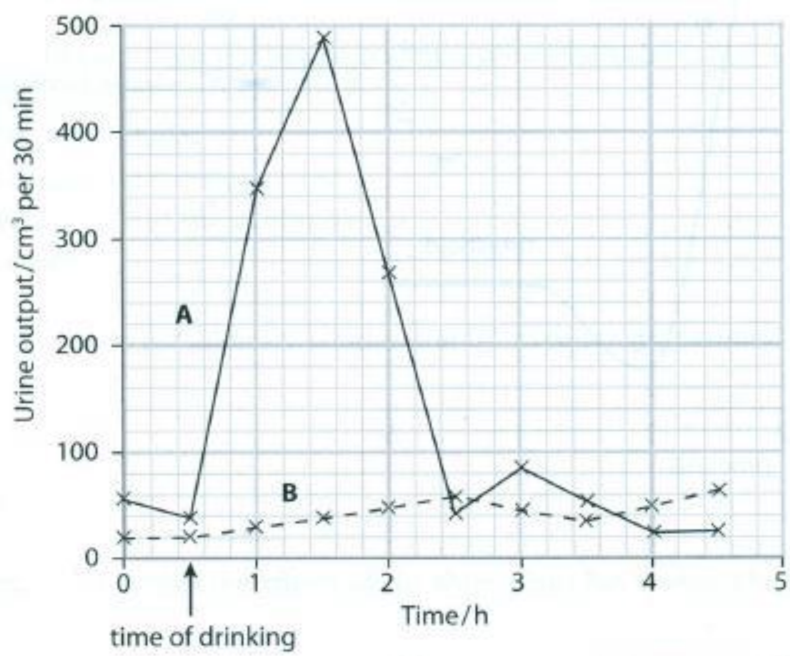
DATA BASED QUESTIONS IN HOMEOSTASIS AND OSMOREGULATION

1. In an investigation of factors that influence urine production, a person was made to drink one litre of water on the first day, and later on the second day, another litre of salt solution. On each day, the person's urine was collected at half-hourly intervals for four hours after drinking. The results are shown on the graphs **A** and **B** respectively.
   Dilute solution has about the same water potential as blood plasma.



(a). Calculate how much urine was produced in the two hours after drinking a litre of,
(i) water (ii) salt solution.
(b) Explain the difference in the results obtained in (a) above.
(c)Describe the role of hypothalamus in regulating blood water content.
(d) Explain why urine production almost stops after serious bleeding.

Possible solutions

(a). (i) **1160cm³/ 1.16dm³;**
(ii) **200cm³/ 0.2dm³**

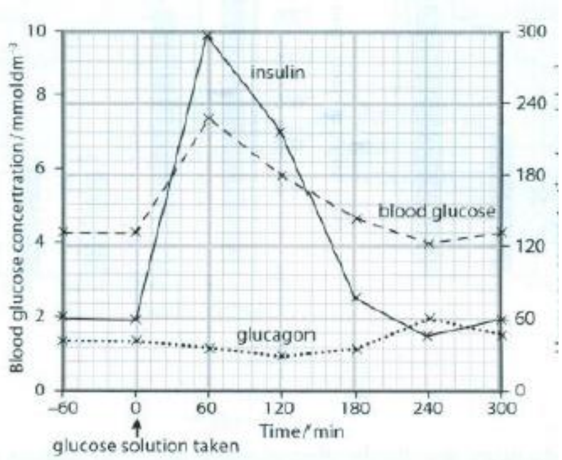
(b) Amount of urine produced on taking water is greater/higher/more than that produced by drinking salt solution; because on drinking water, water is reabsorbed into blood; osmotic pressure of blood is lowered; detected by osmoreceptor cells in hypothalamus; and are less stimulated; less Anti-diuretic hormone/vasopressin is released by the posterior pituitary gland into blood; distal convoluted tubule and the collecting duct become less permeable to water; less water is reabsorbed from the glomerular filtrate back to blood by osmosis; thus a higher quantity of dilute urine is excreted;

(c) Hypothalamus consists of osmoreceptor cells; which detect changes in water content/osmotic pressure of blood;

Osmoreceptor cells are connected to the posterior pituitary gland by efferent nerves; and thus send impulses to posterior pituitary gland about changes in blood water content; stimulating it; to release much Anti-diuretic hormone into blood when blood water content is low; and less Anti-diuretic hormone when blood water content is high;

(d) On serious bleeding, total blood volume decreases; blood is diverted from other tissues including the kidney to the brain; maintaining life; volume of blood flowing to the kidney is thus reduced greatly to an extent that less ultrafiltration and thus no formation of urine occurs;

2.An experiment was carried out to determine the response of pancreatic cells to an increase in the glucose concentration of blood. A person who had been told not to eat or drink anything other than water for 12hours, took a drink of glucose solution.
Blood samples were taken from a person at hourly intervals for five hours, and the concentration of glucose, insulin and glucagon in the blood determined. The results are shown in the figure below.



(a). Explain why the person was told not to eat or drink anything other than water for 12hours before having a glucose drink.
(b)Explain the relationship between glucose concentration and insulin from time of glucose intake and 240minutes.
(c) Other than the concentration of glucose in blood, what other factors must be regulated in the internal environment.

Possible solutions

(a). Glucose may already be high;
Effect of sudden increase in glucose concentration on having a glucose drink would not be observed; as there will be high levels of insulin circulating in blood.

(b) Between 0minutes and 60minutes; both glucose concentration and insulin rapidly increase up to a peak; cuz increased blood glucose concentration above the norm;

