JAIN BIOLOGY

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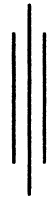
JAIN BIOLOGY

(A Comparative Study in Jain Biology and Modern Biology)



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PUBLISHER'S NOTE

Jainism which is one of the most important branches of Indian Philosophy deals with diverse subjects such as metaphysics, ethics, epistemology, logic, physics, biology, mathematics etc. The learned authors of this treatise on Jain Biology have presented some doctrines of biology described in the Jain scriptures (*Āgama*) as well as some important aspects of modern biology and made a comparative study. By publishing this work, which is probably first of its kind in the field of studies of Jainism, we feel noble proud with the hope that it would be helpful for students of Jainism in understanding the scientific spirit of Jain Philosophy.

A couple of books written in the field of comparative studies of Jain Philosophy and Modern Science by this scholar duo have already been published by our University.* We hope that the present publication will also prove valuable for the readers.

In the wordings of His Holiness Acharya Shri Mahaprajnaji, who is the Anushasta of our University, the authour-duo exemplify "spiritual-cum-scientific" personality. We offer our hearty thanks to them.

Publishers

* 1. Microcosmology : Theory of Atom in Jain Philosophy and Modern Science
2. Neuroscience & Karma

PREAMBLE

The chasm between Religion and Science is quite deep. This is because the scientific mind does not like to accept anything that cannot be experimentally proved while the religious mind needs no proof for anything laid down in the sacred scriptures. The chasm has, unfortunately, prevented mutual interaction, preventing each of them to be benefited by a constructive study of the other side of the chasm.

The wisdom buried in the Jain scriptures and other ancient literature produced by the Jain savants is unlimited. Students of Jainology admit that, many problems of human interest would remain unresolved in the absence of a study of this literature. Regrettably, however, interpretation of this vast literature in modern scientific terms is rather in a scrappy and haphazard form. This essay is an humble attempt to build a small bridge across the chasm with a hope that. "new, interesting and the most fruitful developments will take place" as said by Werner Heisenberg.[1]

Bhagavan Mahavira, being an omniscient, directly apprehended the entire reality and being able to distinguish between what was animate and what was inanimate, he recognized, identified and enumerated six *NIKĀYA*—groups of living organisms. Of these, only two, the mobile organisms with organic bodies and endowed, more or less perceptibly, with the ability of voluntary motion (*trasakāya*) and the plants (*vanaspatikāya*), and recognized by science. The other four groups of living organisms—earth-bodied, water-bodied, fire-bodied, and air-bodied—are not accepted by it. Bhagavan Mahavira, however, clearly

1. Physics and Philosophy, by Werner Heisenberg, Published by George Allen, London, 1958 p.161.

recognized the psychical entity in these four elements and declared them to be animate, adding that these four were much more primitive, i.e., the development and evolution of consciousness in these four were of a very low degree. Nevertheless, they were living organisms and belonged to the psychical order of existence and not to the physical order and it was positively a sinful act to kill or injure them. He not only stressed their existence but threw enough light on their ability to experience pain, their life-span and other characteristics also.[1] The minimum span of life of the earth-bodied organisms is an *antara-muhūrata*[2] only while the maximum duration is twenty-two thousand years.[3]

Their bodies are made-up of molecules of different varieties of earth which also serve them as the sense-organ of touch (which as we know is also the sense-organ of pain). While this consciousness of touch (and pain) is well developed and distinct, the other faculties are latent and indistinct. These organisms breathe and nourish themselves through their bodies, take in earth, water, fire and air.[4]

Now we know that development of life-sciences, such as Biology, came much later than that of Physics and other natural sciences which dealt with lifeless matter, because the former have to study much more complex phenomena which need much finer instruments and apparatus. Plants being more sensitive than other one-sensed immobile organisms, science could study different aspects of plant life and accepted their conscious character and threw light on their mysteries. Enough has been said about the secret life of plants to convince the sceptic about the ability of plants to suffer pain and express anger, affection and hatred etc. Thus science emphatically confirms what was asserted by Bhagavan Mahavira that all one-sensed living organisms are possessed of ten

1. *Āyāro*, 1.39.
2. The term *antaramuhūrta* is explained as duration of time which is more than two time-points (*samaya*—smallest measure of time which is further indivisible) but less than a *muhūrta* i.e. forty-eight minutes.
3. *Bhagavatī*, 1.1.32, p.9.
4. Ibid, 9.34-253,254, p.464.

instinctive faculties.[1] In this respect, plants and animals (including man) are not different.

Preaching of '*ahiṃsā*' (non-injury) is the most important contribution of Bhagavan Mahavira, inspired by infinite reverence for life. The vow of *ahiṃsā* is regarded the principle vow while the other four vows of truthfulness etc. are subsidiary ones to help the fulfillment of *ahiṃsā*. But the essence of *ahiṃsā* is the knowledge of what is animate and what is not. The basic scriptural knowledge is the science of living organisms—the six *nikāyas* and non-injury to them. Killing, crippling, mutilating or injuring even the most primitive earth-bodied organisms in anyway is sinful.[2] *Ahiṃsā* is thus interpreted as—abstinence from imposing pain on any kind of these six *nikāyas*.

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1. Ten Primary—unlearned—instincts (*saṃjñā*) are :
i. Hunger, i.e., the instinct for taking nourishment (*āhāra saṃjñā*),
ii. Fear, i.e., the instinct for flight (*bhaya saṃjñā*),
iii. Sex, i.e., the instinct for reproduction (*maithuna saṃjñā*),
iv. Possessiveness, i.e., the instinct for hoarding (*parigraha*),
v. Anger (aggression),
vi. Arrogance (egoism),
vii. Deceit,
viii. Greed,
ix. Mass mentality, and
x. Cosmic consciousness.
2. Ayaro, 1.19-30.

INTRODUCTION

Biology (bios = life and logos = knowledge) is the science of the psychical order of existence, i.e., the living world. Living organisms are of many kinds and for proper study they have to be classified. All living organisms are broadly classified under three forms, viz. microbes, plants; and animals. Thus the principal fields of study under Biology are Botany, Zoology, and Microbiology. And hence Biology itself is divided into two branches, viz. Botany—study of plants and Zoology—study of animals. Microbiology includes study of micro-organisms, both plants and animals. Viruses, bacteria, algae, fungi, and amoeba like protozoan are some of the examples of microbes. Viruses are so small that they cannot be seen with the light microscope. Electron-microscope is used for their study. Bacteria are simple unicellular microscopic organisms. Algae are aquatic plants. Fungi are cellular or filamentous plants. Protozoa are small microscopic unicellular organisms.

ANCIENT BOTANICAL STUDY

The word 'botany' comes from the Greek word 'botane', which means plant. This word in turn can be traced back to the Greek 'boskein', to graze, which was derived from 'bous', the Greek word for cattle. Thus etymologically, botany is the science of what cattle eat.

Botany, the study of plants, arose from the attempts of primitive men to control their environments and to adapt themselves more advantageously to their sorroundings. Thus the first study of plants must have undoubtedly been centered upon the importance of plants in human life as sources of food for nourishment, of fibres for clothing, of drugs for the treatment of diseases, and of fuel. In due course, certain men, to satisfy a growing human curiosity about the world in which they lived, must have begun to seek answers to questions of intellectual interest and in man' s first attempts to obtain answers to such questions, the science of botany must have had its origin.

From the records in ancient manuscripts and in the form of hieroglyphics etc. it is known that peoples of various civilizations possessed considerable information about the lives and uses of plants, particularly plants of agricultural and medicinal value. Their knowledge was for the most part, of a practical nature, although it did include some fundamental scientific discoveries, such as the discovery of sexuality in the date palm and of the importance of pollination in the development of fruits.

In the orient, the Indians and the Chinese had acquired considerable knowledge of plant cultivation and plant uses for food and medicine, at least 5000 years ago. The ancient races of America, who are regarded by anthropologists as being of Asiatic origin, possessed considerable knowledge concerning utilitarian aspects of plant life. The pre-Incas of Peru were apparently the first American race to plant corn or maize. From Peru, the culture of corn spread both northward and southward until by the early sixteenth century, corn was grown as the major crop plant from Argentina to the St. Lawrence River valley. The study of plants by all these ancient peoples was centered upon one major objective—the practical exploitation of plants as sources of food, beverages, fibres, wood, drugs, and other products which benefit the human life and civilization. Since their interests were so limited, and since they achieved little progress in the discovery and interpretation of fundamental natural laws, they could not be regarded as biologists or botanists.

Botanists usually recognize the beginnings of plant science in the Golden Age of Greece. Most of the early Greek botanists were physicians or drug sellers. About 340 B.C., Theophrastus—a pupil of Plato and Aristotle—wrote a *History of Plants*, in which he deals with the general morphology of roots, stems, leaves, flowers and fruits. Uses of ornamental plants and importance of vegetables and cereals are also given emphasis in this book.

Aristotle, himself, believed that plants had no sensory faculties, and no differences of sex. He reached the unique conclusion that animals have souls and plants do not.

The middle Ages constituted a period of relative inactivity in European science as the period was one of great political changes, of superstition and often of insufficient food, poor sanitation, disease, unceasing warfares—conditions which were inimical to the progress of science.

During the medieval period—between 800 and 300 A.D. Botanical gardens were established in various parts of the Arabian Empire. Baghadad became a centre for the translation and editing of ancient manuscripts into Arabic. However, not until much after, did the study of plants resume the course. During the sixteenth century, botanical gardens became popular and by the middle of the seventeenth century, there was hardly a university or a medical school in Europe without a garden of medicinal herbs and shrubs. Again, however, the study continued to centre around their food and medicinal values.

Modern Botanical Study

Thus the development of Biology, being a science of the living, came much later than the development of physics and chemistry, which dealt with inanimate matter. Many of the foundation stones of modern Botany, divorced from superstition and fantasy, were laid during the closing decades of eighteenth century. TAXONOMY, the study of plant classification and relationships and MORPHOLOGY, the study of plant structure, were the first to develop because they required little technical apparatus. Details of tissue and cell structure had to await the discovery and perfection of magnifying lenses, as a result of which plant ANATOMY began its career.

One of the greatest figures in the entire history of botany was Carolus Linnaeus, a Swedish botanist, whose investigations upon the naming and classification of plants were the most extensive and exceedingly effective in stimulating succeeding generations of botanists to taxonomic research. After the basic principles of chemistry and physics were established, PLANT PHYSIOLOSY, the study of functions aroused interest and grew rapidly. Along with these, there arose PLANT PATHOLOGY, the science of disease and control and more recently GENETICS, the

study of inheritance, ECOLOGY, the study of the relations of plants to their environmental conditions and CYTOLOGY, one of the most recent fields, the microscopic study of cell structure and cell behaviour. Great advances were made during the latter years of the eighteenth century and during the nineteenth century in all phases of plant science.

Research is steadily adding to the knowledge of the lives of plants. Besides Botany, other plant sciences include BACTERIOLOGY, the study of bacteria, which are microscopic plants of great importance in agriculture, industry and medicine.

The study of Biology is valuable in understanding ourselves and our living surroundings. It has greatly helped us in controlling various diseases, in producing better and more foods, and in conserving natural resources. The development of medical, agriculture and various industries is a result of the knowledge acquired through study of biology.

Biology and the allied fields of study have also helped us in wiping out some superstitious beliefs. Smallpox, for example, was for a long time thought to be a curse of an angry goddess. However, it is definitely known now that smallpox is a viral disease and it can be checked and cured. Study of Biology has thus made our life happy and comfortable. Study of Botany is valuable for :

a. It enables man to appreciate his dependence upon plants and his place in nature.

b. It enriches the cultural life of man and enhances the aesthetic appreciation of plants.

c. It forms a necessary informational background for students preparing for careers in horticulture, agronomy, bacteriology pharmacology, etc..

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CONTENTS

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CHAPTER—I

BIOLOGY : SCIENCE OF LIVING ORGANISMS

INTRODUCTORY

The word Biology is defined as—Science of living beings, dealing with the classification, morphology, physiology, nutrition, origin, and reproduction etc. of living organisms, i.e., animals and plants. Modern Biology is an experimental science capable of verification and not a descriptive or passive discipline based on observation of nature. It is considered as one subject, the emphasis being on unity amongst diversity rather than on description of diverse organs and organisms. MAN is included in it both as part and parcel of the ecosystem as well as the only organism capable of influencing it for better or for worse.

Biology divides the entire psychical order of existence into two domains, Animal kingdom and Vegetable kingdom or plants. They can be distinguished from their morphology and anatomy.

The word 'Animal' means—an organised living being, endowed (more or less perceptibly) with life, sensation and voluntary motion. Popularly the word is also used to mean—animal other than man, or sub-human animal; while the word 'Plant' means—living organism generally capable of living wholly on inorganic substances and having neither the power of locomotion nor special organs of sensation or digestion; member of vegetable kingdom. Popularly the word is frequently restricted to smaller plants excluding trees and shrubs. In this essay, the word 'plant' is used in the wider sense to mean trees, shrubs, herbs, grasses, i.e., the entire vegetable kingdom.

In Biological world, plants and animals are connected by the food chain. Green plants make food for themselves and also for animals. Animal food consists of carbohydrates, fats, proteins, vitamins, minerals, and water. Plants draw minerals and water from the soil but prepare the rest. Photosynthesis and transpiration[1] are restricted to plants. Other vital

1. Transpiration—Natural passage of water vapour from inside of the plant out to

processes like digestion, respiration and growth are common to both plants and animals. Circulatory and nervous systems of animals have no parallel in plants. Photosynthesis consumes carbon dioxide and releases oxygen. Respiration in plants and animals does the reverse and so these two gases are balanced. Thus Biology has two branches :

(1) Zoology, the branch of Biology dealing with animal kingdom and the physiology, classification habits, etc., of its members.

(2) Botany, the branch of biology dealing with vegetable kingdom or the science of Plants.

In this essay, we shall try to compare the dissertation on this subject given in the Jain scriptures with known facts given by modern Biology, in simple language avoiding technical terms as far as possible. Let us begin with the scientific view of what life is.

ORIGIN OF LIFE

According to Biology, a living organism is qualitatively distinct from the non-living matter. But how do plants and animals come into existence? Some from seeds, tubers and bulbs; others out of eggs or capsules; still others front buds and cuttings. But can any living organism be created from dead—inanimate—matter?

All organisms are made of cells. Each cell consists of a number of different molecules. Is it not possible to put the molecules together and obtain a living cell ?

ABIOGENESIS OR SPONTANEOUS GENERATION

Ancient scientists (like Aristotle—384-322 B.C.) thought that life can be made from dead matter, e.g. mullet fish is created from mud and sand, when dry ponds get filled with water.

The abiogenesists did experiments like the following: A hay infusion was prepared by boiling a little hay in water and keeping it for several

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the atmosphere, in land plants, it occurs mostly from leaves;
Transpiration stream—passage of watery sap through roots and stem to site from which water vapur is transpired.

days in an open bowl. The liquid soon became cloudy with millions of protozoa, bacteria and fungi.

This theory of spontaneous generation was largely disproved by microbiological studies of Louis Pasteur (1822-1895). He argued that life was not created but fell into infusion from the air as cells or spores. Thus was spontaneous generation buried.

ORIGIN OF LIFE UPON EARTH—CHEMICAL EVOLUTION

When our earth was new, it was a mass of molten lava. Nothing could live in such conditions. But life did appear about a billion years ago. Was this not abiogenesis? Scientists wondered about what happened then. A.I. Oparin was the first to discuss the problem in 1938 and suggested that before the origin of life, there was some sort of chemical evolution. In 1953, Harold Urey and Miller constructed an apparatus wherein the four primitive gases—ammonia, hydrogen, methane, and water-vapour—were continuously circulated and subjected to electric sparks and heat in order to keep the water vaporized. Within a week, a number of organic substances were formed, of which amino acids were the most important. Now amino acids are the units from which proteins are made and proteins and nucleic acids are the least common multiples of life because viruses which are regarded to be on the border line of living and non-living, consist of but little else.[1]

If proteins could be made from simple stuff like this, what about nucleic acids? Some scientists stated that not only nucleic acids but other important substances could be created in this way. Thus, before the appearance of life, the chemicals of life-were created. This is called "Chemical Evolution."

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1. According to Biology, a virus is a very small organism, much smaller than bacteria or other classifiable micro-organisms, visible only in electron-microscope, consisting mainly of nucleic acid and protein molecules. It is unable to multiply outside a living tissue, in which it frequently causes disease, e.g., tobacco mosaic. In man, virus diseases include influenza.

A virus called Escherichia Coli consists of a coat made of proteins and a core of nucleic acid which is injected into the cell of the victim. Within a short time, the injected nucleic acid reproduces itself into hundred of new virus particles.

Since then scientists all over the world have made desperate efforts to synthesize a living cell. Inspite of unbelievable advances and inspite of our accurate and detailed knowledge regarding every material substance which is involved in the making of a cell, no one has yet been able to synthesize a living cell in the laboratory."[1]

LIVING AND NON-LIVING

In its composition, a living organism contains no special element but is mainly made up of some 16 of the 92 elements that occur naturally on the earth. Its functioning is governed by some unique biological laws. The essence of living organism is the set of principles determining the transmission of genetic information from one generation to the next. Besides free will, which is the chief characteristic of life, a living organism also possesses all of the following attributes of organization: excitability, conductivity, contractibility, metabolism, growth and reproduction. One or more of these, but not all, may be possessed by non-living matter. Thus the characteristics of the living are:

(a) Living organisms can grow, reproduce and move;

(b) They are cellular (except for a few);

(c) They convert food into energy;

(d) They are irritable and adaptable;

(e) Each has a span of life after which it dies.

Now the question is,—what is death? The keynote of life is organisation. The body is a living organism and is made up of cells which are specialized for specific functions. They are arranged in an intricate but organized pattern to suit the functions of the body. Cells are grouped

1. According to the Jains, life is not merely a composition of material substance. A non-material soul-substance is also essential to create a live cell. Soul is a substance but not a physical one. And this non-material substance can neither be created nor destroyed. In future, also, scientists may succeed is synthesizing each and every component of cytoplasm—molecules of various proteins, DNA, RHA etc.—and correctly and precisely be able to assemble them, it would never be a live cell. The existence of the soul, distinct from the body, is not merely a concept but a metaphysical reality.

into organs and systems and the integrated sum of these systems is the living organism. Death occurs when the organisation breaks down. Thus organization is life, disorder is death. Life is like a spark ready to kindle fires everywhere. Every living organism carries this spark which has been passed on to it from generation to generation. Therefore, 'All life is one'. This is called the Principle of Unity of Life.

CELLS

Both plants and animals are made up of cells which contain the organelles for physiological processes as well as the chromosomes and genes which are bearers of hereditary characteristics.

Life is continuous and its continuity is maintained by reproduction which may be sexual, asexual or vegetative.[1] In bacteria and yeast, it can be by fusion or budding.

CELL STRUCTURE

We said that the body of a living organism is made of cells which means that the cells are the structural and functional units of a living organism. They exhibit variation in size and shape. The smallest known cell is that of an organism called Mycoplasma, an agent of pleuropneumonia, which measures 100 Å i.e., o.1 micron[2] in diameter. The longest cells are those of fibres in plants which are several centimeters in length. Such sizes, however are extremes for the great majority of cells measure 0.1 to 0.01 mm.[3] In general, cells are rounded, cubical or rod-shaped.

A cell comprises of protoplasm bounded by a plasma membrane. In plant cells, there is a covering called the cell wall which surrounds the plasma membrane. Cell wall is absent in animal cells. It is a characteristic

1. Vegetative reproduction. Reproduction of plants other than by sexual reproduction, seeds or spores may take place by separation from parent plant, e.g., by runner (strawberry), Rhizome (couch grass), or by other methods, e.g., grafting, budding, layering, or rooting of cuttings.
2. A micron is equal to one millionth of a meter or one thousandth of a millimeter.
3. In human body the smallest cells (certain brain cells) are about $^{1}/_{200}$ mm an the largest ones (ova) are about ¼ mm in diameter. Red blood cells, among the smallest cells in the body, are only 7.5 micron in diameter. A muscle cell may be more than 2 to 3 cms long but only 50 microns in diameter.

feature of the plant cell and is a non-living structure secreted by the protoplasm. It is made up of cellulose etc.

Protoplasm includes all the living components of the cell. The cell membrane which encloses it, has a power of selectivity, as it allows the passage of some molecules and not others. The protoplasm can be divided into—cytoplasm and nucleus. Most of the chemical and physical changes involved in cell physiology occur in cytoplasm. It is made up of a ground substance called hyaloplasm in which various organelles viz., plastids, mitochondria, endoplasmic reticulum, ribo-somes, golgi bodies, lysosomes, and centrosomes occur.

Plastids are present in plant cells except fungi and most bacteria. Mitochondria are found in all living cells except bacteria and red blood cells. It can be called the powerhouse as it converts foods into chemical energy. Endoplasmic reticulum helps in the synthesis of lipids and glycogen and forms a transport system for proteins. Ribosomes synthesize proteins from amino acids as specified by the nucleus. Golgi complex form primary lysosomes. Centrosomes form the spindle fibres during cell division.

Nucleus is regarded as the controlling centre of all activities of the cell. It is a dense spherical body, bounded by a membrane, its size varying from 5 to 25 microns. Membrane is porous and permits the passage of material between the nucleus and cytoplasm and vice versa. The nucleus shows a fine network of threads called chromatin. During the division of cells these threads become visible as pairs of chromosomes. The number of these is fixed for a particular species e.g., the pea plant has 7 pairs, while the human being has 23 pairs, the round worm has only a single pair while a certain fern called adder's tongue has 1262 chromosomes. They possess genes' which guide and determine the characters, activities and destiny of each individual cell. The genes are the bearers of heredity.

The chromosomes are made up of two kinds of proteins and two nucleic acids, DNA and RNA. The functions of DNA and RNA have been discussed a little later in this section.[1]

1. The cell structure can be tabulated as under:

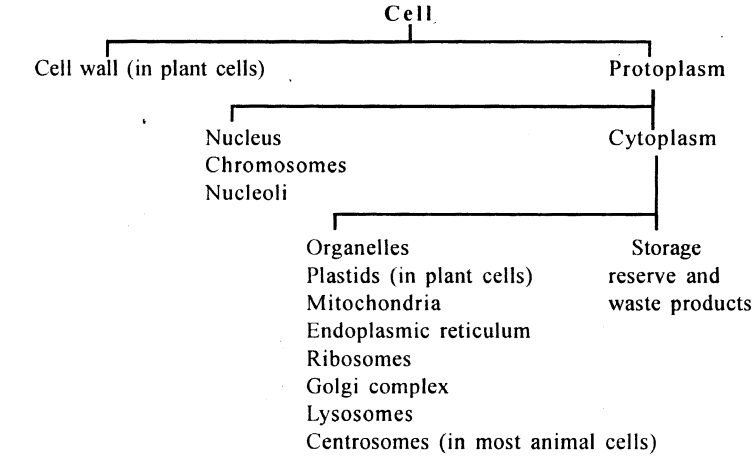
Comparison of Plant and Animal Cell

PLANT CELL	ANIMAL CELL
(i) Cell wall of cellulose present external boundary to cell-membrane	(i) Cell- wall absent. Protoplasm bounded only by cell membrane
(ii) Plastids present	(ii) Plastids absent
(iii) Vacuoles in old cells	(iii) Vacuoles rarely seen

PROTOPLASM AND ITS COMPOUNDS

The cell is a mass of living substance called protoplasm, bounded by a thin, delicate plasma membrane. The protoplasm of a cell contains a phenomenal number of molecules, organic and inorganic. According to Hofmeister, a rough estimate of the number of molecules in a single liver cell is—

Proteins	53,000 x 10
Lipids	165,000 x 10
Small molecules	2.900,000 x 10
Water	225,000,000 x 10



The chemical constituents of the cell are both inorganic (water and mineral ions) and organic (proteins, nucleic acids, carbohydrates and lipids. Water forms 75 to 85% proteins 10 to 20%, lipids 2 to 3%, carbohydrates 1% and inorganic substances 1%).

1. Proteins are of primary importance to the life of the cell, forming about 80% of the dry mass of an animal cell. They are large and complex molecules, composed of sub-units called amino acids which form the building blocks. There are about 20 different amino acids and their sequence in the long chain, which makes the protein molecule so important that substitution of even one amino acid by another may produce drastic changes in the properties of a protein molecule. The possible number of sequences for amino acids in a protein molecule is really large. Hence, the possible varieties of protein molecules is enormous.[1]

Within a species, various groups of individuals synthesize proteins specific only to themselves and not to others, e.g., each of the four major blood groups in man (A, B, AB, and 0) differ from the others only in its proteins.

Most proteins can be grouped in two main classes :

i. Structural proteins are the main components of the framework of several cellular structures as cell membranes, chromosomes etc. They provide tensile strength to the cell-structure being in the form of fibrous threads.

ii. Functional proteins include enzymes and hormones and regulate all metabolic activities occurring inside the cell.

2. Carbohydrates are composed of carbon, hydrogen and oxygen, the last two being in the ratio of 2 : 1. Simple sugars, double sugars and multiple sugars are three main types. Starch is a compound of 24 to 26 molecules of glucose (which is itself a simple sugar). It is in this form that carbohydrates are found in plants.

1. Estimated number of different varieties of proteins in a human body is more than 100,000.

Carbohydrates are the primary source of energy for living organisms. Some are stored as food, starch being the vegetable kingdom's major food storage product. Some form the structural frame work, cellulose being the major structural component in the walls of the plant cells.

3. Lipids (Fats) are the compounds made up of carbon, hydrogen and oxygen but unlike carbohydrates, hydrogen and oxygen are not in the ratio of 2 : 1. They are insoluble in water.

Fats are extremely good sources of energy; in animals they form reserve food besides glycogen; hormones which are steroids (a type of fat), regulate several physiological activities of animals.

ENZYMES AND THEIR ACTIONS

In plants as well as animals, thousands of chemical reactions taking place at a relatively low temperature level and enzymes are the substances which take the place of high temperatures. Enzymes are the most important chemicals in the cells which are synthesized by them as ordered by its nucleus. Even though they catalyse the production of so many substances, they cannot make themselves.

They consist of proteins with or without some other compound. They are effective in minute concentration and they act as catalysts, i.e., bring about chemical changes without themselves undergoing any change. They are specific in action. Many enzymes catalyse only a single chemical reaction with a particular set of reactants and do not act even on similar compounds—For example, the carbohydrates work on carbohydrates only, the lipases react with the fats only and the proteases react with the proteins only. This specificity is related to the configuration of both the enzyme itself and the substance upon which the enzyme works, in much the same way as the indentations of a specific key fit into the lock for which it is made. Some act only in alkaline medium, some in acidic and others in neutral medium; most of them are intracellular; some digestive enzymes are extracellular; they are destroyed at temperatures above 70° C.

NUCLEIC ACIDS (DNA AND RNA)

Nucleic acids are perhaps the most interesting of all molecules in a living cell, because they are capable of reproducing themselves, just like any other living organism. They occur both in the nucleus as well as in the cytoplasm. They are of two kinds, Deoxyribose nucleic acid or the DNA, and Ribonucleic acid or the RNA. Both occur in the chromosomes while several kinds of RNA occur in the cytoplasm.

The chromosomes have two functions :

i. They carry the genes which carry the hereditary characters from parents to offspring and

ii. They are involved in the synthesis of proteins (enzymes) which are required through the life of the living organisms. The entire process of protein synthesis from instruction from genetic code to assembly is carried out by these two nucleic acids.

The DNA molecule is composed of three kinds of substances,

i. A five carbon sugar known as deoxyribose

ii. A phosphate and

iii. Nitrogenous bases of two kinds, purines and pyrimidines. The purines of DNA are of two kinds—adenine and guanine, while the pyrimidines are also of two kinds, cytocine and thymine.[1]

Functions of the DNA molecule :

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1. To imagine a DNA molecule think of a ladder. Each upright member of this ladder is made of molecules of sugar (deoxyribose) alternating with phosphate groups. The rungs, i.e., the steps connect opposite sugar groups. Each rung is made of two parts which meet near the centre. These parts may be of four kinds of bases, adenine, thymine, guanine, and cytocine or briefly, A, T, G, and C. These bases can pair to form a rung in one way only viz.,

A can pair with T and vice-versa.
C can pair with G and vice-versa
A and C or G and T cannot.

