

Topic: Homeostasis

At the end of this topic the students should be able to:

- 1. Define the term homeostasis.*
- 2. Name the main conditions in the human body that need to be kept constant.*
- 3. Describe the structure and function of the skin.*
- 4. Describe how the skin regulates the body temperature through sweating, vasodilation and vasoconstriction.*
- 5. Describe how the liver and the pancreas works together to regulate the sugar concentration of the blood.*
- 6. Explain the concept of negative feedback and relate it to temperature control and sugar control.*

What is homeostasis?

Homeostasis is the term used to describe the keeping of constant conditions inside the body of an organism.

In order for a living thing to function efficiently, there cannot be too much variation in the conditions under which the cells, tissues and organs work.

The main conditions that need to be kept constant in the human body are **temperature (at 37 °C)** and **blood sugar concentration (at 90mg/100cm³ blood)**.

Temperature regulation

The organ responsible for temperature regulation is the skin (the largest body organ) and the three main mechanisms by which this is accomplished are **sweating**, **vasodilation** and **vasoconstriction**. A knowledge of the structure of the skin is important to the understanding of how these mechanisms work.

Structure and function of the skin

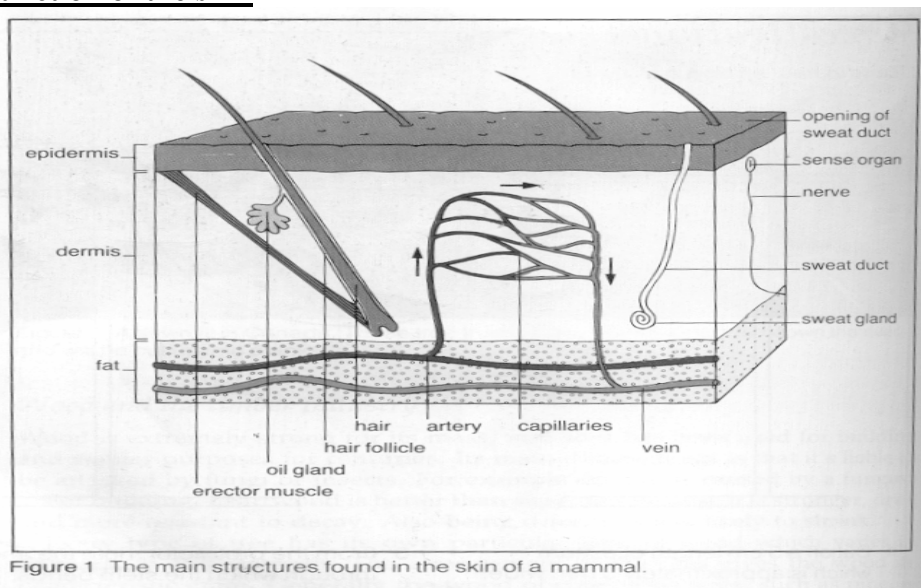


Figure 1 The main structures found in the skin of a mammal.

epidermis – upper thin layer of the skin

dermis – lower thicker layer of the skin; contains most of the structures of the skin

sweat glands – produce sweat

sweat duct – transports sweat to the skin surface

sweat pore – opening of the sweat duct; delivers sweat onto the skin surface

nerve endings – detect changes in the environment e.g. temperature, pain, pressure etc.

sebaceous glands (oil glands) – produces an oily substance called sebum which keeps the skin supple (easily bent)

hair erector muscle – controls the raising and lowering of the hair

blood vessels – supply the skin with blood

The following structures of the skin are involved in temperature regulation:

- the hairs and hair erector muscles
- sweat glands
- nerve endings
- blood vessels

Mechanism of temperature control by the skin

A person is able to detect the temperature of the environment through the nerve endings which lie below the surface of the skin. The temperature of the blood changes with the temperature of the environment. Changes in body temperature are detected as blood flows through the hypothalamus.