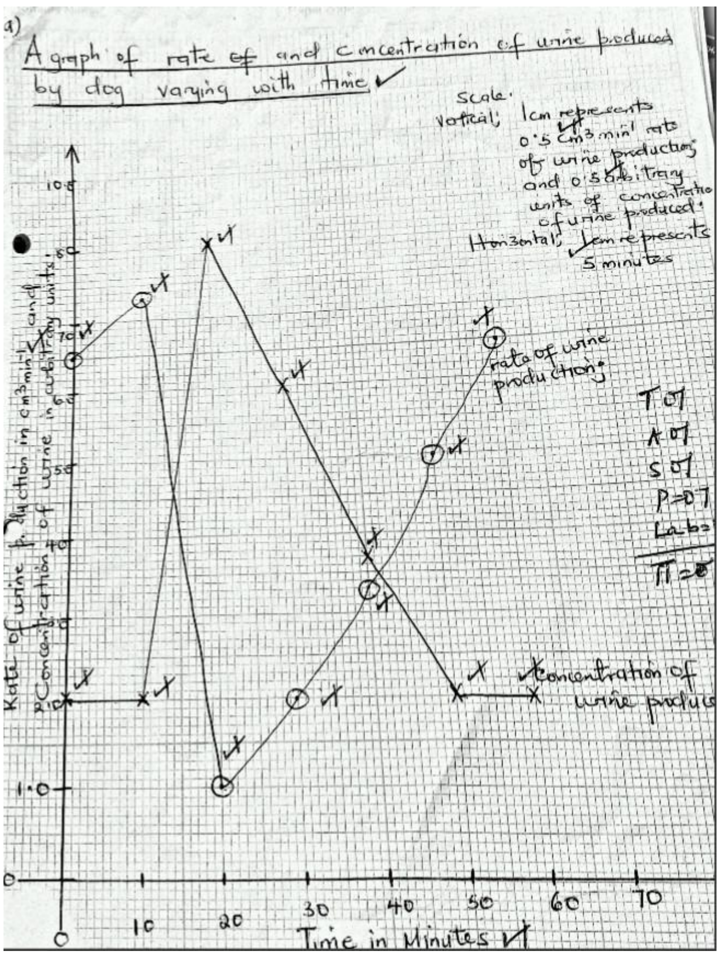
due to absorption from the gut; stimulates secretion of insulin hormone by β-cells of the islets of Langerhans; in the pancreas; into the blood stream, to lower the glucose concentration back to the norm.
Between 60minutes and 240minutes; both glucose concentration and insulin level decrease; because lowering of glucose concentration to norm; due to its conversion to glycogen or fats, oxidation by tissues; inhibits secretion of insulin hormone by the by β-cells of the islets of Langerhans.
(c) Carbon dioxide concentration of blood; temperature of the body; blood pressure; pH of blood; concentration of ions; and osmotic pressure of blood and tissue fluid.

3. An investigation was carried out to determine the effect of a strong saline solution on the rate and concentration of urine produced by a dog. The experiment begun with a dog first being allowed to drink water to its fill. Ten minutes later, it was injected with strong saline solution through the carotid artery. The dog was then monitored closely and relevant measurements taken. The results obtained as shown in the Table below.

Time(minutes)	0	10	20	30	40	50	60
Rate of urine production($cm^3 min^{-1}$	6.5	7.3	1.0	2.0	3.3	5.0	6.5
Concentration of urine(arbitrary units)	2.0	2.0	8.0	6.0	3.7	2.0	2.0

(a). Present the results of the experiment graphically.
(b) Describe the effect of saline solution on the
(i) rate of urine production
(ii)concentration of urine produced by the dog during the investigation.
(c)Explain the observed changes in the rate of urine production.
(d) Explain how animals living in high salinity habitats have overcome their osmotic challenges.

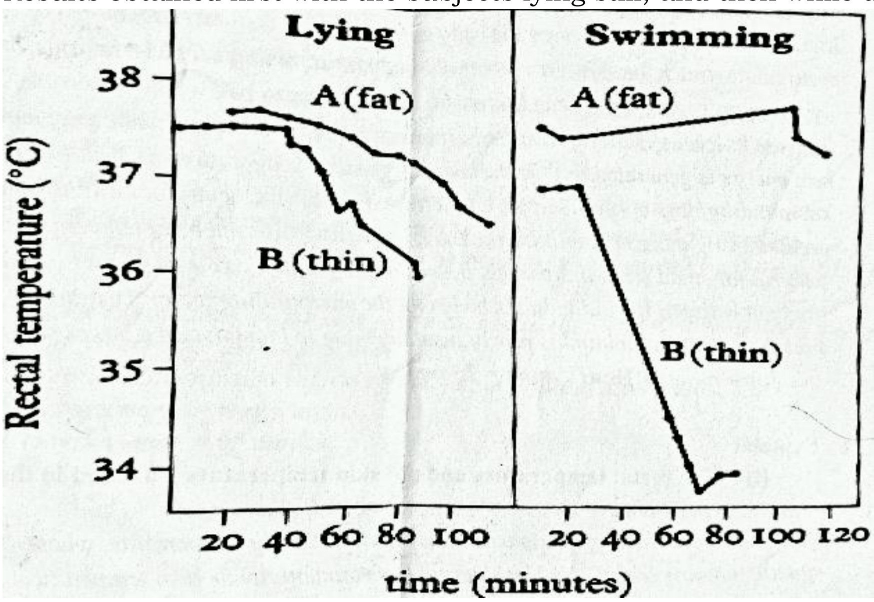
Possible solutions.



(b) (i) From 10minutes to 20minutes; rate of urine production decreases rapidly; to a minimum/lowest rate.
From 20minutes to 60minutes; rate of urine production increases gradually; to its normal level;
(ii). From 10minutes to 20minutes; concentration of urine produced increased rapidly; to a peak;
From 20minutes to 50minutes; concentration of urine produced decreased rapidly; to a normal level;
From 50minutes to 60minutes; concentration of urine produced remains constant;
(c)**From 0minutes to 10minutes; rate of urine production increases gradually; because drinking large amounts of water by the dog; increases its blood volume/decreases the osmotic pressure of its blood/increases the solute potential of its blood;**
From 10minutes to 20minutes; rate of urine production decreases rapidly; because injection of a strong saline solution to the dog; increases osmotic pressure of blood/lowers the solute potential blood/lowers the water potential of blood; detected by osmoreceptor cells of the hypothalamus; neurosecretory cells in the hypothalamus are stimulated; secreting anti-diuretic hormone/vasopressin; from their cell bodies; flows down their axons; to the posterior lobe of the pituitary gland; and released into the blood stream; transported to the kidney; binds to specific receptors in the cell surface membrane of the distal convoluted tubules and the collecting duct; increasing their permeability to water; more water is reabsorbed from the renal fluid into the cortex and medulla; by osmosis; water potential of blood increases; osmotic pressure decreases; lowering the rate of urine production;
From 20minutes to 60minutes; rate of urine production increases gradually; because osmotic pressure of blood has fallen below normal; by negative feedback; anti-diuretic hormone secretion from the axons of neurosecretory cells is inhibited; walls of distal convoluted tubules and collecting ducts become less permeable to water; less water is reabsorbed from renal fluid into blood; large volume of dilute urine is produced gradually;
(d) Marine animals have body fluids hypotonic to surrounding marine water; resulting into osmotic extraction of water from the body tissues; leading to dehydration; and continuous influx of salts into the body by diffusion; thus need to conserve water and remove excess salts; done by the following ways.

Chloride secreting cells in the gills of marine bony fish; that actively extrude salts from the blood into the sea.
Excrete trimethylamine oxide; a soluble but non-toxic nitrogenous waste; whose removal requires little water for its elimination;
Marine teleost constantly drinks vast quantities of water; compensating for water lost.
Marine teleosts have relatively few small sized glomeruli; decreasing filtration rates; producing small amounts of glomerular filtrate; thus little quantities of concentrated urine;
Marine teleosts have long of Henle; increasing the surface area for water absorption from the glomerular filtrate; thus conserving water in the body;
Marine elasmobranchs retain urea; raising the osmotic pressure of body fluids to a point slightly higher than the surrounding sea water; water is drawn into the body;

4.Figure below shows the results of an experiment on the body temperature of two human subjects **A** and **B**. **A** is fat whereas **B** is thin, both subjects had their body temperature recorded at intervals while immersed in water at 16°C. Results obtained first with the subjects lying still, and then while the subjects were swimming.

