

TEMPERATURE REGULATION (THERMOREGULATION)

*Refers to the process by which the body temperature of an animal is kept within narrow limits. This regulation of body temperature at a relatively constant level is also called **thermoregulation**.*

Significance of thermoregulation

- *Most body processes of many animals are controlled by enzymes. These enzymes are protein in nature. Therefore very high temperatures beyond 40°C rapidly destroy them; hence a fall in the rate of reactions they control.*
- *More so; very low temperatures reduce the rate at which enzymes control the different reactions in the body. Therefore temperature should always be kept in narrow limits.*

Heat gain and loss from the animals' body

Heat gain	Heat loss
<ul style="list-style-type: none"> • Metabolism. This releases a certain amount of heat in the body. Mainly from respiration. • Absorption of solar energy by the body; mainly by radiation • Convection. Directly from; warm air; wind or water. • Conduction from hot objects or surfaces for example walking on a warm ground. 	<ul style="list-style-type: none"> • Sweating. During this process the body loses heat through evaporation. Warm water molecules leave the body surface. • Conduction. From the body to the ground; when the body is hotter than the ground such as walking on cemented surface. • Radiation. This is the loss of heat from the body to air currents or water.

Animals can be grouped into two main types depending on their ability to regulate their body temperature.

1. Homoiothermic animals /homoiotherms

*These are animals which are able to maintain/ regulate their body temperature to almost a constant value. Homoiotherms are mainly **birds** and **mammals**. However these animals have been generally referred to as **endotherms**. They are said to be endothermic because they regulate their body temperature using mostly internal body processes; irrespective of that of the environment (ambient temperature). Mammals regulate their body temperature at approximately a set point of 36.9°C.*

Advantages of endothermy (maintenance of a constant body temperature).

- *It promotes the efficiency of body enzymes; hence normal constant body functioning.*
- *It enables most animals to live in a wide range of habitats with varying temperatures.*
- *It enables quick response to the stimuli; since there is enough energy from metabolism. This ensures survival of terrestrial animals.*

Structural adaptations of endotherms towards temperature regulation.

- *Changes in structure and size of hairs (fur) on skin surface. Light fur reflects away heat.*
- *Feathers in birds; protect them against heat loss.*
- *Changes in the amount of fat under the skin. Thin layer encourages heat loss.*
- *Some parts such as ears may become large to provide large surface area for heat loss.*

1 Behavioral means include;

- *Taking a hot drink when it is cold.*
- *Some are nocturnal (active at night).*
- *Taking a cold drink when it is hot.*
- *Roosting in birds; hibernation (state of rest) in some mammals like squirrels.*
- *Sitting near fire during coldness.*
- *Moving into the shade when it is hot.*
- *Panting. This is the extension of the tongue out of the mouth; such as in dogs; to allow evaporation hence heat loss.*
- *Huddling. Individuals come in contact during coldness; such as in chicks to reduce heat loss.*

2. Poikilothermic animals /poikilotherms

*Poikilotherms are animals which regulate their body temperature by varying it with that of the environment. Increased ambient (environmental) temperature; leads to an increase in their body and reduced ambient temperature; decreases their body temperature; temperature for survival. They were previously called cold blooded animals; but this term is not very correct due to the fact that, none of them has a constantly cold blood. These animals are generally referred to as **ectotherms** because their body temperature changes with respect to change in environmental temperature.*

The regulation of body temperature of such animals depends only on their behaviors as shown below.

(a) Response to high temperatures

- *Salivation. This is the smearing of saliva over the neck and legs; such as in tortoises.*
- *Thermogaping. This involves opening of the mouth widely; to allow evaporation of water which takes away excessive heat. For example in crocodiles.*
- *Aestivation. This refers to sheltering under rocks or under surfaces to prevent overheating.*
- *Some can move into shades to cool their body temperature.*

(b) Response to low temperatures

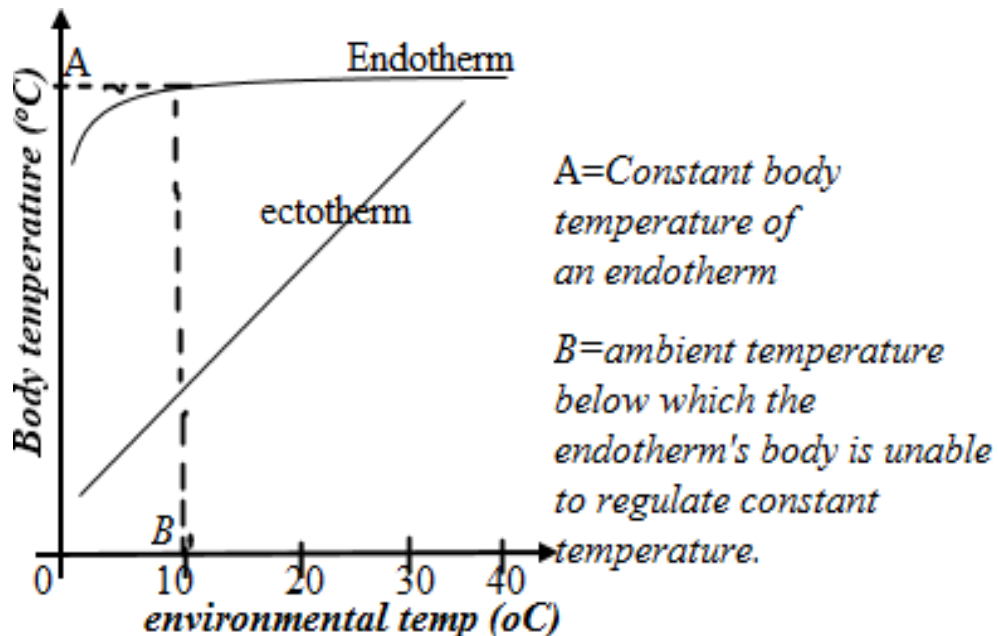
- *Basking in the sun to gain heat; for example in lizards*
- *Hibernation. State of long rest by burrowing in the mud, to lower the body temperature. 11*
- *Burrowing into cracks and crevices during coldness.*
- *Others move towards heat sources*