Now imagine further that the ladder if twisted and you have the celebrated model of the double spiral of DNA molecule. The structure was first described by Watson, Crick and Wilkins in 1953.

(i) **The Genetic Code :** The DNA molecule contains all the information required to make the particular protein molecule. This information exists in the form of a code known as genetic code.

(ii) **Duplication :** The molecule splits along the centre like a zip fastener and each base separates from its partner. Now there are two strands each composed of a 'back bone' of sugar and phosphate with a number of half rungs or bases exposed to the surrounding fluid. Now each strand can gather the bases required to pair with its own (complementary bases) and then the sugar and phosphate as well. From one we can thus have two molecules. This duplication of DNA leads to the doubling of chromosomes for cell division.

The RNA molecule is regarded as a sister molecule to DNA. It differs from DNA mainly in : it is single stranded; the sugar in the upright member is a ribose and not deoxyribose; instead of thymine, it has uracil (U) which pairs with adenine; the other two bases are the same.

Functions of the RNA molecule :

(i) carry message from DNA

(ii) transfer the required amino acids to the ribosome.

(iii) to assemble the protein molecule.

Thus if the DNA is the architect making blue prints, the RNA is the contractor who builds according to the blue prints.

THE STEADY STATE OF LIFE : HOMEOSTASIS

Biologists regard that they can describe nearly all living phenomena in the same terms as non-living. Living organisms contain no special elements but are made out of some 16 of the 92 elements that occur naturally on earth. Not only are these elements a very special set but they are combined together to make molecules more complicated than any others known in the universe. This does indeed point to life as 'peculiar' or 'extraordinary.'

The large molecules, described above, are organized into living organisms, which are not closed systems in equilibrium but in a steady state of continual interchange with the environment, maintained only by continual intake of fuel and expenditure of energy. The great extent of these interchanges has been recognized only since atomic physics made radioactive isotopes available for biological experiments. Thus there is a special form of carbon (14° C) not usually present in carbon compounds except in minute amounts, which has chemical properties identical to normal carbon (12° C) but can be readily identified by the radiation it emits. If we make a lump of sugar with this 14° C and when it is eaten then follow it as it goes through the stomach and intestines, into the blood and from there perhaps to muscles where it acts as fuel and is 'burnt' when the muscles contract. Before long, it will be breathed out of the lungs as radioactive carbon dioxide, perhaps only an hour or two after it was eaten.

By similar methods it can be shown that in most parts of the body there is a quite rapid 'turnover'. The stuff of the cells does not remain the same for long but is broken down and eliminated, its place being taken over by new molecules. And in many tissues the cells themselves live for only a few days and are then replaced. So living consists as it were of a continual death and rebirth. And yet as all these interchanges go on, the integrity of the whole is preserved. This process of self-maintenance is called HOMEOSTASIS. Thus homeostasis is the essential property of life. A living organism is continual expending energy to prevent the dissolution of its body, which would inexorably follow as it does in all non-living systems. What is it then that prevents this from happening ? Surely, there must be some unique principle at work, a vital force that flies away when the organism dies.

But Biologists are not prepared to accept that living depend upon some special non-physical agency or soul.

Can science meet this challenge when it does not yet know for certain how life arose, nor can it make life without the assistance of previously living matter?

CLASSIFICATION

Since we have to deal with hundreds of thousands of different varieties of living organisms, the systematic study demands an efficient and fool-proof system of classification , i.e., arrangement of all varieties (of animals and plants) in a series of groups). Both Biology and Scriptures, have their own systems of classification.

Living organisms which inhabit this earth exhibit a great variety of form, size, and structure. Plants range from simple algae (microscopic water plants) and fungi to huge trees like banyan and pines; while animals range from simple protozoa (a single—cell led microscopic organism) and sponges to elephants and whales. In order to understand such diverse groups of plants and animals, it is necessary to group or classify them in a logical system. The branch of biology which deals with classification, identification and naming of plants and animals is called taxonomy.

UNITS OF CLASSIFICATION

The basic unit is the SPECIES, e.g., housefly, musca domestics, and similar species are grouped into GENERA, (sing. Genus) e.g. Musca is the genus, and the domestica is the species.

1. SPECIES: A species is a group of organisms which resemble each other in all important characteristics. The members of a species are capable of inter-breeding, e.g., all varieties of mango plants, (or all varieties of roses or all races of human beings) belong to the same species. Variations in size, shape and colour form varieties. A species may consist of several varieties or none at all.

2. GENUS: A genus is a group of similar and related species. Thus orange, lemon and grape fruit which belong to different species are grouped into a genus Citrus; similarly, lion, tiger, and the common cat, are grouped into a genus—Felis.

3. Similar genera are grouped into Family,

4. Similar families are grouped into Order,

5. Similar orders are grouped into Series,

Thus, Series under a Class, Classes under a Division and several Divisions form the Plant Kingdom.

In animal classification—

6. Similar classes are grouped into PHYLA (sing. PHYLUM)

BINOMIAL NOMENCLATURE

In classifying a plant or an animal, it is necessary to label it by some name. Normally a plant or an animal is known by its local or popular name which differs from place to place. Therefore, Carolus Linnaeus, a Swedish naturalist, introduced a system of binomial nomenclature. According to this system, every plant and animal is given a double name first its generic (GENUS) and second its specific (SPECIES). Its application by Linneeus in 1753 to plants and in 1758 to animals is now followed universally.

FORM, STRUCTURE, AND CLASSIFICATION OF PLANTS

The main organs of a plant are: root, stem, branches, leaves, flowers, fruits and seeds. Of these root, stem and leaves carry out functions like nutrition and growth and are called vegetative organs while flowers, fruits and seeds are reproductive organs.

1. ROOT

The root is the descending organ which grows towards the soil and fixes the plant to the soil from which it absorbs nutrition for the plant. The primary root grows downwards to form the main root called the tap root. From the main root are produced lateral roots—secondary roots— which branch further into tertiary roots. All these form the tap root system. Roots that grow from any part of the plant other than the radicle are called adventitious roots.

The normal functions of a root are :

i. to fix the plant firmly to the soil

ii. to absorb raw food material (water & minerals) from the soil through the root hairs.

Many roots store food in the form of carbohydrates. They assume definite shapes, as in carrot, beet etc. When adventitious roots store food, they are called tuberous roots as in potato etc.

Some adventitious roots arise above the ground from the stem and are called aerial roots. Some of them are : clinging or climbing roots; stilt or prop roots; columnar roots—as in a banyan tree.

Epiphytic roots : Plants which grow on other trees without taking any food from them are called epiphytes. Their roots grow into spaces of the host tree and fix the epiphyte to it. Some roots hang freely in the air and obtain nutrition from the atmosphere.

Parasitic roots or Haustoria : Plants which not only grow upon other plants but take food from them by sending sucking roots called haustoria (haurire—drain), are called parasites. Total parasites obtain all their food from the host plant, while partial parasites take only water from it but prepare their food with the help of green leaves. They are attached to the roots or the stem of the host tree. [Note : compare this with *vṛkṣayonika*' trees as described in *Sutrakṛtāṅga Sūtra*].

In some plants—beans, peas, etc.—soil bacteria (Rhizobium) enter the root and fix the free nitrogen of the air and make it available to the plant. In return, the plant supplies food and shelter to these bacteria. This relationship is called symbiosis.

2. STEM.

During germination of the seed, the plumule, which grows above the soil and forms stem, the ascending axis of the plant, and with leaves and branches constitutes the shoot. The stem develops branches, leaves, and flowers. In most plants stems stand erect. But when they are thin and long they develop :

i. tendrils and with their help climb up;

ii. or coils round a support

iii. or trail along the ground as grasses

iv. or grow underground as in potato, ginger etc.

The stem—supports branches and leaves, conducts nutrition from roots to different parts and produces flowers, fruits and seeds. Sometimes it takes the function of leaves and turns green as in cactus. In some plants stems go underground as in ginger, potato etc. Bulbs of onion and garlic are modified stems.

3. LEAF

Leaf is a green, flat, lateral, outgrowth of the plant. Leaves develop on acropetal succession from the stem, i.e., older leaves at the base and younger ones at the top. In general, leaves are modified stems designed primarily for the manufacture of the initial food substances. They vary greatly in size, shape and arrangement on the stems. Despite this variation, all leaves have three tissues in common:

a. protective cells to keep water within the leaf and guard cells and stomates to allow CO_2 and O_2 diffusion in photosynthesis and respiration ;

b. chlorophyll-contain cells to manufacture the initial food substances; and

c. veins to translocate water and raw materials to, and manufactured compounds away from, the manufacturing cells.

The main function of leaf is photosynthesis and transpiration. Pinnately compound leaves look like feathers with a central axis and leaf lets borne in two rows one on either side. Palmately compound leaves bears leaflets at the tip of the petiole (leaf stalk). The secondary functions of leaves are, viz., support, storage (as in the bulb of an onion), protection, vegetative propagation, and attraction.

Insectivorous plants have their leaves modified into traps for catching insects.

4. FLOWER

An individual flower consists of groups of modified and highly specialized leaves arranged concentrically, designed specially for the purpose of reproduction. These groups of modified leaves are :

(1) sepals which protect the delicate stamens and pistils when the flower is in the bud stage;

(2) petals which attract pollinating insects;

(3) stamen which consists of a stalk and a pollen sac called an anther which produces pollen which in due course contains pollen grains. (For this reason the stamens are called male sex organs of the plant);

(4) pistil which consists of an ovary, style and stigma; the ovary produces one or more ovules which in due course contains, with other cells an egg. (For this reason the pistil is called the female sex organ of the plant).

A plant develops flowers after it has attained maturity in its vegetative parts. It has two parts, the pedicel or the stalk and the thalamus or the swollen tip with the floral parts.

Many flowers possess bright colours, perfume and nectar (sugary liquid) to attract insects for pollination.

Gynaecium or Pistil is the female reproductive whorl which is made up of three parts, stigma, style and ovary. The stigma receive the pollen grains; the style is the tubular stalk which connects stigma to the ovary which is the swollen basal part formed by the union of one or more carpels which are formed like chambers. A pistil may have only one carpel or two or more. Within each carpel are seen one or many ovules, each arising along the projection called placenta. The ovule attaches to the placenta by a short stalk. In the ovule is an embryo sac with an egg or the female gamete. During fertilization, one of the male gametes from the pollen fuses with the egg.

The flowers which contain all four of the main parts are called complete flowers while others are called incomplete flowers.

One of the most conspicuous features of the plant kingdom to the layman and botanist alike is the infinite variety of size, form, and behaviour of its members. Plants vary in size from structurally simple, microscopic organisms such as bacteria, some of which are only 1/2 micron long by 1/

5 micron wide to seaweeds which may be several hundred feet long, and California redwoods, some of which attain heights of over 350 feet, diameters of 30 feet and weights of 2100 tons (these redwoods are the tallest known land plants). In most cases, each species has a characteristic average size range, but plants are exceedingly susceptible to environmental conditions and individuals are often larger or smaller, depending upon the nature of surroundings in which they have grown.

The forms of plants vary even more than do their sizes. As we shall presently see, there are 340,000 distinct species with numerous varieties. Each species has its own characteristic habit of growth, shape of leaves, method of branching, form, and colour of reproductive structures and other peculiarities which give it a personality of its own. Some plants are trees, others are woody vines, some are herbaceous (soft-stemmed) vines, still others are erect herbs. Some have large leaves, some have small leaves, some have leaves with toothed or otherwise indented margins, while some are with smooth margins. Some have no leaves but consist entirely of stems, roots, and flowers; others have simple bodies not differentiated into roots, stems, leaves or flowers.

Some plants (desert plants for example) grow very slowly, so slowly that any increase in heir size is noticeable only if they are examined at intervals of several years. In tropics, however, growth frequently proceeds at incredibly rapid rates. These are extremes. All green plants manufacture sugar by the process of photosynthesis, but they utilise this sugar in different ways. Some convert them into fatty substances which they store in their tissues; others transform them into starches as storage of foods. Some plants elaborate large quantities of organic acids—citric acid in lemons and oxalic acid in rhubarbs. Some manufacture aromatic oils—dill, caraway, spearmint, sassafras, lavender, peppermint etc.

Another physiological difference among plants is found in their longevity. Bacteria live for 20 or 30 minutes and form two new organisms, which in turn form offspring of their own. At the other extremes of age are certain coniferous trees, such as California redwoods which attain ages over 3000 years. Many wild and cultivated plants are annuals, which live but a singlegrowing season, some are biennials, which live through two

seasons and others are perennials which continue to grow for many years. Trees and shrubs are perennials.

Plants vary, moreover, in their methods of reproduction and in the structure and development of their reproductive organs. Plants are classified in groups to indicate something of their evolutionary positions and their mutual relationships. Reproductive organs and processes, being more stable than roots, stems and leaves, they are the principal criteria of systematic arrangement. Earlier attempts at classification were largely artificial. The more nearly natural systems have grown mainly within the last century.

The most nearly natural system of classification is the division of the plant kingdom into two subkingdoms— "THALLOPHYTA", i.e., plants not forming embryos (algae, fungi) and "EMBRYOPHYTA" i.e., plants forming embryos (mosses to angiosperm). We shall deal with all these in detail in succeeding sections.

More than 340,000 species of plants have been identified under different conditions. The plant kingdom is divided into two groups;

A. **Cryptogams**, lower plants without flower and seed

B. **Phanerogams**, higher plants with flowers and seeds

A. **Cryptogams** are divided into three divisions :

1. Thailophyta—(thailes—a young shoots phytonplant).

Simplest of all plants since plant body is not differentiated into root, stem and leaf and is called the thallus. They are divided into four groups :

(i) Bacteria, the simplest living organisms. They are unicellular and without chlorophyll.

(ii) Algae possess chlorophyll and are able to manufacture their own food by photosynthesis. They mostly grow in water.

(iii) Fungi lack chlorophyll hence they live as parasites. Fungi like penicillum and yeasts have been put to the benefit of mankind.

(iv) Lichens are associations of an algae and a fungus living together, former preparing food while the latter absorbing water and minerals. They grow on tree trunks and other moist places.

2. Bryophyta—they develop root like structures called rhozoids. Their life cycle shows alternation of generations;[1] the main plant is a gametophyte[2] on which the sporophyte[3] (asexual stage) grows as a dependent body, e.g. Mosses with the stem axis bearing leaves. [cf, plants growing on plants (*vṛkṣayonika*) in *Sūtrakṛitāṅga Sūtra*]..

3. Pteridophyta (pteros=fern). The plant body is with roots stem and leaves, highest group of cryptogams. The main plant is a sporophyte while the gametophyte is very small.

B. **Phanerogams** are the most advanced type of plants with flowers and seeds. They are divided into two sub-divisions:

1. **Gymnosperms** (Bymno=naked, sperma=seed). They possess simple, unisexual flowers. The seeds Are not enclosed in the fruit hence they are naked seeds e.g. pines

2. Angiosperms (Gr. angion - case). They are the most highly advanced group of plants, commonly referred to as flowering plants. The

1. An important feature of life and reproduction, obvious in many plants and a few animals, e.g., COELEHTERATA and flatworms. It is seem as the successive alternation of 2 or more types of a single organism. It is most important where the basis of the alternation is the number of sets of chromosomes in the cell nucleus; an individual with two sets (DIPLOID generation) creates another with 1 set (HAPLOID generation) which then gives another diploid generation. The two generations may, or may not, look alike but reproduction is different. The haploid generation produces sexual cells that fuse to start the diploid generation which later, during the production of spores, reduces the number of chromosome sets to 1 again; e.g., in ferns diploid sporophyte is the typical plant, haploid sexual gametophyte is a small button-sized flat green THALLUS.

2. Plant body in which each cell has a haploid cell nucleus and which produces sex cell (gamets) for fusion.

3. Plant body in which each cell has a nucleus with 2 sets of chromosomes (diploid) and which can produce reproductive spores with only one set of chromosomes (haploid). The familiar body of seed plants, ferns and others but not that of mosses.

flowers are complex and the seeds are enclosed in the fruit. They are divided into two classes :

(i) Monocotyledons—the group) with one colytedon in the embryo of the seed.

(ii) Dicotyledons—the group with two colytedons in the embryo of the seed.

Monocotyledons Are further divided into seven series, while Dicotyledons, being the larger group are divided into three sub-class-es each of which is further divided into various series. Each of the series is again divided into orders and the order into families and so on. In the flowering plants study of the family is considered most important.

Of the 342,000 species of plants on record, the following is the rough distribution :

Thailophyta	—	110,000 species
Bryophyta	—	22,300 species
Pteridophyta	—	10,000 spec ies
Gymnosperms	—	700 species
Monocotyledons	—	40,000 species
Dicotyledons	—	159,000 species

From the above, it is seen that angiosperms constitute, 199,000 i.e. 60% of total species of plants.

FORM, STRUCTURE AND CLASSIFICATION OF ANIMALS

The animal kingdom is divided into ten major groups called phyla (sing.—phylum). One of these groups is of CHORDATES and the remaining ones are NON-CHORDATES.

The group CHORDATA is considered as a phylum and is divided into four sub-phyla, of which only in one group, the notochord (a stiff rod of cells below the tubular nerve and above the alimentary canal distinguishing **Chordates** and **Non-chordates**) gets replaced by the

development of a vertebral column or back bone (e.g. mammals, birds, fish, frogs and reptiles) and they are classified as VERTEBRATA. The others are considered as lower chordates or protochordates. Thus INVERTEBRATES include all non-chordata and lower chordates.

Some of the main characteristics of Vertebrata are :

Possession of back bone formed of a chain of vertebrae; presence of a skull (cranium) enclosing the brain; possession of brain and spinal cord; presence of red blood cells with haemoglobin; presence of lungs or gills for respiration; sexes are always separate.

A more up-to-date and convenient method of classifying the animal kingdom is to divide it into:[1]

1. Sub-kingdom : Protozoa—organisms with a body which is not divided into cells; they are ACELLULAR

2. Sub-kingdom : metazoa—organisms with a body sub-divided into number of cells; they are multicellular.

1. The following is the schematic diagram of classification :

ANIMALIA

PROTOZOA — METAZOA

1. Phylum : Protozoa

Branch — 1 PARAZOA — Branch — 2 ENTEROZOA

2. Phylum : Porifera
3. Phylum : Coelenterata
4. Phylum : Platyhelminthes
5. Phylum : Hemathelminthes
6. Phylum : Annelida
7. Phylum : Arthropod
8. Phylum : Mollusca
9. Phylum : Echinodermata
10. Phylum : Chordata

Sub-phylum : Vetebrata

- (i) class : Pisces (Fishes)
- (ii) class : Amphibia (amphibians)
- (iii) class : Reptilia (reptiles)
- (iv) class : Aves (birds)
- (v) class: Mammalia (mammals)

1. Phylum Protozoa :

The cell of these unicellular animals possesses contractile as Well as food vacuoles. Digestion is intracellular, i.e.., within the cell. The locomotion is achieved either by temporary pseudopodic as in amoeba or by whiplike flagella as in Euglena, or by cilia (hair-like processes) as in paramoecium. Reproduction is normally asexual by binary or multiple fission. Examples : Amoeba, found in the mud of ponds; no definite shape just a mass of protoplasm bounded by a thin membrane with a nucleus in the centre; contractile vacuole is excretory in function.

Paramoecium (slipper anmalcule) has an unchanging and definite slipper-like shape; there are two nuclei—a small one surrounded by a larger one; towards either end of the body there is a contractile vacuole surrounded by a few radiating canals; found in fresh water with decaying vegetation.

Euglena contain chlorophyll as in plant cells (botanists regard them as algae). Due to the lashing movements of the flagellum it moves in water.

2. Phylum Porifera :

All the sponges are included in this phylum; aquatic animals mostly marine; though multicellular are incapable of any movement; cells are not organized into tissues and organs. There is neither a mouth nor a digestive tract; reproduction is asexual (by budding or by formation of gemmules) and sexual.

3. Phylum Coelenterata :

Hydra, Jelly fish, Sea-anemone, and Corals are some examples of this phylum. They are aquatic, mostly marine, multicellular and radi-ally symmetrical animals; they exist in two forms—(i) a tubular body having anterior mouth or (ii) an umbrella shaped body with tentacles. There is a nervous system in the form of a nerve net formed of scattered nerve cells (protoneurons) and joined together by nerve processes. Reproduction is by asexual method (budding and fusion) and also by sexual method.

4. Phylum Platyhelminthes :

This includes liverflukes, flat worms (planarians), tape worms etc.; neither the vascular nor the respiratory system is present; the excretory system end in characteristic flame cells; digestive system is incomplete with a mouth but without anus; nervous system comprises of a nerve ring, nerve ganglia and nerve cords; reproductive system is well developed and both the male and female organs are present in the same individual. Some are free living, others are parasitic, the latter pass through several intermediate development stages and live in the bodies of other animals during their life-history.

Liverflukes are parasitic and found in the liver and bile ducts of sheep, cattle etc. and occasionally in men, producing disease called 'liver rot'. Tape worms are parasitic in the digestive tracts of vertebrate animals, including men. They are long, flat, ribbon-like worms.

5. Phylum Nematoda (Nemathelminthes) :

These are unsegmented round worms. There is a complete alimentary canal with a mouth and an anus; circulatory and respiratory systems are absent; nervous system is in the form of a nerve ring; sexes are usually separate. Many are parasitic in animals and cause serious diseases. There are many types as : Ascaris, common intestinal parasite, 12 to 27 cms. in length; Guinea worm causes disease in men called 'naru'; is thread-like and is as long as 90 cms.

6. Phylum Annelida :

These are referred to as the true worms; they are triploblastic, bilaterally symmetrical animals; most of the organs are repeated in all of a large number of segments; digestive tract is complete; circulatory system is of the closed type; respiratory pigment—haemoglobin is dissolved in the plasma; excretory organs are in large numbers in most segments; nervous system consists of a ganglonated nerve cord connected to a pair of ganglia (brain). Many of them have the capacity of regeneration when cut into pieces. Some common exam-ples : Earthworms—mostly found in damp soil amongst decaying vegetation; cylindrical body is

divided into 120-125 segments; they are bisexual. Leech—mostly live in fresh water; some of them are blood-sueking ectoparasites on other animals including men. A medici-nal leech (Hirudo) is used occasionally to suck blood from inflamed parts

7. Phylum Arthropoda (Arthron = joint; Podus = foot) :

This is the largest phylum in the animal kingdom. The number of species here are more than the total number of species of all the rest of phyla put together. They live in oceans, fresh water, lakes, ponds and rivers. They are also found on land. Some are parasitic on animals and many of them lead an aerial life. Some of them form food while some destroy valuable food as pests and some convey diseases. They are tripoblastic, bilaterally symmetrical segmented animals

The head bears sense organs like the antennae and the eyes. The digestive tract is complete and the mouth has lateral jaws. Respiration is by gills, tracheae; both lungs or through the body surface depending upon the habitat of the animal. The blood vascular system is of an open type with a dorsal heart having valvular openings. The nervous system consists of a pair of dorsal cerebral ganglia or brain. The sensory organs are the antennae, simple or compound eyes, auditory organs (as in insects) and a balancing organ. The sexes are usually separate.

The arthropoda includes—crabs, lobsters, crayfish, prawns, centipedes, millipedes, scorpions, spiders, and mites. Being a very diverse group it is divided into four classes :

(a) **Crustacea** — aquatic animals as crabs and lobsters;

(b) **Insecta** — body is divisible into head, thorax and abdomen; three pairs of legs and two pairs of wings; examples : cockroach, butterfly, house fly etc.

(c) **Arachnida** — include spiders, scorpions, king-crabs, ticks and mites.

(d) **Myriapoda** — centipedes and millipedes are included in this.

8. Phylum Mollusca :

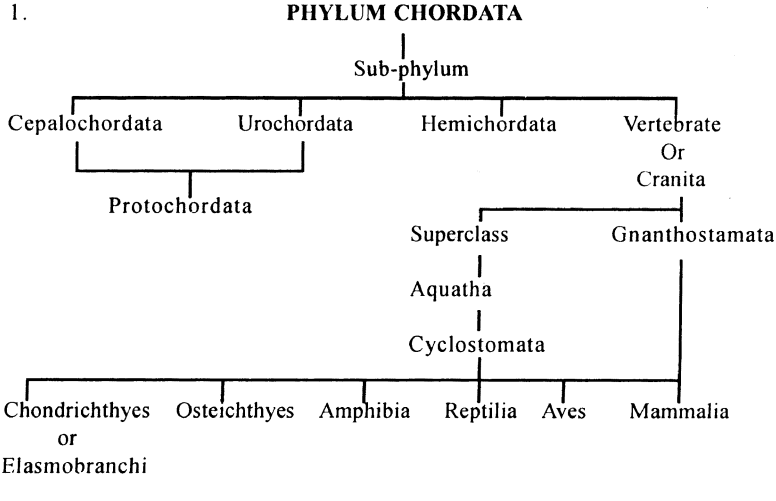
They usually possess a shell of calcium carbonate; unsegmented body is divisible into head, foot and visceral mass. The digestive tract is complete; the circulatory system is almost always well developed and a dorsal heart; respiratory organs are galls or ctenidia or it is by mantle; excretion is by kidneys; nervous system consists of the cerebral pair in the head, pedal pair in the foot, and visceral in the body region. Sexes are usually separate but some are bisexual. Examples of Mollusca—snail, mussel, oyster, cuttle fish and octopus.

9. Phylum Echinodermata (spiny skin) **:**

All the members belonging to this phylum are exclusively marine. Most of them have an endoskeleton of plates of calcium carbonate embedded in the body wall with protruding spines.

Locomotion is by water vascular system; digestive tract is simple and usually complete; circulatory system is radiate, but reduced; respiration is by means of gills, by tube feet etc.; nervous system "has a circular oral nerve ring and radial nerves; sexes are usually separate, alike externally; a few reproduce asexually) by self-division and many generate lost parts. Examples—Starfish, brittle star, sea urchin, sea-cucumber (holothurian).

10. Phylum Chordata[1] **:**



The sub-phylum vertebrata is divided into five classes;

(a) Fishes, amphibians, reptiles, birds and mammals.

Fishes are aquatic vertebrates with fins as locomotor organs and gills as respiratory ones; cold-blooded, i.e., body temperature varies with the ambient. Body is streamlined; ten pairs of cranial nerves present; skin covered with scales; heart is two chambered and contains only deoxygenated blood; red blood cells are nucleated.

There are two subclasses—

(a) Cartilaginous fishes as sharks, sting ray, and saw fish; and (b) bony fishes as seahorse.

(b) **Amphibians** lead a double life, living equally well on land and water; cold blooded with two pairs of limbs (the caecilians Are without limbs and the sirens have only the hind limbs. They are mostly oviparous and their development often involves metamorphoses, involving an intermediate larval form. Examples: frogs, toads, salamander and newts.

(c) **Reptiles** are cold blooded air breathing vertebrates which have adapted themselves completely to land. Some, however, have secondarily taken to water; normally two pair of short limbs with claws, but in some, they are reduced, modified or lost (as paddles in turtles, lost in snakes). There are 12 pairs of cranial nerves; most are oviparous, snakes are viviparous, no metamorphosis.

Examples : turtles and tortoises, (former are aquatic); lizards (garden, wall, flying); chameleons ; snakes—cobra, krait, and vipers are the common poisonous snakes; rat snake and pythons are non-poisonous snakes; crocodiles and alligators.

(d) **Birds** are warm-blooded, adapted to aerial life; streamlined body covered with feathers; fore limbs are modified as wings for flight, hind limbs are used for perching, walking or swimming; some are incapable of flight (running birds—ostrich and kiwi. Flying birds are—pigeons,, ducks (aquatic), parrots, kites, owls (nocturnal).

(e) **Mammals** the highest group in animal kingdom; warm-blooded and terrestrials, a few have become secondarily aquatic and some have become aerial; have many glands (sweat, scent) including the mammary glands in females which secrete milk for nourishing the young; ears have external pinna, eyes have eyelids; heart is 4-chamber; respiration is by lungs only; Cerebral hemispheres are well developed reaching their maximum in human beings; male has a copulatory organ—the penis; fertilization is internal, the embryo is connected to the wall of the uterus by the placenta and are viviparous. Examples: rabbits, rats, bats, squirrels, guinea pigs, cattle, horses; cats—lions, tigers; dogs—wolf, foxes; elephants, giraffes, dolphins, whales, etc. and humans.