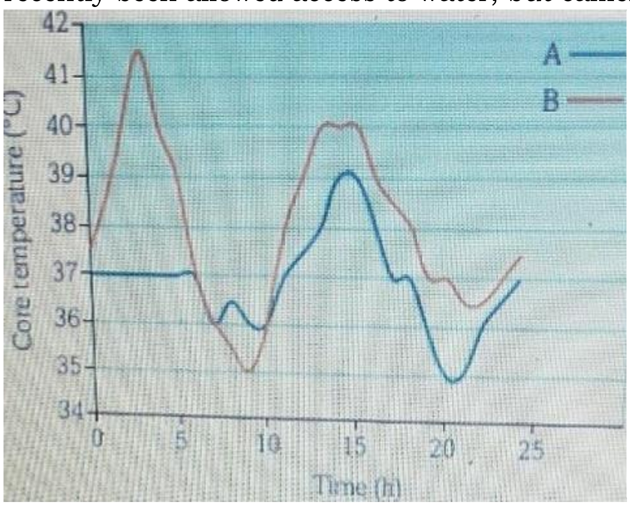


(a). (i) From the figure, state any t**wo** factors that affect the body's ability to regulate body temperature of an individual.
(ii). Describe the effect of change in each of the factors in a(i) above on the rectal temperature.
(iii). Give an explanation for the effects described in a (ii) above.
(b) Explain
(i)Why rectal temperature and not skin temperature was used in the experiment.
(ii) The effect of increasing water temperature to 25°C.
(iii). Why prolonged exposure to severe cold of the living cell at the tips of the fingers may die?
(c) State the **structural** and **physiological** changes that occurred in the body of the thin human throughout the time of experiment.
(d) Explain the adaptations of thin bodied organisms living in extreme cold conditions.

Possible solutions
(a). (i) Size of body; level of activity;
(ii). Body size
When lying, from 20 minutes to 40minutes; decrease in body size, rectal temperature remains constant; then from 40minutes to 90minutes; rapidly decreases rectal temperature;
When swimming, from 10minutes to 30minutes; decrease in body size gradually increases rectal temperature; then from 30minutes to 70minutes; decrease in body size rapidly decreases rectal temperature; to a minimum; then from 70mimutes to 85minutes; decrease in body size gradually increases the rectal temperature;
Level of activity
In a fat subject, from 10minutes to 20minutes; increase in level of activity, gradually decreases rectal temperature;
From 20 minutes to 110minutes; increase in level of activity rapidly increases rectal temperature; up to a peak; then decreases rapidly first; then from 110minutes to 120minutes, gradually decreases;
In a thin subject, from 10minutes to 30minutes; increase in level activity gradually increases rectal temperature; then from 30minutes to 70minutes; increase in level of activity rapidly decreases rectal temperature; to a minimum; then from 70mimutes to 85minutes; increase in level of activity gradually increases the rectal temperature;
(iii) Increase in body size; decreases the surface area to volume ratio; thick subcutaneous fat beneath the skin; insulates the body against heat loss to the surrounding water by conduction and convection;
Increase in level of activity; leads to increased metabolism; more energy is generated within the body; with large body size presenting a small surface area to volume ratio, reducing on amount of heat lost; more heat accumulates in the body ; increasing the rectal temperature; while small body size, with larger surface area to volume ratio and poorly insulated owing to low fat; heat is rapidly lost to surrounding water; decreasing the rectal temperature.

(b) **(i)Rectal temperature represents variation in internal body temperature; whose fluctuations are less affected by external/environmental temperature; while skin temperature represents external temperature; and its fluctuations are greatly affected by changes in water temperature; hence giving inaccurate results for the investigation;**
(ii) Rectal temperature of both subjects decreases gradually/slightly; because increase in water temperature decreases the temperature gradient between the individuals' bodies and surrounding water; decreasing heat loss to the surrounding;
(iii) Temperature of the arterial blood reaching the tips decreases close to zero; inactivating the enzymes controlling cell activities at the tip; impairing their metabolism; which can prove fatal;
(c) structural changes. Vaso constriction; erected body hairs;
Physiological changes increased metabolism; decreased sweating; increased skeletal muscular activity;
(d) Developing thick fur; that traps a layer of warm air; improving on body insulation against heat loss;
Thick layer of subcutaneous layer beneath the skin; for insulation against heat loss;
Increase in body size to reduce surface area to volume ratio; reducing on heat loss;
Sun bathing; hibernation; burrowing in warm areas;
Increased constriction of their superficial blood vessels; allowing little blood to flow near the skin surface; excessive reducing excessive loss of heat through convection and radiation;

5. The figure below shows the core temperature of two camels that were kept together during the day. Camel **A** had recently been allowed access to water, but camel **B** had not had water.

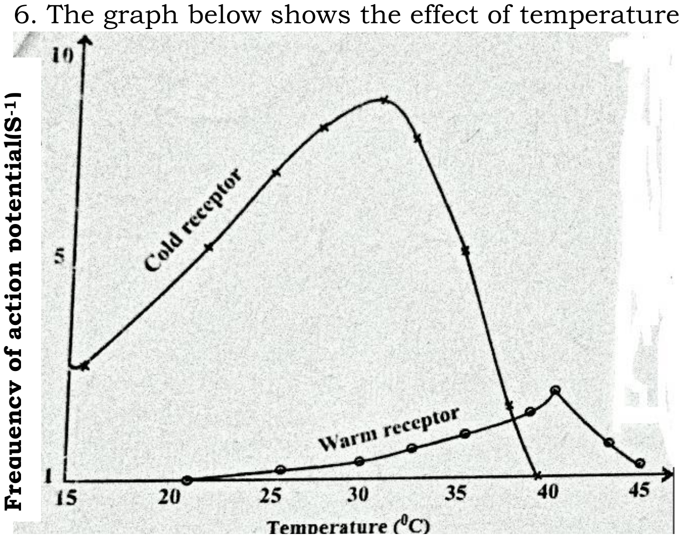


(a). Suggest why the graph records core temperature rather than skin temperature.
(b) Describe the temperature changes in camel **A** throughout the 24hour period.
(c)Suggest at what time external temperatures were at their highest.
(d) Explain why the core temperature of camel **B** fluctuates more than that of camel **A**

