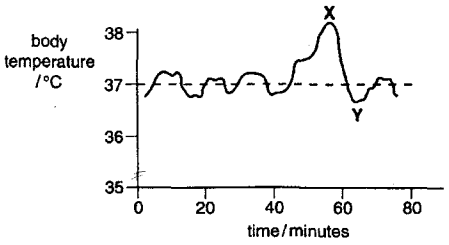
UNIT 12 Homeostasis

MCQ Section

1. The graph shows changes in a person's body temperature plotted against time.



What causes the change in temperature between **X** and **Y**?

A increased air temperature

B increased evaporation of sweat

C reduced blood flow through surface capillaries

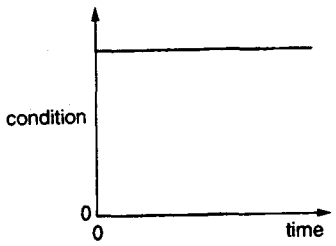
D shivering

[D01/P1/Q23]

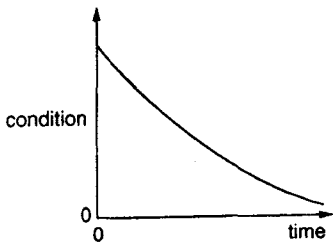
2. The graphs show how four different conditions in the body may change with time.

In which graph is the condition being controlled by negative feedback?

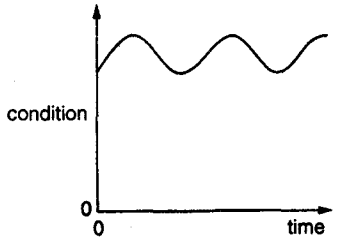
A



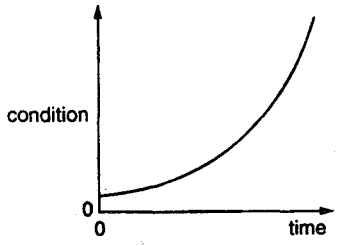
B



C

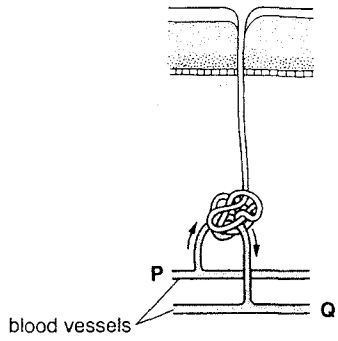


D



[J2001/P1/Q22]

3. The diagram shows a sweat gland with its blood supply.



What changes in concentrations of carbon dioxide and salt take place as blood passes from **P** to **Q**?

	carbon dioxide	salt
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

[J2001/P1/Q23]

1. **B** Evaporation of sweat produced removes heat from the body resulting in a drop in body temperature.

2. **C** The negative feedback mechanism is a homeostatic control mechanism whereby an increase in some condition or activity inhibits the process leading to the increase.

3. **C** Salt and urea from the blood in P diffuses into sweat gland for the production of sweat that is excreted from the skin. The respiring cells in the sweat gland produces carbon dioxide which is carried in the blood plasma by blood vessel Q.

Thinking Process

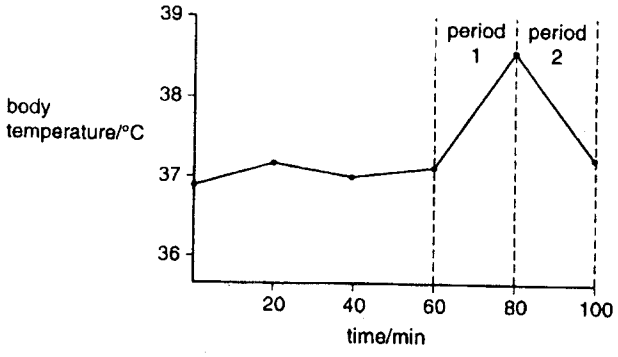
MCQ Answers

4. What happens when the core temperature of the body increases?

	diameter of superficial blood vessels	*urine production*
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

[D98/P1/Q21]

