V) Akrtidhārā (Sequence of non-square natural numbers) : {A}

This is the sequence of natural numbers which are not squares, i.e. if we take away from numbers in *sarvadhārā* (**N**) the numbers in *kŗtidhārā* (**S**), we get this sequence. Thus:

 $\{ \textbf{A} \} \equiv \{ 2, \, 3, \, 5, \, 6, \, 7, \, 8, \, 10, \, \} \equiv \{ a \ | \ a \in \textbf{N} \sim \textbf{S} \}$

Nemicandra gives the number of terms in this sequence as K - \sqrt{K} , which is obvious. He also states that *utkṛṣṭa sańkhyāta*, 3 *utkṛṣṭa asańkhyāta*s and 2 *utkṛṣṭa ananta*s (except *utkṛṣṭa anantānanta*) belong to this sequence. This follows from remarks in previous sec. 4(IV). [1, G.59; p.53].

4.(VI) Ghanadhārā (Sequence of Cubes): {T}

This is the sequence of cubes of natural numbers. Treatment of this by *Nemicandra* is quite interesting and imaginative. He represents this sequence by:

 $\{ \mathbf{T} \} \equiv \{ 1, 8, 27, ..., n^3, ..., [(K/2)^{1/3}]^3, [(K/2)^{1/3}+1]^3, [(K/2)^{1/3}+2]^3, ..., [(K/2)^{1/3}+/]^3 \}, \text{ Where } [(K/2)^{1/3}+/]^3 < K < [(K/2)^{1/3}+/+1]^3.$

He does this by asserting that if *vargaśalaka* of K is an even number, say 2*p*, i.e., K is of the form: $K = 2^{2^{2p}}$. Then in that case, K/2 is a perfect cube and thus lies in sequence {T}. (*tagghaņamantaṁ vinde țhāņaṁ āsaņņaghaņamūlaṁ*...). [1, G.60; p.53].

Before we see why he makes this assertion and then prove his assertion, let us understand two terms commonly used in Jaina literature, viz., 'ardhacheda' and 'vargaśalākā' as they are equivalent to modern log_2 and log_2log_2 respectively. This clearly ushers the beginnings of logarithms with base 2 and in that process Jaina saint-scholars developed almost all the rules of logarithms some 600 years before Napier, who is regarded as the originator of logarithms. [1, G.76; p. 69].

Ardhacheda of any number is number of times it can be halved to get 1. E.g., 16/2 = 8,

8/2 = 4, 4/2 = 2, 2/2 = 1. Thus, 16 can be halved 4 times (to get 1). Hence, we can say:

Ardhacheda (16) = ac (16) = ac (2⁴) = 4. Similarly, one can verify ac (65536) = ac (2¹⁶) = 16. Thus, one can see immediately that ardhacheda or $ac \equiv log_2$. [1, G.76; p. 69].

Now, suppose a number can be obtained by successively squaring 2 for *n* times, then we say *vargaśalākā* (N) = *n*. E.g., as $2^2 = 4$, $4^2 = 16$, then *vargaśalākā* (16) = *vs* (16) = 2. Similarly, $2^2 = 4$, $4^2 = 16$, $16^2 = 256$, $256^2 = 65536$. Then, *vs* (65536) = 4. If we write

 $vs(16) = vs(2^{2^2}) = 2$, and $vs(65536) = vs(2^{2^4}) = 4$, we can immediately see that

 $vargas a l\bar{a}k\bar{a} = vs \equiv log_2 log_2$. I.e., if N = 2^{2^n} , then, $log_2 log_2$ (N) = n.

With the above definitions, we will now see as to why Nemicandra asserts that if

 $K = 2^{2^{2p}}$ or that vs (K) = $log_2 log_2$ (K) = 2p, i.e., vargaśalākā of K is an even number, then K/2 is a perfect cube.

Lemma 3. If *vargaśalākā* of a number is an even number, then half of that number is a perfect cube.

Let vs (K) = 2p. Then, K = $2^{2^{2p}}$.

Now, K/2 = (1/2). $(2^{2^{2p}}) = 2^{(2^{2p}-1)}$.

The power of 2 in the above expression is $2^{2p}-1 = (2^{p}-1)(2^{p}+1)$.

Since $2^{p} - 1$, 2^{p} , $2^{p} + 1$ are 3 consecutive numbers, and as 2^{p} is even, as per number theory, either $2^{p} - 1$ or $2^{p} + 1$ is a multiple of 3. Hence, $(2^{p} - 1) (2^{p} + 1)$ is a multiple of 3, say = 3q. Hence K/2 = 2^{3q} and thus K/2 is a perfect cube. I.e., $(K/2)^{1/3}$ is a whole number.

And for this reason Nemicandra gives few last terms of Ghanadhārā as:

 $[(K/2)^{1/3}]^3$, $[(K/2)^{1/3} +1]^3$, $[(K/2)^{1/3} +2]^3$,, $[(K/2)^{1/3} +/]^3$, where *I* is such a number that $[(K/2)^{1/3} +/]^3 < K$ but $[(K/2)^{1/3} +/+1]^3 > K$. Since nothing can exceed K, this value is rejected and the sequence can be written as:

 $\{\mathbf{T}\} \equiv \{ n^3 \} \equiv \{1^3, 2^3, 3^3, \dots, n^3, \dots, [(\mathsf{K}/2)^{1/3}]^3, \dots, [(\mathsf{K}/2)^{1/3} + /]^3 \}.$

This also shows that number of terms in the sequence is $[(K/2)^{1/3} + /]$. This last place in the sequence is called 'āsannaghanamulasthāna' and its cube, the last term of the dhārā, is called 'āsannaghana'. For an infinite quantity K, it is absurd to talk about K/2 or $(K/2)^{1/3}$ or $(K/2)^{1/3} + /$, etc. However, one must appreciate the imaginative way *Nemicandra* tackles this sequence and in that process introduces operators like log_2 , log_2log_2 and develops them further as we will see later.

The commentator *Mādhava* makes this simpler by his 'ańksandŗaṣți' (numerical symbolism) technique, by deriving the ghanadhārā sequence in following manner.

He takes K = $65536 = 2^{16} = 2^{2^4}$, then vs (65536) =4 is even. And $65536/2 = 32768 = (32)^3$. Further since $40^3 = 64000 < 65536 < 41^3 = 68921$, the sequence can be written as:

 $\{1^3, 2^3, 3^3, \dots, 32^3, 33^3, \dots, 40^3\}$ with 40 = $(65536/2)^{1/3}$ +8 terms.

Just for academic interest, Nemicandra proposes a lemma related to Lemma 3 above.

Lemma 4: If *vargaśalākā* of a number is odd, then $1/4^{th}$ of the said number is a perfect cube.

[1, G.61; p.55].

Let vs (N) = 2n+1, i.e., $log_2log_2 N = 2n+1$. Then, we can write:

$$N = 2^{2^{2n+1}}$$
. \therefore (1/4) $N = 2^{(2^{2n+1}-2)} = 2^{2(2^{2n}-1)}$.

And since the part index in this is $2^{2n} - 1 = (2^n - 1)(2^n + 1)$,

the rest of proof is on the same lines as in Lemma 3 above. Thus, N/4 is a perfect cube.

This can be verified by following numerical examples.

$$(1/4) 2^{2^{1}} = 1 = 1^{3}; (1/4) 2^{2^{3}} = (1/4) (256) = 64 = 4^{3};$$

$$(1/4) 2^{2^5} = (1/4) 2^{32} = (1/4) (4294967296) = 1073741824 = (1024)^3.$$

4.(VII) Aghanadhārā (Sequence of Non-cube Natural Numbers): {D}:

This sequence is of theoretical interest only and can be represented by $\{D\} \equiv \{2,3,...,7,8,...,26,28,29,....,63,65,66,.....\} \equiv \{d \mid d \in N \sim T\}.$

It has all the terms of *sarvadhārā* {N} excluding those belonging to ghanadhara {T}.

The number of the terms of this sequence is, therefore, given as:

K – [(K)^{1/3} +/]. [1, G.62; p. 57].

4.(VIII) Krtimatrkadhārā (Sequence of Square-generating Natural Numbers): {G}:

As the name indicates, this is a sequence of natural numbers which are 'capable' of generating square numbers. We know that as per modern number theory, all the natural numbers are capable of generating squares, since both the sequences $\{n\}$ and $\{n^2\}$ have the same power (cardinal number). However, at the time of *Nemicandra*, there was one restriction that no number can exceed K and as such sequence $\{n^2\}$ should contain all natural numbers up to \sqrt{K} . Hence this sequence can be represented as:

$$\{\mathbf{G}\} \equiv \{1, 2, 3, \dots, \sqrt{n^2}, \dots, \sqrt{K}\}.$$

The number of terms in this sequence is, therefore, equal to \sqrt{K} . [1, G. 62; p. 57].

4.(IX) Akrtimtrkadhārā (Sequence of Non-square-generating Numbers): {F}:

Since any number > \sqrt{K} cannot be regarded as square-generating, this sequence begins with \sqrt{K} +1, and goes up to K, as their squares will exceed K which is not permitted. The sequence then can be represented by:

{F} = {
$$\sqrt{K}$$
 +1, \sqrt{K} +2,, \sqrt{K} +*n*,, *K*} = { f | f ∈ N ~ G }.

The number of terms in this sequence is, therefore, K - \sqrt{K} . Nemicandra then asserts:

Lemma 5 : \sqrt{K} , $log_2 K$ and $log_2 log_2 K$ do not lie in this sequence. (... vaggasalāddhacchedā dhārātidae na jāyanti). [1, G. 63; p. 58].

Obviously \sqrt{K} is not in F since the least member of {F} is $\sqrt{K+1}$. In Lemma 3 above we have seen that K is of the form 2^{2^n} . Then $\sqrt{K} = (2^{2^n})^{1/2} = 2^{2^{n-1}}$. Then,

 log_2 K = $2^n < 2^{2^{n-1}} = \sqrt{K}$, since $n < 2^{(n-1)}$ which can be easily proved by mathematical induction. Hence, log_2 K also does not belong to {**F**}. Further,

 log_2log_2 K = $n < 2^{(n-1)} = \sqrt{K}$, which we have shown just above. And thus, log_2log_2 K also does not belong to {**F**}.

4.(X) Ghanamatrkadhārā (Sequence of Cube-generating Numbers) : {H}:

Like sequence in 4(VIII) above, this can be regarded as a sequence of natural numbers 'capable' of generating cubes. Since no cube can be greater than K, the last term of this sequence is

 $(K/2)^{1/3}$ +/ as we have seen in4.(VI) above (ghanadhārā). Thus, it can be represented by:

$$\{\mathbf{H}\} = \{1, 2, 3, \dots, (n^3)^{1/3}, \dots, (K/2)^{1/3} + 1\}$$

Or, as in (VI) above, Nemicandra calls the last term as cube root of 'āsannaghana', as

$$[(K/2)^{1/3} + /]^3 < K < [(K/2)^{1/3} + / +1]^3$$
. [6, G.64; p. 58].

In numerical symbolism ('*ańksandṛaṣți*'), since K = 65536,

 $(40)^3 = 64000 < 65536 = K < (41)^3 = 68921,$

this sequence in numeric symbolism may be written as:

(603)

{ 1, 2, 3,, 39, 40 }.

Here Nemicandra makes one more assertion as below :

Lemma 6: This sequence contains second square-root of K but not the first square-root. {... *kevalasseva bidiyapadavindamantaṁ ... carimassa ducarimassa ya ņeva ghaņaṁ*) [1, G. 81, 82, p. 73]

Here, by first square-root of K is meant $\sqrt{K} = (K)^{1/2}$ and by second square-root is meant $\sqrt{\sqrt{K}} = (K)^{1/4}$. It contains $(K)^{1/4}$ since $[(K)^{1/4}]^3 = (K)^{3/4} < K$, and it does not contain $(K)^{1/2}$ since $[(K)^{1/2}]^3 = (K)^{3/2} > K$ and since no number can exceed K.

4. (XI) Aghanamatrkadhārā (Sequence of Non-cube-generating Numbers): {J}:

This is defined as sequence of such numbers which are 'not capable' of generating cubes. From the foregoing discussion it is clear that these are the numbers whose cube will exceed K. Hence, the sequence can be represented by:

{(K/2)^{1/3}+/+1, (K/2)^{1/3}+/+2, (K/2)^{1/3}+/+3,, K },

Or, as per numeric symbolism ('ańksandŗașți') : [1, G. 65; p. 59],

{41, 42, 43,, 65536 }.

The number of terms of this sequence is given as K - $(K/2)^{1/3}$ - I which follows from 4(X) above. There is one more interesting observation by *Nemicandra* that this sequence contains *utkṛṣṭa* (maximum) *anantānanta* but may or may not contain some terms of *madhyama* (intermediate) *anantānanta*. I.e., we have to prove that $(K/2)^{1/3}+I$ lies in *madhyama anantānanta*. That K lies in the sequence follows from the definition of the sequence, but to prove that

 $(K/2)^{1/3}+I$ is far greater than *jaghanya* (minimum) *anantānanta*, we have to go deeply in the processes of generating *anantānantas*, which we do not propose to deal with herein.

If we denote *jaghanya anantānanta* by *j*, then as per Annexure, $K >>> j]_3$, where

 $j_{3} >>> j^{j} >>> j$ and from the process of obtaining K from j, it is clear that $j <<<(K/2)^{1/3}$.

Thus, $(K/2)^{1/3}$ +/lies in madhyama anantānanta. (For notation *j*]₃, see [2, p. 55, 56]).

