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**SENIOR FIVE TERM 3**

**TOPIC 5: Homeostasis**

**Competency:** The learner evaluates the regulation and maintenance of optimal internal environment in living organisms by analyzing how organ systems generate and eliminate metabolic wastes and maintain the functioning of cells, to make life choices that promote wellness.

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## Homeostasis:

The term **homeostasis** (from a Greek word meaning staying the same) is used to mean **maintenance of static or constant conditions in the internal environment** of the body. It describes all mechanisms by which a constant environment is maintained in the body.

### Why homeostasis is necessary/significance of homeostasis

Homeostasis is crucial for the survival of all living organisms, as it allows them to maintain a stable, functional internal environment despite constant changes in the external world. The body has to keep proper concentration of oxygen, glucose, osmotic pressure, temperature, pH, the different electrolytes such as potassium and sodium and other nutrients. Without this dynamic balance, cells, tissues, and organs cannot function properly, leading to disease and, ultimately, death

### Mechanism of homeostasis

1. **Negative Feedback:** is a mechanism whereby deviation from a set norm causes a corrective mechanism to restore the norm. For example, increase in the concentration of glucose in blood initiates mechanism that brings the concentration back to normal.

An efficient negative feedback mechanism is the one that detects small changes from the norm and responds fast to prevent big fluctuations from the set point

### Components of an efficient homeostatic system

An efficient homeostatic system possesses several key characteristics that allow an organism to maintain a stable internal environment:

- **Sensitivity/Detection:** The system can detect even slight deviations of a variable (e.g., temperature, pH, glucose levels) from its specific set point.
- **Rapid Response:** Effectors act promptly to counteract deviations and restore balance quickly.
- **Precision of Control:** The system makes corrections that return the variable precisely to its optimal range, avoiding large overshoots or fluctuations.
- **Specificity:** Each receptor and effector is specialized to respond to particular stimuli, preventing cross-interference between different regulatory processes.
- **Negative Feedback:** The primary mechanism of control is negative feedback, where the **response** reduces the original stimulus, bringing the variable back towards the set point.

- **Integration and Coordination:** A central processing center (e.g., the brain's hypothalamus) integrates signals from multiple sources and coordinates the actions of various effectors to produce a unified, effective response.
  - **Adaptability (Plasticity):** The system can adjust its set points and sensitivities in response to changing environmental demands or developmental stages (a concept sometimes called allostasis or rheostasis).
  - **Redundancy:** Multiple, overlapping mechanisms often regulate the same variable. This ensures that the failure of one component does not lead to a complete system failure.
  - **Energy Efficiency:** The system maintains stability with minimal unnecessary expenditure of energy and resources.
  - **Dynamic Stability:** Homeostasis is not a static condition but a dynamic process involving continuous, active adjustments around a set point to achieve active stability.
2. **Positive feedback:** is a mechanism whereby the deviation from the norm causes further deviation. When a person is caught up in a burning building, high temperature increases the activity of enzymes which result into further heat production. Positive feedback mechanism leads to death.

### Examples useful positive mechanism processes

(i) Child birth

During labour release of oxytocin intensifies and speeds up contraction. The increase in contraction causes more oxytocin to be released and the cycle goes on until the baby is born.

(ii) Blood clotting

Once a vessel is damaged, platelets start to cling to injured site release chemicals that attract more platelets. The platelets continue to pile up and release chemical until a clot is formed.

## The homeostatic control of glucose

The normal concentration of glucose in human blood is approximately 90mg per 100 cm<sup>3</sup>, and even after the heaviest carbohydrate meal rarely exceeds 150mg per 100cm<sup>3</sup>. After absorption from the gut various things can happen to glucose in the body.

- It is broken down into carbon dioxide and water, particularly in active tissues such as the muscles.

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- It may be built into glycogen and stored.
- It may be converted into fats and stored in the body's fat depots.
- If glucose is in short supply, glycogen may be broken down into glucose.

The concentration of glucose in the blood and tissue fluids at any moment is determined by the relative extent to which these different processes occur in the body. For example, if there is too much glucose, as after a large meal rich in carbohydrates, the cells convert the surplus glucose, the liver cells convert glycogen lowering its concentration in blood. When the concentration of glucose is lowered in blood, the liver cells convert glycogen into glucose, thereby raising the glucose concentration in the body.

In prolonged deficiency, glucose may be formed from non-carbohydrate source, including fat and proteins. This is called **gluconeogenesis**. This explains the wasting away of tissues, which occur in extreme starvation. This is because the body resort to converting its tissue proteins into carbohydrates.

### **The role of the pancreas in regulation of glucose**

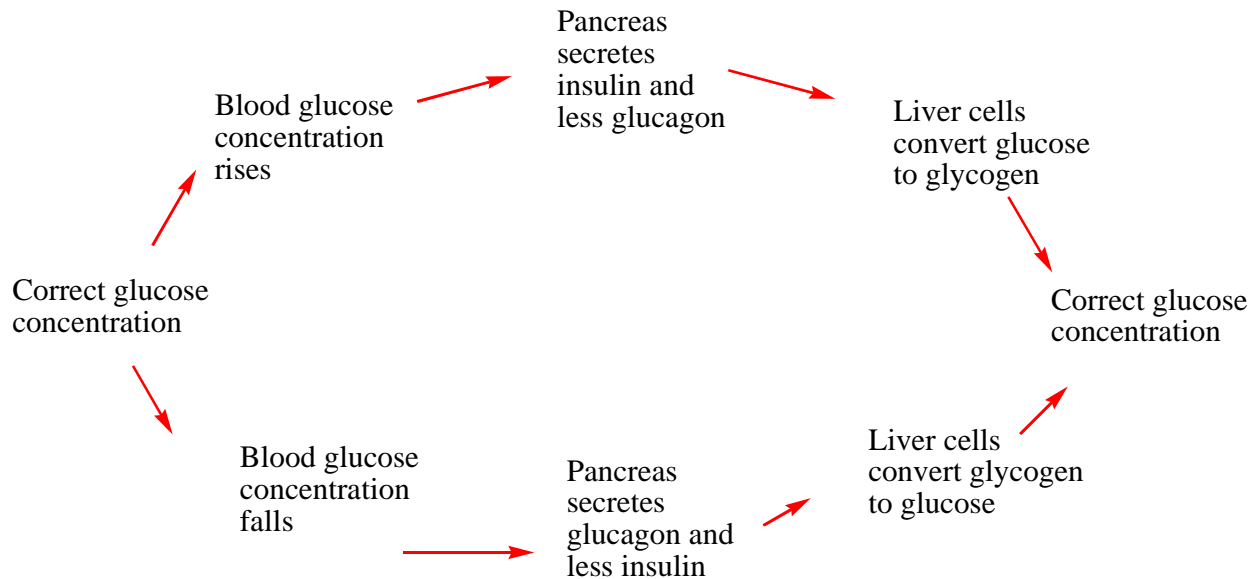
High concentration of glucose in blood triggers the pancreas to secrete the hormone insulin from  **$\beta$ -cells of islets of Langerhans**. This insulin exerts its effect lowering the blood glucose level mainly by

- increasing the conversion of glucose to glycogen and fat by the liver cells.
- inhibits the formation of glucose from glycogen and non-carbohydrate sources (gluconeogenesis).
- Increasing oxidation of glucose into carbon dioxide and water.

Low concentration of glucose in blood triggers the pancreas to secrete the hormone glucagon from  **$\alpha$ -cells of islets of Langerhans** and inhibits secretion of insulin. This increases the concentration of glucose by

- Causes liver cells to convert glycogen and fat by the liver cells.
- Promotes gluconeogenesis or the formation of glucose from glycogen and non-carbohydrate sources

The homeostatic scheme of control of glucose in mammalian body is shown below



**Diabetes mellitus is a disease condition caused by inability of an individual's pancreas to produce enough insulin.**

It is characterized by increased in the blood glucose concentration (hyperglycaemia), and glucose appears in urine (glycosuria). The production of urine increases and the patient may suffer from intense thirst. Later symptoms include severe loss of the body mass, muscular waste and skin lesions. If untreated the patient goes into a **diabetic coma** and dies.

