11.0. HOMEOSTASIS SUGGESTED RESPONSES

1. (a) What is meant by the term *homeostasis*? (01 marks)

- This the process by which the body maintains a constant internal environment**;**

(b) Explain the need for homeostasis in living organisms. (05 marks)

- The body metabolic processes take place within a narrow range of optimum conditions; at a rate that support life**;**
- Homeostasis ensures that the internal conditions are kept within this narrow range for the enzymes to work best**;** by correcting any deviation from the optimum**;** caused by changes in the internal and external environments**;**

(c) Describe the basic components homeostatic control system. (06 marks)

- The detector**;** this detect and changes in the internal environment from the norm and sends this information to the regulator**;**
- The regulator**;** this responds in accordance with the information from the detector by sending out appropriate instructions to the effector**;**
- The effector**;** this carries the events that lead to correction of the deviation; depending on the information from the regulator**;**

(d) Describe the properties of an efficient homeostatic mechanism. (02 marks)

- An efficient respiratory system has detectors that easily detects any small changes in the quantity of the variable controlled**;** and sets into motion measures to quickly**;** return the variable to set norm**;**

2. (a) Giving examples in each case, explain what is meant by the each of the following terms.

(i) Negative feedback. (02 marks)

- This is when a deviation from the norm sets in to motion a series of events that remove the deviation**;** For example; in the control of blood sugar, temperature and blood pH**;**

(ii) Positive feedback. (03 marks)

- This when a deviation from the set norm sets into motion events that cause further deviation; for example axon membrane permeability to sodium ions during depolarisation**;**

(b) Describe the situation in humans where positive feedback occurs.

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(c) Explain the need for the human body to

(i) Control blood sugar levels (04 marks)

- Glucose is the main respiratory substrate; and should be maintained in a range that does not cause harm to the cells;
- Low glucose levels reduced energy production in cells; which can lead to their death;
- High glucose levels leads to cell damage;

(ii) Regulate temperature. (04 marks)

- Body metabolism is regulated by enzyme; which work efficiently within a narrow temperature range;
- Low temperatures would inactivate enzymes; reducing metabolic rates;
- High temperature would denature enzymes; reducing metabolic rate as well

3. Explain how the human body deals with

(a) High blood glucose levels. (06 marks)

- High glucose levels are detect by the beta cells of the islets of Langerhans**;** that respond by releasing the hormone insulin**;** that travels to the liver cells**;** from where it causes the
- conversion of excess glucose to glycogen**;**
- increased rate of glucose respiration**;**
- conversion to fats which are stored under the skin**;** and the glucose levels decrease

(b) Low blood glucose level. (14 marks)

- Low blood glucose levels are detected by the alpha cells of the islets of Langerhans; that respond by releasing the hormone glucagon;
- the hypothalamus also detects the low levels and stimulates the pituitary gland to release
- Adrenal cortical tropic hormone that stimulates release of cortisol; from adrenal cortex
- Thyroid stimulating hormone; that stimulates the thyroid gland to produce thyroxine;
- the growth hormone;
- all these hormones cause the liver cells to convert glycogen to glucose; and protein to glucose; which all increase the glucose levels in blood

4. Explain the influence of temperature on the following processes in plants

(a) Plant growth. (10 marks)

- Temperature is a limiting factor in plant growth**;** as it influences the rate of cells division**;** photosynthesis (metabolic reactions)**;**
- Within suitable temperature range**;** plant growth is occurs at maximum rate**;** because cell division occurs faster**;** enzymes are activated**;** and metabolic rates like photosynthesis occur faster**;**
- Below the suitable temperature plant growth reduces**;** because enzymes are inactivated**;**
- Above the suitable temperature range**;** plant growth reduces; because enzymes are denatured**;**
- Low temperature stimulates flowering**;** germination**;** and induces bud dormancy**;** in some plants

(b) Plant distribution (10 marks)