4.(XII) Dvirupavargadhārā (Dyadic-square Sequence): {U}:

This is a very important sequence in Jaina philosophy as many large numbers referred in their canon belong to this sequence. *Nemicandra* defines this sequence as starting with square of 2, i.e., $2^2 = 4$, and then each term is square of earlier term, viz. 4, 16, 256, 65536 (*paņațţhi*), 4,294,967,296 (*bādāla*), 18,446,744,073,709,551,616 (*ekaţţhi*), etc.

Normally, numerical values in decimal system up to ekațțhi (= 2⁶⁴) were found in many ancient Jaina works. Often *paṇațțhi*, *bādāla* and ekațțhi were denoted symbolically as 65=, 42=, 18= respectively for calculations or for determining higher numbers. *Virasena, Nemicandra* and *Abhayadeva* (11th C. A.D.) even calcualate 2⁹⁶ although it does not belong to this sequence. [3; p. 84], [4; p. 8]. Thus, this sequence can be represented by:

 $\{\mathbf{U}\} = \{2^{2^1}, 2^{2^2}, 2^{2^3}, \dots, 2^{2^n}, \dots, K\} = \{2^{2^n}\}, n = 1,2,3, \dots$

At times the sequence is supposed to start with 2, i.e. = $\{2^{2^{n}(n-1)}\}$, n = 1, 2, ...

Of course, K as last term is *Nemicandra*'s statement, meaning it an infinite sequence. Then, he makes a further significant statement that as we go a numerable (*sańkhyāta*) places (terms), we have vs (A) (i.e., $log_2 log_2$ (A)) then after numerable places ac (A) (i.e., log_2 (A)), then after numerable places we get A, the minimum of *asańkhyātas*, i.e. *jaghanya paritāsańkhyāta*. How all these were regarded as belonging to this sequence can be inferred only indirectly. [1, G.66; p.60].

If A belongs to {**U**}, we may write $A = 2^{2^{p}}$, and then $\sqrt{A} = 2^{2^{p-1}}$, *ac* (*A*) = $log_{2}(A) = 2^{p}$, and *vs* (*A*) = $log_{2}log_{2}(A) = p$. Then as per *Nemicandra* :

 $log_2log_2(A) < log_2(A) < \sqrt{A} < A$ or in other words: $p < 2^p < 2^{2^{n}(p-1)} < 2^{2^n p}$, all belong to {**U**}. The inequality is obvious (see also Lemma 5). But how is it that all these 4 quantities lie in {**U**} was

not made explicitly clear. However, if we see the genesis of A, A is of the form $2^{2^{2}}$, where height of the tower of 2 is very large (of the order of N₀³, where in turn, N₀ \approx 2x 10⁴⁵. Then it becomes immediately obvious that all these 4 quantities belong to **U**. However, form of A as stated above cannot be proved rigorously and may be taken as a hypothesis. Then it will follow that *A*, \sqrt{A} , $log_2(A)$, $log_2log_2(A)$ will belong to {**U**}.

Nemicandra then asserts that minimum *yuktāsańkhyāta* (= A^{A}) also lies in {**U**}. This follows from the fact that $A^{A} = (2^{2^{p}})^{A}(2^{2^{p}}) = 2^{A}(2^{p}.2^{2^{p}}) = 2^{2^{p+2^{p}}}$ and hence it belongs to **U**. Here, *Nemicandra* makes a very interesting statement:

Lemma 7: If a member of $\{U\}$ is obtained by raising another member to its own power, then the *ardhaccheda* (log_2) and *vargaśalākā* (log_2log_2) of that derived member do not belong to $\{U\}$.

In the previous para we have seen that if $A = 2^{2^p} \in \{U\}$, then $B = A^A = 2^{2^{p+2^p}} \in U$. Now we have to show that log_2B and $log_2log_2B \notin \{U\}$.

Now, $log_2B = 2^{p+2^p}$ and $log_2log_2B = p+2^p$, and since $2^p < 2^p + p < 2^{p+1}$,

 $log_2B \notin U$. (This can be proved very easily by mathematical induction). In view of this inequality, $log_22^p < log_2(2^p+p) < log_22^{p+1}$, i.e., $p , (<math>\varepsilon < 1$), it follows that :

 $log_2 log_2 B \notin \{U\}$. [1, G.67; p. 61]. [1, G.73; p. 66].

This will be quite clear if we take some numerical examples. We may write this sequence as: 4, 16, 256, 65536 (= 2^{16}), 2^{32} , 2^{64} , 2^{128} , etc. Now the term 256 = 4^4 is of type discussed in Lemma 7. Here log_2 (256) = 8, and log_2log_2 (256) = 3, both of which \notin **U**. Next term in above sequence of this type is $2^{64} = (2^4)^{4}$, and $log_2(2^{64}) = 64$ and

 $log_2 log_2 (2^{64}) = 6$, both of which $\notin \mathbf{U}$.

Here *Nemicandra* states another result pertaining to a quantity called *sucyańgula* (linear finger), a small measure of length given by $P^{log_2(P)}$, where *P* is another quantity called *Palya* and is frequently referred in Jaina scriptures.

Lemma 8 : If $P \in \{\mathbf{U}\}$, so also does $P_{2}^{\log(P)}$.

As $P \in \{\mathbf{U}\}$, let $P = 2^{2^p}$. Then $log_2 P = 2^p$. Hence, $P^{log_2(P)} = (2^{2^p})^2 = 2^{2^{2p}}$, which shows that $P^{log_2(P)} \in \{\mathbf{U}\}$. This term is *p*th $(= log_2 log_2 P)$ th term after *P* in $\{\mathbf{U}\}$.

The last term of the sequence $\{U\}$ is K, and since there can be nothing greater than K, it is an infinite sequence. About 1000 years back the ideas on infinity were not rigorously developed and as such Nemicandra talks of number of terms of this sequence. He avers:

Lemma 9 : The number of terms in sequence {**U**} whose last term is K is equal to *varga- śalaka* of K, i.e. *vs* (K) = log_2log_2 K. Let us write down again the sequence in the form:

$$\{\mathbf{U}\} \equiv 2^{2^1}, 2^{2^2}, 2^{2^3}, \dots, 2^{2^n}, \dots, K = 2^{2^k}$$
say.

From perusal of the above, it will at once be clear that number of the terms of the sequence is k. But $log_2 K = 2^k$ and $log_2 log_2 K = k$.

 \therefore number of the terms = $k = log_2 log_2 K = vs$ (K).

4. (XIII) Dvirupaghanadhara : (Dyadic Cube Sequence) : {V}:

This sequence is defined as:

$$\{\mathbf{V}\} \equiv \{8, 64, 4096, \dots, 2^{3 \cdot 2^{n-1}}, \dots, (K)^{3/4}\} \equiv \{2^{3 \cdot 2^{n-1}}\}, \text{ or }$$

 $\{\mathbf{V}\} \equiv \{2^3, 2^6, 2^{12}, 2^{24}, \dots, 2^{3 \cdot 2^{n-1}}, \dots, (K)^{3/4}\}.$

The sequence has a property common with *dvirupavargadhārā*, which is:

Lemma 10 : If X and $X^X \in V$, then $log_2 X^X \notin V$ and $log_2 log_2 X^X \notin V$.

We will first verify this by a numerical example (as done by commentator $M\bar{a}dhava$ -candra). Note that first term of the sequence is 8 and the fourth term is $(4096)^2 = 16,777,216 = 2^{24} = 8^8$. Hence 8 and 8⁸ both belong to this sequence. Now $log_2(8^8) =$

 $8 \log_2(8) = 24$ and $\log_2 \log_2(8^8) = 3 + \log_2 3$, and we see that both do not belong to **V**.

For the general proof, let $X = 2^{3 \cdot 2^{n-1}} \in \{V\}$, and

$$X^{X} = [2^{3 \cdot 2^{n-1}}]^{n} [2^{3 \cdot 2^{n-1}}] = 2^{n-1} \{2^{3 \cdot 2^{n-1}}\}] = 2^{n} [3 \cdot 2^{n-1+3 \cdot 2^{n}(n-1)}] \in \{V\}.$$

Thus, $log_2 X^{X} = 3.2^{n-1+3.2^{n}(n-1)} \notin V$, and

$$log_2log_2 X^{X} = log_2 3 + n - 1 + 2^{n-1} \notin \mathbf{V}.$$

Nemicandra then calculates the last term and number of terms of this sequence by a simple manipulation. For this he takes the first term of $dvirupavargadh\bar{a}r\bar{a}$ as 2 instead of 4 (which is more logical) and then **U** can be written as:

$$\{\mathbf{U}\} \equiv \{2, 4, 16, \dots, 2^{2^{n-1}}, \dots, K\}, \text{ with } n\text{th term } u_n = 2^{2^{n-1}}.$$

And we may rewrite {**V**} again:

 $\{\mathbf{V}\} = \{8, 64, 4096, \dots, 2^{3 \cdot 2^{n-1}}, \dots, \mathbf{K}^{3/4}\}, \text{ with } n \text{ th term } \mathbf{v}_n = 2^{3 \cdot 2^{n-1}}.$

We immediately observe that $v_n = u_n^{3}$, i.e. each term of {**V**} is cube of corresponding term of {**U**}. But for last 2 terms of {**U**}, viz. K^{1/2} and K, there cannot be corresponding terms in {**V**} since then they would be $(K^{1/2})^3 = (K)^{3/2}$ and K³, both exceeding K which simply is not permitted. Hence last term of {**V**} must correspond to 3rd term from end of {**U**} which is $(K)^{1/4}$. The last term of {**V**}, then, is $\{(K)^{1/4}\}^3 = K^{3/4}$. Also, as we have seen in earlier sub-section, number of terms in {**U**} is log_2log_2K . Then, number of terms in **P** is 2 less, i.e. log_2log_2K -2. [1, G.81, 82; p.73].

Nemicandra also gives the relationship: $log_2 log_2 v_n \approx log_2 log_2 u_n$ for large *n*. This can be verified by observing $log_2 log_2 v_n = log_2 3 + n \cdot 1 \approx n$ for large *n*. Also, $log_2 log_2 u_n = n$.

4.(XIV) Dvirupaghanāghanadhārā : (Dyadic Cube-o'-Cube Sequence) : {W}:

This is the last among 14 sequences discussed by *Nemicandra*. Each term of this sequence {**W**} is cube of the corresponding term in *dvirupaghanadhārā*, {**V**}, and cube of cube of the corresponding term in *dvirupavargadhārā* {**U**} (in the modified form as shown in the previous section). As we will be discussing some common properties of these (last) 3 sequences, we are showing them below together:

 $\{\mathbf{U}\} = \{2, 4, 16, 256, \dots, 2^{2^{n-1}}, \dots, K\}, \text{ with } n \text{ th term } u_n = 2^{2^{n-1}}, \\ \{\mathbf{V}\} = \{8, 64, 4096, \dots, 2^{3 \cdot 2^{n-1}}, \dots, (K)^{3/4}\}, \text{ with } n \text{ th term } v_n = 2^{3 \cdot 2^{n-1}}, \\ \{\mathbf{W}\} = \{512, 262144, \dots, 2^{9 \cdot 2^{n-1}}, \dots, (K)^{9/16}\}, \text{ with } n \text{ th term } w_n = 2^{9 \cdot 2^{n-1}}.$

It can be observed that $w_n = (v_n)^3 = (u_n)^9$. Now, *Nemicandra* argues, for every term in **U**, there is a corresponding term in {**W**}, except for the last 4 terms of {**U**}, which are K, $(K)^{1/2}$, $(K)^{1/4}$ and $(K)^{1/8}$, because their 9th powers, $(K)^9$, $(K)^{9/2}$, $(K)^{9/4}$ and $(K)^{9/8}$ are all greater than K, which is not permissible. The last term of {**W**} is, therefore, $\{(K)^{1/16}\}^9 = (K)^{9/16} < K$. \therefore the number of terms in {**W**} are 4 less than those in {**U**}, i.e. $(log_2log_2 K)$ -4.

Some elementary relationships between the members of the above 3 sequences are stated as below, which can easily be verified by the readers. [6, g.74; p.67].

- 1) $log_2 w_n = 3.log_2 v_n = 9.log_2 u_n$,
- 2) $log_2 log_2 (u_{n+1} / v_{n+1} / w_{n+1}) = 1 + log_2 log_2 (u_n / v_n / w_n),$
- 3) $log_2 log_2 u_n \approx log_2 log_2 v_n \approx log_2 log_2 v_n$, for large *n*.

The purpose of studying this sequence for Jaina saint-scholars arose due to certain quantities and measure of philosophical entities belong to this sequence. We will not go into semantics or spiritual aspects of these quantities, but only give one simple example as an illustration. After going innumerable places along this sequence, we get the quantity equal to *pradesas* (space points) of *Loka* (universe). *Loka* is defined as equal to cube of *Jagaśreņi*, J = 7 *Rajus*, a linear dimension of cubic universe. J in turn was defined as :

J = (a^3)^{log2P/A} [see sec. 4(XII)]. [1, G.83,84; p.74-76]. Thus, as we have seen therein, J^{1/3} ∈ {**U**}, ∴ J ∈ **V** and J³ ∈ {**W**}.

In fact, *Nemicandra* makes a general statement about the last three sequences that after *sańkhyāta* (numerable), *asańkhyāta* (innumerable) and *ananta* (infinite) places along these sequences, we come across *sańkhyāta*, *asańkhyāta* and *infinite* numbers. The commentator *Mādhava* clarifies this by stating that till *jaghanya asaņkhyātā* terms, and till *Kevalajñāna anantā* terms.