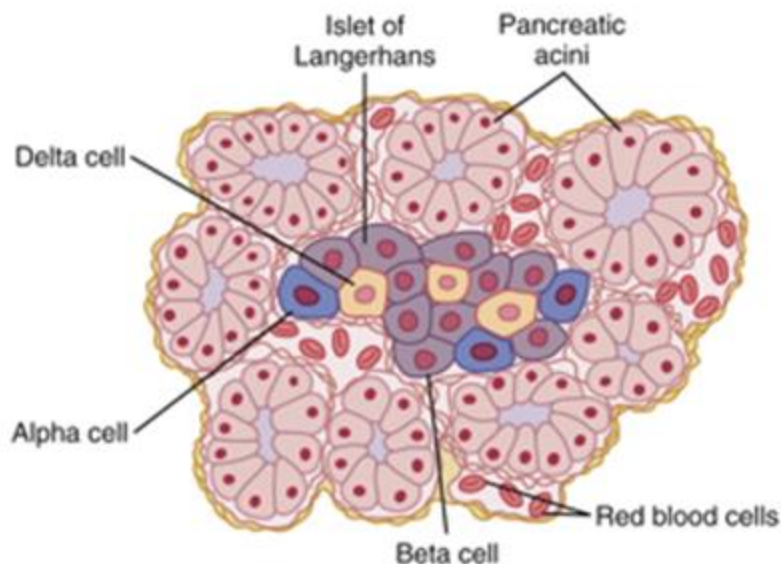
**Diabetes mellitus** is controlled by appropriate doses of parenteral insulin.

A sub-normal glucose concentration is called **hypoglycaemia**. If this is uncorrected, it causes a person to go into coma. Hypoglycaemia is particularly liable to occur during fasting, and one of glucagon's main functions is to counteract this.

### **Cells that secrete insulin and glycogen:**

By suitable staining techniques of islets of Langerhans two types of secretory cells can be distinguished in the islets: **alpha cells and beta cells** figure below:

Microscopic microgram of cells that produce insulin and glucagon



The alpha cells located in the peripheral part of the islet, secrete glucagon, whereas the more centrally placed beta cells secrete insulin. Both hormones are secreted into blood capillaries within the islet; from which they pass into the general circulation to control the secretion of insulin.

## Temperature regulation in Man

The human body temperature must be kept constant because enzymes work best at  $36.9^{\circ}\text{C}$  - optimum temperature. At high temperature above  $40^{\circ}\text{C}$  enzymes are denatured or too low temperatures lead to slowing of metabolic activities and impairing the activities of important organs such as the brain.

### How heat energy is lost or gained the body.

Organisms loss or gain heat from the environment by four physical processes.

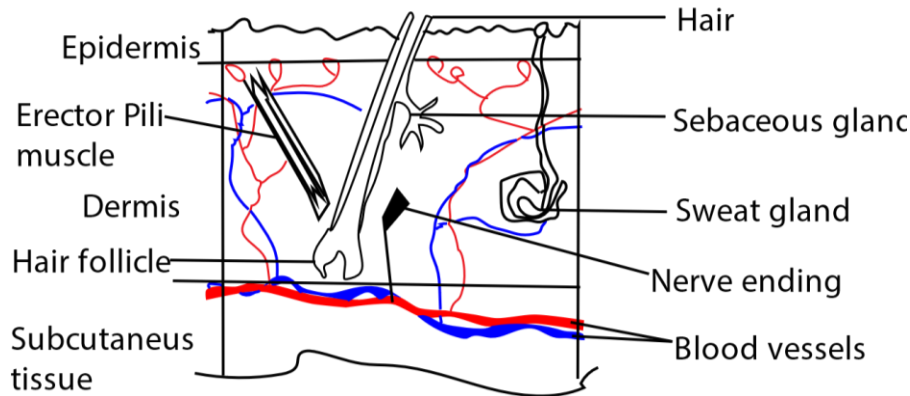
- **Conduction** in the transfer of heat energy from hotter to the cooler of two objects in contact with each other.
- **Radiation** is the heat transfer from a hot body to a cool one that are not in contact. It is a major source of heat loss.
- **Evaporation** is change of a liquid to a vapour, it is accompanied by cooling. This is the cause of cooling accompanied by sweating.
- **Convection:** is the movement of air resulting from local pockets of warm air being replaced by cooler air, and vice versa. There air movement speeds up loss of heat by radiation and evaporation.

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### In addition animals may lose heat through

- Urinating warm urine
- Vomiting
- Spitting
- Defaecating

### The skin



The skin is divided into two main layers, the **epidermis** at the surface, and the **dermis** beneath. Below the dermis is another layer, not strictly part of the skin, called the **hypodermis**.

The epidermis is made up of **stratified epithelium**. The bottom-most layer of cells, the **Malpighian layer**, contains variable amounts of black pigments **melanin** which protects the body from the harmful effects of ultraviolet rays from the sun.

The cells of the Malpighian layer divide repeatedly in a plane horizontal to the surface of the body. As new cells are formed, the older ones get pushed outwards towards the surface, flattening as they do so. After a time, the cytoplasm become converted into scales of **Keratin**, giving rise to **Keratinised layer** at the surface of the epidermis. The keratinised layer protects the skin from damage and makes it water proof.

Oil is secreted on to the surface of the epidermis by sebaceous glands makes the hair supple and enhances the skin's water proofing properties.

The roots of the hair are embedded in the dermis or hypodermis. Running from the side of each hair follicle to the base of the epidermis is **erector pili muscle**. When this muscle contracts, the hair is pulled into a more vertical position. In this position hair trap a layer of air around the skin thereby insulating the skin from heat loss.

The dermis contains **sweat glands** which secrete a salty solution, **sweat**. The sweat passes down the **sweat ducts** to the surface of the epidermis, and its subsequent evaporation cools the skin and blood flowing through it.

The hypodermis contains variable amount of fat (subcutaneous fat) which insulate and prevent heat loss from the body.

### Response of man (endotherms) to cold conditions

1. **The hair is raised** and brought into a more-or- less vertical position by contraction of erector pili muscle. Air gets trapped in the spaces between the hairs and being a poor conductor of heat, it serves as an insulator round the animals. In humans the body hair is much reduced, its placed being taken by clothes. Even so the erector pili muscles contract just the same, resulting in “goose pimple”. In birds the feathers serve the same function as the hair of mammals, being raised in cold weather.
2. **Vasoconstriction: i.e.** the arterioles leading to the superficial capillaries constrict. As a result, the blood flow to the surface of the skin is reduced, thereby cutting down the heat energy from the blood to the surrounding.
3. The metabolic rate increases, the generation of heat inside the body to compensate for heat loss.
4. Decrease in sweating reduce heat loss through evaporation.
5. Shivering: at very low temperature skeletal muscles are stimulated to contract and relax automatically leading to production of heat.

### Behavioural mechanism animals to cold conditions

1. Engaging in exercises (making a lot of noise in some organism)
2. Taking hot drink or bath
3. Wearing heavy clothes
4. Burrowing
5. Hibernation

### Response of human body to hot conditions.

1. **The hairs are lowered:** by relaxation of erector pili muscles, so they lie flat against the surface of the skin, less air is trapped between the hairs, insulation is therefore reduced, and heat energy can be lost more readily by conduction, radiation and convection.
2. **The arterioles** leading to the superficial capillaries dilate. As a result, the blood flow to the surface is increased and more heat energy can be lost to the surrounding.
3. **Sweating or panting occur**, and evaporation of water from the moist skin or tongue cools the blood as it flows through the superficial capillaries. As a means of cooling the human body sweating is extremely important. In dogs and cats sweating is substituted with panting.
4. The metabolic rate decreases, reducing heat energy generated in the body.