Possible solutions

(a). Fluctuations in body core temperature are less affected by external/environmental temperature/sun; and is maintained by negative feedback; while skin temperature represents external temperature; and its fluctuations are greatly affected by changes in the external temperature (sun);
(b) **From 0hours to 6hours; body core temperature remains constant; at the norm/ 37℃;**
From 6hours to 7hours; body core temperature decreases gradually;
From 7hours to 10 hours; body core temperature fluctuates slowly;
From 10hours to 14hours; body core temperature increases gradually; to a peak;
From 14hours to 20hours; body core temperature decreases rapidly; to a minimum; then from 20hours to 24hours; body core temperature increases gradually; back to norm;
(c) At 14hours;
(d)Camel does not contain as much water in its body as camel A; thus cannot use latent heat of vaporization to cool;

6. The graph below shows the effect of temperature on heat receptors in the mammalian skin.



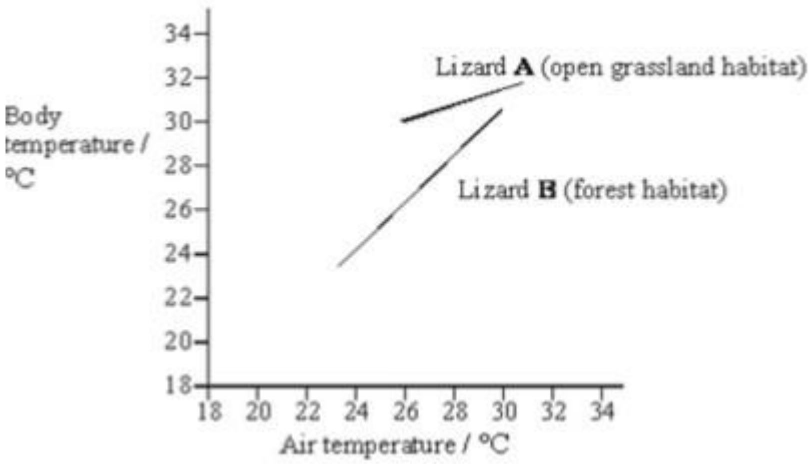
(a)Describe the effects of temperature on the response of
(i) cold receptors (ii) warm receptors
(b) Explain the effect of temperature on the response of;
(i) cold receptor (ii) warm receptor
(c)Suggest the effect of the following conditions on the response of receptors.
(i) Room temperatures (ii) Ice cold temperature.
(d) Explain how a mammal responds to increasing temperatures.
(e) Explain any **four** advantages of endotherms over ectotherms with regard to temperatures.

Possible solutions

(a) (i) At 15℃, frequency of action potential is moderately slow;

Increase in temperature from 15℃ to about 25℃; rapidly increases the frequency of action potential;
Increase in temperature from about 25℃ to 30℃; gradually increases the frequency of action potential; up to a peak;
Increase in temperature from 30℃ to 39℃; rapidly decreases frequency of action potential; to a minimum;
Increase in temperature from 39℃ to 45℃; produces not action potential;
(ii) Below 21℃; no action potential is produced;
At 21℃, Frequency of action potential is slow;
Increase in temperature from 21℃ to 40℃; gradually increases the frequency of action potential to a peak;
Increase in temperature from 40℃ to 45℃; rapidly decreases the frequency of action potentials;
(b) (i) At 15℃, frequency of action potential is moderately slow; because temperature is low; inactivating respiratory enzymes; no ATP is formed; to pump Na^+/ K^+ ions;
Increase in temperature from 15℃ to about 25℃; rapidly increases the frequency of action potential; because action of respiratory enzymes is favoured; increasing on ATP production; allowing much pumping of Na^+/K^+ ions;
Increase in temperature from about 25℃ to 30℃; gradually increases the frequency of action potential; up to a peak; because other factors other temperature inhibit ATP formation by respiratory enzymes;
Increase in temperature from 30℃ to 39℃; rapidly decreases frequency of action potential; to a minimum; because excessive heat rapidly denatures the respiratory enzymes; rapidly decreasing ATP production; to pump the Na^+/K^+ ions;
Increase in temperature from 39℃ to 45℃; produces not action potential; all respiratory enzymes have been denatured by excessive heat; inhibiting ATP production;
(ii) Below 21℃; no action potential is produced; because temperature is very low and far below minimum threshold needed by warm receptors to fire action potentials;
At 21℃, Frequency of action potential is slow; because generator potential is low;
Increase in temperature from 21℃ to 40℃; gradually increases the frequency of action potential to a peak; because action of respiratory enzymes is favoured; and increased kinetic energy of Na^+/K^+ ions; thus increased ATP production;
Increase in temperature from 40℃ to 45℃; rapidly decreases the frequency of action potentials; excessive heat rapidly denatures the respiratory enzymes; rapidly decreasing ATP production; to pump the Na^+/K^+ ions;
(c) (i)Since room temperature , at about25℃ is within the range in which cold receptors are rapidly stimulated; cold receptors would fire action potentials at a relatively faster frequency;
Warm receptors would fire action potentials at a very slow frequency; because this temperature is lower than critical; to stimulate warm receptors;
(ii) Cold receptors would fire action potentials slowly; due decreased to temperatures; which lower the kinetic energy of ions and inactivates respiratory action decreasing their catalytic action; subsequently less ATP is produced;
Warm receptors will fire action potentials rapidly; as the animals needs to escape from this extreme temperature;
(d) Erector pili muscles relax; lowering the hair; air insulation is lost; allowing loss of heat;
Dilation of superficial blood vessels; allowing more blood to flow near the skin surface; heat is lost via radiation and convection;
Increased activity of sweat glands producing much sweat; which on evaporation, latent heat of vaporization is lost; cooling the body;
Decreased metabolic rate; reducing on energy production during respiration;
Taking of cold drinks to cool the body; moving to shades to reduce over heating; reduction in physical exercises to prevent over heating; stretching out increasing surface area over which heat is lost;
(e) Enzyme controlled reactions proceed efficiently; because are able to maintain constant body temperatures;
High metabolic rates; keeps them always active; allowing faster response to stimuli; avoiding danger/predators.
Can live in a wide range of temperatures; hence can live in a wide range of habitats;

7.The graph below shows results of an investigation into the relation between air temperature and body temperature for two **A** and **B** lizards living in different habitats. The investigation took place on a hot sunny day over a period of four hours.