5. The graph shows changes in a person's body temperature plotted against time.

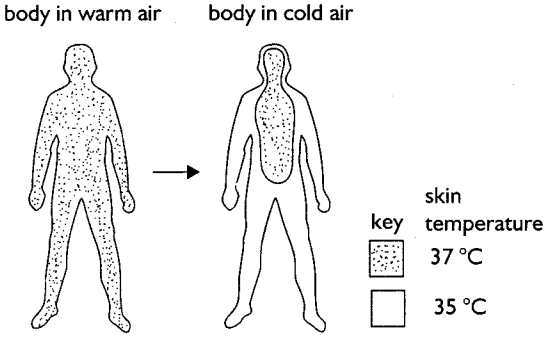


What could cause the changes in body temperature in periods 1 and 2?

	period 1	*period* 2
A	reduced air temperature	increased air temperature
B	reduced air temperature	shivering
C	vigorous exercise	increased sweating
D	vigorous exercise	shivering

[D97/P1/Q22]

6. The diagrams shows skin temperature in a human body when it is exposed to warm air and then exposed to cold air.



What causes the observed change in skin temperature on exposure to cold air?

A less blood flowing just below the skin

B less blood going to the heart and lungs

C more blood flowing just below the skin

D more blood going to the heart and lungs

[J97/P1/Q22]

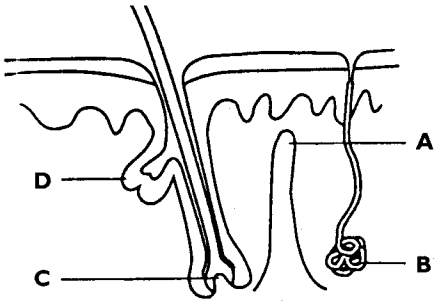
7. What happens when the body temperature falls below 37°C?

	blood flow to skin	*sweating*
A	decreased	decreased
B	decreased	increased
C	increased	decreased
D	increased	increased

[D96/P1/Q20]

8. The diagram shows a section through human skin.

Which structure is a sweat gland?



[J96/P1/Q19]

4. C The diameter of superficial blood vessels increases – vasodilation occurs. This causes in an increase in blood flow to the skin resulting in greater heat loss from blood into the surroundings by radiation.

5. C Vigorous exercise increases rate of respiration producing more heat. Increase production of sweat results in the cooling of the body as evaporation of sweat removes heat from the skin.

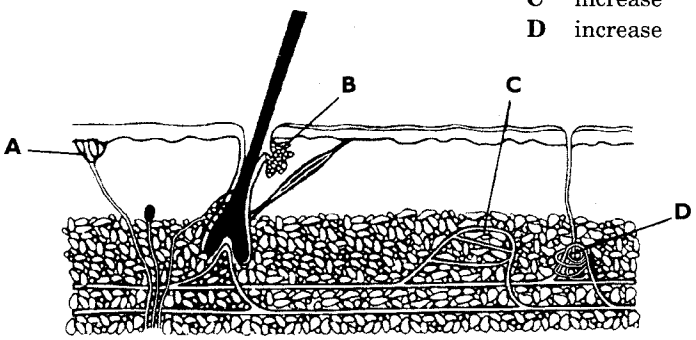
6. A Vasoconstriction occurs in blood vessels of skin.

7. A Blood flow to the skin decreases when the body temperature falls so that there is a lower volume of blood near the skin, thereby reducing heat loss. Sweating (which facilitates heat loss from the body) is reduced to compensate for a drop in body temperature.

8. B Fact.

9. The diagram shows a section through human skin.

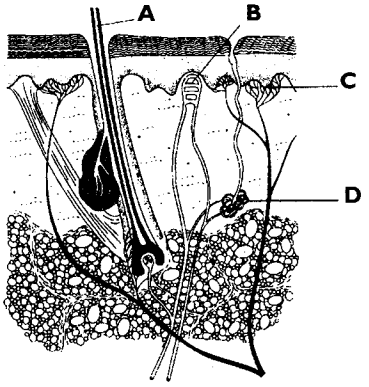
Which structure secretes a dilute solution of sodium chloride and urea?