- Plant are distributed to areas where their bodies can withstand the environmental temperatures;
- C4 plants grow efficiently in hot climatic regions**;** because they can efficiently take up carbon dioxide with minimum loss of water**;** C4 plants are not common in cooler areas**;** because they need more energy to fix carbon dioxide**;** which is a limiting factor in cooler areas**;**

- C3 plants are not common in hot areas because they lose more water during uptake of carbon dioxide**;** water stress reduces their productivity**;**
- C3 plants grow more efficiently in cooler areas**;** where they do not lose much water as they take in carbon dioxide**;**
- CAM plants are mostly found in hot areas**;**
- Temperate plants are distributed in cooler regions; while xerophytes are found in hot dry areas;

Alternative approach

- Plant are distributed to areas where their bodies can withstand the environmental temperatures**;**
- Plants that can withstand high temperatures are located in the deserts**;** as they have mechanisms regulate water loss by transpiration**;** and avoid excess heating**;** while utilising the high light intensities and temperature for their productivity**;** for example the xerophytes and C4 plants**;**
- Plants that cannot withstand high temperatures (can withstand low temperatures) for found in the cooler temperate regions**;** they have mechanisms to prevent over cooling**;** and maximum utilisation of the low temperatures and light intensities**;** for example the C3 plants**;**

5. (a) Explain the adaptations of plants to low temperature. (10 marks)

- **Structural adaptations**

Feature	**Suitability**
• Loss of leaves when it's too cold;	To avoid damage caused by snow;
• Buds are covered by scale leaves;	Protection from cold conditions;
• Needle-like leaves;	Reduce the amount of snow accumulating on the leaf;
• Thick cuticle;	To prevent water loss when it's frozen;
• Low stature;	Keeps them near the ground; where wind speeds and thus rate of heat loss are low;
• Dense rosette of leaves round growing buds that can close during the cold conditions;	Insulate them against heat loss; and protects them from frost damage;

- **Physiological adaptations**

• Produce much abscisic acid	Reduce metabolism; and induce dormancy in buds;
• Short growing periods	To utilise the short periods of good growing conditions
• Produce cold resistant seeds	To survive the harsh winter condtions
• High respiration rates (thermogenesis)	To produce much heat during extremely cold conditions

(b) Explain the effect of low temperature on plant growth. (10 marks)

- Low temperature reduces the primary growth rate of a plant; because enzymes are inactive; and metabolism is slow;
- Root hair membranes of some plants like ferns are damaged by low temperatures; impairing their ability to take up minerals; and plants growth is stunted;
- Low temperatures can induce seed germination (pre-chilling); by lowering the level of growth inhibitors;
- It's a stimulus for flowering in some plants; by activating the hormone "vernalin";
- low temperatures promote bud dormancy in some plants; when plants produce abscisic acid; allowing them to remain alive for the next growing season;
- Low temperature increase hardiness in many woody plants when exposed for a few weeks;

6. (a) Explain the adaptations of plants high temperatures. (14 marks)

Structural adaptations

- Thin leaves; have low heat capacity; to prevent over heating;
- Shinny cuticle; to reflect much of the incident light;
- Thorn (needle-shaped) leaves; permit maximum heat loss;
- Hairs or spines on the leave; shade the more sensitive tissues in the mesophyll of the leave from high energy irradiations;
- High thermal mass; encourages thermal damping;
- Possession of thick succulent tissues like cacti; allows small changes in temperature;

Physiological adaptations

- Vertical orientation of leaves; minimises sun heat gain at midday when heating is greatest;
- Temperature sensitive meristems located well above the ground; or under the ground; where it is cooler;
- Opening of numerous stomata; encourage transpiration; to promote cooling;

(b) Explain how plants respond to an increase in environmental temperature in the presence of adequate water supply. (06 marks)

- More stomata are open; transpiration rates increase; and more heat is lost;
- Production of more abscisic acid; wilting occurs; reducing surface area of the heat; to gain less heat;

7. (a) Explain the influence of temperature on distribution of animals. (10 marks)