We will end our discussion with one advanced problem tackled which brings out clearly the insight developed in various aspects of number field, logarithms etc. In sec. 4(XII) we have seen that $addh\bar{a}palya = P \in \{U\}$ (*dvirupavargadhārā*). Then, Nemicandra asserts that $Addh\bar{a}sagara = 10^{15} \times P \notin \{U\}$. To prove this, let us write $P = 2^{2^p}$. Hence,

$$log_2 (10^{15} \text{x P}) = log_2 (10^{15}) + log_2 P \approx 49.85 + 2^p$$
, and

 $log_2 log_2 (10^{15} \text{xP}) = log_2 (2^p + 49.85) > p$. But, from genesis of P as per sec. 3(III),

 $p < log_2 (2^p + 49.85) < p + 1,$

and hence *addhāsāgara* lies between *p*th and (*p*+1)th term of {**U**}, and \therefore , cannot be in {**U**}.

5. Conclusion.

We have given a survey of some aspects of state of mathematical development around 1000 A.D. as reflected in the works of *Nemicandra Siddhāntacakravarti*, especially his great work on Jaina cosmography, *Trilokasāra*. In fact, his predecessor by about 200 years, *Virasena*, has discussed almost all the above problems and even more advanced problems, in his monumental tomes *Dhavala* and *Jayadhavala*, commentaries on much older works of 2nd or 3rd C. A.D., *Śaţakhaņđāgama* and *Kaşāyapāhuđa*. However, a systematic treatment is given in *Trilokasāra* and hence we have selected this work for this paper. To summarize:

1) Five or six centuries before *Nemicandra*, the decimal place value system with zero having place value was in vogue , at least as revealed by Jaina canon and other works. In their numeration they had separate names for numbers on decimal scale up to 10^{250} .

2) To tackle even unimaginably large numbers, they invented recursive processes similar to one required in representing Graham's Number, g_{64} . Their asańkhyātas (innumerables) and *anantas* (infinites) have remote but striking similarity with Cantor's theory of transfinite numbers and hierarchy of infinites (cardinals and ordinals).

3) *Nemicandra* (10th C. A.D.) studies and analyses the sequence (set) {N} of positive integers and 13 sub-sequences (subsets) emanating from it, viz. sets of even numbers, odd numbers, squares, cubes, etc. Three dyadic sequences studied by him exhibit a queer numeration system which is a combination of dyadic and decimal measure systems.

Mādhavacandra, the commentator and direct disciple of *Nemicandra*, to clarify many concepts uses the technique of numerical symbolism (*ańk sandraṣți*), a precursor of algebraic symbolism. (In fact, another direct disciple of *Nemicandra*, *Keśavavar*,*i*, who is also commentator of other works of *Nemicandra*, makes profuse use of algebraic symbolism by using various signs and symbols).

4) In dealing with these sequences and other famous numbers of Jaina theology, the theory of logarithms with base was fully developed and quite advanced problems in it were tackled. All the following rules were explicitly stated.

i) If $b = log_2 a$, then $a = 2^b$.	[1, G.110; p.106].
ii) $log_2(ab) = log_2 a + log_2 b$.	[1, G.105; p.101].
iii) $log_2(a/b) = log_2 a - log_2 b$.	[1, G.106; p.102].
$iv) \log_2(a^b) = b \log_2 a.$	[1, G.107; p.102].

v) If $a = b^c$, then, $log_2 a = c log_2 b$, and

 $log_2 log_2 a = log_2 c + log_2 log_2 b. [1, G.107, 108; p.103].$

Many of the ideas above started percolating in Western mathematics only from 16th C. onwards. To conceive of such ideas about 500 to 1000 years earlier can be regarded as a supreme achievement of the Indian genius.

ABBREVIATIONS

A: Jaghanya paritāsańkhyāta (minimum of asańkhyāta).

ac: ardhacheda ($\equiv log_2$).

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K: Kevalajñāna (\equiv \infty).
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STN:Śalākā-traya-niștāpana (a recursive operation).

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vs: Vargaśalākā (\equiv \log_2 \log_2)
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29. Jain Units of Space and Time

Rajmal Jain and Anupam Jain

Abstract

Space and time have always been topics of interest in religion and philosophy as they are in scientific studies. However, in philosophy as well as in most of the religions, these are vaguely defined, either qualitatively or in units, which are difficult to convert into units used at the present time. The units of space and time in the domains of religion and science appear paradoxical and thus there is a need to understand them properly.

The philosophy of space and time was both an inspiration for and a central aspect of early analytic philosophy. The subject focuses on a number of basic issues, including whether or not space and time exist independent of mind, whether they exist independently of one another, whether time flows unidirectionally, whether times, other than the present moment exist etc., and many questions related to identity of time in the past and over spatial scales arise. Historically, no unambiguous definition and quantitative aspects of space and time were proposed until the Vedas described cosmology. According to the ancient Hindu cosmology, the universe goes through repeated cycles of creation, destruction, and rebirth, with each cycle lasting 4,320,000 years.

Later, in the period 428-322 BCE, Plato identified time with the period of motion of the heavenly bodies, and space as that in which objects come to be, while Aristotle defined time as the number of change with respect to before and after, and the place of an object as the innermost motionless boundary of that which surrounds it. Somehow, these qualitative statements could not lead the folks to understand space and time quantitatively and hence to measure in units. Nevertheless, over the time, early in the last millennium, in contrast to the ancient Greek philosophers who believed that the universe had an infinite past with no

beginning, medieval philosophers and theologians developed a new concept of the universe having a finite past, with a beginning. This view was inspired by the creation belief shared by the three non-Vedic religions: Judaism, Christianity, and Islam. However, in contrast to this concept, Jainism favors ancient Greek philosophy with "infinite past and no beginning". Most important aspect of Jainism, in contrast to any other philosophy, is the well defined concept of space and time with quantitative description. This enables a unique opportunity to compare the space and time models described in Jainism with that of currently advanced sciences.

In this article, therefore, we briefly define Jain astronomy and its features. We rather describe the concepts of time, length and graduation of zodiacal circumferences. We also describe planets and other celestial bodies in the solar system as discussed in Jainism and compare these descriptions with our current knowledge of modern astronomy. Length units from Atharvaveda Jyotisa (AJ) to Jain astronomy is presented and compared with different systems of units and modern system of units. A brief concept of measurement of time described in Jain canonical texts is presented in context of the evolution of time of the day. Further, the measurement of time employing shadow techniques, like sextant where smaller grids were engraved for better time resolution, is presented. In order to understand the cosmological distances in the universe we first describe the concepts of diurnal and declination circles in Jainism. We give examples of distances estimated for the Earth from the Sun and the Moon. We also consider the estimates of the extension of the Jain universe (14 raju) and compare it with the present knowledge of length of the universe in one dimension. These exercises enable us to compare the units of space and time from microscopic to macroscopic scales in Jainism with that described in the modern science.

Key Words: Space: Angula, Yojana; Time: Samaya, Muhurta

Scriptures Quoted: Anuyogadwara Sutra, Tiloyapannatti, Atharvaveda Jyotisa

1. Introduction

Philosophy of space and time is concerned with the issues surrounding the ontology, epistemology, and character of space and time. While such ideas have been central to philosophy from its inception, the philosophy of space and time was both an inspiration for and a central aspect of early analytic philosophy. The earliest recorded Western philosophy of time was expounded by the ancient Egyptian

thinker Ptahhotep (c. 2650-2600 BCE), who said, "Do not lessen the time of following desire, for the wasting of time is an abomination to the spirit." The Vedas, the earliest texts on Indian philosophy and Hindu philosophy, dating back to the late 2nd millennium BCE, describe ancient Hindu cosmology, in which the universe goes through repeated cycles of creation, destruction, and rebirth, with each cycle lasting 4,320,000 years (Thompson, 2007). Ancient Greek philosophers, including Parmenides and Heraclitus, wrote essays on the nature of time (Dagobert, 1942). On the contrary, Incas regarded space and time as a single concept, named pacha (Atuq, 1994; Stephen and Richard, 2003; Paul and Catherine, 2004). On the other hand, Plato, in the Timaeus, identified time with the period of motion of the heavenly bodies, and space as that in which things come to be. Aristotle, in Book IV of his Physics, defined time as the number of change with respect to before and after, and the place of an object as the innermost motionless boundary of that which surrounds it. But Augustine (1909) presented the first philosophical argument for the reality of Creation (against Aristotle) in the context of his discussion of time, saying that knowledge of time depends on the knowledge of the movement of things, and therefore time cannot exist or begin without creatures or motions (City of God Book XI ch.6).

In contrast to ancient Greek philosophers who believed that the universe had an infinite past with no beginning, medieval philosophers and theologians developed the concept of the universe having a finite past with a beginning. This view was inspired by the creation belief shared by the three non-Vedic religions also called as Abrahamic religions: Judaism, Christianity, and Islam. The Christian philosopher John Philoponus presented another early argument against the ancient Greek notion of an infinite past. His views were adopted by many, including, most notably, early Muslim philosopher Al-Kindi (Alkindus), Jewish philosopher Saadia Gaon (Saadia ben Joseph), and Muslim theologian Al-Ghazali (Algazel). They used his two logical arguments against an infinite past, the first being the "argument from the impossibility of the existence of an actual infinite", which states (Craig, 1979) that an actual infinite cannot exist. "An infinite temporal regress of events is an actual infinite; however, an infinite temporal regress of events cannot exist." The second argument, the "argument from the impossibility of completing an actual infinite by successive addition" (Craig, 1979), states that "The temporal series of past events has been completed by successive addition." But the temporal series of past events cannot be an actual infinite." Both arguments were adopted by later
Christian philosophers and theologians, and the second argument in particular became more famous after it was adopted by Immanuel Kant in his thesis of the first antinomy concerning time (Craig, 1979).

In 1788, Immanuel Kant published the Critique of Pure Reason, one of the most influential works in the history of the philosophy of space and time. He describes time as an *a priori* notion that, together with other *a priori* notions such as space, allows us to comprehend sense experience. Kant denies that either space or time are substance, entities in them, or learned by experience; he holds, rather, that both are elements of a systematic framework we use to structure our experience. Spatial measurements are used to quantify how far apart objects are, and temporal measurements are used to quantitatively compare the interval between (or duration of) events. Although space and time are held to be transcendentally ideal in this sense, they are also empirically real - that is, not mere illusions.

The great debate between defining notions of space and time as real objects themselves (absolute), or mere orderings upon actual objects (relational), began between physicists Isaac Newton (via his spokesman, Samuel Clarke) and Gottfried Leibniz in the papers of the Leibniz-Clarke correspondence. Arguing against the absolutist position, Leibniz offers a number of thought experiments with the purpose of showing that there is contradiction in assuming the existence of facts such as absolute location and velocity. These arguments trade heavily on two principles central to his philosophy: the principle of sufficient reason and the identity of indiscernible. The principle of sufficient reason holds that for every fact, there is a reason that is sufficient to explain what and why it is the way it is and not otherwise. The principle of "identity of indiscernible" states that if there is no way of telling two entities separate then they are one and the same thing, which, however, is not valid due to restrictions in observing limits (Jain, 2008, 2014).

However, in contrast to Immanuel Kant (1788 CE), Jainism considers space and time as important substances in addition to *Jiva* and *Pudgala* of the universe. Therefore Jainism considers defining these two aspects quantitatively though asymptotically and to first approximation employing various techniques (Jain, 2014). It should be noted, however, that ancient texts of Jainism known as Agamas are based on Mahavira's teachings that were compiled sometimes between 4th and 3rd centuries from the orally passed on from teachers to the disciples for several centuries. On the contrary, according to Digambar philosophy, the true Agamas and Acharyas currently do not exist, and everything is finished with the death of acharya Bhadrabahu Swami (433-357 BCE) and Sthulabhadra Swami in 3rd century BCE (Jain, 2015).

Therefore, texts related to Jainism incorporated in the current article should be considered based on the restricted knowledge after Pujya Bhadrabahu and Pujya Sthulabhadra, which was written and passed over by monks over one to next generation in last 2300 years (Jain, 2015). Thus significant scope exists for various corrections/modifications in the re-written manuscripts, understanding and interpretation of original oral texts, translation from one language to other language, and finally interpretation of fundamental concepts of Sutra in general and Units in particular that might have occurred in the last 2000 years after the invention of paper, perhaps first time in China.

In contrast to religions and particularly Jainism the Science is more recent but well developed and quantifies units more precisely. Currently we read, talk and write each quantity in units of science, which is rather better understandable. In this context, we compare units of space and time described in Jainism and other religious domains with currently known units in science.

2. Units of Time

2.1 Historical Perspectives

It is quite natural that ancient people might have felt need for measurement of equal intervals of time. The ancient Sumerians divided the day in three unequal watches down to medieval time (Sarton, 1927). The ancient Babylonians divided the day (day and night) into 12 hours of 30 gesh each, where gesh is equal to 4 min of current time. On the contrary, the Egyptians had divided the day and night into 12 hours each. Later in medieval time the day of 24 hours was adopted. However, in ancient India the day, period between sunrise and sunset, used to be divided into 2, 3, 4, 5 and 15 parts. We find reference in Atharvaveda Jyotisa (AJ) that day and night each was further split up into 15 equal parts known as *Muhurtas*. Such a 30-fold division of an *ahoratra* (day and night) must have impregnated the primordial concept of a standard *muhurta* (~48 min) which no longer denoted a different length of time on different days. Thus the need for corroborating the physical concept of standard *muhurta* as the unit of time might have necessitated the usage of devices like gnomon, water clocks etc. One such experiment has been described in AJ citing text of gnomonic (shadow lengths) devise to standardize the *muhurta* as 1/15 part of an Equinoctial day. The names given to these total 27 (day and night) *muhurtas* are as follows.

Raudra; Sveta; Mitra; Vayu; Suvita; Abhicandra; Mahendra; Balawana; Brahma; Bahusatya; Isana; Tvasta; Bhavitatma; Vaisramana; Varuna; Visvasena; Prajapatya; Upasama; Gandharva; Agnivesa; Satavrsabha; Atmava; Amama; Kranavama; Bhauma; Vrasabha; Raksasa.