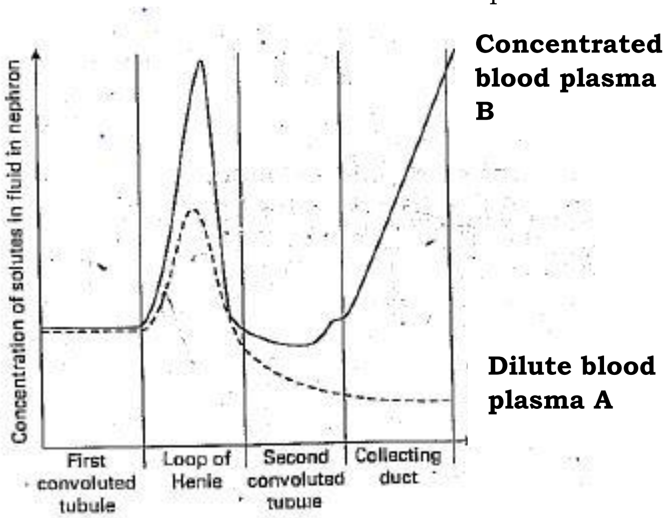


(a). Explain the relationship between the air temperature and the body temperature for lizard **B.**
(b) Suggest an explanation for the different pattern shown by Lizard **A**.
(c)Lizard B moves slowly when its body temperature is 24℃ than when it is 28℃ . Account for the difference in the rate of movements at the two temperatures.
(d) Discuss the adaptations of the camel to overcome heat stress in desert habitat.

Possible solutions

(a) As air temperature increases, body temperature increases rapidly; because lizard B being an ectotherm cannot metabolically regulate its body temperature but instead rapidly gains heat from rising air temperature in the forest habitat;
(b) **As air temperature increases, body temperature increases slightly/gradually/slowly; and is higher than that of lizard B; because lizard A is partly endothermic; thus can metabolically regulate its body temperature on slightly gaining heat from the rising air temperatures in the open grass land;**
(c) Lizard gains more heat at higher temperatures; thus higher rate of metabolism; as increased body temperatures activate the respiratory enzymes; generation more ATP for movement;
(d) Growth of scanty fur/Have bare skin without fur; to reduce on insulation; allowing loss of heat;
Absorb heat and store it during the heat of the day and loses it when the environmental temperatures lower in the night; allowing them to be tolerant to wide fluctuations of temperature;
Hump of fat; to prevent excessive heating of the underlying tissues;
Long skinny legs without fat; to allow it lose heat generated during locomotion;
Walks on two padded toes; to prevent excessive gain of heat during locomotion;
Facing the sun directly during rest; to expose a smaller surface of its body to sun rays; preventing heat gain;
Long eye lashes to protect its eyes from the sun rays;

8. The figure below shows the responses of different regions of the kidney nephrons in humans who were subjected to conditions that result in dilute blood plasma **A** and concentrated blood plasma **B**



(a)Explain how the condition of dilute and concentrated blood arise in humans.
(b) Compare the variation of the concentration of the solute in the fluid in different regions of the human kidney nephrons for individuals with dilute and concentrated blood plasma.
(c) Explain the response of the kidney in human bodies to changes in the concentration of blood plasma.

Possible solutions

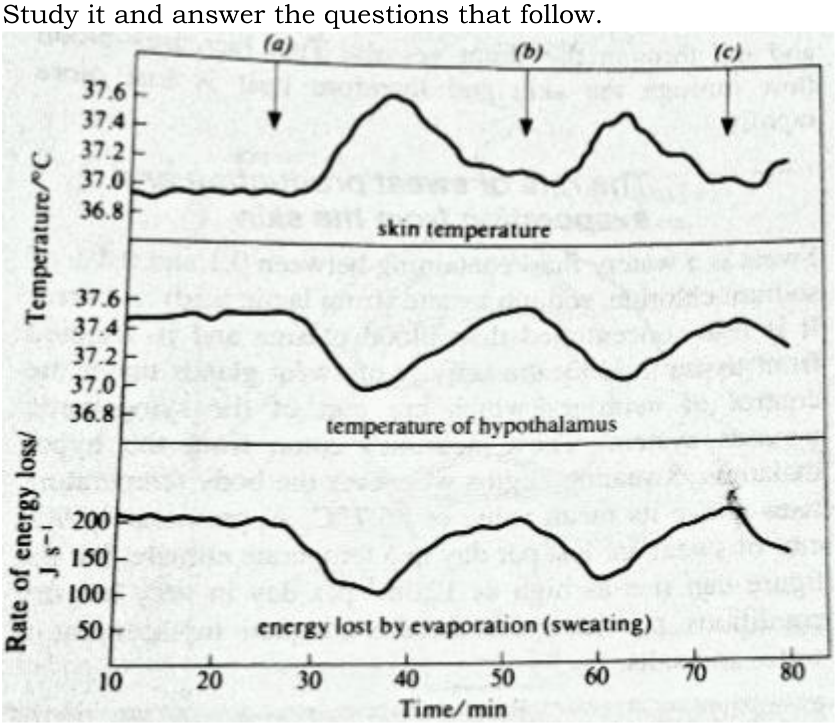
(a)Dilute blood in humans is caused by direct dinking of water; or as a component of succulent foods consumed; decreased sweating in cold conditions; low salt intake;
Concentrated blood results from strenuous exercise; and hot external temperatures; both coupled with excessive loss water through sweating to lose excess heat from the body; subsequently lowering the water potential of blood/ increasing the osmotic pressure of blood;
high salt intake; and its absorption in the gut; increases the salt content of blood;
During vomiting and diarrhea ; less water is reabsorbed into blood; concentrating blood;
(b) Similarities
In both dilute blood plasma, A and concentrated blood plasma B;
-concentration of solutes in the fluid at the first convoluted tubule remains constant; and are equal;

-concentration of solute in the fluid at loop of Henle rapidly increases; to a peak; then rapidly decreases;
-concentration of solute in the fluid at second convoluted tubule gradually decreases up a point;
Differences.

Part of nephron	Concentrated blood plasma B	Dilute blood plasma A
Loop of Henle	**Concentration of solutes in the fluid is higher;** **Higher peak attained;**	**Concentration of solutes in the fluid is lower;** **Lower peak attained;**
Second convoluted tubule	**After a certain point, concentration of solutes in the fluid increases gradually/slowly;**	**After a certain point, concentration of solutes in the fluid gradually/slowly continues to decreases gradually;**
Collecting duct	**Concentration of solutes in the fluid increases rapidly; to the highest;**	**Concentration of solutes in the fluid is remains almost constant/decreases slightly**

(c) In high concentrations of blood plasma; high concentrations of Anti-diuretic hormone is released in blood stream; transported to the kidney; binding to specific receptors in the cell surface membrane of the distal convoluted tubules and the collecting; increasing their permeability to water; more water is reabsorbed from the renal fluid into the cortex and medulla; by osmosis; decreasing its concentration; thus producing small quantities of concentrated urine;
In low concentrations of blood plasma; less ADH is released by the posterior pituitary gland into blood; distal convoluted tubule and the collecting duct become less permeable to water; less water is reabsorbed from the glomerular filtrate back to blood by osmosis; increasing its concentration; thus a higher quantity of dilute urine is excreted;

9.Figure below shows the relation between skin temperature, temperature of the hypothalamus and rate evaporation of sweat for a human in a warm chamber(45℃. Iced water was swallowed at points (a), (b) and (c) on the graphs. Study it and answer the questions that follow.



