THERMOREGULATION

Normal Body Temperature

The animal kingdom can be broadly classified into two depending upon their body temperature. The animals which can maintain their body temperature relatively constant in the face of wide variations of environmental temperature are known as "Warm-blooded animals" or "homeotherms", Whereas, those animals whose body temperature fluctuate with variation in environmental temperature are called "cold-blooded animals" or "Poikilotherms".

Even in homeotherms, who are capable of maintaining constant body temperature different parts of the body have different temperatures. The average temperature measured has been found to lie within a constant range.

The body is hypothetically divided into **core** and **shell.**

Oral Temperature

Average-37degree Celsius(98.6degree F). Oral temperature is affected by many factors.Eg:Cold or hot drinks, chewing gum, smoking, mouth breathing etc. When there is a rise in oral temperature there will be a rise in subclavian arterial temperature.

The body extremities have less temperature compared to others body parts. The scrotum is regulated at 32 degree Celsius

Skin Temperature

The normal temperature of skin is about 33 °C or 91 °F. The flow of energy to and from the skin determines our sense of hot and cold. Heat flows from higher to lower temperature. The most common method of skin temperature measurement is the use of a mercury-in-glass thermometer. The measurement of temperature from the skin surface of the forehead can be measured by using liquid crystal thermometers.

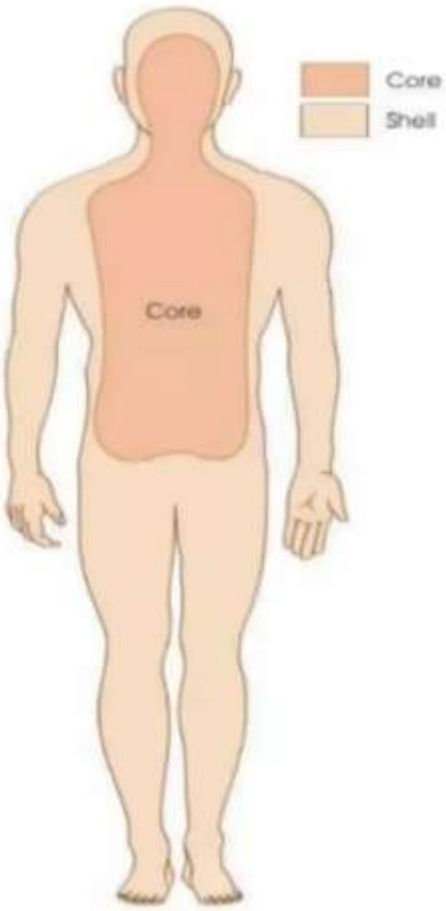
The Core Temperature/Internal Body Temperature

The core temperature(Temperature of intra-abdominal, intra-thoracic and intra-cranial content) is maintained at a constant temperature. Rectal and oesophageal temperatures represent Core temperature. It is the accurate index of the temperature of blood. The hypothalamic thermoregulatory receptors are stimulated based upon the variations in core temperature. The core temperature is 0.5-1 degree Celsius more than the oral temperature. It shows poor reflection of rapid temperature changes in blood.

The sites for recording core temperature; Rectum, Vagina, Oesophagus and Tympanic membrane..

The Shell Temperature

Shell temperature, the temperature of limbs and the surface layer of tranks are included in shell temperature. It exhibits wide variation of the temperature. Although rectal and oesophageal temperatures are most reliable, for practical advantages, oral temperature is taken for routine clinical purposes,



Factors Affecting Normal Body Temperature

1. Age :- Infants show wide range of variations in body temperature. It is due to overall less activity in infants (a) irregular activities (b) brown fat and (c) thermoregulatory mechanisms are not fully developed. Generally, 0.5°C above that of the adults. In infants regulation is imperfect. Hence, range of variation is wider. A fit of crying may raise and a cold bath may lower the body temperature

In old age, temperature is 'subnormal' due to: (a) dreease in activity (b) feeble circulation (because BMR is low) (c) thermoregulatory mechanisms are weak, that is why they are intolerant to extremes of external temperature.

2. Sex:- In females the body temperature may be a little lower. This is due to relatively low BMR and thick layer of subcutaneous fat (non-conductor). During menstruation, temperature slightly falls (0.3°F or 0.17°C). Then it gradually rises and becomes maximum 24 to 48 hours after the ovulation. This rise is due to progesterone level of blood which is secreted by the corpus luteum. Regular record of oral temperature in the early morning is sometimes used to detect the exact date of ovulation in a woman, in clinical practice.

3. Constitutional hyperthermia:- Normal healthy adults with body temperature above normal upto 100°F.

4. Diurnal variation(Circadian fluctuation):- The variation of 1.5°C may occur in normal person.It is highest in the evening (after the day's labour-between 5 and 7 pm) and lowest in the early hours of the morning (after the night's rest). In the night-workers, the rhythm is reversed. The average range of variation is 1 °F (0.55°C) to 1.5°F (0.83°C). This diumal variation is related to exercise and specific dynamic action (SDA) of food. Fasting and absolute bed rest abolishes this variation.

5. Diseases:- Hyperthyroidism - Increased BMR-body temperature is chronically elevated by 0.5°C. (ii) Hypothyroidism (Myxoedema) opposite occurs.

6. Exercises:- May cause increase in temperature upto 40-41°C (104-106°F) due to: (1) Inability of "beat dissipating mechanisms" to handle the greatly increased amount of heat produced.

7. Emotional factors:- Can increase the body temperature by as much as 2ºC. Temperature, humidity and movement of air are directly concerned with the amount of heat loss from the surface and thus affect body temperature.