NUTRITION

Life cannot exist without a source of energy. Without energy plants could not grow and man could not work. Plants use the energy of sun to make foods and man uses the energy in foods to perform his various activities.

All living organisms require a constant supply of energy for their day-to-day activities; to make good the wear and tear of tissues and also to add to the protoplasm, the material necessary for growth. A constant supply of energy is needed in much the same way a steam engine must have a continuous supply of steam. If steam was not available, the engine would not operate.

This energy is obtained from food which includes proteins, carbohydrates, fats, vitamins, water and various inorganic salts. These are referred to as nutrients. Water and mineral salts are inorganic compounds and the rest are organic.

Nutrition involves mainly four steps:

1. Ingestion or intake of food,
2. Digestion or conversion to a simpler form,
3. Assimilation or extraction of energy from the food, and
4. Egestion or excretion of waste matter.

Different organisms have different modes of nourishment:

(a) **Holophytic nutrition** — found in plants having chlorophyll.

In this process the organic material is synthesized out of inorganic raw substances like CO_2 and water in the presence of sunlight and chlorophyll. This type of nutrition is also seen to some extent in lower animals, like Eugena.

(b) **Holosoic nutrition** — takes place in animals in which complex organic food is ingested and sent to digestive system for digestion.

(c) **Saprosoic nutrition** — is one in which the organisms depend upon decaying organic substances which are usually absorbed through their body surface.

(d) **Saprophytic nutrition** — occurs in lower plants without chlorophyll e.g. yeast, bacteria, mucor etc. They absorb the decaying organic food material from their sorroundings.

(e) **Parasitic nutrition** — in which the organisms (either plants or animals) depend upon the prepared food of other organisms (called hosts) for their nourishment (e.g. tapeworm in animals and cuscuta in plants are parasites.)

In hydra (a fresh water multi cellular polyp), digestion occurs within a gastro-vascular cavity—coelenteron. Digestion is both extracellular and intracellular.

In humans, digestion occurs in the mouth, stomach and small intestine where a variety of digestive juices containing enzymes act on the nutrients.

In birds, special organs called the crop and the gizzard are involved in digestion.

In ruminants (cow, sheep), the stomach is four chambered viz., rumen, reticulum, psalterium, and abomasum.

REPRODUCTION

Reproduction is one of the chief characteristics of both plants and animals. It is one of those terms easily understood, but hard to define. When an animal or plant, is produced which is a numerically different individual from the parent or parents from which it originated, reproduction can be said to have taken place. More precisely, reproduction is the ability of living organisms to produce new organisms identical with themselves. In this context, a living organism means either an individual or a part but not at the molecular level. (Reproduction at the molecular level is known as replication). Reproduction also implies the transmission to the offspring of a code which will enable it to reproduce itself with precision in its turn.

When reproduction involves production of specialized cells which usually fuse as a prelude to the development of a new individual, such specialized cells are called gametes and the type of reproduction as SEXUAL or gametic. Reproduction without the involvement of gametes is called ASEXUAL or vegetative. It should be noted that while botanists restrict the term asexual to mean reproduction by means of spores, zoologists use the term to mean any method other than sexual. Generally speaking, asexual reproduction is characteristic of evolutionarily primitive organisms and sexual reproduction of those highly evolved. The reason for this will be explained in due course; for the present, let us review the various types of reproduction met with in plants as well as animals.

CELL DIVISION IN REPRODUCTION

Cell division is essential for both sexual as well as asexual reproduction. It is also the process by which old and dying tissues are replaced. The zygote[1] is the first cell, which divides to form the embryo. The embryo then repeatedly divides to form the adult. Up to this point, cell division is of one kind only viz., Mitosis. When a cell divides by mitosis into two daughter cells, each of them inherits not only the same number of chromosomes as the parent but also the same number of cytoplasmic contents as well which means that the cell, first doubled itself internally before dividing into two.

1. Cell which results from fusion of 2 sex cells (gamates) prior to division and further development.

The zygote contains chromosomes in pairs. One of each pair is from the male parent and the other from the female (homologous chromosomes). Such cells are called diploid. All the vegetative or the body cells produced by mitosis contain the same number of pairs as the zygote. In the humans, there are 23 pairs, in the onion, there are 8 and in maize, there are 10 pairs.

Adult cells at some time, produce sexual cells or gametes which unite to form a zygote. Gametes must therefore have only half the number of chromosomes so that the union of two gametes derives the diploid number characteristic of its species. Gametes are formed from special body cells which usually divide to form four gametes each and each gamete has only half the number, one of each pair (haploid), as the mother cell. This kind of division is called Meiosis. Thus it is made of two successive divisions. The halving of the chromosomes number takes place during the first division only, the second one being similar to the usual mitosis.

Important Features of Mitosis

i. The daughter cells are quantitatively and qualitatively identical to the parent cell.

ii. The chromosome number for a species thus remains same in each cell.

iii. In most plant cells a new wall plate is formed from the centre outwards. Animal cells separate by constriction.

Important Features of Meiosis

i. It originates only in diploid cells.

ii. It always consists of two successive divisions, the first a reduction division and the second an equational division. During first, the two homologies of each pair of chromosomes are pulled away to the two opposite poles. During the second, the daughter chromatics are pulled away to the two opposite poles.

iii. The number of chromosomes is reduced to half, i.e. haploid. The haploid nucleus contains only one member from each pair of homologous.

Thus each gamete contains only one or the other member of two homologous chromosomes and never both together.

iv. The haploid nucleus may contain all paternal chromosomes or all maternal chromosomes or a mixture of both. In the last case, there is a shuffling of paternal and maternal chromosomes.

v. Due to crossing over, each chromatid (which becomes a chromosome) is a mixed chromatid containing a segment of the other chromatid.

Significance of Meiosis :

i. Haploid number of chromosomes resulting from meiosis ensures the diploid number in the zygote and subsequent vegetative cells. Hence a constancy in the number of chromosomes is maintained in the species.

ii. Meiosis induces a very large number of variations, firstly by assortment of maternal and paternal chromosomes and secondly by cross-over. This is one of the ways by which variations are produced. Variations are the raw materials for evolution.

REPRODUCTION IN PLANTS

In Botany, reproduction is generally referred to as propagation. The principal methods of reproduction in plants are also asexual and sexual as in animals.

Asexual Reproduction :

In plants, asexual propagation involves reproduction from vegetative parts of plants and is possible because the vegetative organs of many plants have the capacity for regeneration. Stem cuttings have the ability to form adventitious roots. Root cuttings can regenerate a new shoot system. Leaves can regenerate both new roots and new shoots. A stem and a root (or two stems) can be grafted together to form a continuous vascular connection and a new plant. In short, a new plant can start from a single cell. Any living cell of the plant appears to have all genetic information needed to regenerate the complete organism so that the new

individual is just like the mother plant and it possesses all the characteristic of the plant from which it has been collected.

The advantages of asexual propagation are that it is necessary to grow important plants that produce no viable seeds, such as banana, pineapple, oranges and grapes. Even when viable seeds are available, many crops, if propagated by seed, would not resemble the parents which produced the seed. For example, if seed from a Delicious or Baldwin apple is planted, the apples from such trees would be quite unlike those of the parent and vary greatly in size, shape, colour, and quality, season of maturity, keeping quality, chemical composition, taste and other characteristics. On the other hand if a vegetative bud from a Baldwin tree is grafted, the new tree would bear apples exactly like those of the parent tree. Thus the unique characteristics of many cross-pollinated fruit trees, such as apple, peach, mango etc., can be maintained only if vegetative means of propagation is used. Some plants grown from seed have a long juvenile stage. During this time, the plant not only fails to produce flowers or fruits, but may exhibit some undesirable morphological features. To impart hardiness against diseases, pests and unfavorable climatic conditions, budding and grafting are adopted.

There are certain disadvantages also. No new varieties can be evolved; vegetatively propagated plants are comparatively short lived.

Methods of Vegetative Propagation

Plant parts such as stems, roots and leaves are used for vegetative propagation of plants. Naturally detachable structures such as bulbs or corms are separated and planted individually while rhizomes tubers etc. are cut into sections to obtain new plants from each section.

1. Bulbs:- Most of the bulbous plants produce buds which continue to grow forming daughter bulbs. These can be separated and used as propagating material.

2. Tubers and Tuberous Roots:- An individual tuber is a short, thick fleshy underground stem with scale-like leaves subtending nodes, commonly called eyes, e.g., tubers of the potato. Adventitious shoots develop from tuberous roots.

3. Rhizomes:- The horizontal, thick and fleshy or slender and elongated stems growing underground are known as rhizomes. They have nodes and in tomodes and readily produced adventitious roots. Examples are banana, ginger ferns and many grasses.

4. Corms:- A corm is a solid-enlarged underground base of a stem having nodes and internodes. The gladiolus, crocus and water chestnut are examples of corm-forming plants. Several new small corms called cormels develop from the lower portion of the corm. These in turn are separated and when planted develop into new individuals.

5. Runners:- Runners are specialised aerial stems arising in the leaf axial of plants. The typical runner producing plant is strawberry.

6. Suckers:- Some plants such as pineapple, banana, etc, produce adventitious shoots from the underground portion of the stem or from their horizontal root systems. These are known as suckers and when they strike roots, they may be utilized as propagating material.

7. Offsets (or offshoots):- An offset is a shoot or thick stem arising from the base of the main stem of certain plants, such as date palm. They are girdled and layered for about a year before separation.

PROPAGATION BY CUTTING

Many plants of horticulture interest are now propagated' commercially by means of cuttings, since it is the easiest and most convenient method of asexual propagation. A cutting is a part of a plant which will produce roots and, eventually, a new plant quite true to the parent plant. It may be a piece of stem (stem cutting), a leaf or part of a leaf, a piece of root (root cutting) or even a scale of a bulb. Stem cuttings are the most widely used. They are classified as : cuttings which require leaves and cuttings which do not require leaves at the time they are severed from the parent plant. Thus cutting may be classified as under:

1) Stem cuttings : Herbaceous cuttings usually consist of the terminal leafy portion of stems of herbaceous plants.

Softwood cuttings are usually with some leaves.

Semi-hardwood are usually taken from growing terminal shoots. Hardwood cuttings are made from past season's growth or wood that has become mature.

2) Root cutting : Root cutting, being very easy and supple, is customary in many plants like apple pear cherry etc. Adventitious roots are regenerated and the adventive shoots develop at the proximal end of the root.

3) Leaf cutting : Certain plants with thick and fleshy leaves can reproduce themselves from leaf cuttings. Many ornamental plants are propagated by leaf cutting regardless of whether a root develops from a stem, a leaf or from another root, it develops inside the parent structures. Cells of the parent tissues produce the root promordium, which later on develop into a root. In general, the thin-walled active and living cells—parehchymatus cells—have the most potentiality to give rise to adventitious roots.

PROPAGATION BY LAYERING (LAVERAGE)

Layering is one of the oldest techniques to propagate woody plants. Unlike in stem cuttings, in layering, a stem is induced to root when it is still attached to and sustained by the' parent plant so that the parent plant supplies the new individual with water and food particularly carbohydrates, proteins and with hormones until it makes its own food and hormones. Layering does not require close attention regarding the control of watering, humidity, and temperature of propagating frames that the cuttings often require. When the root formation is complete, the layers are severed from the parent and are treated essentially in the same way as the root cuttings.

PROPAGATION BY GRAFTING

Grafting can be defined as the art of joining parts of plants together so that they will readily unite and continue to grow as one plant. Certain plants can be grafted with ease, others with difficulty.

SEXUAL REPRODUCTION

Sex Expression: The sex expression of plants is based on whether one or both of the sex organs [see flower above] are in the same flower. There are three main types e plants with functional stamens and functional pistils in the same flower—the perfect flower—

Apple, pear, cabbage etc.; plants with functional stamens and functional pistils in separate flower on the same plant—banana, coconut, watermelon etc.; plants with functional stamens and functional pistils in separate flowers on different plants—date palm, papaya, spinach etc.

POLLINATION is the first step in the formation of seeds. It involves the transfer of pollen grains from the anther to the stigma of a flower of the same species. External agents like wind and insect do the job. Less frequent are birds and water. Grasses and palms possess wind—pollinated flowers. Maize has wind-pollinated flowers. Chief pollinating insects are bees, butterflies and moths. Sun flower is insect-pollinated. Only a very few plants get pollinated by water as it is most unsafe medium to survive. Birds and bats also bring about pollination.

Although most plants prefer cross pollination some, with small closed flowers, cannot avoid self-pollination.

FERTILIZATION : the fusion of male and female gametes is called fertilization. The fertilized egg cell gets surrounded by a cell wall and becomes an oospore. By repeated divisions it develops into an embryo with plumule, radicle and cotyledons. The ovule becomes the seed and ovary, the fruit.

The FRUIT develops from the ovary. Its function is to protect and nurture young seeds and to disperse them when mature. It may possess one seed or several ones. The pericarp which covers the seeds may be pulpy or dry.

In cereals like maize, rice, wheat and in all grasses, the fruits have only one seed with a dry pericarp. Each fruit functions like a seed. In the fruits of Mango, Peach and Walnut, the pericarp is divided into three layers—outer skin, middle pulpy mesocarp and inner hard endocarp which covers a singular seed. In the fruits of tomato, chickoo and guava, the

pericarp is divided into outer skin which covers the pulp with many seeds scattered within. Bananas are seedless as the plants get propagated through rhizome and not through the seeds. In peas, beans, and other pulses, the fruit has a dry pericarp with several seeds. In groundnut, soon after fertilization, the flower-stalk goes underground and further development takes place below the ground level. The fruit which is a legume, like peas and beans, has a hard pericarp and looks beaded due to constructions between the seeds. After the seeds are mature, they get separated from the parent and germinate into new offsprings. External agents like wind, water and animals disperse them to avoid competition for space, food and light. Some seeds, as of cotton, are provided with hairy outgrowth which help them fly long distances. Some seeds, as of drumstick, have wings. Seeds which are dispersed by water as coconut have a waterproof coat and float to long distances. In lotus, small one-seeded fruits by spongy top shaped thalamus which floats in ponds and lakes. Birds eat berries pulp but viscid seeds stick to their beaks, they wipe their beaks on tree trunks where the seeds are left to germinate on the? tree trunks and thus become parasites.

SEED STRUCTURE AND GERMINATION: A seed possesses an embryo or the juvenile plant and is covered by one or two seed coats. The embryo consists of a primary axis within embryonic root or radicle, at one end and the embryonic shoot or the plumule with a pair of tiny leaves at the other end. It has one or two cotyledons also. Seeds store reserve foods as carbohydrates, proteins and fats.

The embryo in the seed is a young plant in an inactive state. Seeds remain viable, i.e., capable of germination for a period of 10 to 25 years (dormant period), if stored in a cool dry place. Under suitable conditions of temperature water and oxygen, the embryo grows into a tiny plant called the seedling.

Germination commences by entry of water which activates dehydrated enzymes in the storage cells and the insoluble reserves are converted into soluble forms (digestion). The digested food is absorbed. Soaked in water, the seed swells and the seed coat bursts open. The radicle is the

first to grow downwards into the primary root followed by the growth of the plumule into a shoot above the ground. Now the roots absorb nutrition and green leaves manufacture food for the seedling. The new plant begins to function.

We have seen that in sexual method of propagation, the sex organs of the flower are involved in pollination and fertilization, resulting in the formation of seeds which on germination will produce new plants. Many morphological and biochemical changes take place during seed formation. In general seed formation in angiosperms involves the following events :

(i) Formation of stamens and pistils in the flower bud.

(ii) The anthesis or opening of buds,signaling the maturity

(iii) Pollination—transfer of pollen grains from the stamens (anthers) to the pistils (stigma), germination of the pollen and formation of pollen tube.

(iv) Fertilization of the egg-cell in the ovule with one male nucleus and fusion of the polar nuclei with this.

(v) Growth of the fertilized egg-cell and its differentiation into an embryo and development of seed coat, to protect, it from drying out,, mechanical injury and so on.

Thus, the embryo is the end result of the sexual cycle. It undergoes continuous morphological and physiological changes during seed development. It starts as a single cell, grows rapidly and becomes amass of indifferentiated cells in the early stages. As the growth continues, it is differentiated into an embryonic axis with growing points at each end one for the shoot and the other for the root.

REPRODUCTION IN ANIMALS

ASEXUAL REPRODUCTION

(a) Fission : Reproduction in its simplest form involves the splitting of the whole organism into equal or unequal parts. This is called

fission. It is binary if it results in two daughters and multiple if the result is more than two daughters. The division of the cytoplasm is accompanied by the mitotic division of the chromosomes. Both binary and multiple types of fission are usual and characteristic method of reproduction among protozoans. In parasitic Protozoa where multiple type is more common, the products are called schizonts. The malarial parasite forms schizonts inside red blood cells of the host. When they are liberated, each one penetrates a fresh cell.

(b) Fragmentation : When processes similar to fission take place in some metazoans also, they are called fragmentation. In sea anemones and most of the corals, it is the normal method.

(c) Budding : This process is quite common among coelenterates such as hydra. It results in the production of a group of new celis which eventually form new individuals. The rate of growth of buds is determined by the availability of food.

(d) Regeneration : In this process restoration of a complete, functioning individual from some part of the parent body other than the gamete, takes place. Protozoa, Porifera, Coelenterata and Planaria can regenerate fully from as small as 0.5% of the parent body. Planarians show remarkable powers of regeneration. If an individual is cut into two, the anterior end will regenerate a tail and the posterior end develops a new head. A middle piece will regenerate both a head and a tail, earthworms also have considerable powers to regenerate. In general the regenerative capacity is greater in animals of lower grades of evolution. The exact mechanism of the regulation of regeneration is far from fully understood.

SEXUAL REPRODUCTION

In addition to the asexual methods of reproduction described above, some protozoans also show sexuality accompanied by reproduction. As stated before, the basic characteristic of sexual reproduction is the fusion of two specialized sex cells called gametes. The body formed by the fusion of the two gametes is called a zygote and the term common for all types (and there are many) of sexual reproduction involving a zygote is ZYGOGENESIS.

In protozoa, this is done by two whole animals uniting temporarily for nuclear transfer—conjugation.

Gametic union requires two types of gametes. In metazoans,,one of the gametes is large and heavy, usually with incorporated food material (called the egg or ovum) while the other is smaller and mobile usually with a flagellum (called spermatozoa or sperms). The fusion of such dimorphic gametes is called oogamy, which is generally the rule in metazoans. Despite differences in their appearance, the gametes are alike in one important respect: each has in its nucleus a haploid set of chromosomes, the only difference possible being in the sex-chromosomes.

The development of eggs and sperms is carried out in special organs called ovaries and testes respectively (common term gonad). In the great majority of metazoans an individual possesses either testes or ovary only (unisexual) and thus two types of individuals—female and male—are present in metazoans. There are other differences, called secondary sexual characters, also but they have nothing to do with the reproductary system as such.

The union of gametes—sperm with the egg—is called fertilization. It includes both the union of gametic nuclei and the cytoplasm and leads to restoration of deploy and initiation of cell division. In some animals, fertilization is completed only after the sperm penetrates the egg membrane and enters the cytoplasm. In its simplest form—common in many aquatic animals—the process of fertilization requires only the synchronized discharge of male and female products into a particular limited are of the surrounding water where union takes place. This is external fertilization and to achieve positive results animals have to produce hundreds of thousands of eggs and millions of sperms.

Considering the slim chances and the wastes involved, species belonging to higher phyla have evolved mechanisms to introduce the sperms directly into the body of the female—internal fertilization. Males possess special structures for depositing the sperms into the female and the process is called copulation or mating. Internal fertilization is unavoidable for all animals which lay eggs on land as they must be

protected with impervious coverings. After fertilization the eggs are invested with their outer coverings while still in the oviduct and then they are laid. Thus it is that completely terrestrial animals from earthworm to mammals all have internal fertilization. All animals which lay eggs are called oviparous.

Some animals retain the fertilized eggs inside the mother's body till the development is complete so that, fully formed miniature adults and not helpless eggs come out of the female body. During development, embryo derives nourishment directly from the mother's body. For this purpose it forms a structure called placenta through which diffusion of nutrients and oxygen to the embryo as well as excretory products from the embryo takes place. Animals which never lay eggs are called viviparous (Indian shark and most mammals).

Gradations between oviparous and viviparous exist. Some animals retain the fertilized eggs inside the mother's body till the development is completed but don't form a placenta and so the connection between the mother and the embryo is less intimate than in the viviparous forms. This condition, common among a number of lizards and snakes, is called ovoviviparity.

In some cases both ovary and testis may be present in the same individual. This condition is called hermaphroditism, which is of two types—a) both reproductive organs may be permanently present in an individual as in the case of earthworm or, b) there may be a single gonad which alternately produce sperms and ova. Hermaphrodites are considered primitive and some are found in every phylum. Among vertebrates some fishes are seasonally so. Oyster,[1] the bivalve mollusk found in the sea, is a good example of seasonal hermaphrodite. The larva which attains adulthood will be a male and will discharge sperms in its first season. Later, the same individual produces ova instead of sperms. Sex-reversal may occur several times if conditions are favorable.

1. The oyster of Indian seas is crassostrea. Species of ostrea constitute the edible oyster. Pinctada and some other genera and the pearl-oysters. A single female oyster can produce more than 100 million eggs in a season.

Reproduction from either male or female gamete without the cooperation of a gamete of the opposite sex is called Parthenogenesis. Reproduction by unfertilized ovum (female parthenogenesis) occurs in at-least some animals belonging to all phyla but in some it is obligatory, i.e., is the sole form of reproduction. In bees, rotifers and some others, males are produced pathenogenetically; the fertilized eggs develop into females, or into the queen and the workers as in the case of honey-bee. How exactly the egg is activated in parthenogenesis is still not clear.

REPRODUCTION IN MAMMALS

As in most vertebrates, reproduction in mammals is by purely sexual and zygogenetic means. Sexes are separate. The essential parts of the male system are the testis, epididymis and vas deferens (all paired), and urethra and penis. Sperms formed in testes find their way out through the epididymis and vasa deferentia, and finally through the urethra which passes through the copulatory organ, penis. The essential female organs are the ovary, oviduct, uterus (all paired) and vagina. The ovaries produce ova which find their way to the uterus through the oviduct. On their way they meet the sperms which swim up from the vagina and fertilization takes place. The zygote(s) undergoes divisions, and sooner or later get attached to the wall of uterus and the development is continued in this condition. When the development is completed, the fetus(es) get detached from the wall and are born to the outside world through the vaginal opening. The mammary glands of the mother would have been activated by then so that the young one(s) can be nourished on milk till they are able to fend for themselves.

For the entire process of reproduction as given briefly above, to be completed successfully, a series of precise co-ordination of functions between various organs is necessary, functions are controlled and coordinated by hormones from three sources : (1) the pituitary (2) the ovary and (3) the placenta.

SEX DETERMINATION

In many animals a heteromorphic pair of chromosomes has been identified with sex-determination. In Drosophila for e.g. the female has 2 X chromosomes both alike whereas the male has 1 X chromosome and

another which is morphologically very distinct, called a Y chromosomes. In addition there are 3 other pairs of chromosomes whose homologues are alike. Man has 23 pairs of chromosomes, 22 of which are similar, whose homologues are alike and one heteromorphic pair associated with sex-determination. In some animals, particularly moths and birds, the chromosomes in the male are all paired perfectly with no heteromorphic pair such as the X and Y chromosomes. In these cases the female has the heteromorphic pair of chromosomes. In poultry, the female has only one X chromosomes with no mate. Therefore, the female is known as one having an XO condition for the sex-chromosomes, instead of XY. She produces two kinds of gamets one with an X and the other with none. The first gamet with an X chromosomes produces a male when united with an X from the father, while the second produces a bird with XO condition, a female. Consequently 1:1 sex ratio is maintained. 'Balance' theory of sex determination in Drosophila was proposed by Calvin Bridges (1925). His work began with an accidental triploid (3n) Drosophila (with 3X chromosomes and 3 sets of autosomes). He crossed the triploid (3n) female with a normal male and secured a number of interesting individuals which differed in the number of X chromosomes and the number of sets of autosomes. The results of Bridges experiment are shown in the Table below. He concluded that the presence or absence of Y sex chromosomes is not the determining factor in sexual determination in Drosophila, but rather it is the balance of the number of X chromosomes and the number of sects of autosomes present.

Balance of X Chromosomes and Autosomes in Drosophila Chromosomal Constitution.

Sex	No. of X Chrosomes	Sets of Autosomes	Sex index Ratio X/A
Super female	XXX	AA	1.5
Normal female	XXXX	AAAA	1.00
Normal female	XXX	AAA	1.00
Normal female	XX	AA	1.00
Normal female	X	A	1.00
Intersex	XX	AAA	0.67
Normal Male	X	AA	0.50
Super Male	X	AAA	0.33

Sex-determination in Man

In humans, the situation regarding six-determination is similar to that in Drosophila. The difference in male and female is due to the difference in their sex chromosomes. Both the female and male diploid cells contain 22 pairs of autosomes. In addition to 22 pairs of autosomes the male cells have X and Y sex-chromosomes while the female cells have XX sex chromosomes.

During gametogenesis the female diploid cell produces gamets of only one type. Each female gamet contains 22 autosomes and a single X-chromosome. However in males the X and Y chromosomes migrate to the two opposite poles during meiosis resulting in the production of two types of gamets. One type containing 22 autosomes and one X chromosome and the other contains 22 autosomes and one Y chromosome. The proportion of these gamets in 50:50. Thus it is clear that in humans the maleness is under the control of Y chromosomes.

Intersex : Hermaphroditism is a perfectly natural condition in the animals referred above. On the other hand, if in animals that are normally unisexual, individuals are found bearing the characters of both male and female, it will be an abnormal aberration. In man, for example, individuals are sometimes born with gonads of one sex but ducts and external genitalia typical of or resembling the other sex. Some possess an ovotestis, ovarial and testicular tissues mixed up. Gonads of the left and the right sides may not be alike. Cases such as these are called intersexes and are caused by genetic irregularities. Intersexes are usually sterile.

Gynandromorph: In lower animals, another kind of male-female combination is found more frequently than intersexes. Like the mythological *ardhanārīśvara* these individuals are a mosaic of normal male and normal female. Irregularities of zygote, development or both, can give rise to this condition which is more common among invertebrates, especially insects like spiders, ants and bees.

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CHAPTER–II

SCRIPTURAL VIEW OF LIFE

SOUL AND BODY

According to Jain scriptures, every living organism is an organic unity of two distinct entities: a non-material entity called soul or spirit and a material entity called body. The soul which is the central entity of Jain system is eternal, indestructible and uncreated. Its characteristic nature is consciousness *(cetanā)*, i.e., soul and consciousness are coextensive. Wherever there is life, there is consciousness. Even the lowest class of living organisms is possessed of it. But this does not mean that in all living organisms explicitness of consciousness is identical. E.g. in one-sensed organisms with earth-bodies, it is mostly latent and implicit, while in humans, it is mostly explicit and in certain exceptional cases of men having highest spiritual purification, it may be supernormal.

The soul is entirely distinct from matter and cannot be apprehended by sense-perception; hence it is non-corporeal. The attributes colour, smell, taste, etc., which are invariably associated with matter, are totally absent in the case of soul.

The consciousness *(cetanā)* is manifested in two ways:

(i) **Cognition** — action or faculty of knowing, including sensation, perception, conception etc., and

(ii) **Conation** — desire or volition: exertion of will etc.

Besides these two, conduct or behaviour, which is also assumed to be the natural manifestation of life is also associated with soul.

