A 8

Endothermy and Physiological Mechanism of Regulation of body temperature.

Introduction:- Animal life exists at body temperature which range between -2°c in fish and invertebrates living in arctic waters to +50°c in desert living animals. Some creatures may exist at even more extreme temperatures. Most animals ~~specify~~ simply assume the temperature of their immediate external environment but birds and mammals regulate their body temperature and maintain it at a relatively constant level which is different to that of their immediate external environment. Temperature is important to animals for the reason that within limit an increase in temperature increases the rate of physical and chemical (i.e metabolic) reactions. It is possible to quantify the increase in reaction rates by measuring the Q_{10} value. The Q_{10} is defined as the increase in the rate of a reaction or a physiological process for a 10°c rise in temperature. It is calculated as the ratio between rate of reaction (k) occuring at (x+10°c) and the rate of reaction at x°c.

$$Q_{10} = \frac{k\ (x+10^\circ c)}{k\ (x^\circ c)}$$

Endotherms are animals that generate their own body heat and whose body temperature is derived from internal heat production which is a by product of cellular metabolism and whose body temperature remains relatively constant, irrespective of changes in the temperature of the external environment. Endothermy is generally considered to be a province of birds and mammals. However, some fish are able to maintain a temperature ~~which is significantly~~ in some regions of their body which is significantly different from that of the external environment. Such responses are also observed in some reptiles.

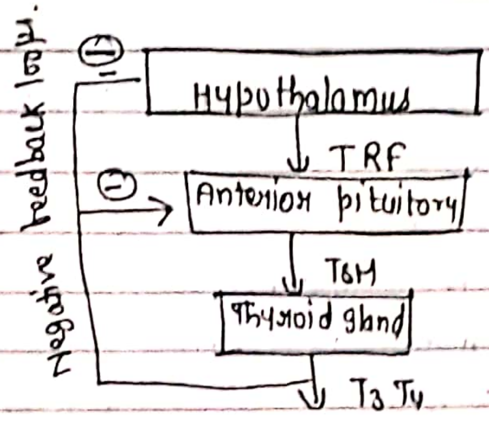
Birds and Mammals are classic endotherms. There is a wide ~~range~~ variation in actual body temperatures (e.g. duck billed platypus has a body temp. of about 30°c while woodpeckers have a body temperature of about 42°c.) In all cases, the body temperature is maintained at its desired level by reaching a balance between heat production and heat loss.

Mechanism of heat Production :→ The principal mechanism for increasing heat production is to increase metabolic heat production in skeletal muscle. Heat is released as a by-product of intracellular metabolism in muscle cells as a consequence of the contractile process. Increased muscular activity is involuntary and termed shivering. other mechanism known as nonshivering Thermogenesis. One mechanism involve brown adipose tissue, sometimes called brown fat, when brown fat is stimulated the fat is metabolized within the mitochondria of the fat cells and heat is produced. O_2 requirements of the animal are immediately increased in order to metabolize the fat. Metabolic heat production may also be increased by the activity of the thyroid hormones→ thyroxine (T_4) and triiodothyronine (T_3). The release of these hormones is under the control of the anterior pituitary gland. Both hormones enter cells where most of the thyroxine is converted to T_3, once this conversion has occured T_3 produces several effects including stimulation of Na^+/K^+ ATPase and several enzymes involved in the metabolism of glucose. Overall the effect is an increase in metabolism and therefore an increase in heat output. In order to sustain this increased metabolism, O_2 uptake must also increase. and this is achieved by a T_3 stimulated increase in the rate of breathing. The release of the thyroid hormones is regulated by a negative feedback loop. when the levels of T_4 and T_3 become elevated, they inhibit further release of TSH from the anterior pituitary gland Thus limiting the release of the thyroid hormones.

There are a number of other mechanisms by which the body temperature of an endotherm may increase. Perhaps the simplest is by absorption of solar radiation, clothing prior to entering a cold environment etc.

Fig. →

★ Vasodilation:- A widening of lumen or interior space of the blood vessels, increasing blood flow.



Metabolic effects e.g increased metabolic rate and heat production.

Mechanism of heat loss :→ Heat which is lost is dissipated to the environment. One way in which this is achieved is to divert blood to the periphery of the animal by vasodilation of peripheral blood vessels. In ma mammals, heat loss is achieved by evoparation of sweat from the skin However, some mammals (e.g dogs, all birds) do not posses sweat glands. In them water is lost from the respiratory tract.

Endothermic Adaptations to Extreme Temperatures:→
~~Mechanism of heat loss~~ Adaptation to extreme cold :→ The simplest way to cope with an extremely cold environment is to tolerate it. This can be achieved by so called regional heterothermy, The maintainance of different parts of the body at the different temperatures. A good example of animals displaying regional heterothermy are arctic birds and mammals. Perhaps the most extreme response seem to low environmental temperature is hibernation. Hibernation may be defined as a reduction in body temperature (i.e hypothermia) accompanied by a corresponding decrease in metabolic rate, heart rate, respiratory rate and so on. Termination of the hibernating rate is achieved by spontaneous arousal with a rapid increase in metabolic rate and body temperature, which returns to its normal value.

Adaptation to extreme heat :→ Endotherms which tend to maintain core body tem-

-perature of around 37-42°C are able to withstand hot environments. There Several strategies that endotherms utilize in order to maintain their core body temperature within normal limits in the face of an excessive increase in exter--nal temperature. The simplest way to increase heat loss is to increase water loss by evaporation. Men and other mammals achieve this by increased sweating. However in dogs, birds the water loss must come from the respiratory tract. Birds display phenomenon called gular fluttering, rapid movement of the throat region which increases evaporation and hence increases heat loss. A potentially more dan--gerous strategy is for the animal to become hyperthermic by retaining metabolic heat and raising its body temperature. A good example is the desert camel. Hyperthermia also presents animals with problems. For ins--tance the elevated body temperature may not be equally tolerated by all organs. In order to perfuse the brain with blood at the correct temperature many such mammals have heat exchanges in the brain whereby the heat in arterial blood flowing into the brain is transferred into venous blood ~~by~~ leaving the brain.

Control of body Temperature in Endotherms:→ Like all control systems, the control of temperature is an example of homeostasis. As such it has the components of any homeostatic systems - receptors, comparators effectors and of course neural elements linking them together.
The receptors which monitor temperature are called thermoreceptors. Generally there are two types of thermoreceptors - those which increase their action potential production in response to an increase in temperature and those which increase action potential production in response to a decrease in temperature. These represent 'hot' and 'cold' thermore--ceptors respectively. Thermoreceptors are found in two locations - the peripheral sensors in the skin, and the central receptors in the hypo--thalamic region of the brain. The first group monitor peripheral changes in the temperature of the animal, while the second group monitor

changes in the core temperature. The hypothalamus is also the site of the set point of temperature, the desired temperature of the body.

It has been proposed that the different regions of the hypothalamus perform different thermoregulatory functions. Anterior hypothalamus is a heat loss center. There is also a posterior heat gain center.