- Animals are found in regions where they are adapted to the surrounding temperature; where they can withstand small fluctuations in their environmental temperature;
- Many are found in regions where temperature is moderate; and enzymes work best; to achieve high metabolic rates;
- Few animals are found in very hot conditions like deserts; because their enzymes would be denatured; and metabolic rates decrease; rates of evaporation of water would increase; leading to dehydration;
- Few animals are found in very cold conditions; because their enzymes would be inactive; and metabolic rates would decrease; ice would form in the cells; leading to their death;

(b) Explain the effect of the environment on the development of mechanisms for temperature regulation in animals. (10 marks)

- Animals living land have more developed mechanisms for temperature regulation; compared to their aquatic counterparts;
- This is because air has a lower heat capacity; while water has a higher heat capacity; and the fluctuations in environmental temperatures are greater on land; than in water;
- in extreme coldness; water freezes and ice floats on top; insulating the water below it from further heat loss; so that the animals can survive;

8. (a) Explain how the mammalian body respond to decrease in the body temperature. (13 marks)

- A decrease in body temperature is detected by the hypothalamus; as blood flows through the brain; and sends impulses to the skin;
- To reduce rate of sweat production; which reduces heat loss by evaporation;
- Erector pili muscles contract; causing the hair to raise; trapping more air; and reduce heat loss by convection;
- Vasoconstriction of skin arterioles; so that more blood flows through the shunt vessels; and minimising heat loss;
- hypothalamus also stimulate release of hormones thyroxine from the thyroid; and adrenaline from adrenal gland; which raises the metabolic rate in the liver; and shivering in the muscles; to generate more heat;

(b) Explain the advantages of being endothermic. (07 marks)

- **Advantages**
- Organisms can survive in wide range of habitant; because they can maintain their own body temperatures;
- Metabolic reactions occur faster; because enzymes are activated; which improves the body efficiency;
- There is quicker response to stimuli; due to rapid transmission of impulses; which leads to increased chances of survival;

9. (a) Explain how the mammalian body respond to an increase in the body temperatures (13 marks)

- An increase in the body temperature is detected by the hypothalamus; as blood through the brain; and sends impulses to the skin;
- The arterioles in the skin dilate; allowing more blood to flow near the skin surface; and increase the rate of heat loss;
- To increase the rate of sweat production; and increase the heat loss by evaporation;
- The erector pili muscles relax; the hairs lie flat on the body; to encourage heat loss by convection;
- The metabolic rate reduces; to reduce the production;
- Increased panting; in dogs and cats to encourage heat loss by evaporation;

(b) Explain the disadvantages of being endothermic. (07 marks)

- High food consumption rates; to maintain a high metabolic rate; to generate enough heat during cold conditions;
- Required better insulation mechanisms; to prevent heat loss during the cold; to prevent body damage from hypothermia;
- Required efficient cooling mechanisms; when the environmental temperatures are hot; to prevent over heating;

10. (a) Describe the adaptations of the mammalian skin to its functions. (12 marks)

- Epidermis; contains melanin; that absorbs ultra violet radiations from the sun;
- Keratinised epidermal cells; protect against abrasion;
- Has blood capillaries; which control the amount of blood flowing near the skin surface; to regulate heat loss;
- Subcutaneous fat; insulates against heat loss;
- Sensory receptors; to transducer stimuli; and inform the brain of the changes in the external environment;
- Erector pili muscles; change the angle between the hairs and the skin; to control heat loss;
- Sweat glands; to produce sweat; and rate increase heat loss from the body;
- Sebaceous gland; produces sebum (waterproof oily secretion); that protects the body against entry of bacteria/dust/water;

(b) Explain the structural modifications of the skin that enable animals inhabit areas of extreme climatic conditions. (08 marks)

- **In extremely cold conditions; there is much**
  - subcutaneous fat; to reduce heat loss;
  - hairs; to trap air; and insulate the body against heat loss by convection;
- **in extremely hot conditions; the skin**
  - has less subcutaneous fat; to encourage heat loss by evaporation;
  - few scanty hairs; to encourage heat loss from the body the evaporation;