There had been, however, much diversity of the relation between Muhurtas and other sub-multiple units of time. In this context Vedanga Jyotisa (VJ) quotes Sutra (verse) as follows.

"A 10.05 *Kalas* make one *Nadika*, two *Nadikas* make one *Muhurta*, and 30 *Muhurtas* or 603 *Kalas* make one complete day.

The above sutra is summarized in Table I presenting time units given in VJ.

Table 1. Conversion of Units of Time in Ved nga Jyotisa (VJ)

Subunits	Equals to
10.05 <i>kalas</i>	1 nadika
2 nadikas	1 muhurta
30 muhurtas	1 ahoratra (day and night)

Table 2. Conversion of Units of Time in Atharvaveda Jyotisa (AJ)

Subunits	Equals to
12 nimesas (blinking of eyes)	1 lava
30 lavas	1 kala
30 kalas	1 truti
30 trutis	1 muh rta
30 muh rtas	1 ahoratra (day and night)

According to Dr. L. Sibaiya (Sibaiya, 1973) one *nimesa* is equal to 27/125 seconds of modern science. On the other hand Table 2 enables us to estimate a different value of nimesa to second conversion as follows.

1 *muhurta* = 324,000 *nimesas* (Table 2) 1 *muhurta* = 48 minutes = 2880 seconds

Thus, 324000 *nimesas* = 2880 seconds

And hence, 1 *nimesa* = 2880/324000 seconds = 0.0088888889 seconds = 8.88 milliseconds

However, we find that there was a lot of discrepancy and diversity in sub units of time in general and in *nimesa*, trutis, lava etc. in particular during Vedic era. Though we do not consider detailed discussion on other forms of units of time but briefly we would like to present Vedic sub-multiple units of time particularly subunits of *nimesa* as shown in Table 3.

Table 3. Sub-units of Nimesa in Veda EraSub unitsEquals to2 parm ?us1 anu3 anu1 trasare?u3 trasare?us1 truti100 trutis1 vedha3 vedhas1 lava3 lavas1 nimesa

It may be noted from Table 3 that

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1 nimesa = 16200 parm nus
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This gives 1 *parmanu K la* (atomic time) = 0.008816200 seconds = 543 nano seconds.

2.2 Unit of Time: Jaina System

It is only Jainism which defines time in two separate entities viz. *Niscaya K la* and *Vyavah ra K la*. We briefly define these two times (*kalas*) and do not consider detail description in this article. The microscopic to macroscopic time scale in Jaina units are by and large *Vyavah ra K la*, which enables us to measure the modification, variation or change of a substance in a given period such as *samaya, avalika, ghadi* etc. (in Jaina) and seconds, minutes, days etc. (in modern science). On the contrary, the time representing absolute characteristic of a given substance is *Niscaya kala*. The *Niscaya Kala* is inhibiting property of the substance for which it remains in its original state (absolutely conserved energy state). The moment it begins to modify/

vary from the original/inhibit state the Vyvahara Kala begins.

Thus, if we represent absolute time (*Niscaya K la*) of a given substance as T_{0} then relative time (Vyvahara K la) for the same substance will be the time elapsing from T_o taken for the change/ modification or transform spatial/ structural form of the substance (energy transfer). For example, for any period/ time a given fundamental element remains in its original state without changing its physicalchemical properties is called as Niscaya K la. However, as soon as its properties start to vary through transmutation/ environment the Vyvahara K la begins. The other example on macroscopic scale we may consider for understanding is formation of the universe. The time for which the cosmic egg was in its energy conserved state it was absolute time but as soon as explosion/bang took place the Vyavhara K la began for the formation of the fundamental particles, celestial objects, solar system and evolution of the Sun, earth and planets etc., are relative to the Big Bang (absolute) time. Similarly, after the formation of the earth (absolute time for the earth), we consider its various motions to measure days, months etc. We also know that each event is associated with change in energy in space as a function of time, which is Vyvahara K la. Therefore the Vyavah ra K la is related to transfer of energy/ momentum in space and time, which, perhaps, was the origin of thought for General Theory of Relativity proposed by Einstein (1915). Thus the Vyavah ra K la (T_r) is a function of energy transfer in 3D relative to absolute state/ time of a matter (pudgala) and can be written by following function. This mathematical definition is given by us for the first time and thus discussions and criticisms are welcome.

 $T_r = f(E_{xvz}, T_o)$

where, Tr is *Vyavah ra K la*,

 $E_{\scriptscriptstyle xyz}$ is energy transfer in three dimensions, and

 T_o is Niscaya K la

We review the units described in Jainism for both *Vyavah ra k la* and *Niscaya k la* in contrast to other system of units. By definition *paramanu k la* is an atom of time (literally). According to Mimansakas, *paramanu k la* is defined as the time taken by an atom to cross a distance of its own size (diameter). The size of the atom, however, underwent change from time to time because atoms are different for different elements and therefore this concept was not acceptable by Jaina. According to Jaina concept, an electron, a fundamental particle of modern atom, is infinitely more gross (same for all elements) than a *paramanu* (Zaveri, 1975). Jaina

scriptures suggested that *paramanu k la*, in a broader sense, denoted the smallest interval, of time, represents different lengths of time at different times in accordance with atom's type and space.

In the above context, Jaina came out with different concept, and according to Jaina canonical texts the "*samaya*" (time literally) is the smallest indivisible part of time (Ram, 1931). "*Samaya*", a unit of time is related with other Jaina units of time as shown in Table 4.

Subunits	Equals to
The smallest part of time	1 samaya
Jaghanya-yukta asankhyat samayas	1 avalika
4446 ²⁴⁵⁸ avalikas	1 <i>prana</i> (breath)
7 pranas	1 stoka
7 stokas	1 lava
38.5 <i>lavas</i>	1 ghati
2 ghatis	1 muhurta
30 muh rtas	1 ahoratra (day and night)
30 ahoratras	1 masa (month)
12 masas	1 varsa (year)

Table 4: The Jaina Units of Time

Table 4 enables us to compute easily the *muhurta* in terms of *avalikas* but not in terms of *samayas* as follows.

1 *muh rta*=16777216 *avalikas*

This gives 1 second = 5825.422 avalikas

In order to estimate the *muhurta* in terms of *samayas*, Jaina canon (Sharma, 1972) classifies counting of numbers in following three categories.

First order number categories:

- 1. *Sankhy t* (measurable);
- 2. *Asankhy t* (non-measurable but not infinite);
- 3. *Ananta* (infinite)

Each of the above category has been further divided into three subcategories as follows.

Second order categories.

- 1. Parita
- 2. Yukta
- 3. Asankhy ta

The second order category has been furthermore split into three more subcategories as follows.

Third order categories:

- 1. Jaghanya (minimum, lowest)
- 2. Madhyama (middle, in-between)
- 3. *Utk?e??a* (maximum, highest)

As it may be noted that the above sub categories by and large are qualitatively based and not defined precisely quantitatively like others specified in Tables 4. However, according to Ram (1931) *Jaghanya-yukta-asankhy ta* (=J) *samayas* make one *valik*. Muni Mahendra Kumar II (Lishk, 1980) computed the least value of J approximately to be

$$(7.58 \cdot 10^{193})^{(5.58 \cdot 10^{193})}$$

Now we know from above that 1 *muhurta* = 16777216 *avalikas*, which enables us to estimate the *samaya* as follows.

$$1 \text{ samaya} = \frac{48 \cdot 60}{16777216 \cdot (7.58 \cdot 10^{193})^{(7.58 \cdot 10^{193})}} \text{sec onds}$$
$$= 1.764 \cdot 10^{-1.469 \cdot 10^{192}} \text{ sec onds}$$

However, we are not convinced of the calculation of J from qualitative statements and hence the final estimated value of *samaya* may not be correct. Authors do not recommend considering this *samaya's* value for any further estimation/ calculation. Nevertheless, the above relation shows that *samaya* is extremely smaller than *parama?u k la*. Thus, the *Niscaya k la*/ *Murta rupa* (energy conservation) for any matter may range between *samaya*/ *parama?u k la* to *asankhyat muhurtas*.

The other confusion in Jaina units is estimation of *avalikas* in a *muh rta*. However, the fact that $\frac{4446}{3773}$ avalikas make a *pr*?*a* (breath) suggests us to speculate that a *muh rta* might have been equal to 3773 *pr*?*as* (breaths) in a particular system and equal to 16777216 *valik s* in other system of time units. When these two systems were intermingled, 3773 *pranas* were equated with 16777216 *avalikas*. Otherwise the division of a *pr*?*a* (breath) into $\frac{4446}{3773}$ makes no sense, albeit being inadequate, for the choice of this number.

Thus, it appears that *Jaina* philosophy, after Mahavira and Bhadrabahu period, proposed new system of units which is, perhaps, better than previous units. However, the least minimum unit *Samaya* could not be proposed in precise quantitative form and that led the whole unit system in confusion. In this context we strongly feel that we must briefly include the time units described by Aryabhata (476 CE) in his *Aryabhatiyam* (Sharma, 1975), which are better comparable with present time units as may be noted from Table 5.

Table 5. Time Units in Aryabhatiyam

Subunits	Equals to
Time taken to Pronounce	
60 <i>Guru Aksaras</i> (letters)	= 1 <i>Vinadika</i> (24 seconds)
60 Vinadikas	= 1 Nadika (24 minutes)
60 Nadikas	= 1 Ahoratra (day and night)

The Aryabhatiyam Saidhantik system of 60-fold divisions of each unit was well established and employed more frequently. Further, it is close to current modern time units which also has 60-fold division system and thus better comparable with modern units. However, the least unit in Arybhatiyam is time taken to pronounce one guru aksara i. e. 24/60 = 0.4 second = 400 milliseconds.

Jaina system of time units could have been better but Jaina had conceived two Suns, each describing half the "diurnal circle" in an *ahoratra* (day and night) or thirty muh rtas, to describe the complete diurnal circle. Otherwise, therefore, the Sun would take 60 *muh rtas* to describe the complete diurnal cycle. However, in context to modern astronomy, now we know that it is only one Sun that describes the complete diurnal circle in 60 *muhurtas*. Nevertheless, the Sexagesimal system of 60-fold division of each unit of time was developed, which, however, is considered to be developed by Sumerians (original dwellers of Babylon) and their successors in Mesopotamia (Bernal, 1954).

So far we discussed units of time from microscopic scale (sub-second) to muh rta and ahoratra. However, Jaina also regarded *K la* (time) as ever turning wheel with neither beginning nor end, which enabled Jaina to define macroscopic time scales. The macroscopic time cycle (*Kalachakra*) has two sub-divisions of time viz. *Avasarpani K la* and *Utsarpani K la* corresponding to descending and ascending phase of time cycle respectively. Each *K la* elapses a total period of 4,62,000 years, which has been further split up into six sub-divisions known as Ara viz. *Susamasusam*; *Susam*; *Susama-dusam*; *Dusama-susam*; *Dusama-dusama*. The period of each sub-division is shown in Table 6, while the cyclic form of *avsarpani* (descending) *Kala* and *utsarpani* (ascending) *K la*, widely known as Jain Cosmic Cycle of Time (*K la Chakra*), has been presented and discussed in this monograph by other authors.

Table 6. Macroscopic time scales (K la Chakra) in Jaina cosmology

S. No	Phase (Ara)	Equals to Years
1.	Susama-susam	400 trillions garopamas (168000 years)
	[10 ¹⁰ Sagaropam	aas = 4.2 years (Jain, 2014)]
2.	Susam	300 trillion sagaropamas (126000 years)
3.	Susama-dusam	200 trillion sagaropamas (84000 years)
4.	Dusama-susam	100 trillion sagaropamas (42000 years)
5.	Dusama	50 trillion sagaropamas (21000 Years)
6.	Dusam -dusam	50 trillion sagaropamas (21000 Years)
		Total period: 462000 years

Thus complete Jain cosmic cycle (*kala chakra*) is of about 9,24,000 years. Jain (2014) showed that period (T) from *Dusam -dusam* (21000 years) to next *Ara* varies as multiple of n where n=1, 2, 4, 6, 8. For example, n=1 leads to estimated period of the next *Ara Dusam* T= 1x21000 = 21000 years, and n=2 leads period of next *Ara Dusam -susam* to be = 2x21000 = 42000 years. Similarly, n=8 leads period of first *Ara Susama-susam* to be T=8x21000 = 168000 years.

However, we wish to mention that the period 462000 years, period for *Avasarpani* and *Utsarpani*, is *vyavahara kala* and not absolute time (Jain, 2015), most

likely relative to temperature and atmospheric change on the Earth as described earlier by Jain (2012), and discussed below with reference to modern science. We do not discuss socio-culture during each *Ara* of *avsarpani* and *utsarpani Kala* rather we suggest the article "Fixing Milestones of Evolution" published in this monograph, and look at the Figure 4 and the related description.

Further, Jain (2012) estimated the cosmic time scale which is generally misinterpreted and described in Jain canonical texts. For example, period of Bhagawan Rishabh Dev is given in Jain texts as *koda-kodi*, interpreting crore multiplied with crore i .e., 10¹⁴ years. He explained that *koda* and *kodi* do not mean crore-rather they represent simply magnitude as follows.

Koda = 1000; *Kode* = 100; *Kodi* = 10

This suggests that the period of Bhagawan Rishabh Dev is not more than 10,000 units of time (years)¹.

It has to be noted that the relationship on time scale between Jaina and modern science is asymptotic and exact nature has to be understood in greater detail through fundamental research. On the other hand it also has to be understood and investigated whether Jaina Cosmic time scale is functioning over local regions or at global scale i. e. over the whole earth. There are views that Jaina *Kala Chakra* operates over *Adhai Dweep* only and not over each continent of the earth. Therefore above findings and asymptotic relationship between Jaina and modern science appears to be of concern but it becomes of great interest to probe it further.