(a). Suggest why iced water was not given until 20minutes after the start of the experiment.
(b)Describe the relationship between the temperature of the hypothalamus and the rate of sweating.
(c)Suggest why the skin temperature rises shortly after the ingestion of iced water.
(d) Explain the response of the hypothalamus on ingestion of iced water.

Possible solutions
(a) To allow the subject's internal body temperature to equilibrate with that of the external temperature;
(b). Between 10minutes and about 27minutes; as temperature of the hypothalamus remains constant rate of sweating also remains constant;
Beyond 27minutes; as temperature of the hypothalamus decreases, rate of sweating also decreases ; and as temperature of the hypothalamus increases, rate of sweating also increases.
(c)**Ingestion of iced water, lowers the body core temperature; subsequently decreasing sweating/rate of evaporation decreases; due to action of hypothalamus in response to ingestion of iced water; latent heat of evaporation is thus not lost from the skin; resulting gradual increase in skin temperature**;
(d) **Ingestion of iced water, temperature of the hypothalamus decreases gradually below norm first; and then increase gradually back to norm; because heat gain centre of the posterior hypothalamus is stimulated; which stimulates corrective mechanisms that increase heat gain/reduce heat loss e.g. through sweating; to raise the temperature back to norm;**

10.Figure .**1** below shows the average blood glucose levels in three major vessels of the liver of an individual, who had meals at 7.00am and 1.00 pm.
Figure. **2** shows the blood glucose levels in a normal and diabetic individual, after both individuals were given sugar solutions at 7.00am.
Study both graphs and use them to answer the questions that follow.

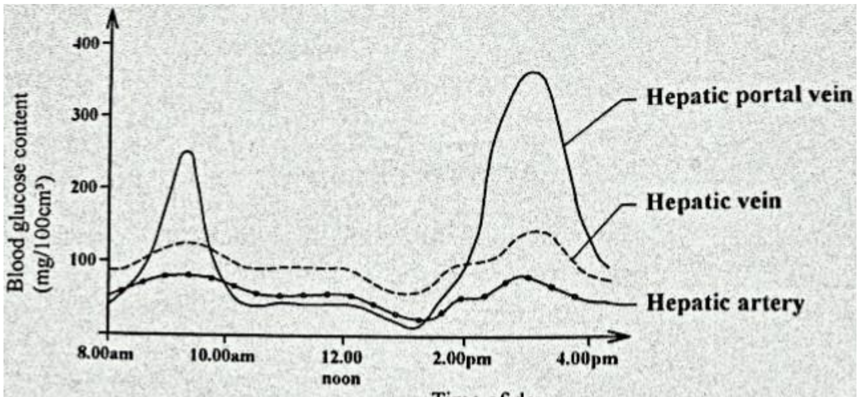


Fig. 1

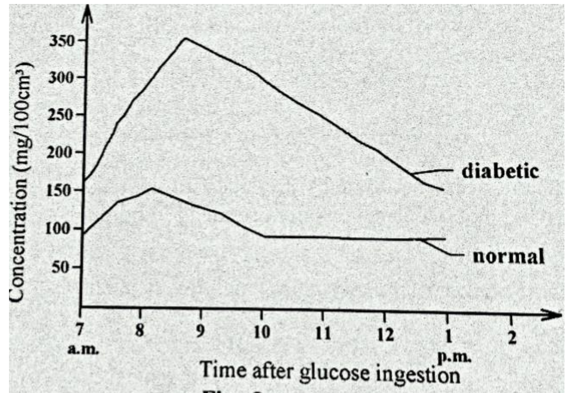


Fig. 2

(a). From the fig. **1** above

(i) Compare the levels of glucose in;

- Hepatic artery and hepatic vein
- Hepatic artery and hepatic portal vein.

(ii) Explain the differences in the levels of glucose in the;

- Hepatic artery and hepatic vein
- Hepatic artery and hepatic portal vein.

(b) From fig. **2** above,

(i) Compare the levels of blood glucose between diabetic and normal individual.

(ii) Account for the observed pattern of the levels of blood glucose in the two individuals.

(c) Why is it significant to regulate the blood glucose level?

Possible solutions

(a) .(i)

Hepatic artery and hepatic vein

similarities

In both the hepatic artery and hepatic vein,

- **Blood glucose level increase and decrease gradually from 8.00am to 10.00am; 2.00pm to 4.00pm; and from 12.00pm to 4.00pm;**
- **Blood glucose level decrease gradually from 10.00am to 12.00noon;**
- **Peak is attained at around 9.00am and 3.00pm;**

Differences

Blood glucose level in the hepatic vein is higher than in hepatic vein throughout/ from 8.00am to 4.00pm;

Hepatic artery and hepatic portal vein

Similarities

In both the hepatic artery and hepatic portal vein,

- **Peak is attained at around 9.00am and 3.00pm;**
- **Blood glucose level decrease gradually from 10.00am to 1.30pm;**
- **Blood glucose level are equal/same at 10.00am, 8.30am and 1.30pm;**

Differences

Hepatic portal vein	Hepatic artery
Blood glucose level is lower from 8.00am to 8.30am; and from 10.00am to 1.30pm;	**Blood glucose level is higher from 8.00am to 8.30am; and from 10.00am to 1.30pm**
Blood glucose level is higher from 8.30am to 10.00am; and from 1.30pm to 4.00pm; / after 1.30pm;	**Blood glucose level is lower from 8.30am to 10.00am; and from 1.30pm to 4.00pm; / after 1.30pm;**
Blood glucose level increases and decreases rapidly from8.00am to 10.00am; and from 1.30pm to 4.00pm;	**Blood glucose level increases and decreases gradually from8.00am to 10.00am; and from 1.30pm to 4.00pm;**
Higher peaks are attained at around 9.00am and 3.00pm.	**Lower peaks are attained at around 9.00am and 3.00pm.**

(ii). Hepatic artery and hepatic vein

Blood glucose level is higher in the hepatic vein than hepatic artery; because of respiration/metabolism the heart.

