Department of biology

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(animal physiology)

Stage (-3-)

LEC- ((3))

Thermal Regulation

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Based on body temperature, animals are classified as warm-blooded **(homeothermic)** animals, which are capable of maintaining a relatively constant body temperature despite great variations of external temperature or cold-blooded **(poikilothermic)** animals, in which the body temperature varies with that of the environment.

Poikilotherms include invertebrates and aquatic animals like fish and amphibians.

Some animals have a high rate of thermal conductance and a low rate of heat production. Such animals acquire heat from the environment and regulate their body temperature quite independently of the heat produced in the body; these animals are known as **ectothermic**.

In contrast to this, a few animals produce sufficient heat due to their own oxidative metabolism and maintain body temperature at a constant level. Such animals are called **endothermic,** which include homeotherms like birds and mammals.

Another category of animals that do not maintain a constant body temperature, but exhibit endothermic regulation during activity, are called heterothermic animals. They are also referred to as facultative endotherms, as they are capable of regulating their physiological temperature at certain times only.

Animals like birds have a higher limit of thermal tolerance **(35 C º-42C º)** due to a higher rate of metabolism.

Body Temperature

The normal range of human body temperature is **(36 °C °to 38C °),** with an average oral temperature of **(37C °).** Within a 24-hour period, an individual's temperature fluctuates from 1C °to 2C °, with the lowest temperatures occurring during sleep. At either end of the age spectrum, however, temperature regulation may not be as precise as it is in older children or younger adults. Infants have more surface area (skin) relative to volume and are likely to lose heat more rapidly. In the elderly, the mechanisms that maintain body temperature may not function as efficiently as they once did, and changes in environmental temperature may not be compensated for as quickly or effectively.

Heat Production ,Cell respiration, the process that releases energy from food to produce **ATP**, also produces heat as one of its energy products. Although cell respiration takes place constantly, many factors influence the rate of this process:

1. **The hormone thyroxin** (and T3), produced by the thyroid gland, increases the rate of cell respiration and heat production.

2. **In stress situations**, epinephrine and norepinephrine are secreted by the adrenal medulla, and the sympathetic nervous system becomes more active. Epinephrine increases the rate of cell respiration, especially in organs such as the heart, skeletal muscles, and liver.

3. **Organs that are normally active** (producing ATP) are significant sources of heat when the body is at rest. The skeletal muscles, for example

This amounts to about 25% of the total body heat at rest and much more during exercise, when more ATP is produced. The liver is another organ that is continually active, producing ATP to supply energy for its many functions. As a result, the liver produces as much as 20% of the total body heat at rest. The heat produced by these active organs is dispersed throughout the body by the blood.

4. **The intake of food** also increases heat production because the metabolic activity of the digestive tract is increased.

5. **Changes in body temperature** also affect metabolic rate and heat production. This becomes clinically important when a person has a fever.

Thermal Regulation

- **Heat Loss through the Skin** Because the skin covers the body, most body heat is lost from the skin to the environment. The amount of heat that is lost is determined by blood flow through the skin and by the activity of sweat glands.

In a cold environment, vasoconstriction decreases blood flow through the dermis and thereby decreases heat loss.

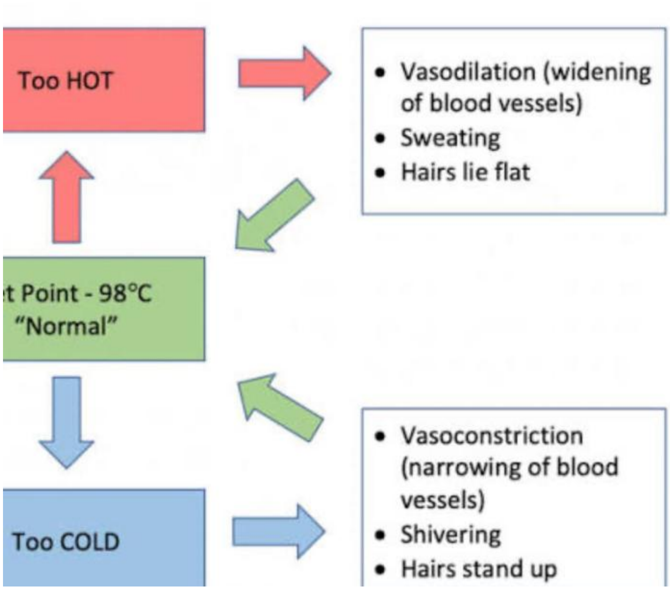
In a warm environment, vasodilation in the dermis increases blood flow to the body surface and loss of heat to the environment. The other mechanism by which heat is lost from the skin is sweating.

- **Heat Loss through the Respiratory Tract**

Heat is lost from the respiratory tract as the warmth of the respiratory mucosa evaporates some water from the living epithelial surface.