### **Adaptations of endotherms to cold environment.**

- The animals develop large volume to surface ratio. i.e. the extremities such as ear tend to be small and the animals tend to be larger.
- Animals in cold environment have thicker subcutaneous fat.
- Animal in cold environment tend to have heavy fur or hairs.
- Animals in cold environment develop high metabolic rates.
- Reduced extremities to reduce the surface area for heat loss.
- Animals in cold environment develop arteries and veins in close proximity, such that as blood flows down the arteries, heat energy passes from it to the much cooler blood which is returning in the opposite direction in the veins. The **counter current heat exchange system** is seen in flippers of dolphins and the legs of ducks, both of which are highly adapted to be in cold water. It achieves two things. First it means that the arterial blood has already been cooled by the time it reaches the end of the limb, so that relatively little heat energy is lost to the surrounding. Secondly it warms the venous blood before it gets back to the main part of the body.

### **Adaptations of endotherms to hot environment.**

- a. Have thin subcutaneous fat layer to promote heat loss
- b. Are small compared to their counterpart in cold region to provide bigger surface area to volume ratio
- c. Have large extremities to increase the surface area for heat loss.
- d. They have many sweat glands to produce sweat whose evaporation cools the body
- e. Have less fur

### **Behavioural control of body temperature by ectoderms**

Many ectoderms respond to high environmental temperature by

- Moving to cool places
- Thermal gaping
- Aestivation
- Migration to cooler places

Ectoderms respond to cool environment temperatures by

- Moving to warm place
- Basking
- Sleeping in piles to reduce heat loss
- Burrowing

### **Adaptations of animals to live in cold environment**

- Hibernating is a behavioural response by many temperate and arctic animals to very cold temperature. The animal responds to very cold temperature by going into a deep sleep. The metabolic rate falls to the minimum required to keep life ticking over. The body temperature also falls, and is maintained at a much lower level than normal. Hibernation

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saves these animal of expending large heat energy in winter whilst the food is scarce surviving extremes of temperatures.

- **By super cooling:** Super cooling is the lowering of the temperature of a fluid to below its freezing point without the formation of ice. Ice crystals can damage tissues and super cooling provides a way of avoiding this. Experiments have shown that certain reptiles can be super cooled to as low as  $-8^{\circ}\text{C}$  without freezing. Plants and fishes also go in for super cooling.
- By freezing tolerance. Some organisms, notably plants and insects can tolerate the formation of ice in their tissues. Certain insects' larvae can recover after as much as 90% of the body has been frozen. In these organism's ice crystals form between, rather than inside the cells; later when the ice melts. In some species of fish ice damage is lessened by the presence of glycol in the tissues. glycerol is used in human blood banks and sperm banks to prevent injury to the cells when they are frozen for storage.
- **By using an antifreeze:** some fish employ anti-freeze such as glycerol and glyco-protein to lowers the freezing point so that the body fluids do not freeze in winter.

### What about high temperatures?

The main adaptation here is tolerance. This enables certain types of algae to flourish in hot springs at temperatures of  $55$  to  $60^{\circ}\text{C}$ . However, it is prokaryotes that show the greatest tolerance. There are many reports of bacteria growing in boiling hot springs to North America and New Zealand, but the jackpot must go to certain bacteria which have been discovered in the hot water rising from sulphate encrusted vents in the deep ocean floor. Some of these bacteria were living at temperatures of  $350^{\circ}\text{C}$ . It is claimed that in the laboratory they reproduced enthusiastically in sea water at  $250^{\circ}\text{C}$ , doubling in number every 40 minutes. Heat tolerant bacteria possess membranes which are more heat stable than those of other prokaryotes, and their enzymes work optimally at temperatures well above those that would denature the enzymes of other organism. e.g. **Thermophilus**, a bacteria which lives in hot springs, possesses enzymes that work best at  $80^{\circ}\text{C}$ .

### The brain and temperature regulation

Thermoregulation centre in the brain is found in hypothalamus. Hypothalamus is sensitive to the temperature of blood flowing through it and responds by sending nerve impulses to the appropriate effector. If the temperature of blood is higher than normal, the thermos regulatory centre detects this and sets into motion the various processes that cool the body and the vice versa.

### The upper and lower critical temperature of the body

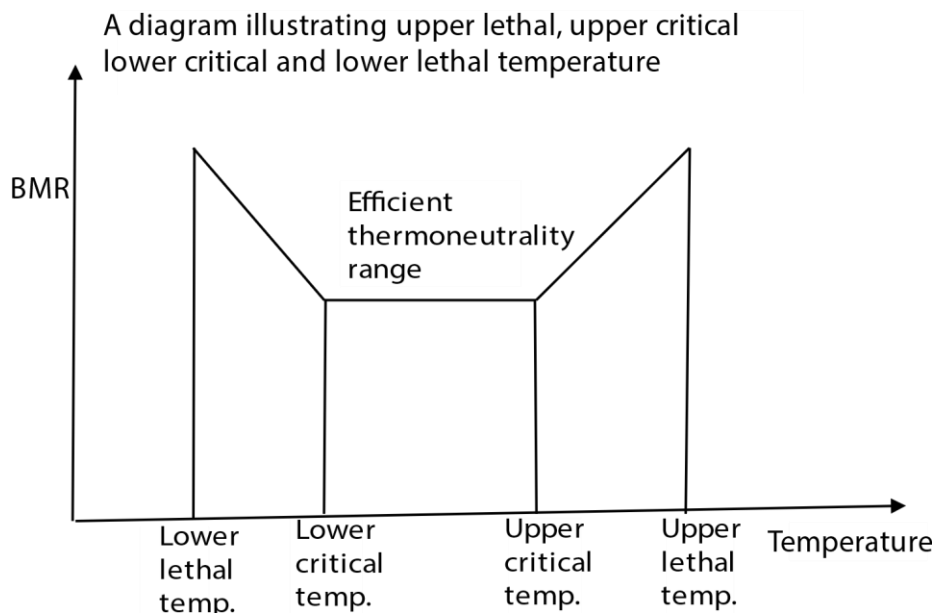
#### (a) The lower critical temperature.

The lower critical temperature is the environment temperature below which physical mechanism such as insulation cannot maintain body temperature. The lower critical

temperatures are lower for arctic mammals (e.g. Eskimo dog, white fox) than for tropical mammals such as man

The lower critical temperature for arctic mammal is about  $-40^{\circ}\text{C}$  while that of man is  $27^{\circ}\text{C}$ . When the animal is cooled below the lower critical temperature, the basal metabolic rate increases to maintain the body temperature until the temperature reaches the lower lethal temperature below which the organism dies for failure to maintain body temperature.

Arctic mammals have lower critical and lethal temperature due big layer of subcutaneous fats and thick fur for insulation; they have small extremities and their arteries and veins from extremities are close to each other to reduce heat loss.



### (b) The Upper critical temperature.

The upper critical temperature ( $29^{\circ}\text{C}$  for man) is the environment temperature above which physical mechanism such as sweating, lowering hair cannot maintain body temperature. The upper critical temperatures are lower for arctic mammals (e.g. Eskimo dog, white fox) than for tropical mammals such as man

When the environmental temperature rises above the upper critical temperature, the basal metabolic rate increases due to increase in body temperature and enzymatic controlled

reaction up to the upper lethal temperature above which enzymes are denatured and the organism dies.

Desert animals have higher critical and lethal temperatures than arctic animals because they have low fat deposits and less hair to insulate the body

### Temperature control in plants

- Transpiration lowers escalating temperature.
- Shiny cuticles reflect heat radiated by the sun.
- Having small leaves reduce surface area for heat absorption.

### Water regulation/osmoregulation in man

Water regulation in man, or osmoregulation, is a complex homeostatic process that maintains the proper balance of water and solutes in the body. It relies on coordinated responses between the brain, kidneys, and endocrine system, involving hormone signaling and a negative feedback loop to ensure fluid balance despite varying intake and environmental conditions.

#### Key components of the osmoregulation system

The two main parts of the water regulation system are the brain, which senses fluid changes and triggers responses, and the kidneys, which adjust water excretion accordingly.

#### The brain and thirst mechanism

The hypothalamus contains osmoreceptors, specialized neurons that monitor the osmotic concentration of the blood. When blood becomes too concentrated (high osmolality), water moves out of the osmoreceptor cells, causing them to shrink. This sends a signal to the hypothalamus.