KARMAN

Rebirth and Karman[1] are the two most important presuppositions of Jain philosophy. Doctrine of rebirth is necessary to emphasize the eternal

1. For detailed discussion on the concept of soul and karman, see Neuroscience and Karma, Prologue, pp. vi-xv and pp. xxvii-xxix.

nature of the soul and the doctrine of karman is needed to explain the infinite variety of the living organisms. From this aspect, the manifestation of consciousness may be expressed in awareness of action *(karma-cetanā)* and awareness of pleasure and pain *(karmaphala-cetanā)*. The doctrine of karman is intimately associated with the causal agency of the soul. Even in the lowest organism, there is the desire to continue pleasurable activity and to discontinue the painful one. This primitive tendency of the soul is just the conative attribute of the soul which develops into conscious choice of an end or purpose which is the characteristic of volitional activity.

The term 'body' implies not one but two different things. The gross or physical body is the one which we actually perceive and which is constituted and nourished by various nutrients taken in the form of food, etc. This body will be given up by the soul after a certain period which is called life-span. Besides this gross body, there is for every soul a microbody called *kārmaṇa śarīra* which is constituted by the subtlemost molecules of a special group of matter called *karma-pudgala* or karmic matter. This microbody is a necessary and inalienable appendage of all living organisms and transcended only at the time of emancipation. But, in the worldly state of existence, every action of a living organism cause a transcendental effect; it generates a certain potential psycho-physical force which manifests itself by determining significant details of the life of the living organism such as—health & happiness or illness & misery. Just as a commercial bond does not lose its validity until and unless the amount is repaid, so also the effect of karmic force generated by an action continues to be potentially valid long after the disappearance of the cause itself. The effect, thus, does not confine itself to one life but may continue for many lives beyond the present one. In other words, the entire gamut of the conditions and duration of the present life is the result of the karman of the preceding ones and the actions during the present life are the causes of the conditions and duration of the future existence. And hence, birth of an individual living organism in a particular species at a particular time and in a particular place is neither arbitrary nor accidental but the very precise result of the individual's karman which again is the result of its actions in the past life or lives. The determination

of the species, the life-span, the social status, feeling of pleasure or pain and such other fundamental factors of the individual's life are the combined result of four *aghatin* categories of karman.

VITAL FORCE AND BIO-POTENTIAL

The soul which animates a particular organism is manifested in various vital functions of the living organism. They can be classified into four groups called *prāṇa* (vital force):

(1) *Bala-prāṇa* or life potency i.e., capacity for three-fold action—mental, vocal and bodily actions; these are three.

(2) *Indriya-prāṇa* or sense awareness, i.e., capacity to apprehend the environment through one or more sense-organs; the number of sense-organs vary with the degree of the development of consciousness; these are five.

(3) *Āyuśya-prāṇa* or duration of life, i.e., the capacity of the organism to survive and persist through a fixed and limited duration of life-span.

(4) *Ucchvāsa-niśvāsa prāṇa* or vital function of respiration, i.e., the capacity to continue breathing.

Thus the four categories of *prāṇa* come to a total of ten.

Now it is not difficult to see that these psychical capabilities have empirical value only if there is its physical counterpart called *paryāpti* (bio-potential). All living organisms are not possessed of all the five sense-organs nor are all endowed with vocal and mental faculties. In other words only those organisms which have the highest degree of consciousness—five-sensed organisms with brain *(samjñīpañcendriya)*—are possessed of all pranas, while the lower ones would be possessed of less. Thus, in a one-sensed organism such as a plant, only *āyuśya, ucchvāśa-niśvāsa*, one of the three *bala-prāṇa,* i.e., *śarīra bala* and one of the five *indriya-prāṇas*, that of the sense of touch, could be explicit and active while the rest would remain implicit and dormant.

In Biology, all the living organisms are divided into two kingdoms—**Animal Kingdom** and **Vegetable Kingdom**—and in the (Jain) scriptures all the living organisms are divided into two domains—**Mobile** and **Immobile**.

(a) The Immobile Organisms *(Sthāvaras)* which are devoid of the ability of locomotion and

(b) The Mobile Organisms *(Trasa)* which are endowed with the ability of locomotion.

The Scriptures further classify living organisms from several different aspects such as *gati*, *jāti*, *kāya* etc.

On the basis of *Gati* (order of existence), there are four types : (1) sub-humans (2) Humans (3) Denizens of hell (4) Denizens of Heaven.

Another aspect of classification is *Jāti* which refers to the number of sense-organs possessed by the organism. Thus there would be:

(1) Organisms possessing one sense-organ — *Ekendriya*

(2) Organisms possessing two sense-organs — *Dvīndriya*

(3) Organisms possessing three sense-organs — *Trīndriya*

(4) Organisms possessing four sense-organs — *Caturindriya*

(5) Organisms possessing five sense-organs — *Pañcendriya*

Yet another aspect of classification is the characteristics of the body (*kāyā*) possessed by the organism. In this case we would have:

(1) Organisms with molecules of Earth as the body — *Pṛthvikāya*

(2) Organisms with molecules of Water as the body — *Apakāya*

(3) Organisms with molecules of Fire as the body — *Taijasakāya*

(4) Organisms with molecules of Air as the body — *Vāyukāya*

(5) Organisms with parts of Plants as the body — *Vanaspatikāya*

(6) Mobile organisms with organic molecules as the body — *Trasakāya*

This is the celebrated *ṣaḍjīvanikāya* classification of Jains.[1]

When we correlate the above aspects, we find that:

All immobile organisms *(Sthāvaras)* possess only one sense-organ, that of touch: there are five kinds of them and they possess first five types of body—Earth, Water, Fire, Air, and parts of Plants or Vegetables.

Those which possess organic bodies are mobile organisms *(Trasa)*; number of sense-organs possessed by them varies from two to five. i.e., they are classified into (a) two-sensed, (b) three-sensed, (c) four-sensed and (d) five-sensed organisms; sometimes Fire-bodied and Air-bodied organisms are included in *trasa* category because they possess some kind of mobility. (See synopsis of *Uttarādhyayana* below). Organisms possessing five sense-organs are further divided into four main categories:

(a) Denizens of hell, (b) Vertebrate sub-human animals, (c) Human beings, and (d) Denizens of heaven (or gods). Each of these are further subdivided into several classes as we shall see later.

Jīvājīvābhigam Sūtra refers to nine different aspects of classification and divides living organisms into two, three, four upto ten classes.[2]

CONTENTS OF JAIN SCRIPTURES— A SUMMARY

A question might be raised as to why Biology should be discussed so exhaustively in the Jain scriptures which are mainly concerned with spiritual aspects of life. The answer is given in the first verse of the 6th chapter of *Uttarādhyayana* ".....the ascetic has undertaken to observe the great vow of non-violence (*ahiṃsā*), and for the proper fulfillment of this difficult vow he must possess precise knowledge of what is animate and what is inanimate." Besides the celebrated aphorism of Bhagavan Mahavira, "*paḍhamaṃ nāṇaṃ tao dayā*"[3] also emphasizes that spiritual discipline must be preceded by knowledge (of the science of living organisms)."

1. Daśaveāliyaṃ, Ch. 4
2. Jīvājīvābhigame, Ch. 1, Sūtra 10
3. Daśaveāliyaṃ, 4/10

The subject of Biology has been dealt with in great details in the following Jain scriptures :

(i) *Prajñāpanā Sūtra*, Chapter 1

(ii) *Uttarādhyayana Sūtra*, Chapter 36

(iii) *Jīvājīvābhigama Sūtra*, Chapter 1

(iv) *Sutrakṛtāṅga Sūtra*, part II, Chapter 3

PRAJÑĀPANĀ SŪTRA

The sequence in this scripture as well as that in *Uttrādhyayana* is very much similar to one another. In both scriptures, the first few *sūtras* deal with inanimate objects. The subject of living organisms is dealt with in *sutras* 10 to 41 as under:

Subject	***Sūtra* No.**
(1) *Siddhātmās* (Pure & Perfect Souls)	11
(2) *Saṃsārī* or Mundane Beings	12 to 41
(i) Five types of one-sensed organs	13 to 24
(a) Earth-bodied organisms	14
(b) Water-bodied organisms	15
(c) Fire-bodied organisms	16
(d) Air-bodied organisms	17
(e) Plants	18 to 24
1. with individual bodies	19
2. with common bodies	20 to 24
(ii) Two-sensed organisms	25
(iii) Three-sensed organisms	26
(iv) Four-sensed organisms	27

(v) Five-sensed organisms	28 to 41
(a) Denizens of hell	29
(b) Vertebrate animals	30 to 34
1. Aquatic animals	31
2. Terrestrial animals	32 & 33
3. Aerial animals	34
(c) Human Beings	35 to 38
(d) Denizens of heaven	41

It can be easily seen that the sequence adopted here is precisely the same as that adopted in *Uttarādhyayana*. The emphasis here is on giving more details of classification, viz. names of various classes.

UTTARĀDHYAYANA SŪTRA

The title of the thirty-sixth chapter of *Uttarādhyayana* is "The Living organisms and Inanimate Things". The first 47 verses deal with the inanimate objects. The subject of living organisms is dealt with in vv. 48 to 246 as under:

Subject	**Verse No.**
(1) *Siddhātmās*—Pure and Perfect souls	50 to 68
(2) *Saṃsārī* or Mundane Beings	69 to 246
(i) Three types of Immobile organisms	71 to106
(a) Earth-bodied organisms	71 to 84
(b) Water-bodied organisms	85 to 92
(c) Plants—Vegetables	93 to 106
(ii) Three types of Mobile (*trasa*) being	108 to 246
(a) Fire-bodied organism	109 to 117
(b) Air-Bodied organisms	118 to 126

(c) Organisms with organic bodies	127 to 246
i. with two sense-organs	128 to 136
ii. with three sense-organs	137 to 145
iii. with four sense-organs	146 to 155
iv. with five sense-organs	156 to 246
a. Denizens of hell	157 to 170
b. Sub-human animals	171 to 193
1. Aquatic animals	171 to 178
2. Terrestrial animals	179 to 186
3. Air-borne (birds)	187 to 193
c. Human beings	194 to 202
d. Gods	203 to 246
1. *Bhavanapati* (Mansion-dwelling gods)	205 & 218
2. *Vyantara* (Forest gods)	206 & 219
3. *Jyotiṣka* (Luminous gods)	207 & 220
4. *Vaimānika* (Empyrean gods)	208, 221-246
a. *Kalpa* (gods subjected to law or custom)	209-10, 221-232
b. *Kalpātita* (gods not subjected to any law or custom)	211
i. *Graiveka* (Neck-dwelling)	212-13, 233-241
ii. *Anuttara* (gods of the highest heaven)	214-17, 242-243

It can be seen from the synopsis of both *Prajñāpanā* as well *Uttarādhyayana* that the authors have adopted the sequence of ascending order of the development of consciousness, i.e., they start with the organisms which possess the minimum consciousness, viz., the

earth-bodied organisms and ends with the highest level of *devas* (gods). This is quite different from the third scripture as we shall presently see.

JĪVĀJĪVĀBHIGAMA SŪTRA

The treatise in this scripture is quite different from the others. Here the dissertation is rather of a specialized nature. It deals with twenty-three characteristic features of living organisms, describing the association of each feature with different classes of living organisms. The classification itself is conventional and the organisms are dealt with in an ascending order of sequence, as in *Uttarādhyayana Sūtra*, i.e., starting with the earth-bodied organisms and ending with *devas*. The *sūtras* are in prose and in the form of question-answer—Gautama, the chief disciple and *gaṇadhara* being the querist and *Bhagavān Mahāvīra* himself giving the answers.

The twenty-three characteristic features are:[1]

1. Number and types of Bodies —*śarīra*
2. Extension in space —*avagāhanā*
3. Physical structure —*saṃhanana*
4. Configuration —*saṃsthāna*
5. Passions —*kaṣāya*
6. Unlearned Instincts —*saṃjñā*
7. Aural colouration —*leśyā*
8. Number of sense-organs —*indriya*
9. Expansion of soul-units (beyond the body) —*samudghāta*
10. Possession of brain —*saṃjñī-asaṃjñī*
11. Sex —*veda*
12. Number of bio-potentials — *paryāpti*

1. Jīvājīvābhigame, Ch. 1, Sūtra 14

13. World-view —*dṛṣṭi*

14. Intuition —*darśana*

15. Knowledge —*jñāna*

16. Activity (of Body, Speech, Mind) —*yoga*

17. Activity of Consciousness —*upayoga*

18. Appropriation of material objects —*āhāra*

19. Metempsychosis —*upapāta*

20. Life-span —*stithi*

21. Expansion of soul-units out-side the body — *Māraṇāntika samudghāta*

22. Departure from past life —*cyavana*

23. Transmigration (to and from) —*gatyāgata*

The *Jīvājīvābhigama Sūtra* disseminates detailed information about the association of each class of living organisms with the above twenty-three characteristic features.

SŪTRAKṚTĀṄGA SŪTRA

The author of *Sutrakṛtāṅga,* Arya Sudharma, has, however, adopted a special stle, quite different from other *Sūtras*. While an ascending order is adopted in the other scriptures, this *Sūtra* starts with the vegetable kingdom. Plants are divided into twelve categories on the basis of their place of origin and the way they obtain their nourishment and devotes as many as 43 paragraphs of the chapter[1] for describing them.

1. Trees which grow from earth — *Pṛthviyonika Vṛkṣa*

2. Trees which grow from 1. (supra) — *Vṛkṣayonika adhyāroha Vṛkṣa*

1. Sūtrakṛtāṅga Sūtra, Part II, Ch. 3, Sūtra 1-43

3. Trees which grow from water— *Udakyonika Vṛkṣa*

4. Trees which grow from 3. (supra) — *Udakayonika adhyāroha Vṛkṣa*

5. Grasses which grow from earth — *Pṛthviyonika tṛṇa*

6. Trees which grow from water — *Udakayonika tṛṇa*

7. Herbs which grow from earth — *Pṛthviyonika auṣadhi*

8. Herbs which grow from water — *Udakayonika auṣadhi*

9. Shrubs which grow from earth — *Pṛthviyonika harita*

10. Shrubs which grow from water — *Udakayonika harita*

11. *Kuhaṇa* which grow from earth — *Pṛthviyonika kuhaṇa* (plants which cause the earth to burst, e.g. mushrooms)

12. *Kuhaṇa* which grow from water — *Udakayonika kuhaṇa*

Four salient features of each of the above types of plants are described in detail:

(a) The location from which the trees originate, obtain their nourishment and are supported. Trees grow either from earth, or water (aquatic plants) or from other trees.

(b) The nature of nourishment; bodies of all types of immobile organisms—earth-bodied, water-bodied and so on; While the earth-based trees get the nourishment through earth, creepers obtain it from the trees on which they grow and water-based trees get it through water.

(c) After growing and maturing, the plants obtain the nutrients from the bodies of the mobile organisms also. They digest and assimilate the nutrient juices from the dead bodies of various mobile organisms.

(d) Various parts of the plants—leaves, flowers, fruits, etc. are possessed of various colours, smells, tastes, etc.

After dealing with plants, the mobile organisms (*Trasakāya*), have been dealt with from para 44.[1] Instead of classifying them in the conventional way, i.e., those possessing two sense-organs and so on, they are associated with different kinds of plants which were dealt with in the preceding paragraphs. Thus we have :

Mobile Beings which are born on—trees growing from the earth, trees growing from the trees, from the roots and other parts of the trees, creepers born on trees, creepers born on creepers, from roots etc. from grasses, from herbs, from shrubs, from *kuhaṇa* (*aya, kayala* etc.) etc., born in earth; then from trees born in water and all the above classes of plant growing from water (instead of earth). These mobile organisms obtain their nourishment from their hosts (all varieties are repeated).

In para 76, the human beings have been dealt with. Here is described the process of reproduction of human beings with many details—fertilization of the seed, conception, pre-natal development of the fetus, birth and growth after birth.

After the humans, it is the turn of the sub-human animals which possess five sense-organs and aquatic and terrestrial animals and birds are dealt with in pp. 77-81.

Now comes the turn of two-, three-, and four-sensed organisms and they are dealt with in pp.82-84. And in the end come the remaining four *Sthāvaras* :

(i) Water-bodied organisms	pp.85 to 88
(ii) Fire-bodied organisms	pp.89 to 92
(iii) Air-bodied organisms	pp.93 to 96
(iv) Earth-bodied organisms	pp.97 to 100

Thus, it can be seen that the sequence followed in *Sūtrakṛtāṅga* is entirely different from the other two scriptures. As regards the question, why the plants, the vegetable kingdom, which is number five in the

1. Sūtrakṛtāṅga Sūtra, Part II, Chapter 3, Sūtra 44.

sthāvara category, have been dealt with first, both *Curṇikāra* and *Vṛttikāra* have stated as under:

Development of consciousness in the organisms of the vegetable kingdom is highest amongst the five *sthāvaras* and practically everyone accepts the plants as animate objects because their animation is so obvious. On the other hand, the animation of the other *sthāvaras* is difficult to prove and be accepted by the people.

It could be noted that there is no mention either of the denizens of hell or those of heaven in this chapter.

Let us now see, in greater details, how each scripture has treated the subject of Biology and also compare this scriptural treatment with the scientific views.

CONTENTS OF JAIN SCRIPTURES: A DETAILED DISCUSSION

PRAJÑĀPANĀ SŪTRA

As in *Uttarādhyayana*, the first to be dealt with amongst the Mundane (*Saṃsārī*) organisms are the Earth-bodied organisms. The treatment is very much similar to that given in *Uttarādhyayana.* Using practically the same words, divisions of subtle and gross as well as under-developed and fully developed are indicated. The two kinds of the fully developed gross classes, viz., the smooth and the rough, are then described in details. Smooth ones are of seven kinds:[1]

Black, Blue, Red, Yellow, White, Pale dust, and Clay.

The rough ones are of 40 kinds; some of which are:

14 types of rocks and metal ores—Earth, gravel, stone, rock, etc., iron, copper, tin, lead, silver, gold, etc., are metal ores.

8 types of other minerals—orpiment (arsenious trisulphide), vermilion (mercuric sulphide), realgar (arsenic disulphide), etc.

18 types of precious and semi-precious stones—diamond, hyacinth, emerald, sapphire, etc., and medicinal earth—*candana,* red chalk,

1. Uttarādhyayana Sūtra, Chapter 36, Verse 72.

haṃsagarbha, kankuṣṭha, sulphur, *candraprabhā,* lapis lazuli, *jalakānta, sūryakānta*, which are again very much the same as in *Uttarādhyayana*, except that 40 varieties[1] in the *Prajñāpanā* are named instead of 36 in *Uttarādhyayana.*[2] It could be easily seen that these numbers indicate only popularly known varieties and has not much significance. In fact the varieties caused by difference of colour, smell, taste, touch, shape, and location are stated to be 700,000.

The distinction between the subtle and the gross is explained separately in the form of a query by the disciple: the distinction has definitely nothing to do with the fineness or grossness in size but is purely transcendental and caused by the fruition of different sub-species of the body-making *(Nāma)* karman, viz. *sukṣma nāma karman*, and *bādara nāma karman.*

WATER-BODIED ORGANISMS:

While dealing with water-bodied organisms, again, there is no significant difference between the two scriptures, except that many more types of water are named in *Prajñāpanā Sūtra*—cold, hot, saltish water, sea water (names of some seas are also given). As before the varieties caused by the colour etc. are stated to be again 700,000.

The same applies to the treatment of Fire-bodied as well as Air-bodied organisms. In every case, we have many more types mentioned by name but the basic classification is identical in both scriptures.

BOTANY

Vegetable kingdom is dealt with in this scripture as follows: The basic classification is identical in both scriptures: subtle and gross; each of which is divided into under-developed and fully developed. However, Jain scriptures give utmost importance to the unique aspect of dividing the plants into two basic categories:[3]

1. Prajñāpanā Sūtra, Ch. 1, Sūtra 20
2. Uttarādhyayana Sūtra, Ch. 36, Verse 73-76
3. In the Modern Botany, the plants are basically of two types:
   (a) Crytoganic—Plants which do not have such obvious organs of reproduction as flowers or seeds; applied to algae, bryophytes and pteridophytes as opposed to

(a) individual-bodied and

(b) common-bodied.

Each organism in the former type of plants called *pratyeka śarīra*, "one body-one soul" organism. But in the latter types of plants called *"sādhāraṇa śarīra"*, some parts have infinite souls sharing one common body, i.e. though each soul is numerically different and is possessed of its own individual *kārmaṇa śarīra,* it does not have an independent physical body of its own. Sharing a single common physical body, infinite souls are born together, breathe together and die together.

First the fully developed, gross, individual-bodied plants are described in detail. They are of 12 types. The detailed nature of classification though referred here, is described in more details in the *Jīvābhigama Sūtra*:

1. *Vṛkṣa* (Tree)—Large perennial plant with self-supporting woody trunk (main stem), developing-woody branches at some distance from the ground.

2. *Guccha* (shrub)—smaller tree without a trunk; many stalks come forth from a single root or bulb.

3. *Gulma*—similar to the above, but bringing forth twigs or stems instead of stalks.

4. *Latā*—creeper e.g. champakavela.

5. *Valli*—climber e.g. gourd etc.

6. *Parvaga*—plants with knots; e.g. sugar-cane.

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pteridophytes as opposed to phaneroganic—plants—angiosperms and gyanosperms.

The main mass of land plants are divided into four divisions: bryophtes, pteridophytes, gyanosperms and angiosperms. Algae are classified seperately because their bodies are not organized on the same general system.

(b) Bryophytes—division of plants comprising 'MUSCINEAE' (mosses—small plants growing in bogs, or in crowded masses on ground, wood, stone, etc.), HEPATICAE (LIVERWORTS--primitive seedless plant allied to mosses), and ANTHOCEROTAE (small green plants with thin flat body), THALLUS, usually found on deep soil.

7. *Tṛṇa*—grass; plants, blades or leaves and stalks of which are eaten by cattle etc.

8. *Valaya*—plants foliation of which are rounded; e.g. palms.

9. *Harita*—small leafy plants with abundant green leaves e.g. bhajis etc.

10. *Auṣadhi*—herbs and careals; plants which die after bringing forth seed.

11. *Jalaruha*—aquatic plants—lotus etc.

12. *Kuhaṇa*—plants which cause the earth to burst; (e.g. mushrooms etc.)

The above classification is identical to that given in *Uttarādhyayana.* What follows now is, however, found in this scripture only.

CLASSIFICATION OF TREES

They are of two classes:

a. Fruits of which have a single seed—*egaṭṭhiyayā*—e.g. mango.

b. Fruits of which have multiple seeds—*bahubīyagayā*—e.g. organge.

(The suffix '*yā*' indicates that each of the above two are of many varieties). Then follow the names of thirty-two types of trees, fruits of which have only one seed, some of which are quite common, e.g. *Neem,* Mango, *Jāmun,* Walnut, Myrobalans, etc. However, the more significant informtion comes thereafter:

Roots of these trees have innumerable souls.

The trunk and each of its branches, twigs, leaves has one soul.

Each flower has many soul; each fruit has one soul.

Similarly trees of which the fruits yield many seeds are also of many types. Then follow the names, some of which, such as Banyan tree, are well known.

As in the previous case, the roots of these trees have innumerable souls.The trunk and each of its branches, twigs, leaves, etc. has one soul. Each flower has many souls; each fruit has as many souls as the number of seeds. This completes the treatment of the trees.

Then follows all the eleven other types of plants, viz. shrubs, grasses upto *kuhaṇas*—Mushrooms. The style of dissertation is similar in all these cases and apart from giving several typical names of the plants of each type, there is nothing very significant. A simile of a sweet preparation called *tilpāpaḍī* in which hundreds of individual tils appear to become integrated without losing their individuality, illustrates how innumerable souls could inhabit a small part of a plant.

To a specific query—Which are the trees of which the trunk and each leaf has a single organism? The answer given is—*tāla, sarala,* and coconut tree and it is added that these are only typical names and all similar trees would have the same characteristics. But the trunks of all trees should not be taken as single organism because the trunks of some trees are also with innumerable organisms *(khandhā vi asaṃkheyā jīviyā).* What is said about the trunk, also applies to all the other parts of the plant. This concludes the dissertation of individual-bodied plants.

COMMON BODIED PLANTS:

Well-known amongst the common-bodied plants are:

Āluya,[1] onion, garlic, radish, ginger, turmeric, and others. The most significant difference between the two types of parts of the plants—individual-bodied and common-bodied—is that while the former would have innumerable organisms, each with its own physical body, the latter would contain infinite souls sharing a common organism. Some parts of the plants may be of the latter type in the earliest stage but would later on be converted into the former type. For instance, every leaf in its infancy is a common-bodied organism but later on as it matures it is converted into a individual-bodied one. Elaborate and detailed criteria are given in

1. Āluya is not potato, but a medicinal plant. See Bhagavatī with Bhāṣya, Vol. II Śataka 7 Sūtra 66.

this scripture for differentiating and ascertaining whether a part is common-bodied or not. Some of the simpler criteria given in the scripture are:

If the central division of a leaf is detectable, it is individual-bodied; if the bark of the trunk or a branch or a twig is thin and the wooden portion is more substantial then it is individual-bodied. On the other hand, if the bark is thicker than the inner part, it is common-bodied ; flowers of cacti are common-bodied. This concludes the dissertation about the plants as well as the immobile, one-sensed organisms.

MOBILE ORGANISMS

The mobile organisms are classified into—two-sensed, three-sensed, four-sensed and five-sensed organisms.

ORGANISMS WITH TWO SENSE-ORGANS

The immobile organisms *(sthāvaras)* possess only one sense-organ, that of touch. Among the mobile organisms *(trasa)* are those which possess two sense-organs—touch and taste. Some of these are:

Earthworms, roundworms and other worms; shells, conches and cowries; *vāsīmukha*, whose mouth is like a chisel or adze—insects such as Curculionidae suit this description; and many others. All of them are *samūrcchima*, i.e., they originate by generation acquivoca and their sexual organs are not developed. On the basis of their place of birth *(yoni)* and other variables, there are 200,000 varieties of organisms with two sense-organs.

ORGANISMS WITH THREE SENSE-ORGANS

Besides the two sense-organs mentioned above they also possess the sense-organ of smell. Some of these are:

All varieties of ants and white ants; bugs, centipedes and cochineal etc.They are of many kinds. As stated above, they are all *samūrcchima* and their sex organs are not developed. On the basis of their place of birth and other variables, there are 200,000 varieties of organisms with three sense-organs. (They do not possess eyes and ears).

ORGANISMS WITH FOUR SENSE-ORGANS

Here the sense-organ of sight is added. Some of these are:

All types of flies, mosquitoes, bees, moths, butterflies, scorpions, and crickets etc. They are of many kinds. As above, there are 200,000 varieties of organisms with four sense-organs. (They do not have ears).

ORGANISMS WITH FIVE SENSE-ORGANS

Here the sense-organs of hearing is added. They are classified into four categories:

1. Denizens of hell
2. Sub-human animals with five sense-organs
3. Human beings
4. Denizens of heaven or gods (*devas*)

Since they have been dealt with similarly in both this as well as in *Uttarādhyayana Sūtra*, we shall refer the reader to the following section for details, to avoid duplication.

UTTARĀDHYAYANA SŪTRA

As can be seen from the synopsis above, the treatment of living organisms starts from verse no. 48 and the first few verses (up to 68) deal with the emancipated souls.

Mundane or *Saṃsārī* organisms are of two kinds; Immobile, i.e. devoid of the power of locomotion *(Sthāvaras),* and mobile, i.e. endowed with the ability of locomotion *(Trasas)*. The sub-divisions of these two is slightly different here than in the preceding scripture. *Sthāvaras* are of three kinds : (a) Earth-bodied, (b) Water-bodied, and (c) Plants or vegetables. Fire-bodied and Air-bodied organisms are classified as *Trasa*, as they are not totally immobile.

(A) EARTH-BODIED ORGANISMS

First to be dealt with amongst the mundane organisms, are the organism whose bodies are the molecules of Earth. Anything that is dug

out, i.e., raw earth—minerals, rocks, metal ores, precious stones, clay etc.,—is animate, psychical order of existence, i.e., the molecules of raw earth are not dead matter. Every molecule is united with a conscious principle—a soul—as its physical body. 'Being animate' means it possesses a sense-organ and has the ability to experience pleasure and pain through it. The sense-organ is that of touch which is also that of pain. Thus digging of earth or handling or processing raw earth amounts to imposing pain on the earth-bodied organisms. When processed by fire, water, etc. the organisms are killed and the soul transmigrates and the product from the earth is rendered inanimate.[1]

Firstly, they are divided into subtle *(sukṣma)* and gross *(bādara)* and both of them are again divided into underdeveloped *(aparyāpta)* and fully developed *(paryāpta)*. The subtle ones are distributed all over the entire cosmos but the gross ones are found in a part of it. [These divisions apply to all immobile organisms *(sthāvaras)*].