[D95/P1/Q19]

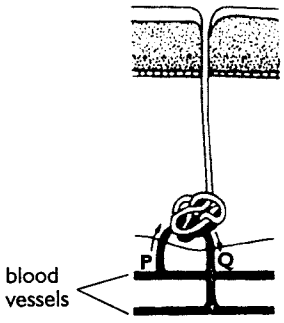
10. The diagram shows a section through the skin.

Which structure detects changes in skin temperature?



[J95/P1/Q20]

11. The diagram shows a sweat gland with its blood supply.



What changes in concentrations of carbon dioxide and salt take place as blood passes from **P** to **Q**?

	carbon dioxide	*salt*
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

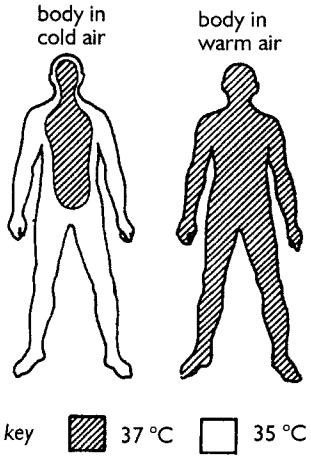
[J94/P1/Q19]

12. Which changes are likely to occur when a hotel cook walks from a very cold store-room into a hot kitchen?

	sweating	*shivering*	*skin blood vessels*
A	decreases	increases	dilate
B	increases	decreases	constrict
C	increases	decreases	dilate
D	increases	increases	constrict

[D94/P1/Q20]

13. The diagrams show skin temperature in a human body when it is exposed to cold air and then exposed to warm air.



What causes the observed change in skin temperature on exposure to warm air?

A less blood flowing just below the skin

B less blood going to the heart and lungs

C more blood flowing just below the skin

D more blood going to the heart and lungs

[D93/P1/Q19]

MCQ Answers

9. D Sweat gland.

10. C Nerve endings form receptors which sense temperature changes, pain and pressure.

11. C Salt is excreted into the sweat glands. Carbon dioxide is produced by the respiring cells and diffuse into the blood.

12. C Sweating — more heat is lost to the surroundings to regulate body temperature. Shivering — decreases to stop heat production by the body. Skin blood vessels — dilate so that more heat is lost to the surroundings.

13. C In warm air, the body tries to lose more heat to maintain its body temperature, thus more heat is lost by blood flowing to the skin.

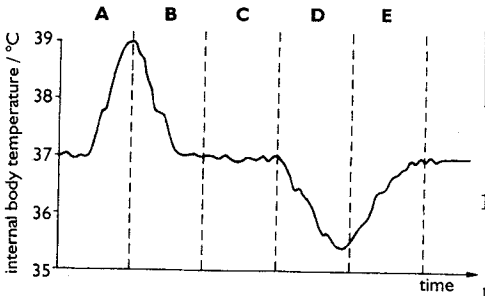
14. D When the body temperature starts to fall below the normal level (37°C), surface blood capillaries constrict to minimise heat loss from the body surface.

15. D Negative feedback mechanisms are used in homeostasis. This could be used in regulating the body temperature or the amount of glucose present in the blood.

16. D Vasodilation occurs and arterioles dilate to allow more blood to flow to the surface of the skin.

14. The graph shows changes in a person's internal body temperature over a period of time.

During which period would the arterioles supplying blood to surface capillaries first become constricted?



[J93/P1/Q20]

15. Four processes that take place in the human body are listed.

1. absorption of amino acids through the villi
2. maintenance of constant body temperature
3. production of lactic acid in muscles.
4. regulation of blood glucose concentration

Which two processes are directly controlled by negative feedback?

A 1 and 3 **C** 2 and 3

B 1 and 4 **D** 2 and 4

[J02/P1/Q21]

16. What happens to the arterioles near the surface of the skin when the body temperature rises?

A They absorb oxygen from the surrounding tissues.

B They dilate and become wider.

C They move nearer the skin surface.

D They take in water from the surrounding tissues.

[D02/P1/Q21]

17. The urine of a person suffering from diabetes mellitus is likely to contain an abnormal amount of

A amino acids. **C** glucose.

B fatty acids. **D** urea.