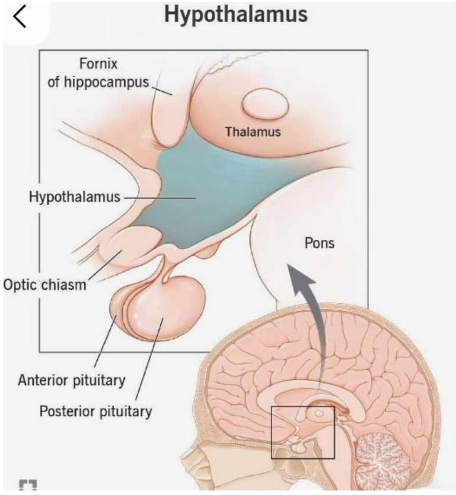
❖ Heat Loss through the Urinary and Digestive Tracts

When excreted, urine and feces are at body temperature, and their elimination results in a very small amount of heat loss.



Regulation of Body Temperature

The hypothalamus is responsible for the regulation of body temperature and is considered the —thermostat" of the body. As the thermostat, the hypothalamus maintains the —settings of body temperature settings by balancing heat production and heat loss to keep the body at the set temperature. To do this, the hypothalamus must receive information about the temperature within the body and about the environmental temperature. Specialized neurons of the hypothalamus detect changes in the temperature of the blood that flows through the brain. The temperature receptors in the skin provide information about the external temperature changes to which the body is exposed. The hypothalamus then integrates this sensory information and promotes the necessary responses to maintain body temperature within the normal range.



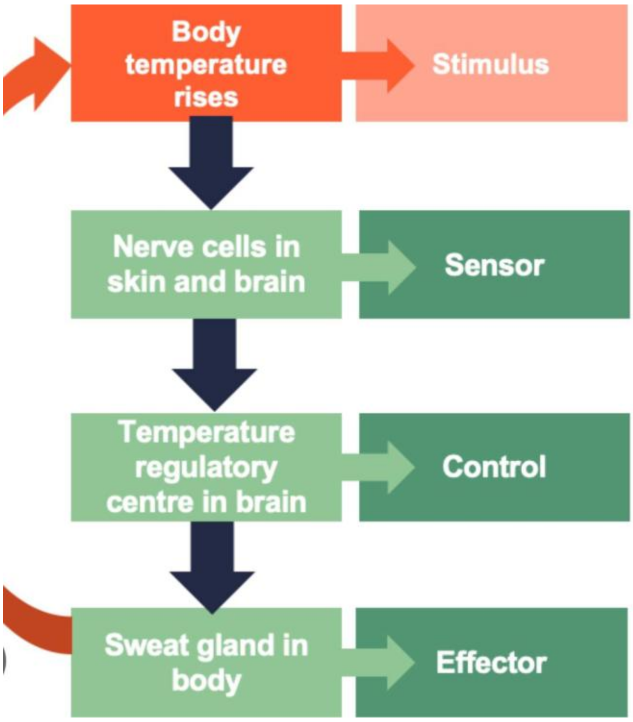
Mechanisms to Increase Heat Loss

In a warm environment or during exercise, the body temperature tends to rise, and greater heat loss is needed. This is accomplished by vasodilation in the dermis and an increase in sweating.

sweating becomes inefficient when the atmospheric humidity is high.

Mechanisms to Conserve Heat

In a cold environment, heat loss from the body is unavoidable but may be reduced to some extent. Vasoconstriction in the dermis shunts blood away from the body surface, so that more heat is kept in the core of the body. Sweating decreases, and will stop completely if the temperature of the hypothalamus falls below about 37C º.



Low temperature effects

The protoplasm can exist in a living state between (0C ° and 45C °) and freezes a few degrees below zero.

Freezing causes:

1- Forming the ice crystals in the cell disturbs the cell organization.
2- Metabolism is greatly lowered, and as such, the rate of oxygen consumption is also very low because the diffusion of O_2 and CO_2 through the ice is very low.
3- The enzymes become inactive.

Fever

A fever is an abnormally high body temperature and may accompany infectious diseases, extensive physical trauma, cancer, or damage to the CNS. The substances that may cause a fever are called **pyrogens**. Pyrogens include bacteria, foreign proteins, and chemicals released during inflammation. These inflammatory chemicals are called endogenous pyrogens. It is believed that pyrogens chemically affect the hypothalamus and raise the settings of the hypothalamic thermostat.

The hypothalamus will then stimulate responses by the body to raise body temperature to this higher setting.

White blood cells increase their activity at moderately elevated temperatures, and the metabolism of some pathogens is inhibited. Thus, a fever may be beneficial in that it may shorten the duration of an infection by accelerating the destruction of the pathogen.

A fever increases the metabolic rate, which increases heat production, which in turn raises body temperature even more. When the body temperature rises above 39.7C ^{o}, the hypothalamus begins to lose its ability to regulate temperature.

The proteins of cells, especially the **enzymes**, are also damaged by such high temperatures. Enzymes become denatured, that is, lose their shape and do not catalyze the reactions necessary within cells.