Then follow the division of gross and fully developed into two kinds: smooth and rough. Smooth ones are of seven kinds:

Black, blue, red, yellow, white, pale dust, and clay.

The rough ones are of 36 kinds:

Stones etc.— Earth, gravel, sand, stones, rocks, rock-salt;

Metal ores— Iron, copper, tin, lead, silver and gold;

Minerals—Orpiment (arsenious trisulphide), Vermilion (mercuric sulphide, Realgar (arsenic disulphide), *Sasyaka* (*dhātu viśeṣa*), antimony, coral, mica, micadust,

Precious stones—Diamond, hyacinth, natron, *aṅka*, crystal, *lohitākṣa*, emerald, *masāragalla*, *bhujamocaka*, sapphire,

The maximum duration (life-span) of the earth-bodied organisms is 22 thousand years, the minimum being less than 48 minutes *(antarmuhūrta)*.

1. In Āyāro and Ācārāṅga Niryukti, the weapons (śastra) are enumerated, which, when operated upon the different beings, kill them. See Ācārāṅga Bhāṣyam, pp.34.

(B) WATER-BODIED ORGANISMS

All types of natural raw water—sea, river, lake, pond, well, etc. are animate and belong to the psychical order of existence, this is they are possessed of 'soul'. Molecules of water are their bodies. As in the case of earth-bodied organisms, they are endowed with the ability or experiencing pain through the sense-organ of touch, which as we know is also the sense-organ of pain. Processing, i.e., handling of raw water in any manner whatsoever imposes pain on these organisms and is therefore a sinful act. Until processed, the raw water remains animate, processing—boiling, chlorinating, etc., kills these organisms and renders the water inanimate.

The gross and fully developed water-bodied organisms are of five kinds:

Pure water, dew, snow, fog, and exudation. Their varieties caused by differences of colour, smell, taste, touch, figure, and place are counted by thousands.

The maximum duration (life-span) of water-bodied organisms is seven thousand years, minimum being less than 48 minutes (*antarmuhūrta*).

(C) PLANTS (VEGETABLES)

All types of plants, growing from earth or from water or from other plants as well as the parts of plants—roots, tubers, trunk, branches, leaves, flowers, fruits, seeds, etc. are animate and belong to the psychical order of existence. They remain animate until they are subjected to processing—boiling, baking, roasting, etc. which renders them inanimate.

The gross and fully developed plants are of two kinds:

(i) Individual-bodied—each soul has its own gross body.

(ii) Common-bodied—infinite souls have a common gross body.

Those who have their own body severally are of many kinds:

Trees, shrubby plants, shrubs, large plants, creepers, grass, palms, plants with knotty stems, mushrooms, aquatic plants, annual plants and

herbs. (Details of these have been given in the section in *Prajñāpanā Sūrtra* above).

Plants which have organisms which have one common gross body are again of many types:

Āluya, Mūlaya (radish), ginger,

Hirilī, Sirilī, Sissirilī, Jāvaī, Keyakandalī, onion, garlic, *Kuḍumbaya, Lohinihuya, Thihū, Kuhaga, Kriṣṇakanda, Vajrakanda, Suraṇa.*

Assakaṇṇī, Sihakaṇṇī, Musumḍhi, turmeric, and many more.

The maximum duration (life-span) of plant organisms is ten thousand years, minimum being less than 48 minutes.

[The section on plants has been dealt with more thoroughly in the previous scripture]

MOBILE ORGANISMS

Mobile organisms are of three types:

(a) fire-bodied, (b) air-bodied and (c) organisms with organic-bodied.

It can be seen that (a) and (b) (supra) which are usually classified as *sthāvara*, and (c) (supra) are regarded as *trasa* because of their mobility of some kind.

(A) FIRE-BODIED ORGANISMS

Fire is animate like earth and water. Whenever a fire is lighted living organisms are also produced simultaneously. Only if a fire is extinguished, the fire-bodied organisms die. The gross and fully developed ones are of many kinds; coal fire, chaff fire, fire, flame of fire, meteors, lightning and many more kinds.

The maximum duration of the life of fire-bodied organisms is three days; minimum being less than 48 minutes (*antarmuhūrta*).

(B) AIR-BODIED ORGANISMS

These organisms are produced in the air whenever a wind of some kind or other is created, naturally or artificially. One type of wind kills the organisms produced in another kind of wind. Thus gross and fully developed organisms are of five kinds : gusty wind (squalls), whirlwinds, thick, high and low winds and the *saṃvartaka* wind, i.e., hurricanes, typhoons etc. thus they are of many varieties.

The maximum duration of the life of air-bodied organisms is three thousands years, minimum being less than 48 minutes.

(C) MOBILE ORGANISMS WITH ORGANIC BODIES

These are of four kinds:

(a) organisms which possess two sense-organs

(b) organisms which possess three sense-organs

(c) organisms which possess four sense-organs

(d) organisms which possess five sense-organs

(a) Earthworms and other types of worms, shells, conches, cowries, leeches and many other kinds of organisms with two sense-organs. The maximum duration of the life of these organisms is twelve years, the minimum being less than 48 minutes (*antarmuhūrta*).

(b) *Kunthu*,[1] different kinds of ants and bugs, white ants, centipedes, cochineal and many other kinds of organisms with three sense-organs. The maximum duration of their life is 49 days.

(c) Different kinds of flies and mosquitoes, bees, moths, scorpions, crickets and many other types of organisms with four sense-organs. The maximum span of life for these organisms is six months.

(d) Organisms with all the five sense-organs are of four kinds:

(I) **Denizens of hell** : They are of seven kinds according to the seven

1. A very tiny insect with a body which is hardly 0.1 mm in size, but is visible. Kunthus are sometime found in old books. Their colour is exactly the same as that of the paper.

hells called *Ratnaprabhā*, etc.[1] The maximum and minimum duration of the life of the denizens of hell is different:

HELL	MINIMUM	MAXIMUM
First	Ten thousand years	1 *sāgaropama*
Second	1 *sāgaropama*	3 *sāgaropama*
Third	3 *sāgaropama*	7 *sāgaropama*
Fourth	7 *sāgaropama*	10 *sāgaropama*
Fifth	10 *sāgaropama*	17 *sāgaropama*
Sixth	17 *sāgaropama*	22 *sāgaropama*
Seventh	22 *sāgaropama*	33 *sāgaropama*

(II) **The sub-human animals which possess five sense-organs** : They are of two kinds:

(a) those which originate by generation acquivoca *(sammurcchima)*

(b) those which are born from a womb

Each of these are again of three kinds:

(i) Aquatic; (ii) Terrestrial; (iii) Aerial (Birds)

(A) Aquatic animals are of five kinds:

1. Fishes; 2. Turtles and Tortoises; 3. Crocodiles;
4. Makaras; 5. Giant whales and porpoises, dolphins etc.

(B) Terrestrial or land animals are of two kinds:

1. Quadrupeds and 2. Reptiles

Quadrupeds[2] are divided into four kinds on the basis of the construction of their feet:

i. Solidungular — with solid hoof — as horses

1. For detailed discussion of infernals (souls), refer to Bhagavaī (Bhāṣya), Vol.-I, Śatak-1, Sūtras 60-73.
2. For a more detailed dissertation of quadrupeds and reptiles, please see this section is Sutrakṛtāṅga Sūtra later on in this article.

ii. Biungular — with cleft hoof — as cattle

iii. Mutiungular — as elephants

iv. Animals having toes with nails — as lions

Reptiles are divided into two kinds:

i. Those which walk on their arms — as lizards

ii. Those which crawl on their breast — as snakes

Both are again of many kinds.[1]

(C) Birds and winged animals are divided into four kinds on the basis of the construction of their wings:

i. Those with membranous wings — as bats

ii. Those with feathered wings — as common birds

iii. Those with wings in the shape of a box.

iv. Those with wings which remain outspread

(III) **Human beings** : They are of two kinds:

(a) humans originating by generatio acquivoca *(sammurchima)*

(b) human born from the wombs of their mothers

Those who are born from the womb of their mothers are of three kinds on the basis of their habitat:

i. Those living in the *karmabhumi*

ii. Those living in the *akarmabhumi*

iii. Those living in interjacent islands

They have in the same order, fifteen, thirty and fifty-six subdivisions. Men originating by generatio acquivoca are also of as many kinds, Human beings live but only in a very small part of the cosmos.

1. In the sūtra there are enormus amount of sub-classification and many examples are given in the sūtras 104-112 of chapter-1 of the Jīvājīvābhigama Sūtra.

(IV) **The gods or the celestial beings** : They are the denizens of heavens, which are of four kinds:

a. *Bhavanapati* (Mansion gods)

b. *Vyantara* (Forest gods)

c. *Jyotiṣka* (Luninous gods)

d. *Vaimānika* (Empyrean gods)

Then follow the sub-divisions of gods:

i. 15 kinds of *Bhavanapatis*,

ii. 8 types of *Vyantaras*,

iii. 5 kinds of *Jyotiṣka*—Suns, moons, planets, stars, constellations.

iv. Details of many different kinds of *Vaimānikas* follow; then their maximum and minimum life-spans are given. In the highest *Anuttaravimāna, Sarvārtha-siddha* there is no difference between maximum and minimum. It is always 33 *sāgaropamas*.

Jīvājīvābhigama Sūtra

The detailed classification of living beings (**no. 1 to no. 19 as given in the tables at the end on page121-131**) given in this scripture[1] is almost the same as that found in the *Prajñāpanā Sūtra* (quoted above on pp. 57-59 of this book). What is more important is the description of each type of living being with reference to twenty-three characteristic features (given on p. 60 of this book).

Let us first discuss about the various types of the twenty-three features and then classify in tabular form at the end.

CHARACTERISTIC FEATURES

1. BODY

There are five types of bodies—

1. *Jivājivābhigama*, 1-13 to 136.

1. *Audārika*—**Gross body**; it consists of the gross material aggregates belonging to the *audārika vargaṇā* (i.e., a group of material aggregates which can be perceived through sense-organs). In the mobile organisms, the constituent matter is in the form of flesh, bone, blood, skin etc. In the immobile beings (such as earth, water, fire, air and vegeta-tion), it is made of the inorganic and organic stuff.

2. *Vaikriya*—**Protean body**; it consists of the subtle material aggregates which can be made to undergo change in form at will. It is a sort of supernatural process. It can be obtained by birth as well as through special spiritual technique.

3. *Āhāraka*—**Conveyance body**; it consists of very subtle material aggregates through which the ascetic who is the possessor of such supernatural power can communicate with the omniscient souls at extra-terrestrial regions.

4. *Taijas*—**Bio-electrical or Fiery body**; it consists of luminous aggregates which are very subtle. It is possessed by all living beings. Through special technique, it can be used as a supernatural power of thermoluminescence and efflugence. In normal course it is used in bio-electrical metabolic processes of life. It accompanies the soul even in transmigration.

5. *Kārmaṇa*—**Subtlemost body**; made of the karmic material aggregates which always accompany the soul even in transmigration.

In the following table, the number of bodies available in the type of living being is given and the serial numbers of the bodies out of the above five bodies which are available in the living being of that type are also mentioned. For example, in the subtle earth-bodies beings, the number of bodies available is three; they are 1—***Audārika***, 4—***Taijas***, 5—***Kārmaṇa***.

2. *AVAGĀHANĀ* (i.e., EXTENSION IN SPACE (HEIGHT OR SIZE))

The soul-units spread throughout the body, the size of which is mentioned as *avagāhanā*. It is measured in units such as—

Aṅgula (which is near about 1.66 inches)[1]

1 *ratni* = 24 *aṅgulas*

1 *dhanuṣya* = 94 *aṅgulas*

1 *gavyuti* = 2000 *dhanuṣya*

1 *yojana* = 4 *gavyuti*

The minimum and maximum *avagāhanā* have been given in the table. In case of protean body, two varieties are given—

1. the *avagāhanā* of the protean body by birth (*bhavadhāraṇiya*).

2. the *avagāhanā* of the protean body when the protean extension is made in the post-birth life (*uttaravaikriya*).

3. *SAṂHANANA* (i.e., PHISICAL STRUCTURE OR BONE-STRUCTURE)

There are six types of *saṃhanana*—

1. *Vajra-ṛṣabha-nārāca*

Saṃhanana stands for bone-strucutre. The word '*vajra*' means pin, '*ṛṣabha*' means the bandage of the bones, and '*nārāca*' indicates inter-locking of bones on both sides. The body in which the inter-locking of the bones and bandage of the bones are cross-tightened is called "*vajraṛṣabha-nārāca*".

Some *ācāryas* identify the pin with the bone itself.[2]

2. *ṛṣabha-nārāca*—Interlocking of bones on one side with half-pin and half-plate or interlocking of bones with pin (*ṛṣabha-nārāca*),

1. Viśva Prahelikā by Muni Mahendra Kumar, p. 236
2. Bha. Vṛ. 1.9

3. *nārāca*—Interlocking of bones on both sides (*nārāca*),

4. *ardha-nārāca*—Interlocking of bone on one side and pin on the other (*ardha-nārāca*),

5. *kīlikā*—Pin between two bones (*kīlikā*),

6. *śevārta*—Two bones bound by skin, sinews and flesh (*śevārta*).[1] There is no bone, veins and arteries, and sinews in the protean body, so it has been described as devoid of bone-joints.

4. *SAṂHANANA* (i.e., CONFIGURATION)

Configuration refers to the general shape of the body, its symmetry, arrangements of its parts and deformities. There are six types of *saṃhanana*—

1. *Samacaturasra*—The most auspicious configuration. Symmetrical body—from all sides.

2. *Nyagrodha-parimandala*—Symmetrical body above the navel only.

3. *Sādi*—Symmetrical body below the naval only.

4. *Kubja*—The limbs of the body such as hands, legs, head etc. are in order, but the chest, back, abdomen etc. are deformed; the hunch-backedness and the like.

5. *Vāmana*—The limbs of the body such as chest, back, abdomen are in order, but the hands, legs, head etc. are deformed; the dwarfish and the like.

6. *Huṇḍa*—The entire body is asymmetrical and ugly. The configuration of the five immobile living beings is *huṇḍa* with a typical shape.

1. *Ṭhāṇaṃ*, 6.30.

CONFIGURATION OF ONE-SENSED BEINGS

Earth-bodied—*masuracanda* i.e., similar to the shape of the *masura*—a kind of pulse which is in the shape of moon.

Water-bodied—*stibuka*—bubble-shaped.

Fire-bodied—*sūcikalāpa*—shape similar to a bundle of needles.

Air-bodied—*patāka*—flag-shaped.

Vegetation-bodied—*aniyata*—irregular; varied in forms.

5. *KAṢĀYA*—PASSIONS

There are four passions—anger, pride, deceit and conceit. Instinctually, they are present even in the most undeveloped forms of living organisms. Only the human beings in higher stages of spiritual practice can become free from them.

6. *SAṂJÑĀ*—UNLEARNED INSTINCTS

There are 10 *saṃjñās*, but in the present context the major four *saṃjñās* are taken into account. They are:

1. *Āhāra Saṃjñā* — Hunger Instinct
2. *Bhaya Saṃjñā* — Fear Instinct
3. *Maithuna Saṃjñā* — Sex Instinct
4. *Parigraha Saṃjñā* — Instinct of Possessiveness.

All living beings have these instincts by births, except the human beings who can become free from them in higher stages of spiritual practice.

7. *LEŚYĀ*—PSYCHIC COLOUR

The concept of *leśyā* is a very special theory of Jain philosophy. According to it, a very special kind of material aggregates get associated with the soul and influence it through their colour, creating psychic colour. This subtle phenomenon continuously goes on within the soul. The *leśyā* has two types of effect—malevolent as well as benevolent. The

three malevolent *leśyās* are—(1) black, (2) blue and (3) grey. The three benevolent *leśyās* are—(4) red, (5) yellow and (6) white. Thus in total there are six types of *leśyā*. The colour of the aura corresponds with the psychic colour. The colour of the material aggregates responsible for this phenomenon is called *dravya leśyā* (psychic colour), while the colour of the psyche is psychic colour. All activities (*yogā*) of mind, speech and body correspond with the psychic colour.

In the following table, the number of *leśyā* available are given and which *leśyā* are available are also indicated.

8. *INDRIYA*—SENSE-ORGANS

There are five sense-organs—

1. The sense-organ of touch
2. The sense-organ of taste
3. The sense-organ of smell
4. The sense-organ of sight
5. The sense-organ of hearing.

The living beings are one-sensed up to five-sensed, being possessed of respectively the above-mentioned sense-organs. Thus one-sensed beings have only one sense, viz., touch and so on.

9. *SAMUDGHĀTA*—EXPANSION OF SOUL-UNITS OUTSIDE THE BODY

Under certain conditions, the phenomenon of *samudghāta* takes place in the soul. When the soul is experiencing intense pain and the like, expansion of the soul-units takes place through the projection of the *pradeśas* of the soul in diverse directions. This is called *samudghāta*. There are seven types of *samudghāta*, which respectively are—

1. *Vedanā*—Expansion of soul-units due to intense pain.
2. *Kaṣāya*—Expansion of soul-units due to intense passions (anger etc.).

3. *Māraṇātika*—Expansion of soul-units due to impounding death.

4. *Vaikriya*—Expansion of soul-units related with the operation of protean body.

5. *Āhāraka*—Expansion of soul-units related with the operation of conveyance-body.

6. *Taijasa*—Expansion of soul-units related with the operation of bio-electrical body.

7. *Kevala*—Expansion of soul-units of an omniscient soul pervading the whole cosmos.

10. *SAṂJÑĪ-ASAṂJÑĪ*—POSSESSION OF BRAIN, NON-POSSESSION OF BRAIN

The lower organisms do not possess mind/brain and hence, are called *asaṃjñī*. Only some five-sensed living beings can have mind/brain. They are *saṃjñī*. Some humans in their higher stage of spiritual practice transcend the functioning of mental cognition (on account of supercognition) and hence, are called "*nosaṃjñī-noasaṃjñī*".

11. *VEDA*—SEX PASSIONS

There are thre kinds—

1. Masculine—Man's sexual passions.

2. Feminine—Woman's sexual passions.

3. Dual—Beings possessed of dual sexual passions (hermophrodite).

The souls in the higher stages of spiritual development (above the 9th *guṇasthāna*) transcend the sexual passions—become *avedī*.

12. *PARYĀPTI*—BIO-POTENTIAL

Bio-potential (*paryāpti*) means the building up of material forces at the very beginning of rebirth.

The *paryāpti* is six-fold, viz., 1. aliment, 2. body, 3. sense-organ, 4. inhaling-exhaling, 6. speech, and 6. mind.

The alimentary bio-potential (*āhāra-paryāptī*) means the production of material capacity functioning as appropriation, transformation and elimination of alimentary matter. The bio-potentials of body etc. are also to be understood similarly. All the six bio-potentials come into existence at the time of rebirth, but the development of the alimentary bio-potential takes place in one instant and of the rest within one *muhūrta* gradually. An organism born in a particular state of existence is *developed* or *under-developed* in respect of bio-potentials according as the development of its relevant bio-potentials has reached completion or remains incomplete.

13. *DṚṢṬI*—WORLD-VIEW

The view of the soul concerning the metaphysical truth is called *dṛṣṭi*. There are three types—

1. *Samyag-dṛṣṭi*—enlightened world-view.
2. *Samyag-mithyā-dṛṣṭi*—enlightened-cum-deluded world-view.
3. *Mithyā-dṛṣṭi*—deluded world-view.

Every soul must have one of these *dṛṣṭis*.

14. *DARŚANA*—INTUITION (i.e., The first phase of the process of knowledge, in which only the generic attribute of the object to be known are aprehended. It is a sort of indeterminate knowledge)

Every soul is possessed of consciousness. There are two types of sentience—

1. *Darśana* (apprehension of generic attribute)
2. *Jñāna* (cognition of the particular attribute)

There are four types of *darśana*—

1. Ocular—intuition through sense-organ of vision.
2. Non-ocular—intuition through sense-organs other than eyes.

3. Clairvoyant intution—extra-sensory intuition.

4. Omniscient intuition—intution quâ omniscience.

The non-ocular intuition is the minimum possible intuition, and hence, every living being is at least possessed of it.

15. *JÑĀNA*—COGNITION OF PARTICULAR ATTRIBUTES.

There are five types of *jñāna*—

1. Perception—Knowledge through senses and mind.
2. Articulate—Communicating knowledge.
3. Clairvoyance—Extra-sensory knowledge.
4. Mind-reading—Knowledge of what others think.
5. Omniscience—Knowledge of omniscient soul.

Every soul is equipped with minimum two types of knowledge—first, second.

Knowledge is classified with respect to the owner. If the owner (soul) has enlightened world-view, his knowledge is *jñāna*, which is indicated by + (plus), and the knowledge of one with deluded or enlightened-cum-deluded world-view is *ajñāna*, which is indicated by – (minus).

The '+ knowledge' is of five types, while the '– knowledge' is of three types.

16. *YOGĀ*—ACTIVITY

The operation of mind, speech and body is called *yoga*. There are three types of *yoga*—

1. Activity of body
2. Activity of speech
3. Activity of mind.

In the highest stage of spiritual development (in the 14th *guṇasthāna*) the soul transcends all activity and becomes free from it. (i.e., *ayogī*).

17. *UPAYOGA*—ACTIVITY OF CONSCIOUSNESS

Consciousness is the characteristic attribute of soul. Its activity is called *upayoga* (i.e., cognitive activity).

It is of two types—

1. *Jñāna* or *Sākāra Upayoga*—Cognition or knowledge.

2. *Darśana* or *Anākāra Upayoga*—Intuition.

Every soul has both types of *upayoga*.

18. *ĀHĀRA*—APPROPRIATION OF MATERIAL OBJECTS (AS FOOD ETC.)

Āhāra does not mean only food, but it includes every material object which is taken in by the soul. All the living beings from no. 1 to no. 19 appropriate the material objects (as food etc.) almost according to the following rules:

1. ***Āhāra* from substance-point of view :** Those material aggregates (*skandhas*) which are made of infinite number of indivisible units (*pradeśas*) are appropriated. The *skandhas* which consist of numerable or innumerable *pradeśas* can not be appropriated as *āhāra* by the living beings.

2. ***Āhāra* from space-point of view :** Those *skandhas* are appropriated which occupy innumerable space-units.

3. ***Āhāra* from time-point of view :** The *skandhas* of any duration—minimum, medium or maximum—can be appropriated as *āhāra*.

4. ***Āhāra* from mode-point of view :** The *skandhas* possessed of colour, smell, taste and touch can be appropriated as *āhāra*. The details of colour, smell, taste and touch are as follows:

   (a) **Colour** — The *skandhas* possessed of one, two, three, four or five colours (with respect to generalised concept) can be appropriated as *āhāra*; (with respect to classified concept), they can be black, blue, red, yellow or white. (This statement

is made only from an empirical standpoint; with respect to the transcendental standpoint, they must be of all the five colours (as they are *skandhas* consisting of infinite number of *pradeśas*). Again, in the same class of colour, the intensity may vary from one unit to infinite units of blackness up to whiteness.

(b) **Smell and** (c) **Taste** — The same rule holds good in case of two types of smell viz., good and bad; and five types of taste, viz., sour, sweet, bitter, astringent and acrid.

(d) **Touch** : The *skandhas* possessed of one, two or three types of touch (with respect to generalised concept) cannot be appropriated as *āhāra*, but those possessed of four, five, six, seven or eight can be (With respect to classified concept). the *skandhas* possessed of hard or soft, heavy or light, hot or cold, gluey (neative electricity) or dry (positive electricity) can be appropriated as *āhāra*. (Again, here also this is only empirically true; transcendentally, they should be of four or eight touches). Again, in the same class of touch, the intensity may vary from one unit to infinite units.

There are some other rules concerning the above-mentioned *skandhas*:

(i) They should be in touch with the soul-units.

(ii) They should occupy the same space-units as the soul.

(iii) They should occupy the same space-units without any gap.

(iv) They may be consisting of a few *pradeśas* as well as many.

(v) They may be situated either in upward direction, downward direction or lateral directions.

(vi) They may be in the beginning, or in middle, or in the end of the duration of their existence (which is of an *antara-muhūrta*[1] time-unit).

1. One *muhūrta* = 48 minutes; one *anataramuhūrta* is between two time-units up to one *muhūrta* less one time-unit.

(vii) The souls of the living beings appropriate only those *skandhas* which are suitable for them to become their *āhāra*; they cannot be unsuitable ones.

(viii) Even among the suitable *skandhas*, the beings appropriate them only through the sequence (or order) and not out of sequence. (By sequence is meant, those which are nearer to the souls).

(ix) As far as the directions are concerned, the souls of the beings would necessarily appropriate the *skandhas* from all the six direftions (viz., east, west, south, north, above and below), if there is no obstruction. In case of obstruction, they may be from three, four or five directions. (The obstruction is due to the supra-cosmic space-units which may be either in three directions or two or one direction; this is on account of the configuration of the cosmic space which is of the shape of three pyramids placed one above the other, with the lowest one facing downwards, the middle one facing upwards and the third one facing downwards). When the living beings are situated at the borderline of cosmic and supracosmic spaces, such obstruction would occur; otherwise for other beings there would be no such obstruction).

(x) All the above rules apply only generally.

(It would mean that statistically, the probability is that they would apply).

19. *UPAPĀTA*—METEMPSYCHOSIS

Every mundane soul transmigrates from one form of living being to another one. This is called as "*upapāta*" or metempsychosis. In this description, it is given that from which type, the soul will come to this (present) life-form.

In the following eleven types of living beings, the humans except those which belong to akarmabhūmi (i.e. the region where agriculture,

trade etc. are not the means of livelihood, but only through nature, the livelihood is obtained), *antaradvīpa* (i.e., the islands situated in between the main continent and the ocean) and which have a life-span of innumerable years, and the sub-humans except those which have a life-span of innumerable years can take birth—

1. Subtle earth-bodied
2. Gross earth-bodied
3. Subtle water-bodied
5. Subtle fire-bodied
6. Gross fire-bodied
7. Subtle air-bodied
8. Gross air-bodied
9. Subtle vegetation-bodied
11. Two-sensed
12. Three-sensed
13. Four-sensed
15. Five-sensed sub-humans born by agglutination

In the following types of living beings, the humans and the sub-humans as above and the gods belonging to the first and second heavens can take birth—

2. Gross earth-bodied
4. Gross water-bodied
10. Gross vegetation-bodied

In the 14. Infernal beings—only the humans which have accomplished bio-potentials except those which belong to the *akarmabhūmi*, *antardvīpa* and have life-span of innumerable years, and the five-sensed sub-humans except those which have life-span of innumerable years can take birth.

In the 16. Five-sensed sub-humans, born of the womb (or egg etc.)—only the humans and sub-humans except as described in the eleven types of beings, the infernals and the gods upto the eighth heaven can take birth.

In the 17. Humans born by agglutination—only the humans and subhumans except as above and except fire-bodied and air-bodied beings can take birth. (Gods, infernals, fire-bodied, air-bodied and humans and sub-humans of innumerable years' life-span cannot take birth here).

In 18. Humans born of womb—the infernals except those from the seventh hell, the sub-humans except fire-bodied, air-bodied and those which have innumerable years' life-span, the humans except those which belong to *akarmabhūmi*, *antardvīpa* and have innumerable years' life-span and all types of gods can take birth here.

In 19. Gods—only the five sensed sub-humans (both born of womb etc. or born by agglutination) and the humans born of womb can take birth here.