11. Explain the factors that affect the rate of heat loss in mammals. (20 marks)

- **The rate of blood flow near the skin surface;** Increase in rate of blood through the skin capillaries; due to dilation of arterioles in the skin; increases the rate of heat loss; Decrease in the rate of blood flow through the skin capillaries; due to constriction of arterioles; decreases the rate of heat loss;
- **The rate of sweat production and evaporation from the skin surface;** increase in the rate of sweat production; and its evaporation from the skin; increases the rate of heat loss from the body; while its decrease, decreases the rate of heat loss; because the evaporating sweat goes with heat inform of latent heat of vaporisation;
- **Amount of insulation between the body core and the environment;** increased insulation in form of subcutaneous fat; and body fur; reduces rate of heat loss from the body; while a decrease in insulation increases the rate of heat loss; because fat is a poor conductor of heat that prevents the heat generated within the body from being lost; and fur traps much air between itself and the skin; reducing heat loss by convection;

- **Size of the body;** the rate of heat loss increases with decrease in the size of the mammal**;** small mammals have higher surface are to volume ratio**;** hence much heat can be lost in the same period of time**;** as a large organism that has a small surface area to volume ratio**;**

12. Explain the adaptations of animals living in areas of

(a) Structural adaptations to high temperatures. (07 marks)

Feature of the body	**Suitability**
• Larger body extremities; and smaller body;	To increase surface area for heat loss;
• Less subcutaneous fat;	Reduce insulation and encourage heat loss;
• Fewer scanty hairs;	To encourage heat loss by convection;

(b) Physiological adaptations to low temperatures. (06 marks)

Feature	**Suitability**
• Deposition of glycerol in blood**;**	Prevent the formation of ice crystals in cells**;**
• Counter current heat exchange**;**	Reduces the temperature gradient between the body and environment**;** reducing rate of heat loss**;** maintaining the core temperature at optimum**;**

(c) Structural adaptations to low temperatures. (07 marks)

Feature of the body	**Suitability**
• smaller body extremities; and larger body;	To reduce surface area for heat loss;
• much subcutaneous fat;	increase insulation against heat loss;
• thick fur;	To trap air; and prevent heat loss by convection;

13. (a) Describe the suitability of the mammalian liver to its functions. (13 marks)

Feature of the liver	**Suitability**
• Has numerous blood vessels**;**	• To transport materials in and out the liver**;**
• Hepatocytes have ✓ prominent Golgi bodies**;** ✓ many mitochondria**;** ✓ glycogen granules**;** ✓ numerous microvilli**;**	• For ✓ secretion of materials**;** ✓ to produce energy**;** ✓ to store energy**;** ✓ increase surface area for absorption of materials**;**
• Kupffer cells**;**	• To defend the body**;** engulf worn out red blood cells**;**
• Undifferentiated cells**;**	• To carry out many activities**;**
• It is large**;**	• To increase its surface area**;**
• Has canaliculi	• To remove bile from the livers

(b) Explain the role of the liver in lipid metabolism. (07 marks)

- Liver cells convert excess carbohydrates to fats; which are stored in the body; and in short supply of glucose; liver cells convert fats to fatty acids; and glycerol; for respiration
- Liver cells remove excess cholesterol from blood; and breaks it down; or synthesise it when required;

14. (a) Explain the fate of worn out red blood cells. (10 marks)

- Old red blood cells are engulfed by phagocytes in spleen/liver/bone marrow;
- These are broken down and their haemoglobin released;
- Released haemoglobin is taken up by the Kupffer cells in the liver; and broken down into haem; and globin;
- The haem group is broken down into iron; and biliverdin;
- Biliverdin is converted to bilirubin; which forms part of bile;
- Iron is stored as ferritin in the hepatocytes; or reused by bone marrow cells to make more haemoglobin;

(b) Explain the role of the liver in carbohydrate metabolism. (10 marks)