[D02/P1/Q25]

18. Which combination of factors helps prevent the loss of heat from the body?

	sweat secretion	arterioles leading to surface blood vessels
A	minimised	constricted
B	minimised	dilated
C	maximised	constricted
D	maximised	dilated

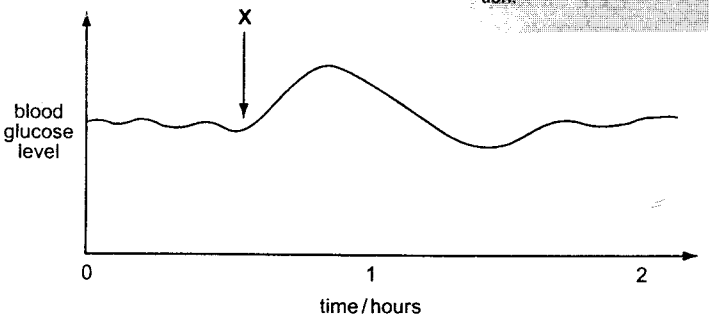
[D03/P1/Q21]

19. On a hot day how would these skin structures respond to help maintain a constant body temperature?

	sweat gland	surface blood vessels
A	decreased sweat production	contract
B	decreased sweat production	dilate (get wider)
C	increased sweat production	contract
D	increased sweat production	dilate (get wider)

[D04/P1/Q20]

20. The graph shows changes in the glucose concentration in the blood of a person during two hours.



What explains the shape of the graph after **X**?

A The person has eaten a sugary sweet meal.

B The person has had an insulin injection.

C The person is suffering from diabetes mellitus.

D The person starts some hard physical exercise.

[D04/P1/Q27]

17. C Diabetes mellitus is a disease whereby the blood glucose cannot be utilized or stored by cells resulting in a high concentration of blood glucose and subsequently some glucose becomes excreted in the urine.

18. A Evaporation of sweat produced removes heat from the body resulting in a drop in body temperature. Vasoconstriction of arterioles causes in a decrease in blood flow to the skin resulting in less heat loss from blood into the surroundings.

19. D A rise in the blood temperature stimulates the hypothalamus and nerve impulses are sent to the sweat glands to increase sweat production. Evaporation of sweat produced removes heat from the body resulting in a drop in body temperature. Vasodilation also occurs so that more heat from the blood can be lost by radiation.

20. A A sugary sweet meal is high in starch and sugar, hence the blood glucose level increases. In order to remove excess glucose, the pancreas secretes insulin, causing the excess glucose to be converted to glycogen in the liver and muscle tissues, thus lowering the blood glucose levels to normal.

UNIT 12 Homeostasis

THEORY Section

Question 1

(a) Explain how, in a healthy person, (i) the body temperature and (ii) the blood sugar, are returned to normal after they have risen above normal levels. [10]

(b) Explain why it is important for Man to maintain a constant body temperature of 37 °C. [2]

[J00/P2/Q7]

Solution

(a) (i) The body controls and maintains its temperature by the process of homeostasis.

This involves a negative feedback mechanism. The increase in blood temperature is detected by the hypothalamus of the brain and feedback this information to the sensory organs in the central nervous system. This cause a series of corrective mechanisms in the body to produce the opposite effect i.e. to reduce the temperature and return it to the normal body temperature of 37 °C.

The adjustments initiated in response to an increase in body temperature include:

1) an increase production of sweat by sweat glands and evaporation of sweat removes heat from the skin.

2) Vasodilation of arterioles and blood capillaries near surface of the skin so that more heat from blood can be loss to the surroundings by radiation.

(ii) The liver control blood sugar levels by a feedback mechanism involving the pancreas and the hormone insulin. Insulin is secreted by, a group of cells called the islets of Langerhans in the pancreas. When the blood glucose level are higher than normal, the pancreas secretes more insulin. Insulin lowers the blood sugar level by making the liver convert more glucose to glycogen causing the glucose level to fall back to normal level.

(b) A temperature of 37 °C is where enzymes work best. It is the optimum temperature for all chemical reactions catalysed by enzymes in the body.

Question 2 (continue next page)

Fig. 6.1 shows a section through human skin.

(a) Explain how the skin is involved in returning the body temperature to normal when the body overheats. In your answer, you should refer to, and identify, structures **A** to **E**. [10]

(b) Explain why temperature control is regarded as an example of a negative feedback system. [2]

[J99/P2/Q6]

COMMENT on QUESTION

"(a) The question requires student to describe the role of the various structures in the skin in the regulation of body temperature."