More glucose is added to blood due to digestion; and absorption of food in the gut; which is transported by the hepatic portal vein to liver; where excess glucose is regulated by glycogenesis/converted to glycogen, establishing normal glucose concentration and then transported by the hepatic vein;

Hepatic artery and hepatic portal vein

Blood glucose level is lower in the hepatic portal vein than hepatic artery from 8.00am to 8.30am because there is little digestion and absorption of the digested food;

Blood glucose level is lower in the hepatic portal vein than hepatic artery from 10.00am to 1.30pm because digestion and absorption of glucose is complete;
Blood glucose level increases rapidly in the hepatic portal vein and increases gradually in the hepatic artery; to peaks; from 8.00am to 9.00am; and from 1.30pm to 4.00pm ; and because glucose is rapidly absorbed into hepatic portal vein; and its regulation; and respiration in the heart; gradually increases its concentration the hepatic artery.
Blood glucose level decreases rapidly in the hepatic portal vein from 9.30am to 10.00am; and 3.30pm to 4.00pm; because no glucose is absorbed.
(b) Similarities
In both the normal and diabetic individual,

- **Blood glucose concentration increases; to a peak; and then decreases;**

Differences

Diabetic individual	Normal individual
Blood glucose concentration increases rapidly	**Blood glucose concentration increases rapidly first the gradually;**
Higher peak is attained	**Lower peak is attained**
Peak is attained later; at 8.30am;	**Peak is attained earlier; at 8.00am**
Blood glucose concentration is higher throughout the time of experiment	**Blood glucose concentration is lower throughout the time of experiment**
Blood glucose concentration decreases rapidly from 10am to 12.45pm;	**Blood glucose concentration remains constant from 10am to 12.45pm;**
Blood glucose concentration decreases gradually from 12.45pm to 1pm;	**Blood glucose concentration remains constant from 12.45pm to 1pm;**

(ii) Blood glucose concentration increases due to absorption after digestion;
Higher peak is attained in diabetic person because of lack of regulatory mechanisms/insulin/malfunctioning pancreas.
From 10am to 1pm, blood glucose concentration in the normal individual remains constant; because of its regulation by negative feedback mechanism/ release of insulin that stimulated the liver to effect correct measures to maintain a constant glucose concentration;
From 8.30am to 1pm, blood glucose concentration in a diabetic individual decreases because of lack of regulation; its excretion/removal urine;
(c)Glucose is a respiratory substrate for cells e.g. brain cells; thus decrease in blood glucose concentration below norm deprives the cells of energy; resulting into fainting/ketosis;
Excess of glucose in blood above norm; increases the osmotic pressure of blood beyond that of the surrounding cells; drawing water from the cells into blood; dehydrating the cells of the body; enzymatic activities are hindered; impairing cellular metabolism;

11.The table below shows heat losses (-) and heat gains (+) in arbitrary units by a naked man at rest at different environmental temperature. All other environmental conditions are kept constant. (**extracted from Advanced biology by Simpkins and Williams page 392)**

Environmental temperature (℃)	**Heat loss (-) and heat gain(+) in arbitrary units**		
	Skin surface		**Body core**
	By radiation and convection	**By evaporation**	
20.0	-160	-20.0	-120
22.5	-135	-22.5	-85
25.0	-110	-25.0	-50
27.5	-85	-27.5	-20
30.5	-55	-30.0	0
32.5	-25	-60.0	+5
35.0	+5	-100.0	+5
37.5	+40	-140.0	+5
40.0	+80	-180.0	0

(a). On the same axes, plot graphs of heat losses and heat gains by radiation and convection at the skin surface and by evaporation at the skin surface and by body core against environmental temperature.

(b) Describe the relationship between heat loss and gain by the skin surface as result of radiation and convection and heat loss as a result of evaporation from the skin.
(c)How does the relationship in(b) affect the losses and gains of heat by the body core?
(d)Explain the trend of heat losses and gains by the;

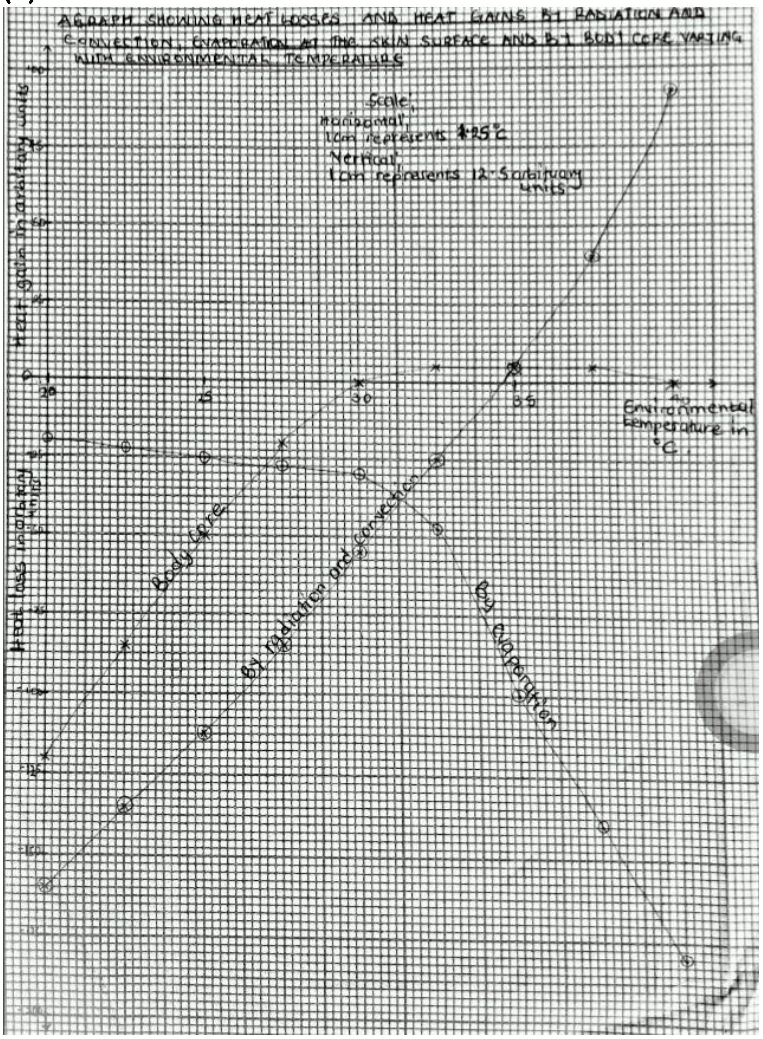
i. Skin surface as result of radiation and convection
ii. Skin surface as a result of evaporation
iii. Body core

(e) What is the importance of maintaining body temperature in animals?

(f) The onset of fever is often accompanied by shivering and a feeling of cold known as chill. Explain these symptoms in terms of the mechanism of control of body temperature.