In cold environmental conditions:

- the body temperature initially falls below normal
- hair erector muscles contract resulting in the raising of the hairs on the skin or the formation of goose pimples in humans
- a layer of air is trapped between the hairs which acts as an insulating layer
- the blood vessels under the surface the skin constrict or get smaller in diameter (**vasoconstriction**) resulting in less blood flowing to the skin surface and less heat loss (pale skin)
- the metabolic rate of the body increases and produces extra heat
- shivering (contraction of involuntary muscles in the skin) occurs which also generates heat
- the body temperature returns to normal

In hot environmental conditions:

- the body temperature rises above normal
- hair erector muscles relax resulting in the lowering of the hairs on the skin
- the layer of air is no longer present thus allowing more heat to be lost
- the blood vessels under the surface of the skin dilate or increase in diameter (**vasodilation**) resulting in more blood flowing to the skin surface (flushed skin) and greater heat loss by conduction, convection and radiation
- sweat production increases - the heat of the body causes the evaporation of the sweat resulting in the lowering of the body temperature (a dog pants to evaporate water from its mouth and tongue)
- the metabolic rate of the body decreases
- the body temperature decreases to its normal value.

Sugar control by the liver and pancreas

After a meal containing a lot of carbohydrates the **sugar content of the blood will increase**. As a result the pancreas secretes the hormone insulin which brings about the lowering of the blood sugar level.

The sugar level is lowered by insulin by the following mechanisms:

1. excess glucose is taken from the blood to the liver and muscles where the glucose is converted to glycogen and stored
2. there is increased oxidation of glucose by the cells of the body to produce energy
3. any additional excess glucose is converted to fat and stored underneath the skin

The result of the above activities is the lowering of the blood-sugar level to its normal value.

When the **blood sugar level falls below normal** (e.g. during fasting) the following corrective actions take place:

- the pancreas secretes the hormone **glucagon**
- glucagon promotes the breakdown of stored glycogen in the liver and muscles to glucose
- this results in the increase of the blood sugar level

Diabetes melitus

A diabetic is someone whose pancreas does not produce sufficient quantities of insulin. This condition can either be inherited or it may just develop as one gets older. It cannot be cured but it can be controlled. Due to the inadequate amounts of insulin, glucose is not readily removed from the blood. This results in the concentration of sugar in the blood being higher than normal.

In order to reduce the blood-sugar concentration to an acceptable level the diabetic patient must take daily intra-muscular shots (injections) of insulin. Since the diabetic has no way of easily determining the blood sugar level, the recommended dosage may be too much causing the blood sugar level to be reduced below its normal value. The diabetic can recognize when this is the case through the signs which follow such as trembling, sweating and weakness. It is therefore advisable that the patient keeps something sweet on hand to compensate in case the sugar level falls too low.

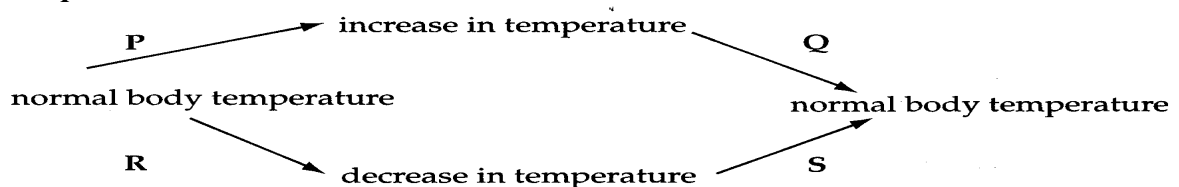
Homeostasis and negative feedback

Homeostasis is achieved by negative feedback. This is a corrective mechanism which returns conditions in the body to their normal state after an increase above or a decrease below the normal value.

Negative feedback systems are very common in biology – they help to keep conditions inside the body constant.

Temperature control and blood-sugar level control both operate by negative feedback mechanisms.

e.g. for temperature control



P and R are conditions which may cause an increase or a decrease in the normal body temperature. Q and S are the corrective actions that are taken to return the body temperature to normal.

Once a condition changes from its normal value, the body immediately sets in place corrective actions to return it to normal. The mechanism is called negative feedback because the changing condition feeds back or stimulates the source to stop producing the change. (Positive feedback works in the opposite way)

Question (Answer each part in complete sentences)

- (a) Define the term homeostasis. (2)
- (b) Describe the role played by each of the following in the regulation of the body temperature of a mammal
 - (i) vaso-constriction
 - (ii) vaso-dilation
 - (iii) sweating (9)
- (c) Explain the roles played by the liver and the pancreas in controlling the sugar content of the blood. (6)
- (d) What is negative feedback and how does it help to maintain homeostasis? (3)