8. Cold and baths:-These have a far greater influence than air at the same temperature, but since the duration of exposure to these baths are short, they have a little effect on the normal body temperature. However, body temperature may remain elevated for a considerable time after a prolonged hot water bath.

9. Sleep:- Because of muscular inactivity, sleep results in a slight fall of body temperature.

10. General anaesthetics or chlorpromazine:- Reduces the body temperature by depressing the activity of the e ascer ascending reticular system. Tubocurarine paralyses the skeletal muscle, and reduces heat production and results in fall of temperature. Antipyretic drugs, e.g. sodium salicylate and acetylsalicylic acid (aspirin) antagonise the action of pyrogen on the hypothalamus, induce cutaneous vasodilatation and sweating and thereby help in in reduction of temperature in febrile states.

11. Posture piloerection and clothing:- They are also important factors which affect the body temperature. All animals and even man may conserve heat or may prevent heat loss by curling them up during exposure to cold.

Heat Production and Heat Loss

Mechanism of Heat production (Thermogenesis)

1. By metabolic activities of the body specially in:

(i) Liver (ii) Heart cause relatively constant heat production.

(iii) Skeletal muscle generates variable amount of heat, but a major source of hest production in the body: At rest, very little heat production.

Heat production under basal (resting) conditions, called basal metabolic rate (BMR) is 1 kcal/kg/hour. This output works out at about 1500 kcal/day in females and 1700 kcal/ day in males.

2. By assimilation of food (SDA-Specific Dynamic Action) of food:
The SDA of a food is the obligatory energy expenditure that occurs during its assimilation into the body. Maximum heat production is seen after ingestion of proteins. Heat production takes place through physiological oxidation of food materials in the body-by combustion of carbohydrates, proteins and fats. Higher fat intake increases heat production. During digestion the peristaltic action of intestines and the activity of various digestive glands produce heat.

3. Heat gained by body from environment or from objects hotter than itself:
It occurs through direct radiation from the sun or heated ground or by reflected radiation from the sky.

4. By endocrine mechanisms:

(3) Epinephrine and nor-epinephrine produce a rapid but short lived increase in heat production

(ii)Thyroid hormones produce a slowly developing but prolonged increase in heat production,

5.A source of considerable heat production is a special type of fat, called "Brown fat":

It makes up a small percentage of total body fat. It is more abundant in infants but is present in adults also. As brown fat celis contain several small droplets of fat mitochondria, increased fatty acids oxidation in mitochondria. Increased heat production(i.e. has a high rate of metabolism).

Shivering increases heat production although not as high as voluntary muscular exercise. Vasoconstriction and Piloerection also help in heat gaining Ingestion of hot foods or drinks contributes to heat production in negligible amounts. Of the organs, the liver contributes the highest amount. Heat produced by liver and heart is relatively constant. The action of some internal secretion and enzymes, c.g. thyroxine and epinephrine (possibly) also helps to beat production.

Increased heat production which occurs by increasing the BMR and metabolic activity is termed Chemical thermogenesis, while the heat production by increased mascular activity is termed Physical thermogenesis.

Mechanism of Heat loss(Thermolysis)

Heat is lost from the body by three channels,

(1) Skin

(2) Lungs

(3) Rectum

(4) Urethra

The processes include radiation, conduction, convection, perspiration evaporation and excretion. The bodily changes that regulate the exchange of heat between the body and the environment are referred to as physical heat regulation.

The processes by which heat is lost from the body when the environmental temperature is below body temperature. It takes place by means of:

1.Skin- As environmental temperature approaches body temperature, radiation losses decline and vaporization loss increases. The rate at which heat is transferred from the deep tissues to the skin is called the "Tissue Conductance".
In humans, other major process transferring heat from the body is by the way of Vaporization of Water from the skin and mucous membrane and respiratory passage. passage. From the skin (proportional onal to the total surface area): 1. Radiation: Due to the difference of temperature existing between the body and the cooler environment heat is lost from the body by radiation (loss by electromagnetic waves). The body however does not radiate to the surrounding air, but through the air to the solid objects in the vicinity. When a number of people are present in a room, they radiate towards one another as well as to the surrounding objects. The amount of radiation from an object is determined by several factors. It is proportional to the surface area of the body, to its emissive power, and to the difference in temperature between the radiating body and the surrounding. The color of clothing's may play a part, white and pastel shades being suitable for tropical climate.

(2) Lungs- On average the water loss from the lungs is approx. 30ml/day. Some heat is also lost via the lungs by raising the temperature of inspired air to body temperature. (iii) Through skin-It consists of the passage of water through epidermis. Eccrine glands are responsible for Thermal Sweating. Apocrine glands help in heat loss through skin surface with salt water, called "Non-thermal sweating"

(3) Recturn- Heat loss takes place as the excretion is expelled out.

(4) Urethra- As the process of micturition takes through urethra, the heat loss also will be taking place.

Vasoconstriction of the cutaneous vessels reduces blood flow and thereby less heat is lost from the body, whereas vasodilatation produces opposite effect. Wearing woollen clothes, which are bad conductors of heat, also decrease the heat loss through conduction, Insensible. perspiration occurs due to continuous diffusion of fluid from the capillaries of the deeper layer of skin to the dry surface of skin. From lungs Evaporation of water in expired air is the main pathway through which heat is lost in dogs and sheep. Heat lost for warming the inspired air is about 2% in man. By excreta: Urine, faeces, etc. about 2%. Protrusion of the tongue facilitates heat loss through salivation in dogs.