In response to the signal, the hypothalamus triggers the conscious sensation of thirst, prompting the person to drink water. It also directs the pituitary gland to release the hormone antidiuretic hormone (ADH), also known as vasopressin.

#### The kidneys and ADH

When blood becomes too concentrated (high osmolality) ADH is released from pituitary gland and travels through the bloodstream to the kidneys; here it increases the permeability of the collecting ducts to water by causing the insertion of water channels called **aquaporins** into their cell membranes. With more aquaporins available, more water is reabsorbed from the urine back into the bloodstream, producing a smaller volume of more concentrated urine.

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If blood osmolality is low, the production of ADH is suppressed. The aquaporin channels are removed, and the collecting ducts become less permeable to water. As a result, more water is excreted as a large volume of dilute urine.

### The renin-angiotensin-aldosterone system (RAAS)

In addition to ADH, the RAAS helps regulate water balance, primarily in response to low blood volume and pressure, which often accompanies severe dehydration.

- The kidneys release the enzyme **renin** when they detect decreased blood volume.
- Renin activates the production of **angiotensin II**, a potent hormone that affects multiple organs.
- **RAAS effects:** Angiotensin II contributes to water retention in several ways:
  - It stimulates the release of **aldosterone** from the adrenal glands, which promotes the reabsorption of sodium and, consequently, water in the kidneys.
  - It further stimulates the release of ADH.
  - It directly promotes thirst.
  - It constricts blood vessels to increase blood pressure.

### The negative feedback loop

The entire process operates as a negative feedback loop that maintains the body's hydration levels within a narrow range.

- (i) **Stimulus:** Dehydration (low water, high solutes) increases blood osmolality.
- (ii) **Sensory input:** Osmoreceptors in the hypothalamus detect this change.
- (iii) **Response:** The hypothalamus triggers thirst and signals the pituitary gland to release ADH.
- (iv) **Effector:** ADH acts on the kidneys to increase water reabsorption.
- (v) **Outcome:** Drinking water and retaining it through the kidneys decreases blood osmolality, bringing it back to normal levels.
- (vi) **Inhibition:** This return to normal inhibits the release of ADH and the sensation of thirst, completing the feedback loop.

Inability of a person to produce insufficient amounts ADH causes diuresis; the disease condition is called **diabetes insipidus**.

### **Water regulation in plants:**

Plants can be classified into three groups according to how much water is available to them in their nature environment.

- **Hydrophytes:** are plants which live partially or completely submerged in fresh water. e.g. water lilies, obviously, such plants have no difficulty getting enough water. Hydrophytes have the following adaptations to get rid of excess water
  - Poorly developed root system to reduce water absorption.
  - Numerous stomata on the upper epidermis of the leaf to increase water loss.
  - Have leaves lack cuticle to promote water loss
  - Have poorly developed xylem to reduced water transported in plant
  - Broad thin leaves to promote water loss.
- **Mesophytes:** grow in normal, well - watered soil. Most land plants in temperate regions belong to this category. Usually the water which they lose by transpiration is readily replaced by uptake from the soil, so they require no special means of conserving water.
- **Xerophytes:** live in dry places such as the hot desert where the water potentials in the soil and air are very low. These plants face the possibility of drastic dehydration and have ways of preventing this.

### **Adaption of xerophytes to drought**

Xerophytes, plants adapted to dry or arid conditions, have evolved a variety of structural (morphological) and physiological adaptations to conserve water, reduce water loss, and maximize water absorption. These adaptations allow them to thrive in environments with low water availability, high temperatures, and intense sunlight, such as deserts and semi-arid regions.

## Morphological adaptations (Structure) in relation to water control

### Leaves

- **Reduced surface area:** Many xerophytes have smaller leaves, or leaves that are modified into needle-like structures or spines, as seen in cacti. A smaller surface area reduces the number of stomata and minimizes water loss through transpiration.
- **Spines:** In addition to reducing water loss, the sharp spines of cacti deter herbivores from eating the water-rich plant.
- **Thick, waxy cuticle:** A thick, impermeable, waxy layer on the surface of leaves acts as a barrier to evaporation, significantly reducing cuticular water loss. The shiny surface also reflects sunlight, which lowers the leaf temperature and further reduces evaporation.
- **Hairy or silvery leaves:** Some xerophytes have a dense covering of fine hairs, or a silvery color, on their leaf surfaces. These hairs reduce airflow over the leaf surface, trap a layer of humid air, and reflect sunlight to minimize heat absorption.
- **Rolled leaves:** In some grasses, like marram grass, the leaves can roll inwards during drought. This encloses the stomata in a humid space, significantly reducing the outward water potential gradient and slowing transpiration.
- **Sunken stomata:** The stomata (pores for gas exchange) are located in pits or grooves on the leaf surface, often in depressions lined with hairs. This traps moist air around the stomata and reduces air movement, minimizing water loss.

### Stems

- **Succulent stems:** Cacti and other succulent xerophytes have fleshy stems that are specialized for storing large quantities of water. These swollen stems can expand and contract to accommodate the water storage.
- **Photosynthetic stems:** With leaves often reduced or absent, the stems of many xerophytes become green and take over the role of photosynthesis.
- **Protective coatings:** Stems may be covered with thick wax or dense hairs, similar to leaves, to further minimize water loss.

## Roots

- **Deep taproots:** Larger xerophytic plants, like mesquite or acacia trees, have very deep root systems (sometimes hundreds of feet long) to access groundwater stored deep underground.
- **Extensive shallow roots:** Many cacti and other desert plants have a wide-spreading, but shallow, fibrous root network. This allows them to quickly absorb any moisture from infrequent, light rainfall before it can evaporate.

## Physiological adaptations (Function)

- **Crassulacean Acid Metabolism (CAM):** Many succulents, including cacti and agaves, use a specialized photosynthetic pathway known as CAM. They open their stomata at night, when temperatures are cooler and humidity is higher, to take in and store carbon dioxide. They then close their stomata during the day to minimize water loss while still performing photosynthesis.
- **Nocturnal stomatal opening:** Even without full CAM metabolism, some xerophytes open their stomata at night to reduce water loss, as the night air is cooler and more humid.
- **Osmotic adjustment:** Xerophytes can accumulate solutes, like sugars and salts, in their cells. This increases the internal osmotic pressure, allowing the plant to maintain cellular turgor and draw water in, even when soil water potential is low.
- **Drought deciduousness:** Some xerophytes, such as the ocotillo, can shed their leaves during prolonged dry spells to significantly reduce transpiration. When rain returns, new leaves are produced.
- **Dormancy and resurrection:** Certain "resurrection plants" can effectively shut down their metabolism and endure extreme desiccation. They appear dead until they are rehydrated, at which point they quickly return to life.

## Life cycle adaptation.

Most species can survive dry periods in the dormant stages e.g. desert ephemerals. Germination, growth and flowering takes place during a few weeks following a burst of rain, after the seeds have been dispersed, the parent plant die and the seeds remain dormant in the dry soil until the next rains come.

## Revision exercise on homeostasis

1. An efficient physiological homeostatic mechanism is one which
  - A. Allow large fluctuation
  - B. Responds to deficiency faster than excess
  - C. Responds to small fluctuation
  - D. Allow positive feedback

C
2. Which one of the following pairs of hormones when released increase the level of blood sugar in the body?
  - A. Secretin and insulin
  - B. Adrenalin and glucagon
  - C. Insulin and antidiuretic hormone
  - D. Secretin and thyroxine

B
3. Which of the following is not involved in a physiological homeostatic process?
  - A. Positive feedback mechanism
  - B. Receptor
  - C. Effector
  - D. Control mechanism

A

\* **Positive feedback amplifies change.** Homeostasis is the process of maintaining a stable internal environment by counteracting changes to return to a set point. A positive feedback mechanism, by contrast, amplifies a change or a stimulus, moving the system further away from its initial state.

4. Which of the following is not homeostatically regulated in the body?
  - A. Glucose
  - B. Water
  - C. Carbon dioxide
  - D. Fat

D
5. Which one of the following is not a requirement for the working of a physiological homeostatic mechanism?
  - A. Receptors.
  - B. Skin capillaries.
  - C. Control mechanisms.
  - D. Effectors.