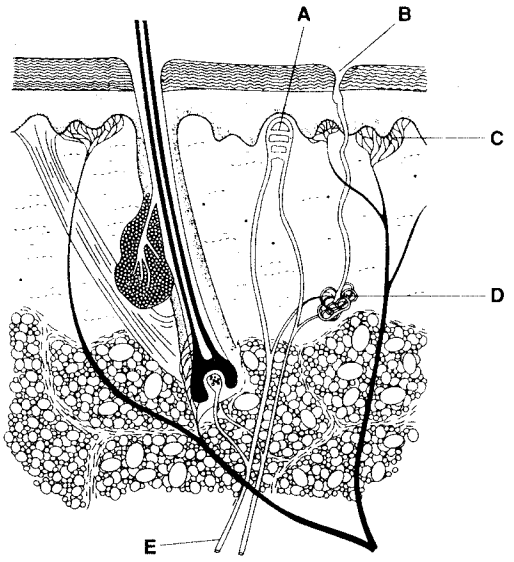


Fig. 6.1

Solution

(a) When the body is over heated, the rise in the blood temperature will be detected by the heat regulating center in the hypothalamus of the brain. Impulses are sent to stimulate the sweat gland, **D**, to increase the production of sweat. Sweat secreted flows through a sweat duct and a sweat pore, **B**, to the skin surface. Heat is removed from the body when sweat evaporates from the surface of the skin.

Vasodilation also occurs. The arteriole, **E**, and surface blood capillaries, **A**, dilate to allow more blood to flow through the skin. The skin receives more heat, which is lost to the surrounding air by radiation, convection and conduction.

Sensory nerve endings, **C**, found in the dermis detect temperature changes in the external environment. Impulses initiated are sent to the sensory area of the brain, which gives the the person a sensation of the increase in body temperature. The person can consciously reduce heat gain by moving to a cooler place or decrease physical activities that generate more heat.

(b) The body controls and maintains its temperature by the process of homeostasis. Keeping a constant body temperature requires homeostatic control which involves: a corrective mechanism and a negative feedback. The negative feedback mechanism helps the body to return to it's normal body temperature of 37 °C, whether the body temperature increases above or decreases below the normal body temperature.

COMMENT on **ANSWER**

"(a) Latent heat is absorbed from the skin when sweat evaporates. "

Question 3

(a) Explain

(i) how, during strenuous exercise, the human body temperature rises, and

(ii) how the body temperature returns to normal when the exercise is over. [6]

(b) Account for the effect of exercise on

(i) the breathing rate, and

(ii) the pulse rate. [6]

[D96/P2/Q7]

Solution

(a) (i) During strenuous exercise, much energy is required and tissue respiration in the muscles (and to a lesser extent in the liver) increases to meet this demand for energy. This produces a lot of heat. Some other metabolic activities also produce heat. The heat generated is distributed to all parts of the body by the circulating blood, resulting in a general increase of body temperature.

(ii) When the exercise is over, the metabolic activities previously invoked to support the high energy requirement (e.g. tissue respiration) slow down so that much less heat is generated. At the same time, the elevated body temperature is monitored by the heat-regulating centre in the brain. The brain sends signals to the sweat glands to produce more sweat so that more latent heat can escape by sweat evaporation from the surface of the skin. Vasodilation of the arterioles in the skin also allow greater blood flow to the skin and enhance heat loss by radiation, conduction and convection. Rapid breathing helps to remove heat too. All these processes allow the excess heat built up in the body during strenuous exercise to be removed until the body temperature returns to normal.

(b) (i) Strenuous exercise causes the breathing rate to increase. This is because more energy is required, and to meet this high demand for energy, the rate of aerobic respiration (process whereby glucose is broken down to release energy) has to increase accordingly. Oxygen is necessary for aerobic respiration, thus the amount of oxygen required rises. At the same time much carbon dioxide is produced as a result of higher rate of aerobic respiration. To satisfy the high oxygen requirement and to remove the large amount of carbon dioxide produced, the breathing rate has to increase.