1. Units of Space

3.1 Historical Perspectives

Man has always been fascinated by religion and the cosmic phenomena. It was customary among ancient Chinese that several astronomical changes were accorded with the advent of any new regime (Yabuuti, 1974). Apropos such traditions length-units had undergone a multitude of alterations at several places in ancient time and it took couple of centuries before they were finally fixed to understandable forms. For example, King Henry I of England had decided that the standard yard should be the length of his arm but in reign of Edward II, a new law

^{1.} However, this view of Rajmal Jain is primary and needs more investigation for validity because of several discrepancies in the units of time as described in this article. Jaina canonical literature does not support it. - Anupam Jain

said that one inch should be the length of three grains of barley, end to end (Lishk, 1980). In India, Hamanyun had ordered the length of a yard to be equal to sum of diameters of 42 Sikandari Coins or 42 finger-widths. Akbar settled his Ilahi Gaz (Divine yard) for 41 finger-widths which worked out to be 29.63 inches, but with the advent of British influence over India, the Ilahi Gaz was fixed at 33 inches (Verma, 1974). However, in 1878, after fixing length of a yard, it was further fixed that 1700 yards make a mile.

There was a great diversity in the measurements of length in different parts of ancient India. For example the large variations in the Indian *Kosa* must have puzzled the Chinese pilgrims and perhaps that is why FA-hian (399-413 CE) used Indian measure "*yojana*", whilst Hwen-thsang (629-645 CE) used his native measure "Li". In this context, we present in this article the mystery of the conspicuity of system of length-units propounded in Jaina canonical literature as well as complexity in the relation between *yojana* and British mile.

3.2 Units of Length in Jaina System

Angula (finger-width) was used fundamentally as a prominent unit of length in ancient India, multiple and sub-multiple units were derived from it. The primeval record of three different magnitudes of an *angula* (finger-width) is found in Jaina Anuyogadvara Sutra (ADS) of which ADS 149.12 sutra states: there are three kinds of an *angula* viz. *atamangula*; *utsedhangula* and *pramanagula*.

ADS sutra further states that a finger width of a person is called *Atamangula* because 12 finger-widths (*angula*) makes one's face length, and nine times the face-length equals the height of the person. The *utsedhangula* is half of the finger-width (*atmanagula*) of Bhagawan Mahavira. Further, one thousand times of *utsedhangula* is the length of one *pramanangula*. The various *angulas* are thus inter-related as follows.

1 utsedhangula = 1/2 atmanagula 1 pramanangula = 1000 utsedhangula = 500 atmanagula

The above three units of finger-width or system of units have end relationship with *yojana* as presented in Table 7.

Table 7. Jaina ADS units of Length

Sub-Units	Equals to
6 <i>angulas</i> (finger-width)	1 <i>pada</i> (length of human foot)
2 padas	1 <i>vitasti</i> (span)
2 vitastis	1 ratni
2 ratnis	1 kuksi
2 kuksis	1 dhanusa (bow)
2000 dhanusas	1 gavyuti
4 gavyutis	1 yojana

The Table 7 enables us to compute 1 *yojana* = 768000 *angulas*, which according to sub-divisions of *angula* mentioned above provides us to measure *yojana* also in three sub-divisions as follows.

1 atma yojana = 768000 atmangulas 1 utesedha yojana = 768000 utesedhangula 1 pramana yojana = 768000 pramananugulas Or else we may say that 1 pramana yojana = 500 atma yojana, = 1000 utsedha yojana

We also include the units of length described in Tiloyapannatti (TP) (Jain, 1958) and present in Table 8.

Table 8. Jaina TP units of Length

Sub-Units	Equals to
Infinitely many parama?us	1 avasannasanna skandha
8 avasannasanna skandha	1 sannasanna skandha
8 sannasanna	1 trutarenu
8 trutarenus	1 trasarenu
8 trasarenus	1 ratharenu
8 ratharenus	1 uttama bhogbhumi balagra

8 uttama bhogbhumi balagras	1 madhyama bhogbhumi balagra
8 madhya. bhog. balagras	1 jaghanya bhogbhumi balagra
8 jagh. bhog. balagras	1 karma bhumi balagra
8 karma bhumi balagras	1 liksa
8 liksas	1 yuka (louse)
8 yukas	1 yava (barley corn)
8 yavas	1 angula (finger width)
6 angulas	1 pada (length of human foot)
2 padas	1 vitasti (span)
2 vitastis	1 hasta (fore arm or cubit)
2 hastas	1 kisku
2 kiskus	1 danda or dhanusa
2000 dandas or dhanusas	1 kosa
4 kosas	1 yojana

We would like to mention that Buddhistic *yojana* is slightly smaller than Jaina *yojana*.

1 Buddhistic yojana = 384000 x 7 yavas 1 Jaina yojana = 768000 x 8 yavas Thus

1 Buddhistic *yojana* = 7/16 Jaina *yojana* (ADS units)

Further, considering above tables 7 and 8 it may further be easily computed that 1 *dhanusa* = 96 *angulas* and 1 *kosa* = 96000 *angulas*.

It has also been known that 1 *angula* (finger width) is equal to ~18.5 mm of modern science units, which reveals that 1 *dhanusa* = 96 *angulas* = 18.5x96 = 1776 mm = 1.776 meter = 72.49 inch = 6.040 feet.

More recently Pokharna (2013) described measurement of length found in the Jaina literature. According to him infinitely many *paramanus* form one *Avasannasannaskhandha*, and 8 *Avasannasanna* units = 1 *Sannasannaskandha*. However, the *paramanu* has been defined as the smallest particle of matter having no length, no breadth and no height. Pokharna (2013) mentions that *param u* is

defined as a particle which can be only thought of but is not practically perceivable, which has no significance in science because physical particle must have some dimension, may be of extremely small magnitude. Thus infinitely large number of *param us* makes one *Avasannasannaskhandha*, so we cannot conclude this as quantitative definition at lower end. But Pokharna (2013) attempted to estimate the size of *Avasannasannaskhandha* considering the breadth of finger as 2 cm. According to him one *angula* (finger breadth) is equal to 8¹² size of *avsannasannaskandha*, which gives one *avsannasannaskandha* = $2x8^{-12}$ cm. However, it may be noted that average finger breadth (width) of modern man is about 1 cm (10 mm) and not 2 cm.

3.3 Relationship between Yojana and British Miles

In context of foregoing tables and discussions it is very difficult to derive precise relationship between yojana and British miles because it will depend upon selection of units. According to Dwivedi (1959) *yojana* is considered as half-yojana (2 kosa) and thus equal to 5 miles. On the contrary, according to Jain (2014) 1 *yojan* = 10 miles based on the estimation of diameter of the Earth by Barhmagupta (628 CE) and Bhaskaracharya (1114-1185 CE), which turns out to be 7905 miles, very close to that estimated by modern scientists of the order of 7917 miles (12742 km). They considered *yojana* to be equal to 10 miles based on 1 *yojana* = 4 *kosas*. The controversy is due to considering different value of *kosa* in different parts of India. For example, Punjabi *yojana* = 5 miles; Gangetic province *yojana* = 9 miles; Bundelkhand *yojana* = 16 miles. However, according to Kaye (1923), Sir Fleet (1907) and according to Sharma (1952) Sir John Bellentine estimated *yojana* = 4545.45 miles. Thus Rajmal Jain (2014) reviewed the controversy in context to Jaina canonical units of length and accordingly he interprets:

1 atma yojana
$$9\frac{1}{11}$$
 = miles = 14.55 km
1 utsedha yojana $4\frac{6}{11}$ = miles = 7.27 km
1 pramana yojana = 4545.45 miles
= 7315.1927 km

Thus according to Jain (2014) earlier derivation of *yojana* is to be referred to *atma yojana* (fundamental *yojana*), and that by Prof. L. C. Jain is to be referred to *pramana yojana* (*Mahayojana*). Perhaps on geological scale *atma yojana* is good

enough while for celestial/cosmic scale *pramana yojana* may be necessary. Earlier, Jain (2001) proposed *yojana* = 6000 km employing citation from Trilokasara, somewhat close to *pramana yojana*.

We would like to briefly discuss the spatial unit *yojana* in context to celestial mechanics as shown in Figure 1 and described as follows considering Mt. Meru as centroid of the Earth.

The Sun, while occupying the innermost *mandala* (Sun's diurnal path on Summer solstice day) is 800 Y (*yojana*) distant from *samtala bhumi* ("Earth having a plane surface", denoting circular area with center at the projection of pole of ecliptic (Lishk and Sharma, 1975). Position of the Sun while describing innermost *mandala* also lies on the periphery of Jambudwipa (Lishk and Sharma, 1978) (isle of Jambu tree) of radius equal to 50000 y. Thus on the summer solstice day, the distance D of the Sun from the axis of Meru supposed to have been placed at the center of Jambudwipa is given as follows:

D = 50000 y (atma yojana; ADS units)

= 100 y (pramana yojana; ADS units)

= 800 Y (*yojana*; TP units)

This gives relationship between two systems of units as

50000 y = 800 Y

However, it should be borne in mind that the tentative z-axis of Meru always remains at a distance equal to the radius of Meru on the flat Earth (cf. Figure 1), apart from true axis of the earth. Radius of the Meru on the flat Earth is given to be 5000 y or 80 Y. Thus the distance between true axis of the earth and the Sun describing the innermost *mandala* is given as:

= Radius of Jambudwipa - radius of Meru on flat earth

800 Y - 80 Y = 720 Y

On the other hand, we know that celestial distances are measured in terms of corresponding distances projected over the surface of the Earth (solid angle). Let us consider s_{max} be the maximum declination of the Sun. Thus on the summer solstice day, north polar distance of the Sun equals the distance of the Sun from true axis of the earth.

$$90^{\circ} - d_{max} = 720 \,\mathrm{Y}$$
 (5)

Thus

(627)

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Figure 1. The approximate form of the Mount Meru.

1 y (atma yojana ADS) =
$$\frac{8}{500}$$
Y (Yojana TP)

Further, we also know that the Sun traverses a distance of 510 Y from the innermost *mandala* to outermost *mandala* (Sun's diurnal orbit on winter solstice day) and vice versa (Lishk and Sharma, 1978, 1974).

Hence $2 q_{max} = 510 Y$ (6)

Comparing and solving eq^{n} (5) and (6), we get

 $d_{max} = 23.541^{\circ}$, a true value within the error limits (due to approximation), however corresponds well with modern declination values.

Now realizing that 1 (arc-minute) = 6080 feet, thus $1^{\circ} = 364800$ feet

We also know that 10000 feet = 1.89 miles, so 1° = 69.09 miles

(628)

510 Y = 2
$$_{max}$$
 = 47 x 69.09 miles

which results in 1Y = 6.37 miles (actual British road distance)

We would like to mention that above results are derived employing a notion of measuring celestial distances projected along the circumference of the earth, whereas Jainas were not aware of rotation and revolution of the earth.

In conclusion, according to Jaina, there exist three different systems of measurement of length viz. atma system, utsedha system and pramana system. Correspondingly any unit of length will have three different magnitudes (ADS units) related to each other is as follows.

1 pramana unit = 500 atma unit = 1000 utsedha unit,

and relation among system of units is as follows.

1 ADS unit = T. P. unit = $\frac{16}{7}$ Buddhistic unit. (7)

3.4 Celestial measurements as described in Jaina Cosmology

In contemporary astronomy in general and Vedic astronomy in particular calculations to estimate the relationship between geocentric and heliocentric latitudes were based on celestial mathematics as demonstrated in Figure 2 where calculation for a planet is presented.

Lunar Zodiac of the Rig-Vedic Hindu system consists of 27 nakshatras (asterisms). On the contrary, Jainas first measured zodiacal stretches of nakshatras in time degree (space-time) and included Abhijit (Lyrae) nakshatra to account for the discrepancy in lunar motion. We present a simple probe into the series of development of graduating zodiacal circumferences into 27 (21/67) days of nakshatra's month (lunar sidereal revolution period). This subsequently graduates into 819 (21/67) muh rtas of a nakshtra month, 54900 muh rtas of a 5 year cycle and 360 saura days (period taken by the Sun to move on 1/360 part of the zodiacal circle) finally leading to the development of equal amplitude system of nakshatras. This led to drop again Abhijit nakshatra with the advent of Saidhantik Astronomy. Here it is essential to introduce that the Jaina Astronomy has a peculiar theory of two Suns, two moons and two sets of nakshatras (Bose et al., 1971), which states:"In Jamboodvipa two moons illuminated, are illuminating and will be illuminating; two Sun shone, are shining and will be shining; and 56 nakshatras viz. 2 Abhijit (Lyrae); 2 Sravanas (Aquilae); 2 Uttrardhas (Saggittarii), occulted, are occulting and will be occulting...two moons".



Figure 2: Technique to estimate the relation between geocentric and heliocentric latitudes of a planet. SP= a_s = Radius vector of the planet with respect to the Sun. EP= a_e = Radius vector of the planet with respect to the Earth. Where, S= Sun, E= Earth and P = Planet

 $-PSQ = L_s$ =Heliocentric latitude of P. $-PEQ = L_e$ = Geocentric latitude of P.

Here we do not wish to enter into the debate of the mystery of real versus counter bodies of texts existed in the Jaina Prakrit texts, Chinese, Greece and ancient Babylon but one will find actually a single set of *nakshatras* constituted the lunar zodiac of Jain. (Jain, 1975).

Thereby we may estimate that: zodiacal stretch (ZS) of every *nakshatra* which may be expressed in time units of *muh rtas* (1 *muh rta* = 48 minutes). In this context, Jaina Prakrit states that "Abhijit combines with moon for 9 (27/67) *muh rtas*. In Figure 3 we present a simple geometrical sketch to demonstrate the celestial latitude of Moon implied in the concept of 'height' above *Samatala*.