B

\* **Core components of homeostasis:** A homeostatic mechanism requires three fundamental components:

- **A receptor (or sensor)** to detect changes in a variable (e.g., body temperature, blood glucose).
  - **A control mechanism (or integrating center)** to process the information from the receptor and determine the appropriate response.
  - **An effector** to carry out the response and restore the variable to its set point.
  - **Skin capillaries are a specific effector.** Skin capillaries are part of the circulatory system and are effectors primarily involved in **thermoregulation**. While they are crucial for maintaining body temperature homeostasis, they are not a universal component required for *all* homeostatic processes, such as blood sugar regulation or osmoregulation.
6. The islets of Langerhans in the pancreas secretes hormones important for regulation of
- carbon dioxide in blood
  - blood protein
  - blood sugar
  - insulin
- C

\* **Insulin and Glucagon:** The islets of Langerhans contain specific cells that produce hormones crucial for blood sugar (glucose) regulation.

- **Beta ( $\beta$ ) cells** secrete **insulin**, which lowers blood sugar levels after a meal by encouraging cells to take up glucose.
- **Alpha ( $\alpha$ ) cells** secrete **glucagon**, which raises blood sugar levels between meals by promoting the breakdown of glycogen in the liver into glucose.

## Section B

7. (a) (i) What is meant by negative feedback in homeostasis? (2marks)  
 Negative feedback is a control system that reverses a deviation from a set point
- (b) Give two characteristics of an efficient homeostatic system (2marks)

An efficient homeostatic system possesses several key characteristics that allow an organism to maintain a stable internal environment:

- **Sensitivity/Detection:** The system can detect even slight deviations of a variable (e.g., temperature, pH, glucose levels) from its specific set point.

- **Rapid Response:** Effectors act promptly to counteract deviations and restore balance quickly.
- **Precision of Control:** The system makes corrections that return the variable precisely to its optimal range, avoiding large overshoots or fluctuations.
- **Specificity:** Each receptor and effector is specialized to respond to particular stimuli, preventing cross-interference between different regulatory processes.
- **Negative Feedback:** The primary mechanism of control is negative feedback, where the **response** reduces the original stimulus, bringing the variable back towards the set point.
- **Integration and Coordination:** A central processing center (e.g., the brain's hypothalamus) integrates signals from multiple sources and coordinates the actions of various effectors to produce a unified, effective response.
- **Adaptability (Plasticity):** The system can adjust its set points and sensitivities in response to changing environmental demands or developmental stages (a concept sometimes called allostasis or rheostasis).
- **Redundancy:** Multiple, overlapping mechanisms often regulate the same variable. This ensures that the failure of one component does not lead to a complete system failure.
- **Energy Efficiency:** The system maintains stability with minimal unnecessary expenditure of energy and resources.
- **Dynamic Stability:** Homeostasis is not a static condition but a dynamic process involving continuous, active adjustments around a set point to achieve active stability.

8. (a) Outline the general features a physiological homeostatic system must have. (3marks)
- Receptor mechanism capable of detecting changes in the environment
  - Control mechanism that initiates corrective mechanism
  - Effector that carry out the corrective mechanism
- (b) What are the qualities of an efficient homeostatic system) (2marks)

Ref to 7(b)

9. (a) Figure 1 shows the average blood glucose levels in the three major vessels of the liver of an individual, who had meals at 7.00 am and 1.00pm. use the information to answer the questions that follow

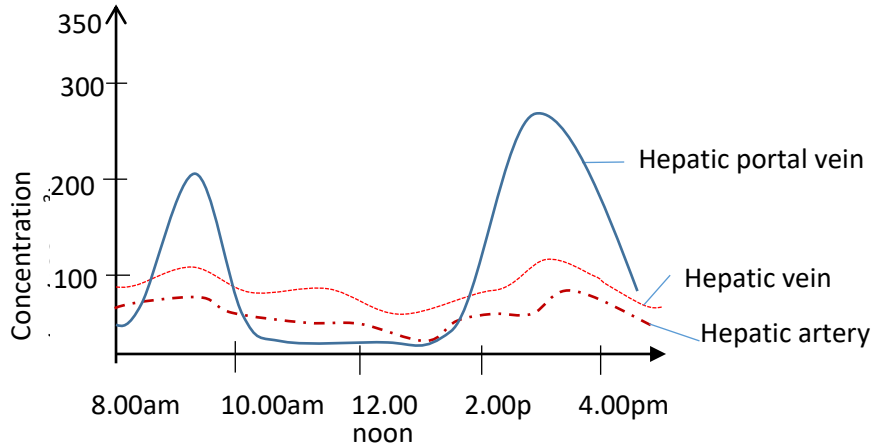


Figure 1

Compare the levels of glucose in:

(i) Hepatic artery and hepatic vein (4mrks)

**Similarities.**

- In both, blood glucose level increases after a meal, reaching maximum within 2 hours of having a meal.
- In each, the blood glucose levels decrease gradually between 10: 00an and 12:00 noon.
- In both, blood glucose levels decrease after about 2 hours of having meals.

**Differences.**

Hepatic artery	Hepatic vein
lower glucose level throughout the experiment	higher glucose level throughout the experiment
Reaches a lower maximum after each meal	Reaches a higher maximum value after each meal.
Between 9:00am and 4:00pm glucose level is lower	Between 10:00am and 1:00pm glucose level is higher.

(ii) Hepatic artery and hepatic portal vein (4marks)

**Similarities.**

- In both, blood glucose level increases after a meal, reaching maximum within 2 hours of having a meal.
- In each, the blood glucose levels remain fairly constant between 10: 00an and 12:00 noon.
- In both, blood glucose levels decrease after about 2 hours of having meals.

**Differences.**

Hepatic artery	Hepatic portal vein
<ul style="list-style-type: none"><li>- Higher glucose level initially.</li><li>- Increases more gradually after a meal.</li><li>- Reaches a lower maximum after each meal.</li><li>- Decreases gradually after about 2 hours of having meal.</li><li>- Between 10:00an and 1:00pm glucose level is higher.</li></ul>	<ul style="list-style-type: none"><li>- Lower glucose level initially.</li><li>- Increases more rapidly after a meal.</li><li>- Reaches a higher maximum value after each meal.</li><li>- Decreases rapidly after about 2 hours of having a meal.</li><li>- Between 10:00am and 1:00pm glucose level is lower.</li></ul>

(i) Explain the differences in the level of glucose in the

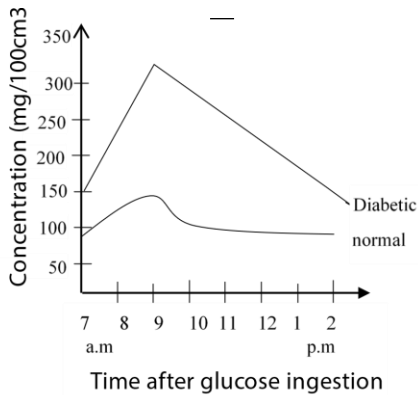
- Hepatic artery and hepatic vein (9marks)

The blood glucose in hepatic vein is slightly higher because it is close to the source (intestines) but the difference in glucose level in both hepatic vein and hepatic artery is slight because in both glucose is under homeostatic control.

- Hepatic artery and hepatic portal vein (9marks)

After meals the glucose level the glucose level in hepatic portal vein shoots up due to absorption from the intestines but later falls due to homeostatic mechanisms.

(b) The figure shows the blood levels in a normal and diabetic individual, after both individual were gives a sugar solution at 7.00 a.m. Study and answer the questions that follow (11marks)



(i) Compare the levels of glucose between the two individuals (5marks)  
Similarities.

- In both, blood glucose levels are above zero at 7:00am.
- In both, blood glucose levels increase after being given the sugar solution to a maximum value and then decrease.