(ii) Exercise increases the pulse rate because of the increased circulation of blood. To deliver extra oxygen required for increased aerobic respiration during strenuous exercise, and to remove carbon dioxide produced as a result of aerobic respiration, blood circulation has to increase. To achieve this, the heart has to pump at a quicker pace, thus increasing the pulse rate.

Question 4

(a) What is meant by the term *homeostasis?* [2]

(b) In what situations might a healthy person's blood glucose level be expected to (i) rise, and (ii) fall? [3]

(c) Explain how blood glucose is normally maintained at a more or less constant level. [7]

[D95/P2/Q9]

Solution

(a) Homeostasis is the process of maintaining a constant internal environment. Regulation of body temperature and osmotic pressure in mammals are some examples of homeostasis.

(b) (i) After a heavy meal, or after intake of food with high sugar content.

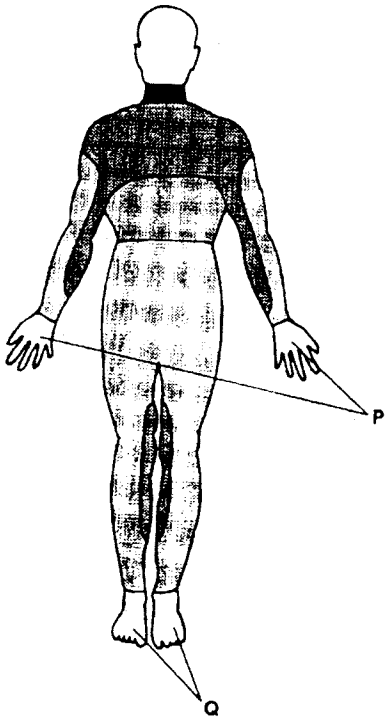
(ii) When exercising, hours after a meal or when fasting.

(c) When there is an increase in blood glucose concentration, insulin is released by the Islets of Langerhans in the pancreas. This causes the conversion of glucose to glycogen for storage in liver and muscles. When there is a drop of glucose in the blood, the liver converts glycogen back to glucose.

Question 5

Fig. 1 shows the variation in skin temperature of a person who has been standing, unclothed, in an air temperature of 16 °C for several minutes. The more heavily shaded the area, the higher the skin temperature.

Fig. 1



(a) Name the region of the body which has the highest skin temperature. [1]

(b) Suggest, with reasons, why wearing a hat is recommended when the air temperature is very low. [2]

(c) Suggest **two** reasons to explain the skin temperatures at **P** and **Q**. [2]

Table 1 shows the blood flow to some regions of the body while at rest and during exercise.

Table 1

Region	Blood flow / cm^3 per min at rest	Blood flow / cm^3 per min during exercise
skin	550	1950
heart muscle	275	775
kidneys	1000	600

(d) Account for the change in blood flow shown in

(i) the skin;

(ii) the heart muscle;

(iii) the kidneys. [5]

(e) Suggest a region of the body, not shown in Table 1, which is likely to have the greatest increase in blood flow during exercise. Explain your answer. [2]

[J94/P2/Q1]

Solution

(a) The neck.

(b) When the temperature is low, one of the regions which lose heat fastest is the head, as can be seen in the figure. Wearing a hat helps to trap a layer of air. Both the hat and the layer of air serve as an insulation against heat loss.

(c) 1. The extremities (hands and feet) have a large surface area/volume ratio, so that more heat is lost to the environment.

2. The main source of heat in the extremities is from the blood flowing through them. In a cold environment, there is vasoconstriction of the skin arterioles, so that less heat is brought to the hands and feet.

(d) (i) There is a very large increase in blood flow to the skin during exercise. This is because a great deal of heat is produced by the muscles. More blood is allowed to flow to the skin so that heat can be lost by radiation, convection and conduction.

(ii) The heart beats faster during exercise so that oxygen can be brought to the muscles at a faster rate. In order to beat faster, the heart muscle also requires more oxygen, hence there is an increase in the amount of blood flow to it.

(iii) Blood flow to the kidney is reduced because more water is lost through sweat. Therefore, less water is brought to the kidneys by the blood for excretion.

(e) *Region:* Muscles.