Figure 3: Notion of celestial latitude of Moon implied in the concept of 'height' above *Samatala*.

The estimates of zodiacal stretch of each *nakshatras* are presented in Table 9.

Table 9

Table of *Nakshatras* and their zodiacal stretches in *Muh rtas*

S.No.	Nakshatra	Astronomical Name	S (Muh rtas)
1.	Abhijit	(Lyrae)	9 (27/67)
2.	Sravana	(Aquilae)	30
3.	Dhanisiha	(Delphini)	30
4.	Satabhisa	(Aquarii)	15
5.	Purvabhadrapada	(Pagasi)	30
6.	Uttarabhadra	(Pagasi)	45
7.	Revati	(Piscium)	30
8.	Asvini	(Arietis)	30
9.	Bharani	(41 Arietis)	15
10.	Krutika	(n Tauri)	30
11.	Rohini	(Tauri)	45
12.	Mrigsirsha	(Orionis)	30
13.	Ardra	(Orionis)	15
14.	Punarvasu	(Geminorium)	45
15.	Pusya	(Cancri)	30
16.	Aslesa	(Hydrae)	15
17.	Megha	(Leonis)	30
18.	Purvaphalguni	(Leonis)	30
19.	Uttaraphalguni	(Leonis)	45
20.	Hasta	(Corvi)	30
21.	Chitra	(Virginis)	30
22.	Swati	(Bootis)	15
23.	Visakha	(Libra)	45
24.	Anuradha	(Scorpii)	30
25.	Jyeshtha	(Scorpii)	15
26.	Mula	(Scorpii)	30
27.	Purvasadha	(Sagittarii)	30
28.	Uttarasadha	(Sagittarii)	45
		(632)	

We can easily compute from the Table 9 that

$$\overset{n=28}{a}(ZS)n = 819 (27/67)$$

Muh rtas = length of a *nakshatra* month (sidereal revolution of the moon)

Where n is the serial number of *nakshatras*, starting from Abhijit as 1.

Further, 67 nakshatra months corresponds to 1 Yuga (5 year cycle)

= 1830 days, and each day of 30 muh rtas (24 hours)

This suggests that lunar zodiacal circumference has been graduated in

819 $\frac{27}{67}$ muh rtas of a nakshatra month. This view is further strengthened by the fact that the zodiacal positions of the moon and sun are also defined in terms of balance of muhurtas of nakshatras occupied by them respectively.

Thus, $L_s \sim L_{m=\frac{1}{2}x} 819 \frac{27}{67}$ muh rtas = 409 $\frac{47}{67}$ muh rtas

Finally, we present the heights of other celestial objects, as described in Tiloy Pannati (T.P.), in Table 10 (Jain, 1958).

Celestial Object	Height in Yojans	Modern U	Modern Units	
	(Y)	(AU)	km	
Stars (Milky-way)	790	$1.7 \mathrm{x10}^{9}$	2.55×10^{17}	
Sun	800	1.0	15000000	
Moon	880	0.00257	384400	
Nakshatras (Orion sta	ars) 884	$8.85 \text{x} 10^7$	1.32×10^{16}	
Mercury	888	0.61	91691000	
Venus	891	0.28	41400000	
Jupiter	894	4.2	628730000	
Mars	897	0.52	78340000	
Saturn	900	8.52	1275000000	

Table 10. Height of Celestial Objects in Yojans

We know that on the full moon day (*Purnima*), $L_s \sim L_m =$ half the zodiacal circumference, where L_s and L_m are the longitudes of the Sun and Moon on the full-moon day respectively.

It may be noted from Table 10 that distances of stars, Sun, and other planets vary between 700 and 900 yojans only according to Tiloy Pannati which is in contrast to measurements made by modern science, also mentioned in this table. This suggests major controversy/ anomaly between Jaina canonical literature and modern science.

4. Units of Distances Measured in Modern Astronomy

Dealing with the numbers involved with the distances to the stars or even with those found in the solar system can be hard going. Astronomers make their lives easier by using a number of rulers (units of distance) for the distances and although they have some strange names they can be very useful for comparing the distances to stars, other galaxies and even the planets in our solar system.

AU (Astronomical Units)

The average distance between the Earth and the Sun is called one Astronomical Unit (AU). AU is the most commonly used for the distances of objects within our solar system. Pluto, previously known as the last planet in the solar system is found at an average distance of 39.47 au from the Sun. Sedna the new body nearly as large as a planet found beyond Pluto is at ~ 76AU when near the Sun and then goes to 880AU from the Sun in its giant elliptical orbit.

Light Years

One of the most common rulers is the light year. The light year is the distance that light travel in one year (365 1/4 days). It is most commonly used for the distances to stars and other galaxies.

The nearest star is 4.2 light years away from our sun. We are 8.3 light minutes away from the Sun, the distance to the outer most planet Pluto is about 13 light hours.

Some other interesting distances in light years are given in Table 11:

Parsec (pc)

Astronomers started measuring distances from the amount that a star moves as the Earth goes from one side of the Sun to the other. Try moving your head and you will see that the position of everything around you changes. One parsec is derived from the smallest angle measurement of 1/3,600th of a degree or an arc second that is the angle that a star at this distance would appear to move in 6 months

Object	Distance in light years
Nearest Star (Proxima Centuri)	4.2
Sirius the dog star (the brightest star in the sky)	8.6
centre of the galaxy	approximately 30 000
Andromeda (one of our nearest neighbouring galaxies)	approximately 2 million
The stars of Orion (Betelgeuse and Rigel)	1400 light years

Table 11. Distances of Celestial objects in Light Years

as the Earth journeys around the Sun. A parsec is 3.2616 light years or 30,857,000,000,000 km. Two parsecs is 6.5532 light years or twice the distance, it is not a measure of change in angles of the stars. Due to the massive distance in the universe astronomers often use multiples of parsec Commonly found units are kiloparsec (kpc), a 1000 parsecs or a megaparsec (Mpc) 1,000,000 parsecs. Below Table 12 is a conversion table for some useful astronomical distance units.

Table 12. Conversion Table of astronomical units

	kilometres (km)	Astronomical units (AU)	Light Years (l.y.)	Parsec (pc)
kilometres (km)	1	149.6 million	9,460,000,000,000	30,857,000,000,000
Astronomical units (AU)	0.0000000067	1	63,240	206,263
Light Years (l.y.)	0.0000000000011	0.000016	1	3.2616
Parsec (pc)	0.0000000000033	0.0000048	0.3066	1

5. Universe in Jaina and Modern Cosmological Models

Lastly, in brief we wish to compare cosmological models and units of extension of the universe. In Jaina astronomical system the universe is represented as shown in Figure 4, which has three sections on the vertical dimension referred as:

Devloka; Madhyaloka and *Adholoka. Devloka* refers to place of demi-gods and heavenly beings, *Madhya loka* refers to the place for humans and animals and *Adho loka (Naraka)* the place for hellish beings. The vertical dimension (height) of the whole universe is proposed as 14 Raju, while the breadth/ width and depth at various locations has been described in great details in some of the articles published in this monograph. It is interesting to note that Jainism believes that the whole universe is finite on spatial scale and is full of life on various physical scales.



Fig. 4. Schematic cartoon representing three sections of the vertical Jaina cosmological model.

On the contrary the modern science believes that the universe does not have finite/ fixed dimension, rather it is expanding. However, a first order approximation of the observable universe consists of the galaxies and other matter that can, in principle, be observed from Earth at the present time because light and other signals from these objects has had time to reach the Earth since the beginning of the cosmological expansion. Assuming the universe is isotropic, the distance to the edge of the observable universe is roughly the same in every direction. That is, the observable universe is a spherical volume (a ball) centered on the observer (Figure 5). Every location in the Universe has its own observable universe, which may or may not overlap with the one centered on Earth.



Figure 5: Visualization of the whole observable universe. The scale is such that the fine grains represent collections of large numbers of superclusters. The Virgo Supercluster - home of Milky Way - is marked at the center, but is too small to be seen.

The best estimate of the age of the universe in most recent time as of 2013 is 13.798 ± 0.037 billion years but due to the expansion of space humans are observing objects that were originally much closer but are now considerably farther away (as defined in terms of cosmological proper distance, which is asymptotically equal to the distance at the present time) than a static 13.8 billion light-years distance. It is estimated that the diameter of the observable universe is about 28 billion parsecs (93 billion light-years), putting the edge of the observable universe at about 46–47 billion light-years away.

In this monograph, a few articles including by Rajmal Jain, Narendra Bhandari and Jeoraj Jain comment significantly in detail about comparisons

between Jaina cosmological and modern universe models. Thus we do not consider further discussions on this topic as objective of the current article is restricted to descriptions of units of space and time. Therefore we plan to estimate the unit Raju at present in modern unit of kilometers.

Bars and Terning (2010) estimated that the diameter of the observable universe is about 28 gigaparsecs (93 billion light-years i. e 8.8×10²⁶ metres). The comoving distance from Earth to the edge of the observable universe is about 14 gigaparsecs (46 billion light years or 4.3×10^{26} meters) in any direction. The observable universe is thus a sphere with a diameter of about 93 GLY or 8.8×10²⁶ m (Jain, 2015). Assuming that space is roughly flat, this size corresponds to a commoving volume of about 4.1×10⁵ GLY³ or 3.5×10⁸⁰ m³. Jainism proposes a volume of about 343 cubic Rajus of the canonical Jain universe. Comparison of volumes of both systems enables us to estimate the Jain unit Raju to be about 1.0067×10^{23} kilometers or ~1.5 GLY. However, the figures quoted above are distances at present time in cosmological time and not distances at the time the light was emitted. For example, the cosmic microwave background radiation that we see right now was emitted at the time of photon decoupling, estimated to have occurred about 380000 years after the Big Bang, which occurred around 13.8 billion years ago. This radiation was emitted by matter that has, in the intervening time, mostly condensed into galaxies, and those galaxies are now calculated to be about 46 billion light-years from us.

6. Relationship between Time and Space Units in Jainism and Modern Science

Currently modern science propounds that mathematically, and in accordance with Relativity, space and time are in some sense interchangeable. But, physicists do not know whether they form co-equal parts or co-spatial-temporal of a larger 'thing' called space-time. However, on the other hand, we know that it is only within space-time that the most complete understanding of the motion and properties of natural objects and phenomena can be rigorously understood. Space and time are to space-time what arms and legs are to humans. In some sense they are interchangeable, but you cannot understand 10,000 years of human history without including both arms and legs as part of the basic human structure. Jain (2015) proposes that space and time when embedded in gravity may be considered as one phenomenon.

Earlier Einstein (1915) stated two postulates:

- 1. The speed of light (about 300,000,000 meters per second) is the same for all observers, whether or not they are moving.
- 2. Anyone moving at a constant speed should observe the same physical laws.

Putting these two ideas together, Einstein realized that space and time are relative - an object in motion actually experiences time at a slower rate than one at rest. Although this may seem absurd to us, we travel incredibly slow when compared to the speed of light, so we do not notice the hands on our watches ticking slower when we are running or traveling on an airplane. Scientists have actually proved this phenomenon by sending atomic clocks up with high-speed rocket ships. They returned to Earth slightly behind the clocks on the ground. Thus space of 3-dimensions and time as fourth dimension are to be coupled to understand the traveling phenomena and is called as space-time continuum.

Muni Mahendra Kumar (2010) has given an excellent description of relationship between time and space units as demonstrated in Jainism in his book on "Enigma of the Universe". According to him Digambara tradition presents two equations (in Tiloyapannatti) which indicate relations between time-units and space-units. In these equations, \log_2 is used.

In the first equation, the relationship between *suci angula* (a linear space-unit) and *addha palyopama* (a unit of time) is described as follows: *s c angula* is equal to *addh palyopama* raised to the power logarithm to the base 2 *addh palyopama*.

$$s\overline{u}c$$
 $a\dot{n}gula = (addh\overline{a}palya)^{\operatorname{og}_2 addh\overline{a}palya}$

Though the units of these two quantities have not been presented but we are aware that the *suci angula* is *prade a* and *addh palyopama* is *samaya* because both of them are the units of measurement of space and time respectively. In this way, if *suc angula* be x *prade a* and *addh palya* be 'p' *samaya*, then

$$x = p^{(\log_2 p)}$$

The second equation relates *jaga reni* (the cosmic row of space units which measures seven *Rajus*) and *addh palya. Jaga reni* is equal to *ghanangula* (a three dimensional space-unit) raised to the power logarithm to the base two of innumerableth fraction of addh palya.

$$Jagaśren \overline{\imath} = (ghan \overline{a} \dot{n} gula)^{\left(\frac{\log_2 addh \overline{a} palya}{innumerable}\right)}$$

Here, ghanangula means cube of $s \ c$ angula, i.e., cube of the number of prade as of $s \ c$ angula.

If Jaga ren = 'j' prade a

and innumerable = a, then

$$j = \left(x^3\right)^{\frac{2\log_2 p}{\underline{c}} \overset{\circ}{a} \frac{1}{\underline{c}}}$$

Joining both the equations, we get:

$$j = p^{\left(\frac{(\log_2 p)(3\log_2 p)}{a}\right)}$$

Or

$$j = p^{\left\{\frac{3(\log_2 p)^2}{a}\right\}}$$

Thus according to Jaina system of units too, the space and time are correlated, however, exact nature of correlation in context of modern units is to be understood. This is an important topic for future investigation. Such investigation should include on one side the space and time embedded in gravity and on the other side both times (*Nischayakala* and *Vyavharakala*) described in Jainism.

7. Conclusions

In this article we discuss the space and Time, which are most debatable issues in religion, philosophy and science. We attempted to derive the units of time and space from historic and ancient systems viz. early civilian era to Atharvaveda Jyotisa (AJ) and to Jaina cosmology, and compare within different system of units and current modern system of units. The units of space and time in domain of religion and science reveal several paradoxes. In order to improve our understanding of the space and time models proposed by different religions and science we propose future investigations related to this subject.