20. *STHITI*—DURATION OF LIFE-SPAN

The total durationof the soul in a particular life-form is its life-span (*sthiti*). The units of time used to measure the life-span are:

1 *Samaya* = individual unit of time

Innumerable *Samayas* = 1 *Āvalikā*

4446 $\frac{2458}{3773}$	*Āvalikās*	=	1 *Prāṇa*
7	*Prāṇa*	=	1 *Stoka*
7	*Stoka*	=	1 *Lava*
38½	*Lava*	=	1 *Ghaḍi*
2	*Ghaḍi*	=	1 *Muhūrta*
30	*Muhūrta*	=	1 *Ahorātra*
30	*Ahorātra*	=	1 *Māsa*
12	*Māsa*	=	1 *Varṣa*

8400000	*Varṣa*	=	1 *Pūrvāṅga*
"	*Pūrvāṅga*	=	1 *Pūrva*
"	*Pūrva*	=	1 *Truṭitāṅga*
"	*Truṭitāṅga*	=	1 *Truṭita*
"	*Truṭita*	=	1 *Aḍaḍāṅga*
"	*Aḍaḍāṅga*	=	1 *Aḍaḍa*
"	*Aḍaḍa*	=	1 *Avavāṅga*
"	*Avavāṅga*	=	1 *Avava*
"	*Avava*	=	1 *Hūhūkāṅga*
"	*Hūhūkāṅga*	=	1 *Hūhūka*
"	*Hūhūka*	=	1 *Utpalāṅga*
"	*Utpalāṅga*	=	1 *Utpala*
"	*Utpala*	=	1 *Padmāṅga*
"	*Padmāṅga*	=	1 *Padma*
"	*Padma*	=	1 *Nalināṅga*
"	*Nalināṅga*	=	1 *Nalina*
"	*Nalina*	=	1 *Arthanipurāṅga*
"	*Arthanipurāṅga*	=	1 *Arthanipura*
"	*Arthanipura*	=	1 *Ayutāṅga*
"	*Ayutāṅga*	=	1 *Ayuta*
"	*Ayuta*	=	1 *Prayutāṅga*
"	*Prayutāṅga*	=	1 *Prayuta*
"	*Prayuta*	=	1 *Nayutāṅga*
"	*Nayutāṅga*	=	1 *Nayuta*
"	*Nayuta*	=	1 *Cūlikāṅga*
"	*Cūlikāṅga*	=	1 *Cūlikā*
"	*Cūlikā*	=	1 *Śīrṣaprahelikāṅga*
8400000	*Śīrṣaprahelikāṅga*	=	1 *Śīrṣaprahelikā*

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1 *Palyopama* = Innumerable years

$10 \times 10^7 \times 10^7$ *Palyopama* = 1 *Sāgaropama*

21. *MĀRAṆĀTIKA SAMUDGHĀTA*—EXPANSION OF SOUL-UNITS BEYOND THE BODY, IMPOUNDING DEATH

As explained in the 9th characteristic feature, the third type of *samudghāta* is undertaken when the death is in proximity. During this *samudghāta*, the soul projects its soul-units outside the present body and reaches the place of new birth, and returns back and then after death, it leaves the present body and takes birth in the new life-form.

In the present topic, it is described whether a soul belonging to a particular soul-group (life-form) would undertake the *māraṇātika samudghāta* or not.

22. *CYAVANA*—DEPARTURE FROM THE PAST LIFE

When the soul leaves a particular life-form, it is called *cyavana*—departure. In the present topic, it is described whereafter departure, where they can take their re-incarnation.

23. *GATYĀGATI*—TRANSMIGRATION–TO (*GATI*) AND TRANSMIGRATION FROM (*ĀGATI*)

All life-forms are divided into four kinds of 'order of existence', viz.,

1. Infernal
2. Sub-human
3. Human
4. God

In the present discussion, we get the information about the *gati* and *āgati* in a particular life-form.

In the following table, the numbers of *gati* and *āgati* are given, the serial number of them being the same as given above.

Sūtrakṛtāṅga Sūtra

Though the title of Chapter No.3 of Part II of this scripture is given as "Science of Nutrition (*āhāra parijña*)", a more appropriate title would be "Science of Living Organisms". More than 40 paragraphs deal with vegetable kingdom, i.e. Botany and the remaining ones deal with other classes of living organisms, i.e. zoology.

BOTANY

SEED[1] is the most fundamental thing in the study of plants. Seed is the material cause of the entire vegetable kindgom and it is also the end product, i.e. the life of a plant begins with the germination of the seed, passes through several stages and terminates with the production of seed. The chapter therefore starts with the classification of seeds. They are of four kinds[2]:

(i) Seeds of some plants are located on the top e.g. *Koraṇṭaka* — *agrabīja*

(ii) Seeds of some plants are located in the root e.g. Lotusbirk — *mūlabīja*

(iii) Seeds of some plants are located in the knots e.g. Sugarcane — *parvabīja*

(iv) Seeds of some plants are located in the stem e.g. fig tree, woodapple tree — *skandhabīja*

Terms *ahābieṇaṃ* and *ahāvagaseṇa* refer to the material and the auxiliary causes of the reproduction of a particular species of plant. The former *(yathābīja)* asserts that the plant which develops from a seed will be similar to its parent (from which the seed was shed). One cannot grow a mango-tree from the seed of a neem-tree. The latter term *(yathāvakāśa)* means the soil, water, time etc. which are the auxiliary causes for reproduction. One can get a crop of rice only if one sows the rice-seed in a well tilled soil, in the rainy season and so on. One cannot grow rice on rocky soil without adequate water and in summer. All the auxiliary causes are necessary for the reproduction of plants.

Terms *kammovaga* and *kammaṇiyaṇeṇaṃ*,[3] on the other hand, refer to the transcendental causes of the reproduction of a particular species

1.In Botany, seed is defined as—Fertilized and ripened ovule (female gera-cell) which can be shed from its parent plant and is capable of developing into another plant similar to its parent. Within protective coat (testa) is as embryonic plant, usually with its own food supply.

2. Daśavaikālika Sūtra, Ch. IV, Sūtra 8.

3. Sūtrakṛtāṅga Sūtra, Part II, Ch. 3, Sūtra 2.

of plant. Birth of an individual organism(animal or plant) in a particular species, at a particular time and in a particular place is neither arbitrary nor accidental but the very precise result of the individual's karman, which again is the result of its actions in the past life or lives. The determination of the species, the life-span, the time and the place of birth, the status, feeling of pleasure or pain and all such other fundamental factors of the individual's life are the combined result of the four *aghātin* karman viz., (i) body-making *(Nāma)* karman, (ii) status-determining *(Gotra)* karman, (iii) feeling-producing *(Vedanīya)* karman and, (iv) life-span determining *(Āyuṣya)* karman and their relevant sub-categories. This is referred to by the terms,[1] *tajjoṇiā, tassambhavā,* and *tavvakamma.* The organism which comes into existence as a plant or a part of a plant is the result of the rise of vegetable *(vanaspatikāya-sthāvara) nāma* karman.

In this canon the vegetable kingdom is classified into:

(1) TREES: These are perennial plants with self-supporting woody main stem, usually attaining a large size and developing woody branches at some distance from ground. Those which grow from the ground have their roots below the earth's surface and which attach them to earth and convey nourishment to its parts from the soil.[2]

(2) Trees which are born from trees: Instead of originating and growing from the earth, this class of trees spring from other trees which have their roots in the earth. Since they have no direct connection with the earth, they get their nourishment from the trees which support them.

(3) Trees which are offshoots of the trees which themselves grow from other trees which are earth-based. They obtain their nourishment from the above trees from which they have sprung.

(4) Parts of the tree-based trees—root, tuber, trunk, branches,

1. Sutrakṛtāṅga Sūtra, Part II, Ch. 3, Sūtra 2.
2. Some trees grow in colossal heights and live for hundreds of years. Perhaps the highest trees are WELLIGTONIA (sequia giganta); average height 275 feet; native of california, U.S.A., where they have lived more than 2000 years. Next to them are DOUGLAS FIR (pseudotsuga taxifolia), 200 feet; Western North America; Ash 140ft; Larch 150ft.; Silver Saple 130 ft. Scots Pine 120 ft.; Cedar, Beech and Horse Chestant 100ft.

twigs, leaves, flowers, fruits, seeds—

These four sub-divisions of trees are repeated by substituting

(a) creepers (b) grasses (c) herbs (d) shrubs in place of trees.

The last are *Kuhaṇas* which have no sub-division.

A) Creepers are defined as plants that creep along ground or trees,

B) Grasses are defined as small plants, blades and leaves and stalks of which are eaten by horses, cattle, etc. Plants belonging to the order Gramineae (in Botany cereals, reeds and bamboos are included while popularly they are excluded).

C) Herbs are defined as plants of which leaves etc. are used for flavor, food, scent and medicinal purposes. Their stems are not woody or persistent but dies down after flowering.

D) Shrubs are neither trees nor grasses nor herbs. They are defined as woody plants without main trunk of tree but divided into separate stems from near the ground and with above-ground parts which persist in winter.

Nourishment of Plants

We now come to the literal meaning, as discussed in the scripture, i.e. the nourishment (of plants) in Botany.

All the living organisms obtain their nourishment (for survival and growth) from the nutrient fluids extracted from the earth. This is referred to by the phrases, "*puḍhaviṇaṃ siṇehaṃāhāreṃti*". Term, '*siṇeha*' (*sneha*) means nutrient fluids; trees which have their roots in the earth have the ability to extract various nutritive substances from the soil, transform them into a fluid mixture and conduct this watery sap, rich in nutrients, upwards through the stem and distribute it to all the parts.This nutritive mixture is composed of the inorganic minerals (earth-bodies), water-bodies, fire-bodies, air-bodies, bodies of plants; they deprive many mobile and immobile organisms of their life and extracting the nutrients

from their dead bodies, ingest them in the form of the above-mentioned sap. The nutrients are digested, absorbed and assimilated by the trees which build various parts from these. Such parts are of different colours, smells, tastes, touches and forms.[1]

In the same way and in nearly the same words, all other classes of plants, vegetables, viz., grasses, herbs, and shrubs growing from earth and growing from trees etc. are treated. After finishing with these trees, the creepers, grasses, herbs and shrubs growing in water are taken up and they are also treated in nearly the same way and in nearly the same words. Names of further sub-divisions of neither the trees nor grasses etc., have been given. The only names given are those of the last special class of plants *(vanaspativiśeṣa)* growing on the earth; these are :

Aya, Kaya, Kuhaṇa, Kaṃḍuka, Uvvehaliya, Nivveliya, Sacatra, Catraka, Vasaṇiya and *Kura.*

Similarly names of the special class of plants growing in water, are given; these are :

Udaka, Avaka, Panaka, Saivāla, Kalambuka, Jalakumbhī, Kaśeruka, Kacabhaṇiya, Utpala, Padma, Kumuda, Nalina, Subhaga, Saugaṃdhika, Puṇḍarika, Mahāpuṇḍarika, Śatapatra, Sahasrapatra, Kalhara, Kokanada, Arvinda, Tamrasa, Kamalamūla, Kamalanāla, Puṣkara and Puṣkarākṣibhaga.

Some of these are easily identifiable:

Avaka is grassy plant growing in marshy land—Blyxa Octandra.

Saivāla is the aquatic plant Vallisneria, popularly known as *kalambuka* is the *Kadamba*—Nauclea *Kadamba.*

1. According to Biology, green plants are auto-trophic, i.e., they are capable of living and growing by manufacturing all its food from inorganic compounds; only compounds they need are carbon-dioxide, oxygen, water, and various mineral salts. An autotrophic organism will also need a supply of energy, which can come from sunlight. To convert by the process of Photosynthesis, inorganic elements into organic nutrient in the form of carbohydrates by combination of energy from sunlight, water from the cell and carbon-dioxide from the air. Oxygen is eliminated during the process.

Kaśeruka is a kind of grass—Scirpus Kysoor.

Utpala, *Padma*, *Kumuda*, and *Nalina* are well known varieties of lotus; *Puṇḍarika* and all those which follow are all varieties of lotus or parts—stalks, fibres, eyes etc.—of the lotus.

ZOOLOGY

We now come to the discussion of different class of organisms, which are endowed with the power of voluntary locomotion and which possess organic-bodies. The organisms which are dealt with here are those mobile ones which are very intimately associated with the trees, creepers, grasses, herbs, and shrubs etc., be they grown from earth or water and which were dealt with in the preceding paras. These mobile organisms are born on them and live and grow on them obtaining their nourishment from the different parts—roots, leaves, flowers, fruits, seeds, etc.,—of these trees etc. They also ingest earth-bodies, water-bodies etc, as described before and digest and assimilate the nutrients from them.

Though the text is spread over 30 *sūtras* (paras)[1], these organisms are not classified or subdivided. On the contrary different paras repeat the same things and in nearly the same words all the different classes of earth-based and water-based plants.

HUMAN BEINGS

Only one *sūtra* (*pārā*)—no. 76—deals with humans in this canon. Humans are classified into three kinds on the basis of their habitats—(a) born in *karmabhūmi*, (b) born in *akarmabhūmi* and, (c) born in interjacent islands.[2] They are also classified as Aryans and Non-aryans. Sex of each human is determined in accordance with one's karman and the seed from

1. Sutrakṛtāṅga Sūtra, Part II, Ch. 3, Sūtras 76-100.
2. According to the Jain canons, among the innumerable continents and oceans only Jambū, Dhtātakikhaṇḍa, and the half of the Puṣkara consitute the habitat of humans. Jambūdvīpa is the innermost (of the continents) and has Mount Meru at its centre. It is circular in shape and has a diameter of one lakh yojanas. Therein exists the seven regions, viz., Bhārata, Haimavata, Hari, Videha, Ramyaka, Hairaṇyavata, and Airāvata. Desecting these seven regions are six mountains running lengthwise from east to west.

which one is born. The womb of the mother in which the fertilization of the female seed—ovum—by the male sperm takes place, plays an important part in the process of reproduction of a human being. The entire process is briefly described but there is insufficient information for us to make a coherent story.

1. REPRODUCTION

Living organisms perpetuate their species from one generation to another through the process called reproduction. It is a duplication and transmission of characteristics from parent to offspring. In lower organisms, reproduction is often a simple matter of division of cells. In five-sensed organisms including humans, sex comes into operation, i.e., reproduction requires two parents—a male and a female. Reproductive cells called gametes, which are produced in the reproductive organs of both sexes, are a special variant of cell. The female gamete is called ovum *(rajaḥ)* and the male gamete is called sperm *(śukra)*.

2. CONCEPTION

The incredible sequence of events that occur before birth, resulting in the formation of a perfect human being, is one of the most amazing parts of the human story. Fertilization is the union of the ovum with the sperm which takes place in the mother's womb. In humans, a mature viable ovum is surrounded by a barrier (tough membrane). An estimated 35 million sperms are needed to break a large enough hole in the barrier for a single sperm to enter the ovum. As soon as this is accomplished, the ovum fuses with the sperm and prevents the entry of additional sperms. Now the male pronucleus with 23 chromosomes unites with its

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In the second continent, viz., Dhātātakikhaṇḍa, Varṣās, i.e., the seven regions are twice than those of Jambūdvīpa.

In Puṣkarārdha (half of Puṣkara) there is the same number of regions as in Dhātātakikhaṇḍa.

So there are five Bharatas, five Airāvatas and five Videhas (one each in Jambū, two each is Dhātātakikhaṇḍa and two each is Ardha Puṣkara); these are the Karmabhūmis (that is, the life is sustained by agriculture, trade and socio-economic security organization). The rest including Devakuru and Uttarkuru are 30 Akarmabhūmis. Interjacent Islands are seven groups of eight islands, each situated intermediate between the continents.

counterpart—the female pronucleus—and the full complement of 46 chromosomes align themselves in 23 pairs in the fertilized ovum. The single integrated cell is ready to receive a soul.

Precisely at this instant a transmigrating soul, which is conscious substance enveloped in a microbody—*karma śarīra*—arrives in the womb (transmigrating from its previous life) and animates this fertilized ovum which becomes its physical body through a stage by stage biological process called *paryāpti*.[1] A new human being has been conceived.

The above process of fertilization and conception is referred to by the following terms:

Terms, '*ahābīena*', '*ahāvagāseṇa*' and '*kammakaḍāe joṇie*' refer to the above. Here in the case of humans, *bīja*, i.e., the seed means the ovum fertilized by the sperm. It is popularly believed that when the sperm is more powerful, the issue will be a male, when the ovum is more strong, the issue would be a female and both are equal in strength, the issue would be a eunuch. The second term '*yathā avakāśa*' refers to the reproductive organs of the female, i.e., the womb. For a successful reproduction, the womb must be active and efficient as also there should be the seed. The third term is complementary to the two above. It indicates that the effort would not be successful if the womb is unsatisfactory. The child-bearing age of a woman is from 15 to 50 years.

Term '*mehuṇavattiyāe*' means the sexual intercourse. Sperm, the male gamete, must be delivered into the womb of the mother where the ovum would be awaiting fertilization. This is done by the actual act of copulation. The *Cūrṇikāra* says that embracing, kissing and caressing may precede the act of copulation but conception will occur only if the sperm is delivered by ejaculation within the womb. The phrase '*te duhao vi*

1. Processs of paryāpti is the acquisition and consumption of the potential vital faculties necessary for survival and functions of life. It is completed in six stages : 1. Āhāra paryāpti is the instantaneous union of the soul and the fertilized cell, 2. Śarīra paryāpti—adoption of the fertilized cell as the physical body, 3. Indriya paryāpti, 4. Śvāsocchvāsa paryāpti, 5. Bhāṣā paryāpti, 6. Mana paryāpti—the sequence of the consumption of the potential faculties of sense-organs, respiration, speech, and thought respectively.

siṇehaṃ saṃciṇaṃti' refers to the entry of the sperm into the mature ovum by penetrating the surrounding barrier and fusing of the pronuclei of both gametes as described above. It is only then that the integrated cell is ready to receive the animating conscious principle, the soul. If there is no entry of an animating soul upto a short specific period, the cell would decompose and would be excreted.

3. PRENATAL DEVELOPMENT

Now the single cell with a full set of 46 chromosomes, (23 from the mother and 23 from the father) divides into two duplicates of itself. This is the first in the series of many divisions and the cells divide again and again in a long process of development in which many changes occur in a precise sequence. Using the instructions spelled out in the DNA blue-prints contained in the nucleus of the fertilized and animated cell, the embryo produces all the different organs in a precise sequence following a harmoniously regulated time-schedule. The growing embryo is attached, first by a stalk and then by a rope like umbilical cord to the placenta.[1] It receives nourishment from the mother's humers through the placenta via its umbilical life-line.

The passage, "*te jīvā māuoyaṃ piusukkaṃ tadubhaya-saṃsaṭṭhaṃ kalusaṃ kibbisaṃ tappaḍhamayāe āhāramāhāreṃti. tao pacchā jaṃ se māyā nānāvihāo rasavaīo āhāramāhāreṃti, tao egadeseṇaṃ oyamāhāreṃti. aṇupuvveṇaṃ vuḍḍhā palipāgamaṇupavaṇṇā, tao kāyāo abhiṇivaṭṭamānā itthiṃ vegayā jaṇayaṃti, purisaṃ vegayā jaṇayaṃti, napuṃsagaṃ vegayā jaṇayaṃti. te jīvā ḍaharā samāṇā māukkhīraṃ sappiṃ āhāreṃti, āṇupuvveṇaṃ vuḍḍhā oyaṇaṃ kummāsaṃ tasathāvare ya pāṇe—te jīvā āhāreṃti puḍhavisarīraṃ āusarīraṃ teusarīraṃ vāusarīraṃ vanassaisarīraṃ tasapānasarīraṃ. ṇāṇāvihāṇaṃ tasathāvarāṇaṃ pānāṇaṃ sarīraṃ acittaṃ kuvvamti. parividdhaṭṭhaṃ taṃ sarīraṃ puvvāhāriyaṃ tayāhāriyaṃ vipariṇayaṃ sāruvikaḍaṃ saṃtaṃ (savvappanattāe āhāreṃti?).*"

1. Placenta—organ formed in uterus of placental mammals by close union of tissues of mother and embryo. It serves to nourish embryo.

When a human body is born, it is already about nine months old. It has spent these nine months of life, since conception, living as a parasite within the body of its mother. During this period it increases from a microscopic single cell to 3 to 4 kgs. mass of protoplasm composed of nearly 10 trillion cells, integrated into various functional systems.

4. BIRTH

Birth inevitably brings a certain amount of trauma for the infant. For nine months, it has rested in gently supporting fluids. The sheltering environment is suddenly replaced by air. The oxygen supply from the mother is cut off. With a convulsive gasp the newborn draws in air and fills its tiny lungs for the first time. A baby's existence and growth is dependent partly on hereditary programmed instructions contained in its DNA and partly in the instructions from the fruition of the body-making (*nāma*) karman. Organ-building, joint-building, structure-building, survival, and growth would be the outcome of the joint action of the DNA and various sub-species of the body-making (*nāma*) karman.

SUB-HUMAN VERTEBRATE ANIMALS

Para nos. 77 to 81 deal with the vertebrate animals which are possessed of five sense-organs. The process of reproduction in their case is very much similar to that of the humans requiring two parents and generally as described above. However while humans are viviparous, the sub-human animals are of three kinds:

(a) Viviparous—animals which bring forth their young in a developed state and whose embryo develops within its mother, obtaining nourishment from maternal tissues, e.g., placenta. All placental mammals are viviparous and so are certain animals (in botany germinating while still attached to the parent plant).

(b) Oviparous—animals which produce their young by means of eggs and lay eggs at the stage when there has been little of any development of embryo.

(c) Ovoviviparous—animals which produce their young by means of eggs which develop and hatch within its mother's body and

may obtain nutriment therefrom but is still separated from its mother by membranes of the fertilized egg.

Phrase, "*tao kāyāo abhiṇivaṭṭamāṇā aṃdaṃ vegayā jaṇayaṃti, poyaṃ vegayā jaṇayaṃti*" refers to this alternative manners of birth of the young from the mother's womb: "*abhinivaratmāna*" means emerges out from the mother's body; "*amdam*" means egg; and "*potam*" means fully developed infant.

These sub-human vertebrate animals are of three kinds:-

1. Aquatic animals 2. Land animals 3. Aerial animals

(1) AQUATIC ANIMALS: Para 77 deals with aquatic animals, (*jalacara*). Their subdivision in this scripture is identical to that given above in *Uttarādhyayana*, viz.; fishes, turtles and tortoises, crocodiles and alligators, *Magaras*, whales & dolphins. Some of them are born as eggs and some are brought forth as fully developed young animal. Their varieties caused by (difference of) colour, smell etc., are counted by thousand.

(2) LAND ANIMALS: Pp. 78 to 80 deal with two types of terrestrial or land animals (*sthalacara*)—quadrupeds and reptiles, the latter again being of two kinds—snakes and lizards. All these are again sub-divided into many kinds as under: the quadrupeds are of four kinds on the basis of the shape of their feet.[1]

i. Solidingular—animals with solid hoof, as horses; (*ekakhura*)

ii. Biungular—animals with cleft hoof as cattle; (*dvikhura*)

iii. Multiungular—animals as elephants; (*gaṇḍipada*)

iv. Animals having toes with nails, as lions; (*sanakhapada*)

1. In Biology the term 'UNGULATES' was used—it is now obsolete—for hoofed mammals, (UMGULA means hoof, talon or claw) such as ARTIODACTYLA AND PERISSODACTYLA. The former meant—even toed ungulate mammals, with the aid of each foot lying between the 3rd and 4th toe—as cattle, hippopotamus, pigs, camels, giraffe, dear, sheep, antelopes. The latter meant ungulate mammals which walk on hoofed toes with weight-hearing aid along 3rd toe, which is larger than the others in most cases e.g., rhinoceros, horse, tapir.

The reptiles are of two kinds:

i. Those which are limbless and walk on their breasts, as snakes, pythons, *āsālika* and *mahoraga.*

ii. Those which have short limbs and walk on their arms as all varieties of lizards such as iguanas, ichneumons, chameleons, geckos, etc. all varities of rodents such as rats, mice, porcupines, etc. frogs, khoras, mongooses, and many others.

(These names are not to be found in *Uttarādhyayana* but they are given in *Prajñāpanā*).

In the case of reptiles, some are brought forth as eggs while some are born as fully developed young ones.

(3) BIRDS AND FLYING ANIMALS : The birds and flyng animals (*khecara*), are dealt with in para.81. On the basis of the types of their wings they are divided into four kinds:

i. Those with membranous wings as bats

ii. Those with feathered wings as common birds

iii. Those with wings which never open[1]

iv. Those with wings which never close

This sub-division of the flying animals is again identical to that given in *Uttarādhyayana.* Samudaga, the third type mentioned above are said to live outside the human habitat. The passage, "as long as they are young, they are hatched by their mothers' warmth" is special to these organisms.

After the completion of the treatment of vertebrate sub-human animals with five sense-organs, as above, we would have expected that organisms with four, three and two sense-organs would be dealth with. Instead, we find the following three paras dealing with parasities and

1. Birds of the family Spheniscidae—penguins and several genera of sea-birds of southern henisphere, have their wings reduced to scaly 'flippers' with which they cannot fly but can swim under water.

vermin and there is no indication whether these are possessed of two or three or four sense-organs.

PARASITES AND VERMIN

Para. 82 deals with mobile organisms which originate and grow on the animate as well as inanimate bodies of various mobile as well as immobile organisms. They obtain their nourishment from the nutritive fluids (humors) which are produced in these or by these bodies. Similarly, para. 83 deal with the vermin originating and growing in the excreta—filthy substances as urine, faces etc.,—of the humans as well as sub-human mobile organisms (immobile organisms are excluded). Similarly para. 84 describes the vermin '*carmakīṭa*', i.e., a skin parasite which originates in the living or dead bodies of mobile as well as immobile organisms. There is no further dissertation about these organisms except the usual statement that they are of thousands of varieties because of the difference in their colour, place etc.

Term, '*anusuya*' in para. 82 indicates the parasitic nature of the organisms which are born on the bodies of other organisms. Similarly term, '*duruvasambhava*' in para. 83 and '*khuraduga*' in para. 84, indicate vermin infesting excreta and the skin of other organisms respectively.

IMMOBILE ORGANISMS (*STHĀVARAS*)

The rest of the chapter, i.e., paras. 85 to 100 is devoted to the dissertation of the four remaining immobile organisms, viz., (a) water-bodied; (b) fire-bodied; (c) air-bodied; and (d) earth-bodied organisms.

(a) WATER-BODIED ORGANISMS: Para.85 deals with those water-bodied organisms which are multiformed-yonikas, i.e., which originate and grow in the form of water on or in the bodies of manifold mobile and immobile organisms. Para. 86 deals with those water-bodied organisms which are water yonikas, i.e., which originate in water produced by manifold mobile and immobile organisms. Para. 87 deals with those water-bodied organisms come forth in water-bodies produced by other water-bodies. And finally para.88 deals with those water-bodied organisms which come forth as mobile organisms in the water produced by water bodies.

Thus we have four different *yonikas*.

The organisms which are born on or in the bodies of other organisms have molecules of water as their bodies. And then it is said that this water body is produced by wind, is condensed by wind and is transported by wind. It moves upward with an upward wind, downwards with a downward wind and moves in the horizontal direction if the wind moves horizontally. (they are of several kinds such as) mist (water-vapour precipitated in droplets smaller and more condensed than those or rain), hoarfrost (ice crystals-formed by condensation of water vapour below freezing point), snow, hailstones (pellets of frozen water falling in shower), dew (water-vapour condensed on cool surfaces on or near the ground) and rainwater. (Note: all these are varieties of RAW water produced as NATURAL phenomena). The water-bodied organisms obtain their nourishment from the nutritive fluids (humers) of the bodies of the various mobile and immobile organisms (in or on which they are originated as stated before). And the bodies of these water-bodied organisms are of many varieties.

The dissertation in respect of other yonikas is similar except that each kind obtain their nourishment from the environment in which they are produced.

(b) FIRE-BODIED ORGANISMS: There is hardly and difference in the treatment of fire-bodied organisms from that of water-bodied ones and the four paras. 69 to 92 just repeat what has been said in the preceding four paras, substituting fire-bodied organisms in place of water-bodied ones.

(c) AIR-BODIED ORGANISMS: Four paragraphs which follow—paras. 93 to 96—treat air-bodied organisms in the same way as the preceding ones treat fire-bodied organisms.