- When there is excess glucose in the blood stream; the beta cells of the Islets of Langerhans release insulin which causes liver cells to take up more glucose; and break it down during respiration; Liver cells also convert excess glucose to glycogen; and fat; and stored in the liver;
- When blood glucose level is low; the alpha cells of the Islets of Langerhans release glucagon; which causes the conversion of glycogen to glucose in the liver cells;
- Cortisol hormone; increases rate of synthesis of enzymes in the liver which convert amino acids; and glycerol; into glucose;

15. (a) Explain how the rate of heat production in the body is controlled. (14 marks)

- When the body temperature falls below the norm; it is detected by the hypothalamus as blood flows through the brain;
- The hypothalamus releases the thyroid releasing hormone; which stimulates the pituitary to release the thyroid stimulating hormone; that stimulates the thyroid gland to release thyroxine; that increases the metabolic rate increase rate of heat production;
- The hypothalamus as well send impulses to the skeletal muscles; causing them to contract repeatedly; which also generates more heat;
- Adrenal medulla also secretes adrenaline which increase the metabolic activity;
- When the body temperature increases beyond the set norm; the hypothalamus responds by inhibiting release of thyroxine; and metabolic rate falls; and contraction of skeletal muscles is inhibited; so that less heat is produced;

(b) Explain how the camel overcomes the problem of heat stress in its habitats.
(06 marks)

- Has tissues that are heat tolerant; hence can withstand high body temperature;
- Counter current flow in the nasal passage; cools inhaled and exhaled air;
- Tends to face the sun when at rest; to minimise heat gain;
- Stands off the ground when hot; to minimise heat gains;
- Fur; insulates the body against heat gain and loss from environment;
- Able to maintain high body temperature reduces the temperature difference between the body and the environment; reducing the rate of heat gain;
- Long tail; increases surface area for heat loss;
- Light coloured fur; to reflect much of the incident light rays;
- Walks on toes with pads; to minimise heat gain;

16. (a) Explain the role of the hypothalamus in temperature regulation. (10 marks)

- The hypothalamus contains thermoregulatory centre; that detects changes in the body core temperatures; and sends impulses to correct the deviation
- When temperature core increases above the set norm; the heat loss centre in the anterior hypothalamus is stimulated; which responds by causing a decline in metabolic rate; increased sweat production; and vasodilation of skin arterioles; so as to increase rate of heat loss;
- When temperature core temperature decreases below the set norm; the heat gains centre is in the posterior stimulated; and responds by sending impulses to skin to cause vasoconstriction; reduced sweating; and metabolic rate increases through the release of thyroxine and adrenaline;

(b) Explain the role of the skin thermoreceptors in temperature regulation
(06 marks)

- The skin contains hot; and cold thermoreceptors;
- Hot receptors are stimulates by increase in temperature; while cold receptors by decrease in temperature;
- They detect temperature changes on the surface of the body; and send impulses to the;
  - Hypothalamus; allowing the changes in the core temperature take place;
  - Cortex; for the organism to feel cold or hot;
- allowing the body to make rapid and precise adjustments to maintain a constant core temperature;

(c) Explain the advantages and disadvantages of being ectothermic. (04 marks)

- **Advantages of being ectothermic**
- Lower food consumption; because they do not generate heat internally from metabolic reactions for temperature regulation;
- **Disadvantages of being ectothermic**
- They are restricted to habitants where their bodies withstand temperature of the environment;
- Metabolic rate is normally low; hence lower body temperatures reduces the activity of the organism; speed of impulse transmission is low; hence slow response to stimuli;

17. (a) What is meant by the term "*efficiency range*" (01 mark)

- This is the temperature range within which physical mechanisms alone can regulate the body temperature;

(b) Explain the factor the affect the low critical temperature of mammals. (07 marks)

- Low critical temperature is the lowest environmental temperature below which physical mechanisms alone cannot maintain a constant body temperature;
- This depends on the amount of insulation between the body and the environment; and body size;
- Mammals with much fur; and subcutaneous fat; lose heat slowly; hence their low critical temperatures are lower; than mammals with less fur and less subcutaneous fat;
- Large sized mammals have smaller surface area to volume ratio; compared to the smaller ones; and lose heat slowly; hence have lower low critical temperatures; compared to the smaller ones;
- Mammals with smaller extremities; lose heat more slowly; than those with larger extremities; hence their low critical temperature is lower in comparison;