The future investigation also needs to be focused on a number of basic issues,

including whether or not space and time exist independently, particularly in context to Jainism which refers to *Nischaya kala* and *Vyavhara Kala*, while, the modern science considers only one time.

In this article therefore, we rather describe the concepts of time, length and graduation of zodiacal circumferences. We also describe planets and other celestial bodies in the solar system as discussed in Jainism and compare with our current knowledge in the modern astronomy.

We described time units starting from Sumerians to Babylonians era. Smallest unit of time in Babylonian era was *gesh*. On the contrary, in Atharvaveda Jyotisha (AJ) day and night were split up into 30 *muhurtas* implying that one *muhurta* is equal to 48 minutes of modern time. The *muhurta* is still a popular unit of time for everyday life, celebrations and cultural activities. However, the smallest unit of time was proposed as *nimesa*, which was further made equivalent to 16200 *parmanukala*. We compared the AJ system with Jaina system of units. However, in this article we gave, for the first time, brief but more scientific definitions of *Nischayakala* and *Vyavharakala*, basic foundations of time in Jaina system. We also described smallest of unit of time in Jaina context i.e *Samaya* and the larger units viz. *muhurtas* etc. We also presented Aryabhata system of units of time in this article.

With regard to units of space we started describing Length units from Atharvaveda Jyotisa (AJ) to Jaina astronomy. In this article a significant description of length units, and comparison among several systems of units as well as with current modern system of units has been presented. For example, the man started to measure the length in a variety of ways since he appreciated the nature but could not arrive to meaningful unit until 1878 AD when 1700 yards were fixed as one mile. On the contrary, Jaina canonical literature Anuyogadwara Sutra (ADS) describes measurement of length through unit known as *Angula* (finger width), which was further presented in three magnitudes. We described in greater detail the measurement of space units, their magnitudes, gradations starting from micro (*angula*) to macro scale (*yojana*). We also compared the units of length in ADS with that described in Tiloypannati (TP), and discussed the discrepancies between two units system.

In context to macro units, we also considered description and derivation of units of celestial objects for better understanding of the cosmological distances in the universe. We first described in great detail the concepts of diurnal and declination circles in Jainism. We give examples of distances estimated for the Earth

from the Sun and the Moon. Estimation of zodiacal extension of planets and *nakshatras* has been presented. It has been noted that Jaina astronomy could not correctly arrive on real distances of planets, Sun and Moon from the Earth, which, in contrast to modern science estimation, is a paradox/anomaly, a subject of future investigation. We also considered the estimation of the extension of the Jaina universe (14 *Raju*) in modern units and found 1 *Raju* is equal to ~1 x 10^{23} kilometers or 1.5 Giga Light Years (GLY). These exercises enabled us to compare the units of space and time from microscopic to macroscopic scales in Jainism with that described in the modern science.

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AUTHORS



Anupam Jain,

M.Phil, Ph.D. (Meerat Univ.) Professor of Mathematics, Govt. College, Sanver Madhya Pradesh. Formerly, Professor & Head, Department of Mathematics, Govt. Holkar Science College, Indore. Author: 15 Books,130 Research Papers; 125 General articles; Expertise: History of Mathematics, Jain Mathematics;. Editor, Arhat Vacana. Indian Research Communication; Director, Ganini Jnanamati Shodhapiths, Executive Ditector & Hon. Secretary-Kundkund Jnanapith, Founder President, Research Promoting and Communication Society (Indore), General Secretary-Tirthankar Rishabha Dev Jain Vidwat Mahasangh (Hastinapur). Federation of Jain Research Organizations and libraries (Jamshedpur).

Awards: Shastri Parishad Journalism Award , Jnanamati Award, Tirhankar Rishabh Dev Award, Ahinsa International Journalism Award, Vishva Maitri Seva Samman, Vagishvari Award, Jain Agam Manishi Award, Acharya yogindra Sagar Memorial Award.

E-mail:anupamjain3@rediffmail.com



Aragam R. Prasanna

Ph.D. (Applied Mathematics), Formerly Senior Professor and Dean, Physical Research Laboratory, Ahmedabad. Visiting Scientist at the International Centre for Theoretical Phsyics, Trieste, Italy. Awarded Alexander von Humboldt Fellowship to work at Universty of Bonn, Germany. President of Indian Association of General Relativity. Member International General Relativity and Gravitation Association; Fellow Gujarat Science Academy. Author: over 95 papers and book: From Space and Time to Spacetime. E-mail: aragam@gmail.com



Ashok Kumar Jain

M.Sc., Ph.D (Botany), FBS, FLS, FES, LL.B. Hon. Director, Institute of Ethnobiology & Professor of Botany at Jiwaji University, Gwalior. Fellow of Linnean Society of London, Indian Botanical Society, Society of Ethnobota nists, Society of Bionaturalists, Indian Aerobiological Society and others. Authored/ edited five books and 95 research papers. Recipient of V Puri Medal by Indian Botanical Society and J W Harshberger Medal by Society of Ethnobotanists. Dr. Jain is working on various scientific aspects of Jainism, specially related to microorganisms.

Email: asokjain2003@yahoo.co.in



Bachh Raj Dugar

Professor in the Department of Non-violence and Peace. He was Director, Research in Jain Vishva Bharati University, Ladnun, Rajasthan. Currently he is Vice Chancellor of that Institute.

He has more than 30 years of experience in teaching at the postgraduate level, guided 25 Ph. D. scholars and has made seminal contribution in various national and international seminars and conferences. He has more than 70 research papers and more than 15 books to his credit in the field of Non-violence, Culture of Peace, Conflict Resolution, Training in Non-violence, Philosophy and Human rights.

He has successfully completed many research projects on Value Education, Training in Nonviolence and Domestic Violence. He has been a member of Board of Studies in various universities, Member of Academic Council, and Board of Management. Email: dugarbr@gmail.com



Christopher Key Chapple

Doshi Professor of Indic and Comparative Theology, Department of Theological Studies, Director of Master of Arts in Yoga Studies, Loyola Marymount University, Los Angeles, CA, USA Email:cchapple@lmu.edu



Gyan Chand Jain

B.V.Sc., A.H., M.V.Sc., Ph.D. (Physiology), Fellow ISSAR, and ARS. Veterinary Surgeon, Director, Indian Institute of Veterinary and Animal Science, Jaipur. expertise: endocrinology, embryo transfer and In-vitro fertilization. over 275 papers, six books. Recepient of Bharat Jyoti Award. E-mail: drgcjain08@gmail.com



Jai Prakash Narayan Mishra

M. Sc, Ph. D., D.N.Sc, Dip. Yoga, Registrar, JVBU, Professor and Head Deptt. of Science of Living, Preksha Meditation and Yoga. JVBI, Ladnun. Presently Professor and Dean, School of Life Sciences, Central University of Gujarat, Gandhi Nagar E-mail: jpnmishra@gmail.com



Jeoraj Jain

Ph.D. Engineering (Dr.-Ing.) from Germany. Worked with Tata Motors and as Technical and Investment Consultant. Recipient of National Award in Fabrication Technology. He has several Technical papers to his credit. Research on structure and quality of water. Authored several books. Proposed a theory of life without DNA and RNA and a theory on the mechanism of characterization of water.

E-mail: dr.jeorajjain.38@gmail.com



Jinendra Kumar Surana

M.Sc (Geology) University of Rajasthan. Formerly Superintending Hydrogeologist, Government of Rajasthan; State Engineer, Govt. of Algeria, Algiers Member, Science Study Centre, Udaipur, Scholar of Jain philosophy. E-mail:jinendra.surana@gmail.com



Laxmi Chand Jain

Ph.D. (Physics), Professor of Physics, Govt. Engineering college, Jabalpur, (M. P); Editor: Purusharth Deshana by Aacharya Vishuddha Sagar ji; Jain Yoga Darpana by Pt. B. L. Jain, and Tarun Shankhnada. Author: Amrit Bindu and Akshara Amrit, several papers on Jainism in various Jain magazines.





Narayan Lal Kachhara

B.E., M.E. (Mech.), Ph.D. (University of Salford, U.K.). Teaching Assignments: Universities in India and abroad; Director, Kamala Nehru Institute of Technology, Sultanpur; Principal, Motilal Nehru Regional Engineering College, Allahabad.

Interests: Religious and social causes. Scientific spiritualism, scientific nature of Jain philosophy; Author: Several books including Scientific Exploration of Jain Doctrines. Awards: Jain Agama Manishi Award, M.G. Saraogi Foundation, Kolkata, Invited speaker, Parliament of World's Religions, Melbourne Currently Professor Emeritus, Dpt. of Jainology and Comparative Religion and Philosophy, and Advisor to BMIRC, JVBI, Ladnun.

E-mail nlkachhara@yahoo.com.


Narendra Bhandari

Ph. D., Physics. Research in Planetary and Space Sciences, Tata Institute of Fundamental Research, Mumbai, University of California, San Diego, and Physical Research Laboratory, Ahmedabad. Studied Moon samples brought by Apollo and Luna missions of NASA and USSR. Made pioneering contributions to India's first Mission to Moon, Chandrayaan-1, Member, Moon Mission Task Force, Science Advisory Board of ISRO and Mars Orbiter Mission .Eelected President, International Lunar Exploration Working Group (2005-2007). Awarded Outstanding Achievements Award of ISRO, Vikram Sarabhai award in Planetary and Space Sciences, National Mineral Award of Government of India and Special Certificate of NASA. Authored several books: Planetary Science; Jainism: Over 250 Research papers. E-mail: nnbhandari@yahoo.com



Paras Mal Agrawal

Research Professional and visiting Professor in Oklahoma State University, Stillwater,USA. Published four books and 70 research papers in the area of Physics. A renowned Jain scholar, published more than 100 articles, ten book-chapters, and two books in area of Jainology. Honored by the Gyan Sagar Foundation with the prestigious 'Jain Laureate' award.

E-mail:parasagrawal@hotmail.com



Pratap Sanchetee

MBBS, MD, DM (Neurology). Served Armed Forces Medical College. Academic interests: Geriatrics, public health and research on meditation. Executive editor, Medical Journal Armed Forces India, Editor, Journal of Indian Academy of Geriatrics. Professor, Jodhpur School of Public Health (JSPH). Visiting Professor and chair experimental Reseacle at BMIRC, Jain Vishav Bharti Institute Ladnun. Sanchetee Hospital, 429, Pal Link Road, Jodhpur-342008, E-mail: pratap.sanchetee@gmail.com



Raghavan Rangarajan

Ph.D. (Physics), Theoretical Physics Division, Physical Research Laboratory, Ahmedabad. Studied at Princeton University and the University of California at Santa Barbara; Post-Doctoral fellow at the Houston Advanced Research Centre. Areas of research: cosmology and particle physics, specifically Inflation, Dark Matter, the Matter-Antimatter Asymmetry of the Universe and the Cosmic Microwave Background. Other interests: Science education; College students interaction, specifically Advanced B.Sc. (Physics) Programme in Ahmedabad ; Editor of Physics Education, Journal of the Indian Association of Physics Teachers. E-mail : raghvan@prl.res.in



Rajmal Jain

M.Sc. PhD (Physics), FGSA, Outstanding Professor and Dean, Kadi Sarva Vishva Vidyalaya, Gandhinagar. Expert in solar astronomy. Professor, Udaipur Solar Observatory and Physical Research Laboratory, Ahmedabad. Carried out satellite borne observations of Solar X rays aboard Indian space Mission SOXS. Jain scholar of eminence and social service, specifically related to children's education. Awards: Fellowship Award, Royal Astronomical Society, London, International Young Astronomer Award from NOAO/USA; Vigyan Purskar, Govt. of Rajasthan; Jain Ratna; Lifetime Achievement Award, Govt. of Madhya Pradesh; Social service and education "Sadbhavna Foundation"; Over 150 Research papers and 200 articles.

E-mail:rajmal_9@yahoo.com;



Ratna Kumar Shah

M.A. (Applied Maths) Pune University. Professor of Mathematics and Astronomy, (Retd.) Fergusson College, Pune. Expertise: History of Mathematics, Jaina Mathematics, Author: 20 papers and Books. Enagaged in Translation of 3 Agmick work. E-mail:ratankumarshah@yahoo.co.in

Rudi Jansma

Ph.D. Neo-tropical Ecologist; Studied biology and chemisry; Specialization: tropical phytosociology, soil science and nature preservation, Universities of Utrecht and Wageningen, The Netherlands; Comparative non-western philosophies in relation to the cyclicity in Nature, causality, ecology and evolution, Cultural attitude towards nature in the pre-Christian Americas and Indian cultures including Jainism. Publications on Jainism, Theosophy, Ecology, Evolution and Consciousness and Hinduism. Author: Handbook Hindoeisme (Dutch), and Ecology of savannas in Suriname (South America). Global Philosophical and Ecological Concepts - Introduction to Jainism, Ecology Religion, Consciousness, Mind and Brain, Beyond Sustainable Economy (Editor). etc.

E-mail: rudijansma@gmail.com



Samani Chaitanya Prajna

Ph.D. (Philosophy), Professor, Department of Jainology and Comparative Religion and Philosophy, Jain Vishva Bharati Institute, Ladnun, (Rajasthan) India. Areas of specialization; Jainism, Asian Religions, Comparative Religion and Philosophy, Preksha Meditation and Yoga, Science of Living, Nonviolence, Sanskrit, and Prakrit Language and Literature.