Differences

Diabetic	Normal
<ul style="list-style-type: none"> <li>- Higher glucose level at all times.</li> <li>- Glucose level increases rapidly after the sugar meal and reaches a higher maximum in about 2 hours.</li> <li>- Decreases rapidly after about 2 hours and never attains a constant value.</li> </ul>	<ul style="list-style-type: none"> <li>- Lower glucose levels at all times.</li> <li>- Glucose level increases gradually after the sugar meal and reaches a lower maximum in about 1 ½ hours.</li> <li>- Decreases gradually after about 1 ½ hours and attains a constant value within about 3 hours.</li> </ul>

(ii) Give explanation for the observed pattern of the levels of blood glucose in the two individuals (5marks)

- both individuals have blood glucose levels above  $0mg/100cm^3$  initially because glucose has to be in the circulation of sustain metabolic functions.
- Increase in the glucose concentration after the sugar meal in both individuals is due to the direct absorption of glucose into the blood stream from the alimentary canal however, that of a normal individual increases gradually because the blood sugar level is more under homeostatic control than in a diabetic individual.
- In a normal individual, an increase in the blood glucose level as a result of the sugar meal stimulates the Islets of Langerhans in the pancreas to secrete the hormone insulin. Insulin acts on the cells of the liver, muscles and adipose tissue to reduce the blood sugar level.
- A diabetic individual produces either none or insufficient amounts of insulin so that the homeostatic control of blood glucose is impaired. As a result, a diabetic individual always has higher blood glucose levels which always fluctuate and never attain a constant value as in the normal individuals.

(iii) What is the significance of the physiological process illustrated in the figure 1 and 2

- it ensures that the body cells are always continually supplied with the correct amount of glucose required for normal cell function.
- It ensures that the blood contains the correct amount of glucose necessary for maintaining the correct osmotic pressure.
- It indicates that the liver plays the key role in regulating the blood glucose levels.
- It indicates that regulation of blood glucose level should occur quickly for the body organs to function normally.

10. (a) What is meant by negative feedback mechanism in the body process? (3mark)

Negative feedback is a control system that reverses a deviation from a set point

(b) Describe how each of the following affects the metabolism of carbohydrates

(i) insulin (3marks)

- it increases the rate of uptake of glucose by muscle and fat cells through a number of glucose channels in the cell surface membrane.
- - Insulin increases the utilization of glucose by the cells in the process of respiration.
- Insulin increases the rate at which glucose is converted to glycogen in the liver and muscle cells (glycogenesis).
- Insulin inhibits the formation of glucose from non-carbohydrates sources in the liver (gluconeogenesis) and also inhibits the process of glycolysis.

(ii) adrenaline (3marks)

- It increases the rate of conversion of glycogen to glucose. This increases the blood sugar content.
- It increases the rate of production of glucose from non-carbohydrate sources in the liver.
- It increases the rate of utilization in the muscle cells in the process of respiration

(c) Describe how hormones from the ovary and pituitary gland interact to control the human menstruation cycle.

In this question, you are meant to identify the hormones produced by the ovary and pituitary gland during the menstrual cycle and illustrate how they interact to bring about the events of the menstrual cycle.

Hormones produced by the ovary include progesterone and oestrogen while the pituitary gland produces luteinizing hormones (LH) and follicle stimulating hormone (FSH) which interact as shown to control events of the menstrual cycle.

During the early menstrual phase, levels of oestrogen and progesterone fall. This induces the pituitary gland to secrete FSH and LH.

Increased levels of FSH stimulate one or more Graafian follicles to start growing. It also stimulates follicle cells to secrete oestrogen. The levels of oestrogen in blood increase gradually for a few days and reaches the peak on the 12<sup>th</sup> day of the cycle. High oestrogen concentration inhibits FSH secretion which induces increased production of LH within 12hrs.

The high LH causes ovulation with subsequent formation of corpus luteum.

During the post ovulatory phase, corpus luteum secretes progesterone. Progesterone acts on the uterine wall to promote cellular proliferation in preparation for implantation and also maintains corpus luteum.

High levels of progesterone and oestrogen inhibit the secretion of LH and FSH.

If fertilization occurs, the corpus luteum degenerates. Progesterone level reduces markedly and the uterine wall is shed in menstruation. This initiates events of the next cycle (i.e. this is day 1 of the next cycle).

## Revision Question on temperature regulation

1. Which one of the following conditions is correct about ectoderms?
  - A. Have cold blood which is warmed by the surrounding
  - B. Regulate body temperature mainly by metabolic reactions
  - C. Much of the heat in their bodies is gained from the surroundings.
  - D. Lack means to regulate body temperature.

C

### Explanation

- **Definition of ectotherms:** Ectotherms are animals that rely on external sources of heat to regulate their body temperature.

- **External heat sources:** These animals use behaviors such as basking in the sun or lying on a warm rock to absorb heat from their environment to raise their body temperature. When they get too hot, they seek shade or water to cool down.
- **The term "cold-blooded" is inaccurate** because an ectotherm's body temperature can be quite warm when they are in a hot environment or after basking in the sun.

**Why other options are incorrect**

- **A. Have cold blood which is warmed by the surrounding:** The term "cold blood" is misleading, as an ectotherm's blood can be warm.
  - **B. Regulate body temperature mainly by metabolic reactions:** This describes endotherms (warm-blooded animals), which use internal metabolic processes to generate heat.
  - **D. Lack means to regulate body temperature:** Ectotherms do regulate their body temperature, but they do so primarily through behavioral strategies (like seeking sun or shade) and physiological adaptations, not through internal metabolic heat production.
2. A mammal eats more food than a reptile of equivalent body weight because the mammal
- A. Lives longer
  - B. Controls its body temperature
  - C. Egests more food
  - D. Does not absorb heat from its surrounding B
- \*Mammals require a lot of food to provide energy to maintain body temperature by replacing heat losses.
3. Which one of the following occurs in a mammal when its thermoregulation centre detects a lower temperature of blood than normal?
- A. Shivering
  - B. Decreased metabolic rate
  - C. Flattening of body hair
  - D. Increased sweating A

**Shivering:** This involves rapid, involuntary contractions of skeletal muscles. This muscular activity requires significant energy (ATP) and generates heat as a byproduct, effectively raising the core body temperature.

4. The main difference between endotherms and ectoderms is that ectoderms
  - A. Gain their body heat from internal sources
  - B. Gain less heat than endotherms
  - C. Gain the body heat from external sources
  - D. Are lower animals while endotherms are higher animals. C
5. Desert mammals' lower lethal temperature is higher than that of a mammal living in cold regions because a desert mammal has
  - A. Small extremities
  - B. Poor insulation mechanism
  - C. Thick fur
  - D. Small surface area: volume ratio B

### Explanation

The "lower lethal temperature" is the environmental temperature below which a mammal can no longer produce enough metabolic heat to maintain a stable body temperature and dies of hypothermia.

- **Desert Mammals:** Animals in hot climates are adapted to dissipate heat efficiently. They typically have thinner fur/fat layers (poor insulation) and a higher surface area-to-volume ratio (e.g., larger ears, longer limbs, smaller overall size according to Allen's and Bergmann's rules) to maximize heat loss. This poor insulation makes them less effective at conserving heat in cold conditions, so their lower lethal temperature is relatively high (they succumb to cold more quickly).
- **Cold Region Mammals:** Mammals in cold regions are adapted to conserve heat. They have thick fur or substantial fat layers (good insulation) and a low surface area-to-volume ratio (smaller extremities, larger bodies). This excellent insulation allows them to withstand much colder temperatures, so their lower lethal temperature is very low (they can survive even in extremely cold conditions).

Therefore, a desert mammal has a higher lower lethal temperature because its adaptations (including poor insulation) favor heat dissipation rather than heat conservation.

6. Which one of the following is the reason for hibernation of a humming bird every night?
  - A. Its metabolic rate is so high
  - B. It is too cold
  - C. It feeds on nectar from flowers which close at night
  - D. Its relatively large surface area would lose too much heat A

### Explanation

Hummingbirds are among the smallest endotherms (warm-blooded animals) and possess the highest metabolic rate of any animal when active. This extreme metabolism is necessary to power their rapid wing beats (up to 80 times per second) and hovering flight, requiring them to feed almost constantly during the day.