Explanation: During vigorous muscular contractions, the muscle cells use up oxygen in tissue respiration to provide energy. Therefore, there is a very great increase in blood flow to the muscle cells, so that more oxygen can be transported.

COMMENT on QUESTION

"(d) Think about what happens during exercise and how the three organs (skin, heart and kidneys) can help to restore the body to its original state."

COMMENT on ANSWER

"(a) The neck is the region which has been shaded most heavily in the figure.

(b) Two main reasons are: head loses a lot of heat, and a hat serves as an insulator.

(d) More heat is produced by the muscles, heart beats faster to bring oxygen to the muscles, more water lost through sweat.

(e) The muscles which are working during exercise will require the greatest blood flow to bring oxygen for tissue respiration."

COMMON ERROR

"(d) iii) Students often explain why there is a greater blood flow to the heart rather than to the heart muscle."

Question 6

(a) What is meant by the term *homeostasis?* [2]

Fig. 6 shows the body temperature of a person before, during and after taking a cold bath. (The temperature of the bath water was 22 °C.)

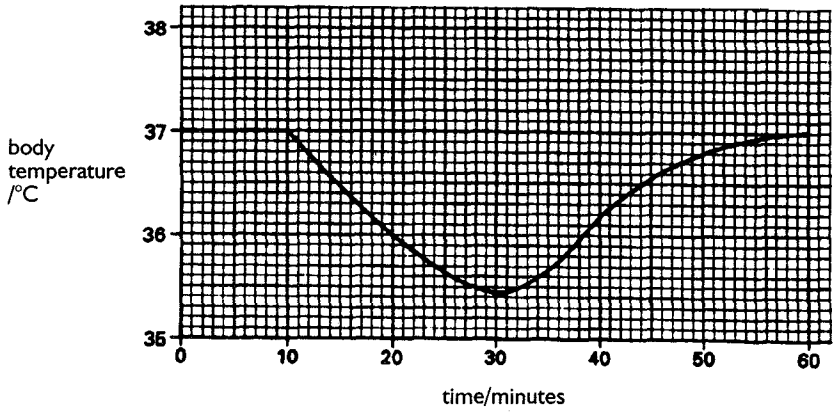


Fig. 6

(b) For how long was the person in the bath? [1]

(c) Explain why the person's body temperature fell. [2]

(d) Explain the roles played by the following in helping to return the body temperature to normal:

(i) the liver;

(ii) blood vessels in the skin;

(iii) muscles of the body. [6]

[D93/P2/Q5]

Solution

(a) Homeostasis is the process of maintaining a constant internal environment. Regulation of body temperature and osmotic pressure in mammals are some examples of homeostasis.

(b) 20 minutes.

(c) In a cold bath, the body tends to lose much more heat through convection and conduction causing the body temperature to fall.

(d) (i) In the liver, heat is produced as a result of numerous chemical activities occurring there. This heat is distributed by the blood to other parts of the body.

(ii) The low external temperature brings about a reflex constriction of the skin arterioles. Less blood flows through the skin and less heat is lost.

(iii) Tissue respiration is very active in muscles, setting free large amounts of heat which is distributed to different parts of the body by the blood.

COMMENT on **ANSWER**

"(b) The period between 10 and 30 minutes on the graph, when the body temperature was dropping. "

Question 7

(a) Explain how **named** excretory substances in the blood are removed by

(i) the lungs,

(ii) the kidneys,

(iii) the skin. [8]

(b) Explain why the loss of oxygen from a leaf of a plant may be described as excretion. [2]

[J02/P1/Q8 or]

Solution

(a) (i) The metabolic waste in the lung is carbon dioxide. Gaseous exchange takes place in the lungs. Oxygen is absorbed into the body by the blood, and carbon dioxide is released into the environment. Carbon dioxide is carried as bicarbonate ions in deoxygenated blood. Deoxygenated blood in the capillary walls of the lungs break down to release carbon dioxide. This CO_2 then diffuses out of the capillary walls and across the alveolar walls into the alveolus. During expiration, carbon dioxide and water vapour are expelled out of the lungs.