Visiting Professor, Florida International University, Miami,



USA, member, Jain Education Research Foundation, Miami, USA; She organized Conferences in India and abroad and delivered over 25 invited lectures in USA, UK, Hong Kong, Bangkok, China, South Korea, Indonesia, Nepal, Greece. Author: books on Jain Philosophy and Jainism and over thirty articles and essays in different course books, journals, souvenirs, and proceedings. Past Executive Director, Bhagwan Mahavira International Research Center at JVBI, Ladnun.

E-mail: cpragya108@gmail.com;



Samani Unnata Prajna

Samani Unnata Prajna did her Bachelor of Science from Bangalore University in 1994. She was initiated as a Samani in 2003 from His Holiness Acharya Mahaprajña. She received her Master of Arts (MA) degree in 2003 and Master of Philosophy (MPhil) in "Jainism and Comparative Religion and Philosophy" in 2006, from Jaina Visva Bharati Institute.

She is currently an Instructor at Florida International University, Miami, USA since 2013. She translated, Acharya Mahaprajña's commentary on Shravaka Sambodha', a work on Jain laity composed by Acharya Tulsui and has presented papers at conferences, on ethical issues related to 'Spirit Possession', 'Disabled Fetus' and other subjects like 'Samudghtta: Round the World in Nano Seconds' and other subjects.

She is conducting research on Preksha Meditation at FIU -'Impact of Preksha Meditation (PM) on Pulmonary Function and Cognitive Skills and Epigenetics', the epigenetic test added to the cognitive & pulmonary function test.

E-mail:upragya@icloud.com



Samani Vinay Prajna

B.Sc, M.A.,M.Phil (Jainology), Carrying out research for Ph.D.; Assistant Prof. Department of Jainology, Jain Vishva Bharti Institute, Ladnun, India; Book: Transform Your Self (translated from Abhamandal (Hindi).Participated in Parliament of World Religions, (Australia, 2009), lectured at University of Houston, Rice University, Yale University, etc.

E-mail:bhikshu11@gmail.com



Shyam Lal Godawat,

M. Sc (Ag), Ph.D. Maharana Pratap University of Agriculture & Technology, Udaipur; Head, Department (Plant Breeding & Genetics) and Dean, Rajasthan College of Agriculture, Udaipur. Developed many high yielding hybrids and composites varieties of maize; 80 research papers and many popular scientific articles; Interests: Jainism and social service.

E-mail:shyamgodawat@gmail.com



Sohan Raj Tater

Ph. D. Formerly Vice Chancellor, Singhania University; Adviser, Jain Vishva Bharati University, Ladnun, Emeritus Professor, Trinity World University (U.K.), NAIU (U.S.A.), Jagannath University (Bangladesh), Jodhpur National and JJTU. Specialization: Philosophy, Yoga and Education

Awards: Indira Gandhi Rastriya Akta Award, Samaj Bhushan, Yuvak Ratna, Indo- Nepal Harmony, Bharat Excellence Award, Jain Gyan Vigyan Manishi, Samaj Ratna, Maharshi Patanjali International Award, Indo- Bhutan, Vidhya Bhushan, Naturopathy Ratna and Yoga Ratna National awards.

E-mail:sohan.tater@gmail.com



Subhash C. Jain

Professor Emeritus in the Department of Civil and Environmental Engineering at the University of Iowa, Iowa City, Iowa, USA. He is currently enrolled as a Ph.D. student in the Department of Jainology at the University of Madras, Chennai and is writing his dissertation on rebirth. He is keenly interested in delving into the nature of reality.

E-mail:subhash-jain@uiowa.edu



Subhendra Mohanty

B.E. (Mechanical Engg), Ph.D. (Physics), Professor, Theoretical Physics division at Physical Research Laboratory, Ahmedabad. Expertise in Cosmology and Inflation, Neutrino physics, Astroparticle physics and General Relativity. E-mail: mohanty@ prl.res.in



Surendra Singh Pokharna

Ph. D, Physics, Post Doctoral (Biophysics), Indian Institute of Science, Bangalore, Post Graduate Diploma (Operations Research, ORSI). Assistant Professor of Physics (1979-1986) Sukhadia University. Senior Scientist at SAC (ISRO), Ahmedabad, (1986-2004). Chief Operating Officer (COO), Hitech Outsourcing Service (2004-2011, presently Consultant. Active interest in Physics, Biophysics, Remote Sensing, Operations Research, Systems Studies, Indian Culture, portal development. About 150 publications.

Email: sspokharna15@yahoo.com



Sudhir Vadilal Shah

MD (medicine), DM (neurology). A renowned and senior neurologist of Gujarat (> 25 year). "Training abroad: U.T. medical school, Houston, USA on stroke, Thromolysis, Queen sqare NHNN London, UK on epilepsy and parkinsonism. "Professor & Head of neurology, at NHL Medical College. "Director of neuroscience, Sterling hospital, Ahmedabad. "Honorary Neurologist to H. E. Governor of Gujarat.

Immediate past president, Ahmedabad Neurology Association; executive member, IEA; secretary, AAON (Alzheimer), past president Ahmedabad Physician Association. "Active member of various national & international neurological societies, including AAN, ENS, WFS & ISS.

"Received International award for Neurology and future medicine from UNO, 2003. "Included in "Gujarat- Power 100 list", since last 10 years."Author of four books for public education, on various medical/neurological disorders (Diseases of Brain & nervous system) "Research on prolonged fasting" gave him outstanding international recognition. He has been awarded Padma Shri by Government of India.

Religious Activity: "Founder Chairman National Jain Doctors' Federation - NJDF (of India) and now international coordinator of NJDF.

E-mail: sudhirshah@hotmail.com



Suresh Chandra Agrawal

M.Sc., Ph.D. (I.I.T.-Kanpur) Professor and Head-Department of Mathemetics Institute of Advanced Studies, C.C.S. University, Meerut Diriector and Ex. V.C. Shobhit University, Meerut, Expertise-Fluid Dynamics & Stability theory, History of Mathematics, Author of Several books and more than 100 research papers, Guided more than 20 student for Ph.D.



Tej Mal Dak

MA, Ph.D. (Sociology), Director Institute of Social Development, Served: Government of India, Ministry of Agriculture, Vidya Bhawan, Udaipur; Haryana Agriculture University, Hisar; Mahatma Gandhi Gramodaya Vishvavidyalaya, Chitrakut; Jain Vishva Bharati Institute, Ladnun; Secretary General, Indian Society of U3A's Field Research projects in social change, rural and tribal development, Health and nutrition etc. Author: several books.

E-mail:isdu2001@yahoo.co.in



Varsha Shah

Research Assiatant in K. J. Somaiya Centre for Studies in Jainism, Somaiya Colleage, University of Mumbai, Mumbai E-mail:shahvarsha8@gmail.com



Veer Sagar Jain,

Ph. D. Head, Department of Jain Philosophy, Lal Bahadur Shastri Rashtriya Sanskrit Vidyapeeth, New Delhi. Awards: Acharya Umaswami Award, Mahaveer Puraskar, Rishabdev Puraskaar, etc.; Publications: 100 research papers, 21 books, including Bhartiya darshan mei Atma Parmatma, Nyay Mandir etc. Email: veersagarjain@gmail.com



Viney Jain

A biophysicist and radiation biologist, Dr.Viney Jain received his postgraduate and post-doctoral training from the universities in Goettingen, Kiel and Frankfurt/M, Germany. He has been a recipient of the fellowship of the German Academic Exchange Service (DAAD) and the prestigious research fellowship award of the Alexander von Humboldt Foundation, Germany.

Author of more than 150 original research publications in peerreviewed scientific journals, he served on the faculties of the Physical Research Laboratory, Ahemdabad, All-India Institute of Medical Sciences, New Delhi; National Institute of Mental Health and Neurosciences, Bangalore, Delhi University, Delhi and as a visiting professor/scientist at several universities in India, Germany, U.K., France, Netherlands and USA. He superannuated in 1998 from the post of Director, Institute of Nuclear Medicine and Allied Sciences, Delhi. Subsequently, he served as Professor Emeritus at the B R Ambedkar Centre for Biomedical Research, University of Delhi and as Visiting Scientist at the Wright State University, Dayton, Ohio, USA. Presently, he is Professor Emeritus at JVBI, Ladnun and advisor to the International School of Jain Studies, New Delhi.

He has served as President of Indian Photobiology Society and Indian Society for Radiation Biology. He has edited and co-authored 3 monographs in the field of radiation sciences and has been a member on the editorial boards of International Journal of Radiation Biology and Indian Journal of Experimental Biology. Email: vineyjain@gmail.com





Aquaguard water

Tap water



RO Water



Bottled mineral water



Water treated with Gobar Ash

Tap water boiled

and cooled



Distilled water

Fig. 6 Aura photographs showing the existence of two types of water-living and non-living (Note the Green colors in the lower Rectangular aura field)



Fig. 7 Distinctive Transition from Living to Non-living water under different parameters (Quantity of CDBP and Temperature) (Note the color changes in the nucleus of Aura). (See colour image on page 658)

Bhagawan Mahavira International Research Center Jain Vishva Bharati Institute (Deemed University), Ladnun Website: www.jvbi.ac.in/bmirc

E-mail: bmirc.jvbi@gmail.com

Bhagawan Mahavira International Research Center (BMICG) has been established in the Department of Janology & Comparative Religion & Philosophy of Jain (Nathan Bharill Institute (Deemed University), Ladiun, Rajasthan. BMIRC facilitates scholars to undertake tsudies, cuture, environment and ecology, spirtula appects of life, and holisich eablit, and carry out innovative studies with an aim of evoluating the Jain doctrines and developing them further for them practical applications to personal and basist, beably, markical applications to personal and basist, beably, markical applications to personal and basist, beably, markical applications to ensatistical personal and basist, eablity, and logic, att and science of Jain spirtual practices, physiological and psychological effects of medical sciences, consciousness and cognitive powers, talenyative, thereastly, psychokinessis, etc., interdisciplinary areas of philosophy and physics, chemistry, biology and mathematics, ethics, environment and ecology, and applications of Jain doctrines and their impact on society

Besides the main centre (BMIRC) at Ladnun, plans are underway to set up sub centers at other suitable places, such as at Koba, Gandhinagar and Mumbai, through cooperation of local scholars and Institutions.

The Centre offers unique opportunities to enthusiastic scholars, scientists, academicians, and social and philanthropic organizations for undertaking scientific and invozitive research in collaboration mode. Cooperation has been initiated between several organizations in India and abroad for developing research activities which include some well known Institutions, Universities, and Laboratories etc. Individual scholars are encouraged to join in this collaborative effort Universiti (funding, joint and content of the scholar several scholars), several particular content of the scholar scholars, several establishing laboratories and research conters at differen places and online interaction, etc.

This monograph containing status papers on several aspects of Jainism and science is the first initiative of BMIRC, necessary to provide baseline information required for undertaking research activities in this area.



Jain Philosophy and Scientific Quest

Since time immemorial, the philosophers and scientists of different schools and streams have asked the question, "Who created this world? Why? When? And How?" Jain philosophy maintains that the world is not a Creation of anybody like God. It just exists out there since beginning less time and would remain so for ever.

The world is made of two basic ingredients Jiva (living being) and Ajiva (nonliving entity). When these two intermingle they take a certain form, which is the world. Both liva and Aiiva

are basic elements, the world is their expanse. There are three factors characterizing every Jiva and Ajiva – dirnaroya (continuity), which works alongside the other two viz, utpuda (creation) and rayage (destruction). Everything is prone to change there is one element, dirnaroya, that is not amenable to change.

Any substance has two attributes persisting and successive. The former is called guna (property) and it implies that the *dravga* (substance) is eternal. The latter is called *paryaga* (mode), which denotes movement or capacity to change. What we perceive through our senses is only the *paryaga* and not the basic element of anything, *ji*oa or *aji*a.

The soul is annuta (non-coporeal) and cannot be perceived or known by senses, mind and intellect. Its attribute is consciousness which is known only through its furthicin, it cannot be directly comprehended through sensory perception. The soul illuminates itself as well as others. It is capable of knowing itself as well as the objective world. Souls and the material bodies exist bound with each other, in contact with each other provading each other, stuck with each other through mutual attraction and unitied with each other through mutual identification. Jizn has both the capabilities – consciousness and capacity to acquire, whereas the *pulgala* (matter) is non-conscious but has the property to get attracted.

In the present age of science one feels exalted by calling one's religion as a "scientific" one. It is easier to consider jainism as a scientific religion but life that lainism qualifies itself to be placed in the category of a science due to its spirit of scientific inquiry. It explores the truth through scientific mode and does not stop till that truth is fully realized. Since our world is constantly changing, the truth also has two aspects viz., (1) eternal and (2) ever changing. Both are inevitable jain philosophy has accepted both change and non-change as the two aspects of truth. Jain philosophy concedes to both, the soul as well as matter, since both of them have independent existence.

Why Jainism does not believe in God as the Creator? Jainism says that any fundamental existence can have no creator. Modes have creator. All the modes of soul are created by the soul itself and the modes of *pudgala* are created by *pudgala*. Soul can create its modes through volition; *pudgala* has no volitions on the modes of *pudgala* are created by *pudgala*. Soul can create its modes through volition; *pudgala* has no volitions on the modes of *pudgala* are created by *pudgala*. Soul can create its modes through volition; *pudgala* has no volitions on the modes of *pudgala* are created by *pudgala*. Soul can create its modes through volition; *pudgala* has and (2) Man- made Laws. The search for truth means the search for Universal Laws. Modem science has developed itself on the basis of such research. If finds out the Laws and a new secret is revealed. The philosophical search for truth is nothing else than the realization of the Elemal Laws. Same is the objective of science, which explores these Laws through experiments and observations.

- Acharya Mahaprajna

(From Philosophical Foundations of Jainism)





Jain Vishva Bharati Institute, Ladnun

E-mail : jvbiladnun@gmail.com / Website : www.jvbi.ac.in.