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Significance of — Regulation of Temperature in Mammals

It is difficult to overestimate the importance of the advance in living organization that is made possible by the maintenance of a high and constant temperature. Sir Joseph Barcroft pointed out that many refinements of organisation can only operate under constant conditions. For instance, if there is a constant temperature, elaborate patterns of activity can be set up, in the cerebral Cortex, allowing for persistent and complicated memories. Similarly, in various parts of the body there are intricate sets of Biochemical reactions, that would be disturbed by large temperature fluctuations. At the same time achievement of high temperature allows a greatly increased level of activity. The birds and Mammals have been experimenting independently with high temperature for probably more than 100 million years, but it may be that one or both groups will eventually make still more spectacular innovations of organisation on this basis, including perhaps the use of still higher temperature.

It is not known how temp-regulating mechanism first arose. The Prototherians (Egg laying mammals). Platypus and Echidna posses hair and they probably diverged from the other mammals, not later than the early Jurassic period, nearly 150 million years ago. Therefore it seems that the mammalian like began to be warm-blooded earlier than this date, as also did the line that was leading to the birds. This may have been a response to either cold or warm conditions; reptiles are severely limited in their distribution by temperature. It is also possible that the condition did not follow any special climatic change but that the early Avian and Mammalian Stocks were pioneers, driven by the competition of their many reptilian cousins to seek life in colder or hotter land regions, which were not yet inhabited by tetrapods.

Cold will make a reptile dormant, unless the animal can be active enough to keep itself warm by the heat produced as a by- product of muscular activity.

This will be made more easy, if the animal is large and, of couse, especially if a heat insulating mechanism is developed. It is not difficult to understand how a temperature above that of surroundings could be achieved by sufficiently active reptilian animals.

Even at the present day the heat of muscular work, remains the chief source of heat in Mammals. In the early stages of the evolution of high temperature, alteration of heat production, was probably the main means of temperature regulation, as it still is today in monotrems and bats. In all mammals a fall of external temperature calls forth extra muscular activity by shivering. The high mammals also possess a mechanism for the control of heat loss and they maintain a constant temperature largely by this downward regulation.

Control of Temperature-regulating mechanism is centred on the Hypothalamic region of the forebrain, especially in the Tubercinerum, which is large in birds and mammals. In this region their are cells, that serve as detectors; when the blood is too hot or too cold, nerve impulses are sent out to vary the rate of heat production or heat loss, and the temperature is kept steady with little oscillation. After removal of the tuber an animal no longer regulates properly, its temperature fluctuates with that of its surroundings. Other parts of the Brain also play a large part in regulation and it has long been known that stimulation of the Caudate nucleus of Corpus striatum, for instance by puncture, causes a temporary rise in the

temperature which may reach as high as 42°C. It is not clear how these various heat regulating centres are related.

If cooled blood reaches one of these regions the shivering mechanism is set in action; conversely perfusion of the Carotid arteries with overwarm blood causes sweating or panting. Heat producing systems other than muscles may be called upon. The Liver and other organs give out heat in the course of their work and it is possible that during periods of sleep they may be stimulated to increased activity and greater heat output. Thyroid secretion increases the basal metabolism and thus the amount of secretion produced by the Thyroid affects the temperature. Other Endocrine glands are probably also involved.

Heat Conservation :- Hair tends to trap a layer of air, which insulates the body, reducing heat exchange with the Environment. The air retaining capacity is increased in some mammals by a roughening of the surfaces of the hair, which causes them to stick together to make a pelt. The hair are not of the same kind all over the surface of the body; often longstiff hair are found mingled with softer fur. In many mammals the hair changes according to the time of year so as to provide a thicker covering in winter than in summer.

The hair do not grow straight out from the skin but are placed obliquely, so that they all set in a particular direction, giving the coat its characteristic reaction to brushing. It has been suggested that the primary direction of the hair provides a backward slope, which would prevent them from catching in grasses. The reasons for the deviations from this direction, which occur in many mammals are not understood.

Not all mammals use an air layer for the retention of heat. In the whales and walruses the body is covered with a thick layer of fat called Blubber in the Dermis of their skin, the hair are reduced to a few vibrissae. In man, hair are present over most parts of the body, but their function is mainly tactile and heat is conserved mainly by a layer of fat in the skin. Very large mammals, such as Elephants or Rhinoceros have little need to minimize heat loss, since their surface is small relative to the large heat producing volume the hair are accordingly reduced. Related species that existed during glacial periods had well developed hair.

Heat loss :- Various agencies are responsible for control of the heat loss. The convection from the surface of the body can be controlled by changing the position of the hair. The skin contains devices for losing as well as for retaining heat. The sweat glands are derived from the Epidermis but lie deeply in Dermis. They tubular glands much coiled at their inner ends and surrounded by myo-epithelial cells contain contractile fibries and serve to expel the secretion. The sweat is watery solution, whose evaporation serves to cool the body. The amount of liquid (sweat) produced is controlled by the action of nerve fibres of the sympathetic nervous system. Sweat glands are not properly developed in all the mammals e.g. in cats these glands are confied to the pads of the feet. In man they occur all over the body, most abundantly in the axilla and groin. They are altogether absent from the skin of whales and sea cows.

The amount of heat lost from the surface is also controlled by regulating the flow of blood. When the whole capillary bed is used the skin becomes flushed and loses much heat, also the sweat glands receive more blood. In cold conditions a set of Arterio-venous anastomoses is opened up so that the blood short circuits the capillaries and the skin becomes blue or white. These processes are influenced by the hypothalamus. The surface of the lungs also provides a means of heat loss. Animals such as dogs which have few sweat glands resort to panting.

Large animals use special means for losing heat, for instance the African elephant increases its total surface area by nearly one-sixth (1/6) when it raises its ears. The flapping movements of ears are more frequent in large elephants than small. The flow of blood to the ears is increased in hot weather. The ears are used for heat loss in smaller animals also. In North America the hares have longer ears in the warmer southern regions.

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