Advantages of ectothermy (body's dependency on environmental temperature)

- *Animals consume small amounts of food; since heat is obtained from the environment not body metabolism.*
- *Animals have the ability to modify their behavioral patterns; to regulate body temperature.*

- *There is no need of having efficient cooling and heating mechanisms by the body.*

The relationship between body temperature and environmental (ambient) temperature



Physiological means of temperature regulation in endotherms

*Endotherms mainly mammals; are able to regulate their body temperature mainly by using their body processes (physiological). Thermoregulation as a homeostatic process is controlled by a thermoregulatory center of the hypothalamus located in the brain. This center has **one set** of thermo receptors which receive messages (signals) from **another set** of thermo receptors in the skin; about the changes in body temperature due to its external environment.*

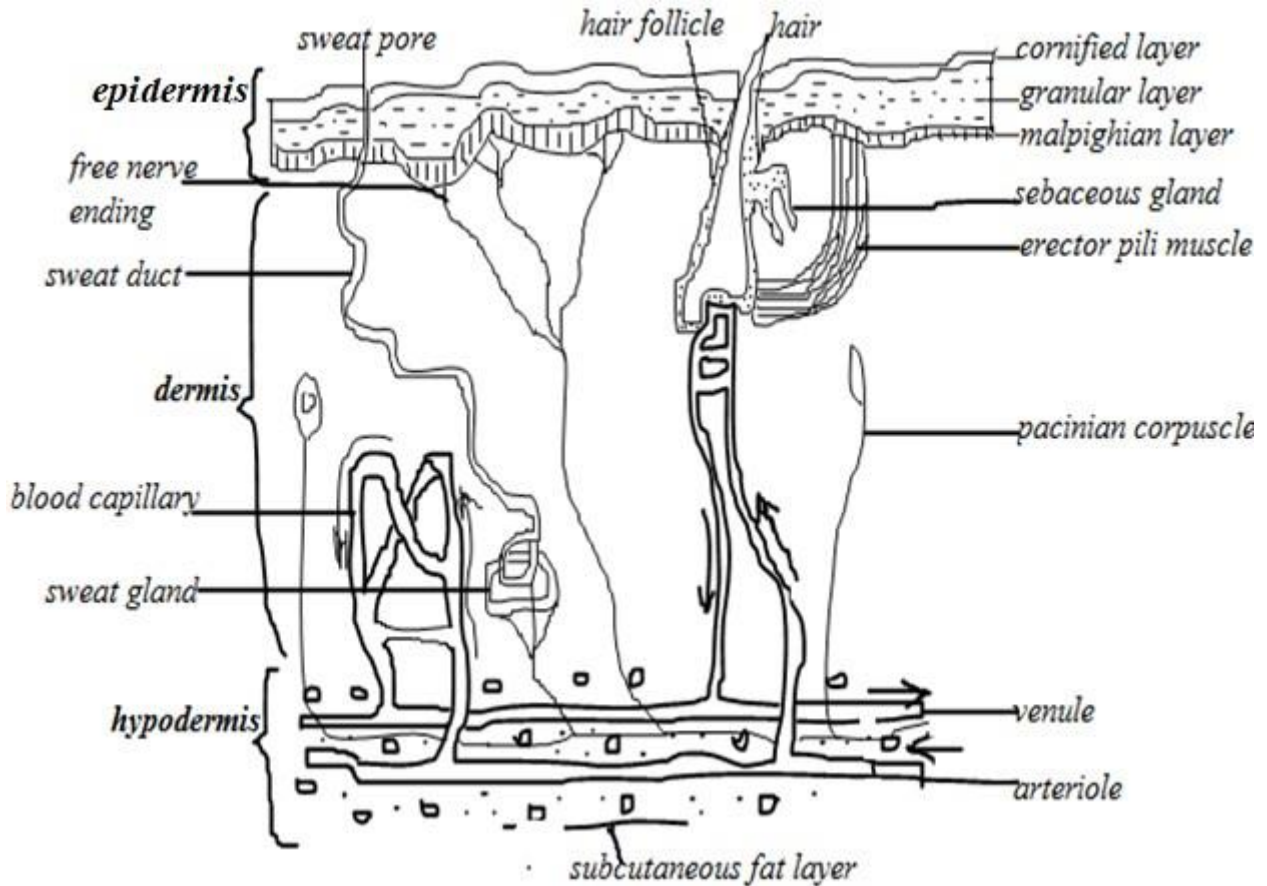
The thermo receptors in the hypothalamus in turn send messages (responses) to different body effectors to adjust the body temperature to norm (set point). This is another example of negative feedback mechanism of homeostasis. During these changes the skin is highly involved (study the structure of the skin below!)