(d) EARTH-BODIED ORGANISMS: Four paragraphs which follow—paras. 97 to 100 deal with Earth-bodied organisms in the same manner. In para. 97 various kinds of earths are indicated. After giving a couple of names reference is made to *Uttarādhyayana* for the names of many types of earth. Otherwise they treat the Earth-bodied organisms in the same way as the preceding ones treated Fire-bodied and Air-bodied organisms.

We shall now discuss about the Nourishment (of animals) in the scriptures and in Zoology.

A significant difference between the dissertation given in *Sūtrakāṅga Sūtra* and the other two scriptures is the importance given to nourishment of the organisms here, while this aspect is totally absent in the other two. Organisms on planet earth are chemical beings, whose organic- bodies are made up mainly of carbon compounds. Body of one organism (or its parts) would provide nourishment for another organism.

Scriptures assert that all organisms without exception, mobile as well as immobile, must take nourishment for survival. Food is of three kinds—animate, inanimate, and mixed.

Animate food refers to the intake of live organisms. This is of six kinds:

a. Earth-bodied organisms are taken in the form of minerals
b. Water-bodied organisms are taken in the form of raw water
c. Fire-bodied organisms are taken in through skin
d. Air-bodied organisms are taken in through skin
e. Plants & their parts are taken in as vegetables, fruit etc.
f. Mobile orgtanisms are taken in by carnivores

Inanimate food consists of the bodies of organisms (from which the soul has transmigrated) mixed with inorganic substances.

Scriptures specify three ways of the intake of nourishment:

'*Oja āhāra*'—When a soul arrives at the place of its metempsychosis, it is bereft of a physical body, but is accompanied by the subtle bodies. To build up the physical body for the new life, it unites with the body-building matter—earth or water or ovule or the fertilized cell—which is consistent with its new life. This initial intake of the body-building matter, which would become its new body is *oja āhāra*.

'*Loma āhāra*' or '*Roma āhāra*'—Intake of nourishment through (the pores of) skin or the sense-organ of touch is *loma āhāra*. Intake of sunlight

and ingredients of the air—oxygen, carbon-dioxide etc.—are instances of loma ahara. This type of intake is believed to be continuous and ceaseless.

'*Prakṣepa āhāra*'—Ingestion of nourishment through mouth is called *prakṣepa* or *kavala āhāra.*

Some *Ācāryas* have explained these in a different way:

'*Prakṣepa āhāra*' is the assimilation of the external matter after ingesting it into the gross body through the sense-organ of taste.

'*Oja āhāra*' is the assimilation of external matter after its intake through the sense-organs of smell, sight and sound in the gross body.

'*Loma āhāra*' is the assimilation of external matter after its intake through the sense-organ of touch only in the gross body.

It can be seen that whatever is the manner of intake, the significant factor about nourishment is its assimilation (absorption into the system) which is preceded by digestion and metabolic processes inside the body.

The passage which describes the manner of nourishment of all organisms in this scripture and which is repeated again and again is already given [see page no. 85]. This passage is translated as..... "these organisms consume earth-bodies, water-bodies, fire-bodies, air-bodies and vegetable-bodies: depriving the life of manifold mobile and immobile organisms they render their bodies to become inanimate; these inanimate bodies which had already been taken-in by them through their sense-organ of touch, are digested, metabolised and assimilated by them."

The identical passage is repeated in all the paragraphs and applies universally to all organisms, mobile as well as immobile—in respect to their nourishment.

In the case of human beings, this passage is preceded by the following: "(the human beings) at first (i.e. at the instant of their conception) feed on the unclean, foul (substance) which is produced by the menses of the mother and the semen of the father. And afterwards

they absorb their nourishment through the placenta, (which is formed by the interlocking of fetal and maternal tissues). Gradually growing and attaining proper dimensions, they come forth from the womb. As long as they are infants they are nourished by their mothers' milk and fat; but when they grow up they ingest boiled rice and gruel and both mobile and immobile organisms." This also applies with minor variation to the vertebrate sub-human animals.

In Biology, organisms are divided into two kinds:

1. AUTOTROPHS — Organisms capable of living and growing by manufacturing all its food from inorganic compounds. A green plant is autotrophic because the only compound it needs are carbon dioxide, oxygen, water and various mineral salts. Such an organism will also need a supply of energy which can come from sunlight (PHOTOTROPHISM) or breakdown of inorganic compounds (CHEMOTROPHISM, i.e., obtaining energy by oxidation of inorganic compounds. When applied to an autotroph the organism is said to be chemoautotrophic or chemosynthetic).

Photosynthesis—Formation within the green plant CHLOROPLAST—solid body inside plant cell which contains chlorophyll; sight of photosynthesis—(or other pigment system in some algae and bacterial) of organic nutriment (food) in the form of carbohydrate by combination of energy from sunlight and carbon dioxide from air. Oxygen is eliminated during the combination.

2. HETEROTROPHS — Organisms dependent for food on other organisms, living or dead.

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CHAPTER-III

BIOLOGY IN JAIN SCRIPTURES : A CRITIQUE

NATURE OF LIFE — SCRIPTURAL VIEW OF LIFE

SOUL AND BODY

According to Jains, every living organism is an organic unity of two distinct entities — A non-material conscious principle called soul and the material or physical body animated by the soul. While the soul is consciousness (*cetanā*), non-corporeal (*amūrta*) and imperceptive to senses (*arūpi*), the body, by itself, is devoid of consciousness (*acetana*), corporeal (*mūrta*) and perceptible to senses (*rūpi*), because it is made up of molecules of matter. Again according to Jains, there is not one but two different bodies. The gross or physical body that we actually perceive is constituted by ordinary matter, nourished by matter ingested in the form of food. It is changing every moment, degenerates with ageing and is given up by the soul after a certain period of time, i.e. at the end of the life-span. The soul itself, being eternal and indestructible, transmigrates to begin another life.

Besides this gross body there is for every soul a subtle body which is called *kārmaṇa śarīra*. This body is also constituted by molecules of matter which are quite different from ordinary organic or inorganic matter. They are so much more subtle that they are massless. This subtle body cannot be given up but remains as an inalienable appendage of the soul during its transmigration and metempsychosis. This is transcended only when the soul attains disembodied emancipation which is its pure and perfect state. But in the meantime in its mundane state the soul undergoes metempsychosis from one species of organism to another. And the birth and rebirth of an individual soul in a particular species at a particular time and in a particular place is neither arbitrary nor accidental but the very precise result of the individual's karman which again is the result of its actions in the past life or lives.

In the scriptures this is asserted with great emphasis. Thus in *Sūtrakṛtāṅga Sūtra* we come across the terms, '*Kammovaga*'[1] and '*Kammaniyaneṇaṃ*',[2] which respectively means 'under the influence of karman' and 'because of the karman'. These are expounded as under: the birth, life-span and activities of each and every living organism are the result of the fruition of its own karman. e.g. a plant comes into existence because the conscious principle of the plant, due to the rise and fruition of specific sub-species of the body-building (*nāma*) karman and life-span determining (*āyuṣya*) karman provide the necessary impetus for its metempsychosis as a plant in a particular place, i.e., in a particular soil. Fruition of karman is the causal force which guides and brings about as its effect the existence of the plant. In short, the species, the place or location and time are all determined by karman. *Nidāna* in the second term means causal potency. While the conscious principle of the plant is eternal and uncreated, the body of the plant comes into existence because of the karman associated with that soul in the form of a *karmāṇa śarīra*. It is this subtle body—*kārmaṇa śarīra*—which is the causal force for producing the gross physical body which is seen as a plant or an organ of a plant.

In Biology, seed is the fertilized and ripened ovule of flowering plants, containing embryo capable of developing into a plant by germination. Seed, like other parts of the plant, is an animate or living organism. According to Jains, the process of germination proceeds because of the *kārmaṇa śarīra* of the soul in the seed. This is indicated by the terms, *ahābieṇaṃ*, *ahāvagāseṇa*, etc..[3] The souls which on account of their karman are to be born as trees may be embodied in the seed or in earth

1. Sūyagaḍo Vol. 2, Ch. 3 Sūtra P 261.
2. Ibid., Vol. 2 Ch. 3 Sūtra 2 p 262.
3. Sūyagaḍo Vol. 2, Ch. 3 Sūtra 2 P. 183—tesia ca ṇaṃ ahabieṇaṃ ahāvagāseṇaṃ ihegahiyā satta puḍhavijoṇiyā puḍhavisaṃbhavā puḍhavikassa, tajjoṇiyā tassaṃbhavā tavvakkama kammovaga kamaṇiyaṇeṇaṃ tathāvakkama nāṇāvihajoṇiyasu puḍhavisu rukkhttāe viuttamti.

According to the (kind of) seed and place (of growth) of these plants, some organisms—born in earth, originated in earth and grown in earth, having in it their birth, origin, and growth, being impelled by their karman and coming forth in it on account of their karman, growing there in particles of earth, the origin of various things—come forth as trees.

and thence they transmigrate (impelled by their karman) to the seed which brings forth the trees.

NATURE OF LIFE — SCIENTIFIC VIEW

A living organism is qualitatively distinct from the non-living matter, i.e., the differences between them are of kind rather than of degree. Functioning of the former is governed by some unique biological laws. The essence of a living organism is the set of principles determining the transmission of genetic information from one generation to the next.

The living organisms are composed of the same constituents as the rest of the Earth, but they possess, besides free will, which is the characteristic of life, all the following attributes:

Organisation, excitability, conductivity, contractility, metabolism, growth and reproduction. One or more of these, but not all may be possessed also by non-living matter.

In its composition, a living organism contains no special element but is mainly made up of 16 of the 92 elements that occur naturally on the Earth. Not only are these elements a very special set but they are combined together to make molecules more complicated than any other known in the universe.

A biogenesis or a spontaneous generation—theory that life, particularly micro-organisms, can originate from non-living matter—was not accepted by many scientists and was largely disproved by microbiological studies of Louis Pasteur. Chemical evolution, i.e., creation of chemicals of life such as nucleic acids before the appearance of life upon Earth is generally accepted.

The question as to whether the intricate phenomena of life could be explained in scientific terms, has produced two schools of thought—Vitalism and Mechanism. Vitalists (Biologists) do not accept that living depends upon a non-material soul but they accept the presence of a vital essence, or force which is peculiar to living organisms and which is different from all other forces found outside of living things. This vital force is not explainable in terms of physico-chemical phenomena and

cannot be studied, because it resembles no other force in existence and is beyond man's analysis and understanding. This vital force is produced by the unique and large molecules, which are organized into living organisms.

The Biologists believe that:

1. Living organisms contain a selected set of all the chemical elements present in other material systems.

2 These elements are organized in a way that is not only unusual but unique, the class 'living organisms' is a set of one.

3. They are not closed systems in equilibrium, but in a steady state of interchange with the external environment maintained by continual intake of fuel and expenditure of energy. Thus, carbon which is the most common constituent of foodstuffs, goes through the stomach and intestines into the blood and from there to a muscle where it is burnt to give energy when the muscle contracts. In a couple of hours after eating it will be breathed out as carbon dioxide. This process of self-maintenance is called homeostasis. They thus act with an aim, they show homeostasis (teleology or teleonomy).

There is much evidence that bodies of all living organisms on Earth from plants, jellyfish (the simplest of animals that has a nervous system) to apes and humans, all use the same DNA code and similar amino acids. And although they know in some details what the vartious substances involved in the composition of a living cell are, NO ONE HAS YET SYNTHESIZED A LIVING CELL IN THE LABORATORY. It is admitted by them that the true living cells are much more complicated and they doubt whether they would be ever made artificially.

We can emphatically say that they would never be made artificially because life is not merely a composition of MATERIAL SUBSTANCES. A non-material SOUL-SUBSTANCE is also essential to create a live cell. The soul is a substance but not a material one and this non-material/non-physical substance is eternal; it can neither be created nor destroyed. A soul animates a particular organism and manifests itself in various vital

functions of life. They can be classified into ten groups called *PRĀṆA* (vital force).

1. *Āyuṣya prāṇa* — ability to keep alive for a predetermined life-span which maintains the unity of the body and soul; when it terminates, death occurs.

2. *Śvāsocchvāsa prāṇa* — ability to breathe is an essential (vital) function for survival.

3. *Śarīra balaprāṇa* — vigor of the physical body as a whole.

4. *Vacana bala or bhāṣā balaprāṇa* — ability of vocal expression, both articulate and inarticulate.

5. *Manaḥ balaprāṇa*— ability to think, remember and imagine.

6. to 10. *Indriya prāṇa* — ability of utilising the perspective power of each of the five sense-organs.

Now it is not difficult to see that any of these psychic faculties is of no empirical utility without its physical counterpart called bio-potential (*paryāpti*). This means that only an organism possessing five sense organs and the brain (*samjñi pañcendriya*) would be possessed of all the ten *prāṇas*, while the lower ones will be possessed of less. For instance, in a one-sensed organism, such as a plant, only four *prāṇas*, (which is the bare minimum), could be active, viz., *āyuṣya prāṇa*, *śvāsocchvāsa prāṇa*, *śarīra balaprāṇa* and only one *indriya prāṇa*, that of touch. All the rest would be dormant. It should be noted that ability for communication (*bhāṣa balaprāṇa*) is possessed by two-sensed and higher organs.

BIOLOGY VIS-À-VIS SCRIPTURES : A COMPARATIVE STUDY

CLASSIFICATION

Biologists believe that at some time in the course of evolution, the differentiation of living organisms into plants and animals occurred. They cannot logically say that the animal kingdom originated from the plants or vice versa, though it seems probable that earth's first organisms were

capable of synthesizing complex organic compounds from the simple inorganic substances of air and soil, a process which is characteristic of plants rather than animals. What criteria, if any, may be used to separate plants from animals? Possibly there may be four criteria, all of which are rather unsatisfactory.

Firstly, animals are unable to manufacture their own food and are completely dependent upon plants, either directly (herbivorous animals) or indirectly (carnivorous animals) for their nutrition. In contrast, most plants are able to make their own food and are more or less independent of external sources of food supply.

Secondly, animals possess a limited scheme of growth, in which the mature individual attains a certain maximum size and characteristic form. In plants, however, the maximum size attainable by members of a given species is exceedingly variable and depends in considerable degree upon conditions of the external environment.

Thirdly, most plants are equipped with a structural framework of cellulose. Animals lack cellulose.

Lastly, most animals possess the ability of moving from place to place. Plants are firmly anchored in the soil in which they grow.

We have seen that in Biology, the psychic order of existence on this Earth is first divided into two kingdoms—the animal kingdom and the plant kingdom. Thus, all animals are included in the former and all plants in the latter. In a descending sequence the classification consists of seven categories:

(i) kingdom (ii) phylum—for animals; division—for plants,
(iii) class, (iv) order, (v) family,
(vi) genus, and (vii) species.

SPECIES : In the ascending sequence, species is the basic unit, defined as a group of individuals which are genetically distinct, reproductively isolated and similar in morphological characteristics. E.g. Panthera leo, the lion, and Panthera tigris, the tiger, are species of the genus panthera.

GENUS (pl. Genera) : assemblage of related species evolved from a common ancestor. The genus panthera is differentiated from the related genus felis which includes other wild cats.

FAMILY: It includes related genera. All types of 'cats' belonging to different genera are grouped under the family felidae.This family is distinguished from canidae which includes dogs and foxes.

ORDER : Assemblage of related families; both the above families are placed under the order carnivora.

CLASS: Assemblage of related orders; the order primates which includes man, monkey, ape, etc., and the above order carnivora are included in the class mammalia.

PHYLUM (pl. Phyla): Organisms of different classes having some features in common are included in a phylum. The phylum chordata includes a number of classes such as amphibia, reptilia, and mammalia.

In the case of plants, several classes constitute a DIVISION which is equivalent to the phylum of the animal kingdom.

Compared to the above, the Jain systems of classification are very much simpler. One of the ways is to classify according to the number of sense-organs possessed by the organisms. Thus the entire psychical order of existence is divided in just five classes only: one-sensed, two-sensed, three-sensed, four-sensed, and five-sensed.

The organisms with only one sense organ—sense of touch—are naturally the most primitive. They are called *STHĀVARAS*—immobile—as they are devoid of the ability of locomotion. They are further divided into five sub-classes according to the nature of their bodies. Thus we have earth-, water-, fire-, and air-bodied organisms and plants (with vegetable body).

Amongst the five *sthāvaras*, organisms possessing only one sense-organ, PLANTS are the most highly developed ones. This truth has been indicated by both commentators of *Sūtrakṛtāṅga Sūtra*—*Curṇikāra* and *Vṛttikāra*—

A question was raised—In Jain scriptures, traditionally, plants are put as number five in the list of *sthāvaras*; why then did the author deal with them first? They have replied thus: "Among the five *sthāvaras*, only the vegetables are far more advanced than the other four, i.e., the consciousness of the plants is very much more recognisable. Masses also accept them as living organisms and hence any dissertation in respect to them would be readily acceptable. To convince people about the psychical character of the other four *sthāvaras* is much more difficult; that is why they have been dealt with later.[1]

It is obvious from the development of the life-sciences such as Biology coming much later than that of Physics etc. which deal with lifeless matter that Biology would have to make much advance to be able to investigate and corroborate or reject the infinitesimal consciousness of the four categories of living organisms with earth-bodies or water-bodies.

PLANTS

Scriptures first divide the plants, as they do all *sthāvaras*, in two kinds—subtle and gross, and both of them are either fully developed or partially developed. This criterion for division appears to be unique with the Jains.Here the subtlety has no reference to the size of the Organism—whether microscopic or megascopic— but is associated with a specific sub-species of body-making (*nāma*) karman called "*sukṣma nāma karma*" and "*bādara nāma karma*". The organisms which exist under the fruition of the former are designated subtle (*sukṣma*) and the other ones are gross (*bādara*). The subtle sthāvaras are distributed all over the cosmos but the gross ones are found only in a part of the cosmos and not everywhere. Again the fully developed and partially developed refers to the initial stage of organisms when beginning a new life after metempsychosis. All organisms have to undergo a progressive process of attaining bio-potentials (*paryāptis*) in six stages:

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1. "ete. vaṇassaikāiyā, logovi sanpaḍivajjati jivanti jeṇa suhapannavaṇijjattikauṇā paḍhamam bhaṇitā, sesā egiṃdiyā puḍhavikāiyādayo cattāri dusaḍḍhanijjattikauṇā pacchā vuccanti." Chūrṇi p. 384, Vṛtti patra 98.

(i) The first is *āhāra paryāpti*—the union of the soul with the fertilized ovule; this is instantaneous;

(ii) The second is *śarīra paryāpti*—adoption of the ovule as its physical body by the soul; These are followed by the acquisition of the capabilities of perceiving through sense organs, breathing. communicating and thinking. Until the consummation of all the potential faculties, the organism is partially developed (*aprayāpta*). After consummation it is fully developed (*paryāpata*). Since there is a possibility of the organism dying before becoming fully developed, this is made a basis of division. Thus partially developed is only a transitional stage and so there are no further divisions which leaves the gross and fully developed plants.

The gross and fully developed plants are of two kinds:

(a) Plants in which each soul possesses its own physical body

(b) Plants in which many soul share one common physical body

This is again a unique principle enunciated by Jains. Besides the fact that there are innumerable living organisms in each living plant—the integral plant is one soul; separate soul pervade each organ (leaf, flower, fruit etc.) while some organs have innumerable souls—a class of some plants are such that in some of their organs, each soul does not have a body of its own but a large number—infinity—of soul are compelled to share a common body. They come into existence together, breathe and live together and die together. Onions, garlic, ginger, *āluya* (which is not to be confused with *ālu* or potato) are such plants.

Those which severally have their own body are again divided into twelve categories in accordance with their morphology: (these are given in the section "Biology in *Prajñāpanā Sūtra*").

Those plants in which many souls have to share a common body are also given in that section. According to Biology, these are:

1. Rhizine—a thick stem which grows horizontally under ground; common examples are:ginger, canna.

2. Corm—a round fleshy stem which grows upright underground; common examples are : elephant's foot, sword lily.

3. Stem tuber is the swollen tip of an underground branch. Potato is the best example of stem tuber.

Bulbs of onion and garlic are in reality modified shoots with food stored in leaf bases and the buds respectively. A rule of thumb is—(a) whatever grows underground, roots bulbs tubers; (b) immature leaf in which central vain or mid rib is no discernible—are organs in which a common physical body is shared by infinite souls.This is the reason why onions, garlic etc., are regarded as taboo by Jains. Plants which grow from plants (*vṛkṣayonika vṛkṣa*) treated in *Sūtrakṛtāṅga Sūtra*, refer to 'epiphytes' and 'parasotes' of biology. According to the former epiphytes and the like grow not only from trees but also from grasses, herbs, shrubs, and all other kinds of plants except '*kuhaṇas*' such as *Aya*, *Kaya*, *Kandu*, *Uvvehaliya*, etc., because there are no Ayas originating from Ayas but only through their seeds. Again there is similar exhaustive treatment for water plants in the former but not much importance given to them as a special category in Biological treatment. The scripture gives the following varieties of water plants:

Udaga, *Avaga* (agrassy plant growing in marshy land—Blyxa Octandra), *Sevalā* (Vallisneria), *Kalambuka* (*kadamba*—Nauclea *Kadamba*), *Kacchabhaniya*, *Kaseruka* (Scripus Kysoor), *Utpala, Padam*, *Kumuda*, *Nalina* (all four being well-known varieties of lotus, *Subhaga*, *Saugandhika*, *Puṇḍarika*, *Mahāpuṇḍarika*, *Śatapatra*, *Sahasrapatra*, *Kalhara*, *Kokanada*, *Aravinda* and *Tamarasa* (all varieties of lotus), *Kamalamūla*, *kamalanāla*, *Puṣkara* (stalks and fibres of lotus).

Morphologically, the Scriptures enumerate the following plant organs: roots, bulbs, stem (trunk), branches, twings, leaves, flowers, fruits and seeds. Beyond giving the names, the scriptures assert that each of these organs are animated by one or many souls. We do not come across much information about different types of roots such as true and adventitious roots; epiphytic and parasitic roots etc as given in Biology. Same is the case with the other organs.

In the *Prajñāpanā Sūtra* mention is made of two types of trees whose fruits are (a) with a single seed— *Egaṭṭhiyaya*—(mango, jamun) and (b) with many seeds—*bahubiyagaya*—(tomatoes, pomegranates).

In Biology, however, the fruits are of four types:

1. Caryopsis — each fruit functions like a seed; maize, rice, wheat and in all grasses, the fruits have only one seed with a dry pericarp.

2. The drupe—fruits of mango, peach, pericarp covers a single seed; it has a skin, pulp, and hard carp.

3. The berry—fruits of tomato, chikoo; percicarp has outer skin and pulp with many seeds scattered within.

4. Legumes—peas, beans and other pulses; a dry pericarp with many seeds.

SEED is the origin as well as the ultimate organ of the plant. Only Sutrakritanga Sutra deals briefly with seeds mentioning four types according to their location in the plant. Biology gives many details which include the process of germination.

ANIMALS

In the animal kingdom, the mobile organisms—*trasakāya*—comprise of organisms with two to five sense organs. This is the animal kingdom of Biology. The entire kingdom Animalia, beginning with unicellular amoeba and ending with the humans, covering 10 phyla are but the terrestrial fauna from the trasakaya of Jains who add denizens of the hell and the heaven also to this category.

According to Biology, a large majority are non-chordates. Out of the ten phyla—major groups—only one is of chordates which are distinguished from the non-chordates by the presence of a stiff rod of cells called the notochord below the tubular nerve and above the alimentary canal. In higher animals this notochord gets replaced by the development of a vertebral column—spine or backbone—qualifying the animnals to be called vertebrates. Here again out of the four subphyla of

the phylum CHORDATA only in one, the animals are classified as vertebrata. Non-chordata along with the primitive chodates, which do not possess the vertebral column are called invertebrates. Thus, this single structural feature appears to be basic in the system of classification of animals in Biology.

There are significant differences in the treatment of higher animals in Biology and scriptures. As we have seen, in scriptures higher animals are those who possess all the five sense-organs and the brain. Obviously these are what Biology classifies as vertebrates.

Now if we study the chart of PHYLUM CHORDATA, we find that the animals of the three out of the four sub-phyla are invertebrate marine animals such as sea-squirts etc. These are not 'fishes' which are vertebrates, i.e., animals with five sense organs and brain (*saṃjñī pañcendriya*), but animals with three or four sense organs only. Only the vertebrates are with five sense-organs.

Sub-phylum vertebrata is divided into five classes:

(a) fishes; (b) amphibians; (c) reptiles; (d) birds; (e) mammalia.

Comparing this with the scriptural contents, we find that they are treated under five-sensed organisms as follows;

In *Prajñāpanā Sūtra* from 28 to 41 sutras;

In *Uttrādhyayana Sūtra*, verses 171 to 193;

In *Sūtrakṛtāṅga Sūtra* in paras 77 to 81

In all of them they are divided into three classes;

Aquatic animals (*jalacara*); terrestrial—lan-based—animals (*sthalacara*) and aerial animals—birds—(*khecara*)

Aquatic animals are sub-divided into fishes, tortoises, crocodiles, whales and porpoises etc. Thus turtles, tortoises and crocodiles are grouped together with fishes as aquatic animals instead of as reptiles in Biology. Similarly whales are not fishes but mammals. Reptiles, which are again divided into lizards (with short limbs) and snakes (without limbs), are grouped with quadrupeds as two kinds or land-based animals. Rats

and mongooses are grouped with lizards. Quadrupeds are sub-divided into four kinds, on the basis of the morphology of their feet (hoof and claw). Then the winged animals are divided into four kinds on the basis of the morphology of their wings. The first kind includes all the familiar and unfamiliar feathered birds; the second kind refers to animals like bats who have membranous wings. The third type have wings like a box which do not open and are useless for flying. No examples are given, but if what is implied is flightless birds, than ostrich and kiwi belong to this type. We also come across a GENUS of extinct gigantic flightless birds—Aepyornis—resembling Moas (flightless birds like ostrich) and known from their remains found in Madagascar. The last type is quite intriguing but it is explained that this kind is not found on the Earth.

This manner of classification differs from the five classes of the sub-phylum vertebrata as mentioned above. Here the fishes, amphibians and reptiles are described as cold-blooded (Piokilothermal) animals, i.e., their body temperature cannot be maintained at a fixed norm but varies with the surrounding atmospheric changes. Birds and mammals are warm blooded (Homoiothermal) vertebrates, i.e., their body temperature is maintained at a fixed norm irrespective of the changes in the atmospheric temperature.

Fishes are either cartilaginous or bony. Amphibians are those animals, like frogs and toads, which live equally well in water as well as on land. Reptiles include turtles, tortoises, lizards, snakes and crocodiles. Birds include arboreal—living in trees—as well as aquatic birds like ducks.

The fifth class of vertebrates are mammals which form the highest group of animals in the animal kingdom. They are so called because they possess, among many other glands, the mammary glands in females, which secrete milk for nourishing the young. Rabbits, rats, bate, squirrels, guinea pigs, monkeys, apes, and men are mammals.

In Biology, we do not find any sub-division of humans. But in scriptures, men are sub-divided on the basis of their geographical habitat which is also very peculiar and cannot be compared with any thing in Biology.

Understandably there is no mention of the denizens of hell or heaven in Biology. Scriptures, on the other hand, give much detailed description of these two ultraterrestrial beings which are already given earlier. We do not think it necessary to elaborate on them in this section.

NUTRITION

Nutrition is defined as receiving of nourishment. Every living organism must receive nourishment to survive. Nutrition—

(a) supplies its needs of energy for its day-to-day activities;

(b) makes good the wear and tear;

(c) adds to the protoplasm, the material necessary for growth. A properly adequate nourishment must include: carbohydrates, proteins and fats: water, vitamins and minerals.

These are referred to as Nutrients. Water and mineral salts are inorganic and the rest are organic. Water, vitamins and salts are simple and are absorbed without digestion while the others are complex and need digestion before they can be absorbed. These are in brief the known facts proved by science.

Now let us see what scriptures say about nutrition.