(c) Heat exhaustion in humans occurs at a lower temperature in

(i) More humid environments. (06 marks)

- In hot more humid conditions the body loses heat slowly; because the rate at which sweat evaporates from the skin is low; as the atmosphere is saturated with moisture; while in less humid conditions; the diffusion gradient greater; allowing faster evaporation of sweat from the body; which leads to cooling;

(ii) Still air than windy conditions (08 marks)

- In hot conditions, much sweat is produced by the body which evaporates from the body with some heat; allowing it to cool;
- In still air, the evaporates sweat remains around the body; saturating the air around the body; and reducing the diffusion gradient; while in windy conditions the evaporated moisture around the body is taken away; replacing it with unsaturated air; that encourages further evaporation and hence heat loss from the body;

(d) Explain the response of a mammalian body to

(i) An increase in temperature above the efficiency range. (04 marks)

- The ability of the body to regulate temperature breaks down;
- Increase in temperature further activates enzymes; which increases the metabolic rate hence generating more heat; in a positive feedback mechanism; (metabolic rate doubles for every 10^0C rise in temperature) heat exhaustion takes place and the individual dies;

(ii) A decrease in temperature below the efficiency range. (04 marks)

- The physical mechanisms alone fail to maintain constant body temperature; metabolic rate increases; to provide more heat;
- With further decrease in temperature, the chemical mechanisms also breakdown; and individual dies;

18. (a) Explain why plants suffer permanent physiological damage when exposed to high temperatures in high humidity. (05 marks)

- In high humidity, transpiration rates are low; because the water vapour diffusion gradient between the leaf and atmosphere is low; the plant cannot lose heat; leading to overheating and denaturation of enzymes; leading to slowing of metabolism of plants;

(b) Explain who ectotherms control their body temperature. (14 marks)

How to avoid overheating/ reduce heat gain	How to gain more heat/ avoid heat loss
• Becoming lighter in colour; to reduce heat absorption; e.g some lizards	• Becoming darker in colour; to absorb more heat;
• Aligning the body parallel to the sun rays; reducing the surface area of the body exposed; to absorb less heat;	• Aligning the body at right angles to the sun rays; increasing the body surface area exposed; to absorb much heat;
• Opening the mouth; to increase heat loss by evaporation; e.g crocodiles;	•
• Moving to cooler places like burrows; eg lizards	• Moving to warm places/ basking in the sun; e.g. lizards
• Moving to the water when it is too hot; to cool the body	• Moving to water when it's too cold;

19. (a) Explain the role of the liver in protein metabolism. (10 marks)

- Excess amino acids; are deaminated in the liver; the amino group is removed from an amino acid; and converted into ammonia; which is converted in to urea; while the remaining carbon compound is used for respiration;
- Transamination; where new amino acids are synthesised by the liver; by transferring amino groups from one amino acids to another;
- Synthesis of plasma proteins; such as albumin/fibrinogen/globulins; from amino acids occurs in the liver cells

(b) Explain what is meant by the term *hibernation*? (03 marks)

- Is a state in which the metabolic rate of animal is lowered to a minimum; in response to a decrease in environmental temperature; which leads to a decrease in the body temperature; so as to allow the organism survive such conditions

(c) Explain the importance of hibernation in animals. (06 marks)

- During periods of extremely cold conditions; there is low supply of food; and the high rate of heat loss; thus animals sets the optimum temperature at a low set-point; the metabolic rate reduces; and body temperature falls;
- This reduces energy expenditure; and enables the organisms to survive the cold; during periods of short food supply;

(d) Explain why hibernation is more common in small animals than large ones. (06 marks)

- Small animals have a large surface area to volume ratio; than larger animals;
- Their rate heat loss is therefore higher than in larger animals;
- To maintain high metabolic rate;, they would need to consume more food; which is in short supply during very cold conditions;

THE END; FOR NOW