(ii) The waste products removed by the kidneys are excess water, urea and excess mineral salts. The amount of water re-absorbed by the kidney is regulated by the action of the anti-diuretic hormone (ADH). When there is loss of water from the body through sweating or other activities, the kidney tubules become more permeable to allow more water to be re-absorbed by the body. Urea and excess mineral salts are removed from the blood in urine.

(iii) The skin removes heat, excess water, urea and mineral salts from the body. The main function of the skin would be in temperature regulation. Sweat glands in the skin absorb salts and water from the surrounding blood capillaries to produce sweat. In this way, it regulates temperature as well as serving a function in excretion.

(b) Water is a product as well as a reactant in the process of photosynthesis. Carbon dioxide and water react with sunlight to form glucose, oxygen and water in plant cells. Oxygen in not required by the chlorophyll cells to produce food. It is but a by-product of photosynthesis.

COMMENT on **ANSWER**

"(b) The light-dependent stage of photosynthesis requires light energy. It involves the photolysis of water. In the dark reaction, carbon dioxide is reduced by hydrogen to form glucose. There is no requirement for oxygen in these processes as well. "

Question 8

Fig. 2.1 shows the blood pressure in the main artery of the arm of a person before and immediately after having a hot bath.

(a) Using Fig. 2.1, calculate the rate of the person's heart beat before having the bath. [1]

(b) While in the bath, the person's body temperature rose from 36.7 °C to 38.5 °C.

State two likely effects of the change in body temperature on the person's face. Explain what causes each effect. [6]

(c) (i) Suggest an explanation for the change in the person's blood pressure immediately after having the bath.

(ii) What was the effect on the rate of heart beat of having the bath? [2]

(d) Suggest two effects of prolonged exposure to temperatures below 0 °C. [2]

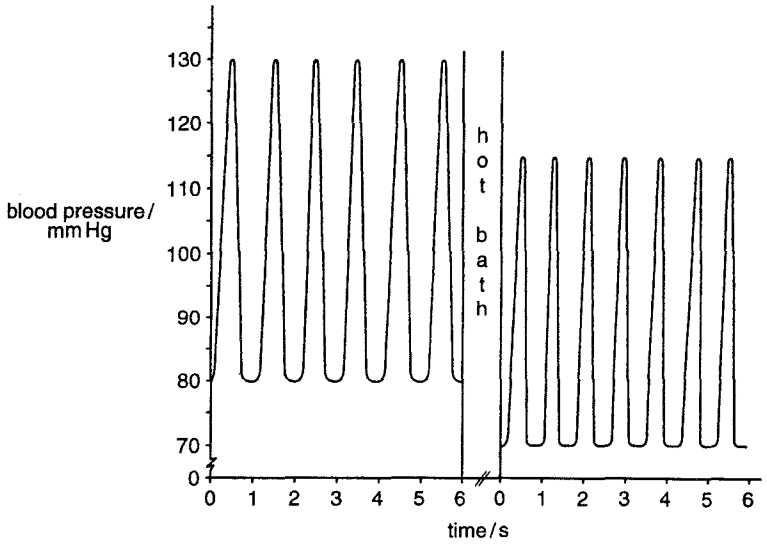


Fig. 2.1

[D02/P2/Q2]

Solution

(a) rate of heart beat = $6 \times 10 = 60$ beats per min

(b) *Effect 1*: The face becomes redder.

Explanation: Arterioles and surface capillaries become dilated to bring more blood to the surface of the skin so that more heat can be lost by radiation and convection.

Effect 2: Sweat produced

Explanation: Sweat glands become active, producing more sweat. Evaporation of sweat removes excess heat and causes a cooling effect.

(c) (i) The blood pressure is lowered. Vasodilation results in arterioles with a larger lumen for blood flow, thus decreasing the rate of blood flow and the pressure exerted by the arteriole walls.

(ii) The heart rate increases to 7 beats in 6 seconds or 70 beats per minute.

(d) 1. violent shivering causing fatigue.

2. slow pulse rate due to slow heart rate.

COMMENT on **ANSWER**

"(d) Prolonged exposure to temperatures below freezing point result in a decrease in the core body temperature to a level at which normal muscular and brain functions become impaired. In severe cases, breathing becomes erratic and very shallow and the victim becomes semi-conscious and the heart may even stop."