Structure of the mammalian skin

The skin is made up of two main layers namely; the epidermis; and dermis. Below the dermis layer of the skin is another layer called hypodermis; responsible for skin attachment to the body muscles. The epidermis is

composed of; the upper layer of dead cells called cornified layer; below which are; granular and malpighian layers. The dermis is the lower layer with; sebaceous glands; blood capillaries; nerve endings and sweat glands.

Vertical/longitudinal section through the mammalian skin



Functions of the parts

- (i) **Cornified layer.** This consists of flattened dead cells; continuously shed from the skin. It provides a water proof barrier and protection against dangerous chemicals.
- (ii) **Granular layer.** This is the second layer from the topmost; consisting of living cells. These cells become pushed outwards to replace the eroded cells of the cornified layer.
- (iii) **Malpighian layer.** This is the last layer of the epidermis; which consists of actively dividing cells. New cells are sent to the upper layers. It also secretes and stores a pigment called **melanin**; which determines body colour; and screens the ultraviolet rays from the sun. Albinos lack melanin; but may have other pigments like carotene (yellow).

- (iv) **Hairs.** *These are structural proteins (with a fibrous protein: **keratin**); which grow from the follicles in the dermis. They protect the skin surface and help in temperature regulation.*
- (v) **Sebaceous glands.** *These open into the hair follicles and secrete an oily substance called sebum which keeps the hairs water proof; prevent cracking of the cornified layer; and destroy some bacteria.*
- (vi) **Erector pili muscle.** *This is mainly responsible for controlling the raising and lowering of the hair on the skin surface; during different environmental temperatures.*
- (vii) **Sweat glands.** *These are tiny and long tubes in the dermis of the skin. They contain secretory cells for; excreting salts excess water in sweat; sweat is also used for temperature regulation.*
- (viii) **Nerve endings.** *These receive different stimuli and send them to the nerve fibres; which carry information to the brain. There are three important types of such nerve endings namely; Pacinian corpuscle for pressure; free endings for pain; and meissner's corpuscle for touch.*
- (ix) **Subcutaneous fat layer.** *This is a tissue that lies within the last layer below the skin called hypodermis. Contains fat cells for storage of excess fats in the body. Using the fats stored; it is able to insulate the body against heat loss.*

Regulation of mammalian body temperature by the hypothalamus when the;

1. Body temperature is higher than normal

The hypothalamus responds by stimulating the body processes that encourage heat loss and reduce or cut down the rate at which heat is produced.

- (i) **Sweating.** *Sweat is a watery fluid containing dissolved salts produced from the sweat glands in the skin. This carries heat from the surface of the mammalian body; during evaporation. This brings about cooling of the body.*
- (ii) **Vasodilation.** *This refers to the increase in diameter of the blood vessels that bring blood towards the skin surface. This allows more blood*

to come into contact with the surface of the skin; allowing heat loss by conduction to; and convection from; the skin surface.

- (iii) *The hair erector muscle relaxes. The relaxation of this muscle brings about extension of the lower part of the hair follicle. This flexes the hair; making it appear lying flat/ horizontally; on the skin surface. Hairs lying flat on skin surface reduce the amount or thickness of insulating layer of warm air. This allows more heat to be lost.*
- (iv) *Decreased metabolic rate. The lower the metabolic rate such as respiration; the lower the amount of heat produced. This reduces the rate of heat loss by the body.*

2. Body temperature is lower than normal

The animal employs body mechanisms that control over-cooling by; reducing or cutting down heat loss; and increasing heat production.

- (i) *Decreasing sweat production. This helps to reduce heat loss by evaporation.*
- (ii) *Vasoconstriction. The superficial blood vessels (under the skin) reduce in diameter and lower down wards into the dermis. Hence less blood reaches the skin surface; reducing the rate at which heat is lost.*
- (iii) *The erector pili muscles contract. This results in raising of hairs upright on the skin surface; hence trapping a large insulating layer of warm air. Warm air is a poor conductor of heat; hence reduce heat loss.*
- (iv) *Increased metabolism. This increases the amount of heat produced; hence raising the body temperature back to normal (set point).*
- (v) *Shivering. This refers to the spasmodic contractions of body's skeletal muscles; to generate heat. This occurs in coldness in order to raise the body temperature to normal.*