The subject of nutrition of living organisms is not discussed either in *Prajñāpanā Sūtra* or *Uttrādhyayana Sūtra*. In *Sūtrakṛtāṅga Sūtra*, the title of chapter 3 is "knowledge of food: and in each paragraph there is a passage (which is repeated) dealing with the nutrition of living organisms. The passage is: "These living organisms (plants which grow from Earth) are nourished by the fluids from the earth (nutrients drawn from the earth) which is the origin (birth places) of many living organisms; they consume the bodies of the earth-bodied, water-bodied, fire-bodied, air-bodied organisms and plants as well as the bodies of the mobile organisms (*trasa prāṇa śarīra*); they render the manifold immobile and mobile organisms inanimate by depriving them of life; the inanimate bodies of these manifold organisms, consumed now or before—at the time of their birth—or absorbed by their rind and which were already added to

the protoplasm of their bodies, are fully digested observed and assimilated (by them). And from these they—the plants which grow from the earth—bring forth their various parts and organs which are of manifold colours, smells, tastes, touches as well as forms and structures", i.e., ultimately the nutrients (from the food) after assimilation by the plant become the material of which its different parts, as branches, leaves etc. are formed and these parts are of various different colours etc.

Thus according to the scriptures, basically, nutrition consists of bodies of different kinds of living organisms. It should be carefully noted that what is consumed is the BODY which is the material component of all living organisms, because even if a living organism is taken as food, it gets killed and becomes devoid of life, i.e., the non-material soul transmigrates leaving the material body to be consumed.

Now if we collate the list of essential nutrients specified by biology we find that:

Mineral salts are the bodies of the earth-bodied organisms.

Waters are the bodies of the water-bodied organisms.

Energies and substances formed by burning are the bodies of the fire-bodied organisms.

Airs are the bodies of the air-bodied organisms.

Carbohydrates are the bodies of the plants organisms.

Proteins are the bodies of the mobile organisms.

Thus, there is no fundamental difference between the Biological and scriptural statements about nutrition. Let us examine this more critically.

According to Jain scriptures, each and every type of raw-mineral,[1] element or compound occurring naturally, is animated by earth-bodied

1. What is meant by 'RAW' is : (i) Naturally produced, i.e., brought into existence by nature and not artificially synthesized; (ii) Unprocessed, i.e., not subjected to any operation by man-made implements so as to change the natural characteristics.

Thus only RAW EARTH and RAW WATER are animate. Once they are subjected to any operation by man-made implements they become inanimate matter.

living organisms. It remains animate until it is processed after which it becomes inanimate matter. This matter is therefore, the mass of bodies from which the souls have transmigrated. Thus when any living organism takes in a mineral, which is an essential constituent of nutrition for all living organisms from plants to human beings, it consumes the bodies of the earth-bodied organisms.

Similarly each and every drop of raw water, rain or dew, water in seas, rivers, lakes, wells etc. is animated by innumerable water-bodied living organisms. It remains animate unless it is processed, after which it becomes inanimate water. Thus, whenever any living organism consumes water, which is regarded most essential for sustaining life, it consumes the bodies of the water-bodied organisms.

The case of the intake of the bodies of the fire-bodied and air-bodied organisms is more complex. Let us first discuss the fire-bodied organism. It is true that no living organism on earth can consume live fire; but again we are not considering the intake of live fire but the bodies of the fire-bodied organisms. Now we know that in the process of photosynthesis, by which the green plants make carbohydrates by the combination of sunlight, water and carbon dioxide; sunlight is an essential ingredient. And we also know that sunlight is the energy, radiated in the form of heat and light, from the raging natural fire within the body of the sun. Thus energy radiated from fire of any type, in the form of heat contains the bodies of the fire-bodied organisms. Also substances burnt by fire are the bodies of fire-bodied organisms.[1] Fire might be produced by any type of combustion or atomic fission or fusion.

Now let us consider the air-bodied organisms. The term used in Jain scriptures for them is '*vāyu kāya*' which literally means wind-bodied (organisms). The names of some kinds given in *Uttarādhyayana* are: squalls whirlwinds, thick winds, high winds, low winds etc. Basically all these imply 'moving air' and not stationary air. This means that when air moves, i.e., it becomes wind, it also becomes a *yoni* for the living organisms which take the air as their bodies and which are therefore called air-

1. Bhagavatī Sūtra, Ch. 5, Sūtra 53.

bodied (or to be precise wind-bodied) organisms. What is the minimum velocity at which air becomes wind? Unfortunately we do not find such information in any of the three scriptures.

It is customary to exclude both fire-bodied and air-bodied organisms from the list of immobile (*sthāvara* organisms) and included them in the list of mobile ones (*trasa* organisms) though their existence is the result of the fruition of *sthāvara nāma karma* and not *trasa nāma karma*. This is because they are dynamic and not static like the other three—earth-bodied, water-bodied organisms and plants. And for this reason they are called '*GATI TRASA*', i.e., they are included in the mobile list by the virtue of their being dynamic.

What is the significance of this virtual transfer? Authors of this essay consider that the emphasis on the dynamic character of these organisms signify that their bodies are made of ENERGY.

Scriptures never considered matter and energy to be fundamentally different—as did science until recently—but modification of the same substance. Fire energy and wind energy are the two forms of energy which possess the property of being the 'yoni' of the fire-bodied and air-bodied organisms respectively.

Let us review, briefly, the scientific view regarding matter and energy. Until Albert Einstein established, in 1905, a fundamental truth about physical reality viz. matter and energy are not different elements as pictured by pre-relativity scientists—the former inert and tangible and latter active and invisible—but two different manifestations of the same cosmic entity instead of being two different entities. Matter was energy in a frozen state while energy was matter in dynamic state. He expressed the interchangeability of matter and energy by the most famous equation in the history of science: $E = mc^2$. The liberation of energy in any form—chemical, electrical or nuclear—involves the loss of an equivalent amount of matter.

The simplest instance of the liberation of energy is burning of coal where $O_2 + C = CO_2 +$ energy, giving 92 units of energy per gram of mixture. If instead of molecular fusion of these two atomic species, we

have a nuclear fusion between their nuclei, the energy liberated per gram of mixture will be 14 x 10^8 units, i.e., 15,00,000 times as great. Nuclear energy can be liberated by fission—splitting of the nuclei of heavier elements into nuclei of two lighter elements—and fusion—combining or fusing of two nuclei of the lighter elements into one nucleus of a heavier element. In the sun the tremendous liberation of energy and extremely high temperatures— 6000°C at the surface and 20 million°C in the centre— are the result of the second type, i.e., the fusion of four hydrogen nuclei into one nucleus of helium.

Fission and fusion, are also common in everyday phenomenon that occur any time we burn anything. For example, they occur in the lighting of the match, the cellulose in the match being fissioned into its components carbon and hydrogen. These are then fissioned with the oxygen of the air.

Now we come to the question of dead bodies of the mobile (*trasa*) living organisms being consumed by the trees which grow from the earth. From the just concluded discussion on the dead bodies of the various *sthāvara* living organisms, we saw that these are essential items of nutrition in the form of minerals, water etc., for all living organisms. What happens to the organic bodies of the mobile living organisms?

"Dust thou art and to dust returnest" sang the seers. All that lives must die and when they die their bodies are consumed by a special group of living organisms called decomposers. These are the bacteria and fungi which convert the dead bodies to simple substances like CO_2, H_2O, and compounds of Nitrogen. All these are reabsorbed by the primary producers and come back into circulation. Thus flow of food is linked into a chain by the plants and various animals.

Let us very briefly see how the food chain is formed. Since green plants make a major part of their own food, they are called autotrophes and the primary producers. They are eaten by the herbivores for their growth and metabolism. Since they are the first of all animals to eat the plants, they are called primary consumers. Next the carnivores eat the herbivores, they are known as secondary consumers. The secondary

carnivores may in turn be eaten by a succession of other carnivores, the tertiary carnivores. A simple example of food chain is:[1]

Sun—Cabbage—Cabbage white caterpillar—thrush—kestrel.

In reality, the relationship is seldom so simple. An animal would consume several kinds of food and in turn becomes the food of several ohers.Thus the food chains are intertwined into a web and we speak of Food Webs rather than of chains.[2]

Thus matter is cycled and so is never exhausted; energy is always lost and must be replenished.[2]

So now we know that the dead bodies of the mobile living organisms, from those with two sense-organs to those with five sense-organs which include MAN are recycled and consumed by plants to begin the new cycle.

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1. Flow of Energy: Though nothing is lost from the substance of the dead bodies, energy is lost totally and for ever.

The maximum quantity of energy received by the earth from the sun is 7500 k. calories (the average being about 3000 k.calories) per square meter per day. Of this only 1% to 5% is converted to food during primary production. Of the average of 3000 only 1500 k. cals are used by green plants and from this only 15 k. cals worth of new growth is produced. Thus, during the first step the reduction factor is 100. Of the 15 k.cals available to the primary consumers, they can use only 1.5 k. cals for their growth. Out of this the secondary consumers' share is only 0.15 k. cals while the tertiary's is very meager indeed.

2. Food chain in the Sea: Primary production starts with the phytoplankton, the minute algae an flagellates of the surface layers of the sea. The primary consumers are zooplanktons, considered to be the insects of the sea. Krills, Arrow Worms etc. The secondary consumers are smaller fishes and squids which are preyed upon by larger and larger consumers like Medisae, tunas, dolphins, sword fish, toothed whales and the greatest of all the Baleen Whale. (It is both a vegetarian as well as carnivore).

Table

Types of Beings	1 No. of Bodies	2 Extension in Space (Height or size) Minimum	Maximum	3 Physical Structure
1. Subtle earth-bodied	3–1,4,5	Innumerableth part of 1 *aṅgula*	Innumerableth part of 1 *aṅgula*	Sixth *saṃhanana*
2. Gross earth-bodied	3–1,4,5	Innumerableth part of 1 *aṅgula*	Innumerableth part of 1 *aṅgula*	Sixth *saṃhanana*
3. Subtle water-bodied	3–1,4,5	Innumerableth part of 1 *aṅgula*	Innumerableth part of 1 *aṅgula*	Sixth *saṃhanana*
4. Gross water-bodied	3–1,4,5	Innumerableth part of 1 *aṅgula*	Innumerableth part of 1 *aṅgula*	Sixth *saṃhanana*
5. Subtle fire-bodied	3–1,4,5	Innumerableth part of 1 *aṅgula*	Innumerableth part of 1 *aṅgula*	Sixth *saṃhanana*
6. Gross fire-bodied	3–1,4,5	Innumerableth part of 1 *aṅgula*	Innumerableth part of 1 *aṅgula*	Sixth *saṃhanana*
7. Subtle air-bodied	3–1,4,5	Innumerableth part of 1 *aṅgula*	Innumerableth part of 1 *aṅgula*	Sixth *saṃhanana*
8. Gross air-bodied	4–1,2,4,5	Innumerableth part of 1 *aṅgula*	Innumerableth part of 1 *aṅgula*	Sixth *saṃhanana*
9. Subtle vegetation-bodied	3–1,4,5	Innumerableth part of 1 *aṅgula*	Innumerableth part of 1 *aṅgula*	Sixth *saṃhanana*
10. Gross vegetation-bodied	3–1,4,5	Innumerableth part of 1 *aṅgula*	slightly more than 1000 *yojanas*	Sixth *saṃhanana*
11. Two-sensed	3–1,4,5	Innumerableth part of 1 *aṅgula*	12 *yojanas*	Sixth *saṃhanana*
12. Three-sensed	3–1,4,5	Innumerableth part of 1 *aṅgula*	3 *gavyutis*	Sixth *saṃhanana*
13. Four-sensed	3–1,4,5	Innumerableth part of 1 *aṅgula*	4 *gavyutis*	Sixth *saṃhanana*

Types of Beings	1 No. of Bodies	2 Extension in Space (Height or size) Minimum	 Maximum	3 Physical Structure
14. Infernals (five-sensed)	3–2,4,5	Innumerableth part of 1 *aṅgula* by birth.	500 *dhanuṣas*. They (infernals)	Not possessed of *saṃhanana*
15. Sub-humans (five-sensed)–born through agglutimation	3–1,4,5	Innumerableth part of 1 *aṅgula*	* (See p. 132)	Sixth *saṃhanana*
16. Sub-humans (five-sensed)–born through agglutination	4–1,2,4,5	Innumerableth part of 1 *aṅgula*	* (See p. 132)	All the six types of *saṃhanana*
17. Humans (five-sensed)–born born through agglutination	3–1,4,5	Innumerableth part of 1 *aṅgula*	Innumerableth part of 1 *aṅgula*	Sixth *saṃhanana*
18. Humans (five-sensed)–born through womb	5–1,2,3,4,5	Innumerableth part of 1 *aṅgula*	3 *gavyutis*	All the six types of *saṃhanana*
19. Gods	3–2,4,5	Innumerableth part of 1 *aṅgula*	7 ratnis by birth, 100000 *yojanas* by post-birth between extension.	Not possessed of *saṃhanana*

Types of Beings	4 Configuration	5 Passions	6 Unlearned Instincts	7 Psychic Colours	8 Sense-organs	9 Expansion of soul-units (beyond the body)	10 Possessed of Brain
1.	*masurchanda*	All the four	All the four	3–1,2,3	1	3–1.2.3	Not possessed
2.	*masurchanda*	All the four	All the four	4–1,2,3,4	1	3–1.2.3	Not possessed
3.	*stibuka*	All the four	All the four	3–1,2,3	1	3–1.2.3	Not possessed
4.	*stibuka*	All the four	All the four	4–1,2,3,4	1	3–1.2.3	Not possessed
5.	*sūcīkalāpa*	All the four	All the four	3–1,2,3	1	3–1.2.3	Not possessed
6.	*sūcīkalāpa*	All the four	All the four	3–1,2,3	1	3–1.2.3	Not possessed
7.	*patāka*	All the four	All the four	3–1,2,3	1	3–1.2.3	Not possessed
8.	*patāka*	All the four	All the four	3–1,2,3	1	4–1.2.3,4	Not possessed
9.	*aniyata*	All the four	All the four	3–1,2,3	1	3–1.2.3	Not possessed
10.	*aniyata*	All the four	All the four	4–1,2,3,4	1	3–1.2.3	Not possessed
11.	*huṇḍa*	All the four	All the four	3–1,2,3	2	3–1.2.3	Not possessed
12.	*huṇḍa*	All the four	All the four	3–1,2,3	3	3–1.2.3	Not possessed

Types of Beings	4 Configuration	5 Passions	6 Unlearned Instincts	7 Psychic Colours	8 Sense-organs	9 Expansion of soul-units (beyond the body)	10 Possessed of Brain
13.	*huṇḍa*	All the four	All the four	3–1,2,3	4	3–1.2.3	Not possessed
14.	*huṇḍa* by birth *huṇḍa* by post birth protean extension	All the four	All the four	3–1,2,3	5	3–1.2.3	Both–possessed of brain, also not possessed.
15.	*huṇḍa*	All the four	All the four	3–1,2,3	5	3–1.2.3	Not possessed
16.	all the six configurations	All the four	All the four	3–1,2,3	5	5–1.2.3,4,5	Possessed of brain
17.	*huṇḍa*	All the four	All the four	3–1,2,3	5	3–1.2.3	Not possessed
18.	All the six configuration	All the four, also free from passions	All the four, also free from unlearned instincts	All the six. Also free from *leśyā*	5	7–1.2.3,4 5,6,7	Possessed of brain and also neither possessed nor not possessed.
19.	*samcaturasra* by birth, various shapes by post-birth protean extension	All the four	All the four	All the six.	5	5–1.2.3,4,5	Possessed of brain.

Types of Beings	11 Sex passions	12 Number of Bio-potentials	13 World-view	14 Intuition of generic attributes	15 Cognition of specific attributes
1.	Dual	4^{+-}1,2,3,4	1–Deluded	Non-ocular	2^{-}1,2
2.	Dual	4^{+-}1,2,3,4	1–Deluded	Non-ocular	2^{-}1,2
3.	Dual	4^{+-}1,2,3,4	1–Deluded	Non-ocular	2^{-}1,2
4.	Dual	4^{+-}1,2,3,4	1–Deluded	Non-ocular	2^{-}1,2
5.	Dual	4^{+-}1,2,3,4	1–Deluded	Non-ocular	2^{-}1,2
6.	Dual	4^{+-}1,2,3,4	1–Deluded	Non-ocular	2^{-}1,2
7.	Dual	4^{+-}1,2,3,4	1–Deluded	Non-ocular	2^{-}1,2
8.	Dual	4^{+-}1,2,3,4	1–Deluded	Non-ocular	2^{-}1,2
9.	Dual	4^{+-}1,2,3,4	1–Deluded	Non-ocular	2^{-}1,2
10.	Dual	4^{+-}1,2,3,4	1–Deluded	Non-ocular	2^{-}1,2
11.	Dual	5^{+-}1,2,3,4,5	2–Enlightened, Deluded	Non-ocular	2^{-}1,2
12.	Dual	5^{+-}1,2,3,4,5	2–Enlightened, Deluded	Non-ocular	2^{-}1,2
13.	Dual	5^{+-}1,2,3,4,5	2–Enlightened, Deluded	Ocular, non-ocular	2^{-}1,2

Types of Beings	11 Sex Passions	12 Number of Bio-potentials	13 World-view	14 Intuition of generic attributes	15 Cognition of specific attributes
14.	Dual	All the six $^{+-}$	3–All the three	Ocular, non-ocular clairvoyant's	3^{+-}–1,2,3
15.	Dual	5^{+-}–1,2,3,4,5	2–Enlightened, Deluded	Ocular, non-ocular	2^{+-}–1,2
16.	All the three	All the six $^{+-}$	3–All the three	Ocular, non-ocular clairvoyant's	3^{+-}–1,2,3
17.	Dual	5^{-}–1,2,3,4,5	1–Deluded	Non-ocular	2
18.	All the three, also free from sex passions	All the six $^{+-}$	3–All the three	All the four	All the five
19.	Male and female	All the five $^{+-}$ (5 & 6 together)	3–All the three	Ocular, non-ocular clairvoyant's	3^{+-}–1,2,3

Types of Beings	16 Physical Yoga	17 Yoga Activity	18 Ypayoga	20 Life-span (minimum)	Life-span (maximum)
1.	1-Bodily	Both-*Sākāra Anākāra*	Appropriation of material objects as food etc. (Details already given)	*Anataramuhūrta*	*Anataramuhūrta*
2.	1-Bodily	Both-*Sākāra Anākāra*		*Anataramuhūrta*	22000 years
3.	1-Bodily	Both-*Sākāra Anākāra*		*Anataramuhūrta*	*Anataramuhūrta*
4.	1-Bodily	Both-*Sākāra Anākāra*		*Anataramuhūrta*	7000 years
5.	1-Bodily	Both-*Sākāra Anākāra*		*Anataramuhūrta*	*Anataramuhūrta*
6.	1-Bodily	Both-*Sākāra Anākāra*		*Anataramuhūrta*	72 hours
7.	1-Bodily	Both-*Sākāra Anākāra*		*Anataramuhūrta*	*Anataramuhūrta*
8.	1-Bodily	Both-*Sākāra Anākāra*		*Anataramuhūrta*	3000 years
9.	1-Bodily	Both-*Sākāra Anākāra*		*Anataramuhūrta*	*Anataramuhūrta*

Types of Beings	16 Physical Yoga	17 Yoga Activity	18 Ypayoga	20 Life-span (minimum)	Life-span (maximum)
10.	1-Bodily	Both-*Sākāra Anākāra*		*Anataramuhūrta*	10000 years
11.	2-Bodily, Vocal	Both-*Sākāra Anākāra*		*Anataramuhūrta*	12 yesrs
12.	2-Bodily, Vocal	Both-*Sākāra Anākāra*		*Anataramuhūrta*	(49 x 24) hours
13.	2-Bodily, Vocal	Both-*Sākāra Anākāra*		*Anataramuhūrta*	6 months
14.	3-Bodily, Vocal, Mental	Both-*Sākāra Anākāra*		10000 years	33 *sagaropamas*
15.	2-Bodily, Vocal	Both-*Sākāra Anākāra*		*Anataramuhūrta*	** (See p. 132)
16.	3-Bodily, Vocal, Mental	Both-*Sākāra Anākāra*		*Anataramuhūrta*	** (See p. 132)
17.	1-Bodily	Both-*Sākāra Anākāra*		*Anataramuhūrta*	*Anataramuhūrta*
18.	3-Bodily, Vocal, Mental	Both-*Sākāra Anākāra*		*Anataramuhūrta*	-
19.	3-Bodily, Vocal, Mental	Both-*Sākāra Anākāra*		10000 years	

Types of Beings	22 *Cyavana* (Departure)	*Gati*	23 *Āgati*
1.	**Humans**–They can take birth in the realm of humans except those which are born in *akarmabhūmi*, and *antardvīpa* have the life-span of innumerable years. **Sub-humans**–They can take birth in the realm of sub-humans of one-sensed up to five-sensed except those which are the inhabitants of *bhogabhūmi* and have the life-span of innumerable years.	2–Sub-human, Human	2–Sub-human, Human
2.	"	2–Sub-human, Human	3–Sub-human, Human, God
3.	"	2–Sub-human, Human	2–Sub-human, Human
4.	"	2–Sub-human, Human	3–Sub-human, Human, God
5.	"	1–Sub-human	2–Sub-human, Human
6.	"	1–Sub-human	2–Sub-human, Human
7.	"	1–Sub-human	2–Sub-human, Human
8.	"	1–Sub-human	2–Sub-human, Human
9.	"	2–Sub-human, Human	2–Sub-human, Human
10.	"	2–Sub-human, Human	3–Sub-human, Human, God

Types of Beings	22 *Cyavana* (Departure)	23 *Gati*	*Āgati*
11.	"	2–Sub-human, Human	2–Sub-human, Human
12.	"	2–Sub-human, Human	2–Sub-human, Human
13.	"	2–Sub-human, Human	2–Sub-human, Human
14.	**Humans**—They (infernals) can take birth in the realm of humans except those which are *samurcchima* (i.e., born of agglutination) and have the life-span of innumerable years. **Sub-humans**–They (infernals) can take birth only in the realm of five-sensed sub-humans born of womb, egg etc. except those which have the life-span of innumerable years.	2–Sub-human, Human	2–Sub-human, Human
15.	Among the five-sensed sub-humans born of agglutination– (a) The Acquatics can take birth in all the four realms– **In infernals**–only in the first hell viz., *ratnaprabhā*. **In sub-humans**–all types of sub-humans (including those which have numerable years' life-span, quadrupeds, birds). **In humans**–in all *Karmabhūmis*, not in *akarmabhūmis*, *antardvīpas*, having life-span of numerable years as well as innumerable years. **In gods up to *Vānamantara* (Forest gods)**–excluding the *jyotiṣka* (Luminous gods) and other higher gods. (b) The Terrestrials are also to be described like the Acquatics. (c) The Birds (or winged animals) are also to be described like the Acquatics.	4–All the four	2–Sub-human, Human

Types of Beings	22 *Cyavana* (Departure)	*Gati*	23 *Āgati*
16.	Among the five-sensed sub-humans born of womb, egg etc.– (a) The Acquatics can take birth in all types of beings except those which are the gods above the eighth heaven. (b) The Terrestrials can take birth in all types of living beings except those which belong to the infernals from fifth up to the seventh hell and the gods above the eighth heaven. (c) The Birds/Winged animals can take birth in all types of living beings except those which belong to the infernals from fourth up to the seventh hell and the gods above the eighth heaven.	4–All the four	2–Sub-human, Human
17.	**Humans**–They (the humans born of agglutination) can ..... *Karmabhūmi* and those which are born of agglutinatio. **Sub-humans**–Sub-humans of all types.	2–Sub-human, Human	2–Sub-human, Human
18.	All types of beings; or get emancipated.	5–All the four realms	4–All the four realms
19.	**Humans**– They (gods) can take birth in humans which are earth-bodied, water-bodied, vegetation-bodied, and five-sensed sub-humans born of womb, egg etc. and have life-span of numerable years.	2–Sub-human, Human	2–Sub-human, Human

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Types of Beings	Sub-humans (five-sensed)– born through agglutimation	Sub-humans (five-sensed)– born through agglutimation
1. Acquatics	1000 *yojanas*	1000 *yojanas*
2.Quadruped Terrestrials	*prthaktva** *gavyutis*	6 *gavyutis*
3. Reptile Terrestrials which walk on their arms	*prthaktva yojanas*	1000 *yojanas*
4. Reptile Terrestrials which crawl on their breast.	*prthaktva dhanuṣya*	*prthaktva gavyuti*
5. Birds and Winged Ones	*prthaktva dhanuṣya*	*prthaktva dhanuṣya*

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Types of Beings	Sub-humans (five-sensed)– born through agglutimation	Sub-humans (five-sensed)– born through agglutimation
1. Acquatics	One *Purva* x 10^7 years	One *Purva* x 10^7 years
2.Quadruped Terrestrials	84000 years	3 *Palyopama*
3. Reptile Terrestrials which walk on their arms	53000 years	One *Purva* x 10^7 years
4. Reptiles Terrestrials which crawl on their breast.	42000 years	One *Purva* x 10^7 years
5. Birds and Winged Ones	72000 years	$\frac{1}{\text{innumerableth}}$ *palyopama*

* *prthaktva* means 2 to 9.

GLOSSARY

Anther	—	See Stamen.
Angiosperms	—	Flowering plants with seeds en-closed in a fruit.
Asexual Reproduction	—	Reproduction by spores.
Assimilation	—	Conversion of digested foods into protoplasm.
Binomial Nomenclature	—	The system of denoting a plant or an animal by two Latin names the first for its genus and the second for its species.
Carpel	—	Floral part bearing ovules.
Centrosome	—	An area in animal cell which in-cludes a pair of small granules, called centrioles.
Chioroplast	—	A plastid which is green due to chlorophyll, pigment which makes plants look green.
Coelenteron	—	See gastro—vascular cavity.
Crop	—	The dilated middle part of oesopha-gus in birds. It stores and softens hard grains.
DNA	—	Deoxyribonucleic acid. A self duplicating molecule which is the genetic material of living organ-isms
Enzymes	—	Catalysts found in living cells. They are proteins which catalyse many reactions.

Epiphyte	—	A plant throwing from another plant using it merely for support. See parasite
Fertilization	—	Process of union of male and female gametes.
Gastrovascular cavity	—	The central cavity in animals (Coelenteron) like Hydra where digestion occurs.
Genus	—	A group of related species.
Gills	—	Specialised respiratory organs in fish, lobster etc.
Gizzard	—	The posterior part of the stomach in birds.
Haustoria	—	Parasitic roots for drawing nutri-tion from the host.
Lichen	—	A co—operative society of alga and fungus.
Locomotion	—	Movement for change of position.
Nucleic acid	—	Chemical compound found in all living organisms, now thought very important in inherited material; forms complex compounds (nucleo—proteins) with proteins. See DNA & RNA.
Organelle	—	Any structurally distinct body within CYTOPLASM of cells.
Ovule	—	Structure produced by a flower, which later develops as a seed.
Parenchyma	—	Basic tissue of plants made up of cells, cellulose and inter—cellular spaces.
Plastids	—	Organelles present in plant cells, carrying pigments. See chlorophyll.
Plumule	—	Immature shoot system forming part of embryo of seed.
Pollen	—	Powdery substance discharged from anther of flower, male element in pollination.
Pollination	—	An act of transfer of pollen from anther to the stigma of the flower of same species.

Radicle	—	Immature root forming part of embryo of seed. Cf plumule.
Ribisomes	—	Organelles involved in assembling protein molecules as ordered by DNA.
RNA	—	Ribonucleic acid — self duplicat-ing nucleic acid concerned in protein synthesis.
Ruminant Stomach	—	A four chambered stomach in mammals like cattle, sheep etc.
Sexual Reproduction	—	Reproduction by gametes or sex cells.
Species	—	A term denoting a group of related plants or animals.
Stamen with	—	Part of flower which produces male sex cells, comprising stalk plus head (anther) pollen sacs that burst to release pollen grains.
Tissue	—	A group of similar cells doing one particular function.
Trachea	—	Term used for :—wood vessels in plants wind pipe in higher animals Breathing tubes for insects.

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णाणस्स सारमायारो

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