At night, or when food is scarce, they cannot feed, and their energy reserves (stored fat) would be depleted within a few hours if they maintained their normal metabolic rate. To survive the long period without food, they enter a hibernation-like state called **torpor** every night. During torpor, their metabolism slows dramatically (by as much as 95%), their body temperature and heart rate drop significantly, allowing them to conserve enough energy to survive until the next morning's first feeding.

### Why D is wrong

Hummingbirds have a large *surface area-to-volume ratio* due to their small size, which does lead to rapid heat loss. This is an underlying physical challenge that contributes to their high metabolic demands and the need for torpor, but the immediate reason for entering torpor nightly is the necessity to conserve energy due to their extremely high metabolic rate and inability to feed.

7. Which one of the following may happen when a mammal is subjected to severe cold?
  - A. The superficial blood vessels are dilated
  - B. The hair is lowered
  - C. Sweating or panting occur
  - D. The rate of metabolism increase D
8. Heat loss is most efficiently reduced in body extremities of endotherms having
  - A. **Veins and arteries parallel and close to each other**
  - B. Thick fur
  - C. Thick subcutaneous layer
  - D. few sweat glands A

### Explanation

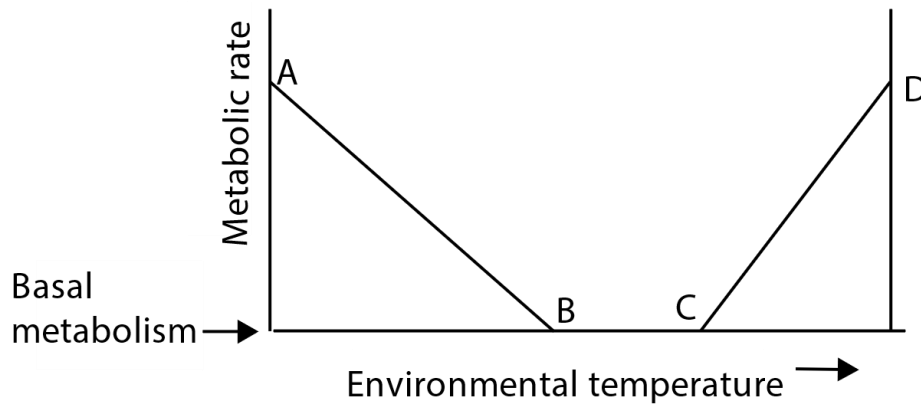
This anatomical arrangement describes a **countercurrent heat exchange system**.

- **How it works:** Warm arterial blood flowing from the body's core to the extremity (e.g., a leg or flipper) runs parallel and in close proximity to the cooler venous blood returning from the extremity.

- **Heat transfer:** Heat is transferred by conduction from the warmer arterial blood to the cooler venous blood before the arterial blood reaches the end of the limb.
  - **Outcome:** This pre-warms the returning venous blood and significantly cools the arterial blood before it reaches the surface, minimizing the heat lost to the cold environment. The heat is effectively "recycled" back into the body's core. This is the most efficient mechanism specifically for conserving heat in the extremities of endotherms living in cold climates, such as the legs of wading birds and the flippers of dolphins.
9. Which of the following is a chemical mechanism of coping with cold environment in mammalian body?
- A. Vasoconstriction
  - B. Shivering
  - C. Raising of body hair
  - D. Insulation by the subcutaneous fat B
10. Temperate mammals such as polar bear have lower lethal temperatures than tropical ones. This is because of
- A. Better insulation mechanisms in the tropical mammals
  - B. Body colour
  - C. Larger size in temperate mammals
  - D. Better insulation mechanism in temperate mammals D
11. A mammal eats more food than a reptile of equivalent body weight because the mammal
- A. lives longer.
  - B. controls its body temperature.
  - C. egests more food.
  - D. does not absorb heat from its surroundings. B
12. Which of the following environmental factors has a direct effect on all organisms
- A. Light
  - B. Humidity
  - C. Temperature
  - D. Rainfall C
- \*Temperature affects enzyme activity, at low temperature enzymes are inactive, at very high temperatures enzymes are denatured.

**Paper 1 section B**

13. Figure below shows the variation of metabolic rate with environmental temperature in a mammal



(a) What do points B and C represent?

(i) B: **Lower critical temperature** (1mark)

(ii) C: **upper critical temperature** (1mark)

(b) Explain why the metabolic rate

(i) Is constant between points B and C (2mark)

Between B and C metabolic rate is constant because behavioural and physical means are enough to maintain body temperature.

(ii) Increases from point B to A (2marks)

B-A metabolic rate increases to generate heat for maintenance of body temperature

(iii) Increases from C to D (3marks)

C to D metabolic rate increases because increase in temperature increases the rate of enzyme action

(c) Explain how point B would differ between an animal living in cold regions and that living in warm region. (02marks)

Temperature B is lower for animals living in cold environment because they have higher insulation, (i.e. large subcutaneous fat and thick fur).

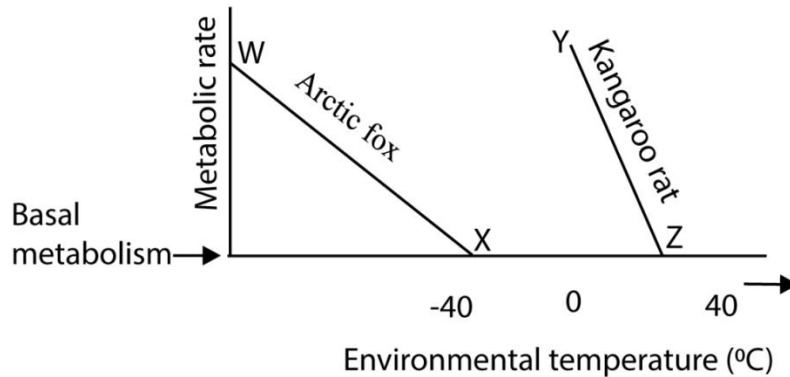
14. (a) (i) Outline the general features a physiological homeostatic system must have (3marks)

- It should have a receptor to detect variation from the set point
- It should have a set point
- It should have a controller to coordinate part of homeostatic mechanism

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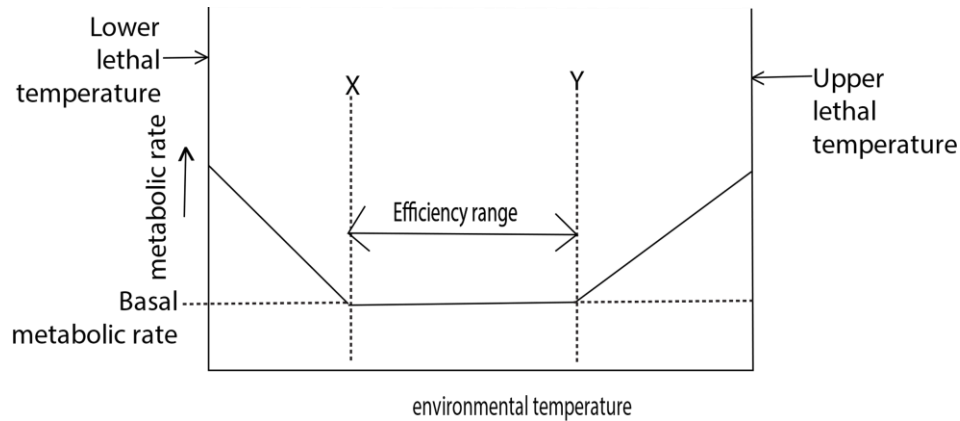
- It should have an effector to restore the set point
- (ii) What are the qualities of an efficient homeostatic system? (2marks)
- It should respond rapidly to small deviations from set point

(b) Figure below shows the metabolic rates of the arctic fox (curve WX) and the Kangaroo rat (curve YZ) in relation to environmental temperature.



- (i) What do points X and Z stand for? (1mark)
  - Lower critical point
- (ii) Give two differences in metabolic rates of the Kangaroo rat and the arctic fox in relation to environmental temperature. (2marks)
  - The critical temperature of arctic fox is lower than that of Kangaroo
  - Below the critical point metabolic rate in arctic fox raises slowly
- (iii) What do the differences you have stated (b)(ii) imply? (2marks)
  - Arctic fox has better insulation than kangaroo rat

15. The figure shows the variation of metabolic rate with environmental temperature in a mammal



(a) What do temperature X and Y represent? (01marks each)

- (i) X – lower critical temperature
- (ii) Y – upper critical temperature

(b) What does the efficiency range mean? (02marks)

- in efficient range the body is able to control its constant temperature by behavioural and physical means.

(c) Explain the variation of metabolic rate with environmental temperature outside the efficient range. (05marks)

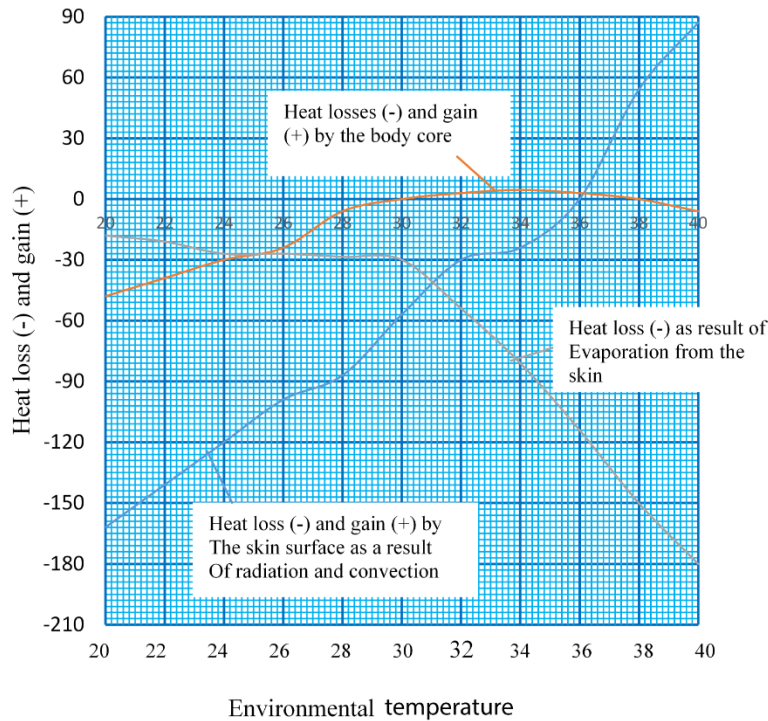
- Below the lower critical temperature metabolic rate increase to generate heat to maintain the body temperature
- Above the higher critical temperature metabolic rate increases due to increase the enzymatic activity.

(d) The efficiency range is not fixed but differs from animal to animal. Giving a reason, state how point X would differ between animals living in cold environment and that living in a hot environment. (02marks)

- X is lower for animals living in cold environment because they have higher insulation i.e. thick fur and big deposit of subcutaneous fats.

16. Heat loss (-) and heat gain (+) were monitored and recorded, of a naked human being at varying environmental temperatures. The heat losses and gain by the internal body environment body core), heat losses and gain by the skin surfaces as a result of radiation and convection and also heat losses as a result of evaporation, with varying environmental temperature, are shown in figure below:

Study the figure and answer the questions that follow



(a) Describe the relationship between the heat loss and again by the skin surface as a result of radiation and convection and heat loss as a result as a result of evaporation from the skin. (4marks)

At 20°C, heat loss by radiation and convection is much higher (162 units) than that due to evaporation from the skin (18 units)

Between 20-27°C, heat loss by evaporation from the skin increases gradually while loss through radiation and convection decreases rapidly.

Between 27-28.8 °C, loss through evaporation is constant while loss through radiation and convection continues to reduce.

Between 28.8 -31°C, evaporation loss begins to increase more rapidly to equal to the due to radiation and convection by 31° C.

From 31 -40°C, loss through evaporation increases very rapidly while that through radiation and convection decreases more gradually to zero at 35.0°C and then the body starts gaining heat through radiation and convection rapidly up to 40°C.

(b) How does the relationship in (a) affect the losses and gain of heat from the body core (3marks)?

At 20°C, the body core is losing heat at a rate of 51units.

Heat loss decreases gradually from 20°C until it reaches zero at 30°C

From 30 -33°C, the body core gains heat gradually and then at a constant rate between 34°C and 37.4°C.

Between 37.4 -40°C, the body loses heat gradually.

(c) Explain the trend in heat losses and gain by the

(i) Skin surface as a result of radiation and convection (10marks)

At 20 °C, the body is at a much higher temperature than surrounding and so the temperature gradient is high, favouring loss of heat from the body surface mainly by radiation convection.

As environment temperature increases, the temperature gradient reduces so that heat loss through radiation and convection reduces while that through evaporation increases gradually .

Between 32 -35.4°C, the temperature gradient is so small that heat loss through radiation and convection reduces more gradually until it reaches zero at 35.4°C.

Between 35.4 -40<sup>0</sup>C, now the temperature gradient reverses so that environment temperature becomes higher than body temperature. As a result, the body starts to gain heat by radiation and convection from the environment.

(ii) Skin surface as a result of evaporation (08marks)

At 20<sup>0</sup>C, external temperature is very low compared to the normal human body temperature. As a result, the skin surface blood vessels constrict to reduce blood flow to the skin and also the rate of sweating is greatly reduced by the thermoregulatory Centre. As such, loss of heat by evaporation from the skin surface is low.

At the same time, the erector muscles and skin surface hairs are standing on end. This traps a layer of air close to the surface, which on top of being an insulator, also traps vapour close to the skin. This results in a very low rate of evaporation from the skin surface.

As temperature increases, between 20 -27<sup>0</sup>C, the vapour trapped in the hairs evaporates and also the rate of blood flow to the skin improves, sweat production increases and therefore heat loss by evaporation increases gradually.

(iii) Body core (12marks)

Heat loss from the body core occurs by a combination of radiation, convection, evaporation and conduction; however, the body has regulatory mechanisms that resist subtle changes in core body temperature.

At 20<sup>0</sup>C, the body is losing heat by a combination of evaporation, radiation and convection, though much of the heat is lost through radiation and convection.

- To resist a subtle drop in core body temperature, the metabolic rate of the body core increases and the individual starts to shiver. These activities generate heat within the body core to make up for the losses from the body surface.

- As a response to low core body temperature, the hypothalamus triggers a reduction in sweat production, reduction in blood flow to the skin surface and contraction of the erector pili muscles so that the surface hairs stand on end.
- All these events reduce heat loss from the body core from the body core until it is zero at 30<sup>0</sup>C

As environment temperature comes close to the core body temperature remains constant for the range 34.8 – 37.4<sup>0</sup>C

Above 37.4<sup>0</sup>C, events are reversed in order to prevent subtle increases in core body temperature.

- The erector muscles relax so that the surface hairs lie flat on the skin surface, trapping no air between them.
- Blood flow to the skin surface is increased and
- Sweating increases so that heat loss from the body surface by evaporation increases greatly.
- Metabolic heat production and shivering stop.

The end result is that the body core starts to lose heat to the environment from 38-40<sup>0</sup>C in order to give off the excess heat and maintain a constant body temperature

(d) What is the importance of maintaining body temperature in animals (3marks)

Temperature must be maintained at a value optimum for the action of enzymes upon which the organized functioning of cells depends. At higher temperature Enzymes being protein in nature are denatured while at low temperature they are inactive.

17. (a) Mammals in cold habitats usually have a large body size as a result of extra fat deposits under the skin.

- The big size reduces the surface area to volume ratio and therefore reduces the rate of heat loss from their bodies across the surfaces.
- The fat deposits under the skin insulates and prevents heat loss to the environment.

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(b) Strategies of the camel to overcome heat stress include:

- Possession of tissues which are tolerant to wide ranges of temperature.
- The camel stores heat in its tissues during day when temperature are very high and then loses it during the night by radiation, conduction and convection and not evaporation, when temperatures are low
- During the day, the camel behaves like an ectothermic animals, allowing its temperature to get close to those of the environment. This reduces the temperature difference between the hot air of the desert and its body so that the rate of heat gain from the surrounding is reduced.
- The fur that the camels skin acts as an efficient insulating barrier by reducing heat gain and loss by convection and conduction.

**Thanks**

**Dr. Bbosa Science**