Possible solutions

(a)



(b)**Between 20℃ and 30℃; as heat loss by evaporation from skin surface increases gradually; heat loss by radiation and convection at the skin surface rapidly decreases;**

Between 30℃ and 40℃; as heat loss by evaporation from skin surface increases rapidly; heat gain by radiation and convection at the skin surface rapidly increases;

(c) From 20℃ to 27.5℃; loss of heat by body core decreases rapidly ; then from 27.5℃ to 30℃; loss of body heat decreases gradually;

From 30℃ to 32.5℃; gain of heat by body core increases gradually; to a maximum; then from 32.5℃ to 37.5℃; gain of heat remains constant. From 37.5℃ to 40℃;gain of heat by body core decreases gradually;

(d) (i) From 35℃ to 40℃;heat gain by skin via radiation increases rapidly; because environmental temperatures are much higher than the body temperature;

From 20℃ to 35℃; heat loss by skin via radiation and convection decreases rapidly because body temperature is slightly lower than the surrounding;

(ii) From 20℃ to 30℃; heat loss from skin surface by evaporation increases gradually; because environmental temperature is slightly higher environmental temperature; allowing less loss of heat through sweating;

From 30℃ to 40℃; heat loss from skin surface by evaporation increases rapidly; because of vaso dilation; and more heat is lost via buccal, nasal and tracheal cavities;

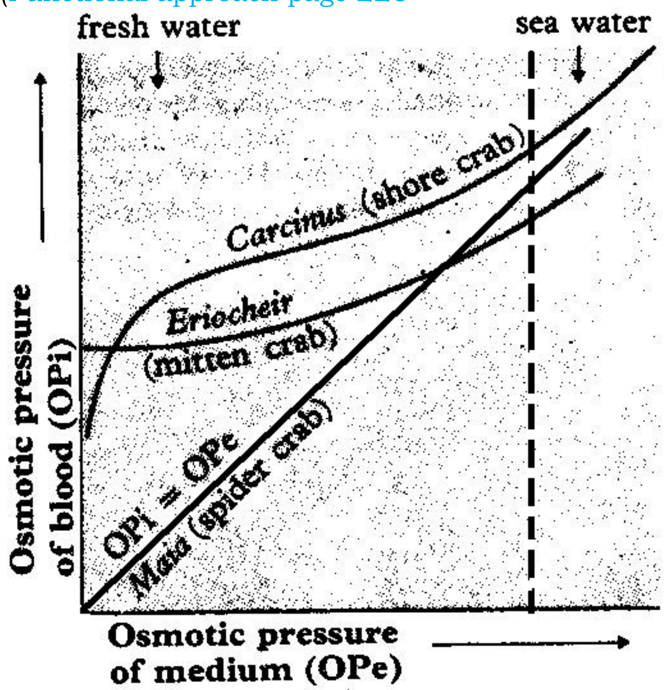
(iii). From 20℃ to 30℃; heat gain by body core increases because body core temperature is lower than norm; heat gain centre in the posterior hypothalamus is stimulated; which stimulates corrective mechanisms that increase heat gain/reduce heat loss; e.g. to the skin to vaso constrict its arterioles; erection of erector pili muscles; raising body hairs that trap air mass around the skin; and improving on insulation; to skeletal muscles to rapidly contract; causing shivering; yielding more energy; to adrenal and thyroid glands to secrete adrenaline and thyroxine hormones respectively; to increase the metabolic rate; to yield large quantities of heat energy; all which bring body core temperature back to norm;

From 30℃ to 40℃; environmental temperature is slightly higher than body core temperature; much heat is gained through radiation; heat loss centre in anterior hypothalamus is stimulated; which stimulates corrective mechanisms that reduce heat gain/increase heat loss; e.g. reduced metabolism; vasa dilation; increased sweating; flattening of hairs; decreased muscular activity; all of which bring the body core temperature to norm;

(d) Enzymes work with a narrow range of temperature; very high temperatures above the norm, denature enzymes; and very low temperatures inactivate enzymes.

(e)Fever is due to resetting of the 'thermostat' in the hypothalamus at a higher temperature; by pyrogens (toxins produced by pathogenic substances or neutrophils); and until the body core temperature rises to that temperature, the normal body temperature is too low; and the body reacts as if it has been cooled; thus responding by shivering; and the body continues to feel cold until the core temperature reaches the temperature of the thermostat in the hypothalamus;

12. The figure below shows the relationship between the internal osmotic pressure of blood(OPi) and external pressure in the surrounding medium(OPe) of three marine invertebrates
(Functional approach page **220**



(a). With reasons, suggest the likely habitat for each animal.
(b) Apart from osmoregulation, state **two** other ways by which marine animals can withstand dilutions of its surrounding environment.

Possible solutions

(a)

Animal	**Likely habitat**	**Reasons**
Carcinus	**Estuarine/brackish water;**	**Can osmoregulate at boundary between sea water and fresh water/ powers of osmoregulation break down if external medium becomes too dilute or too concentrated**
Eriocheir	**Fresh water;**	**Can osmoregulate in fresh water only;**
Maia	**Marine water;**	**Cannot osmoregulate at all**

(b).- Possession of highly tolerant tissues to wide range of salinities.

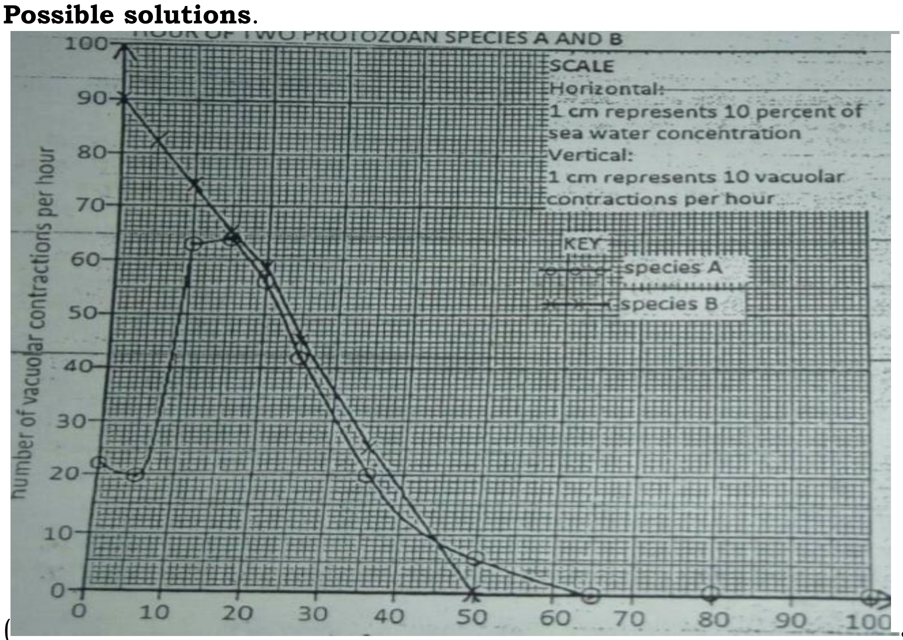
-Behavioral means e.g. the estuarine snail(*Hydrobia*) burrows into the mud when the tide is going out; thus escaping from periodic dilutions of its external medium;

13.In an experiment, two species of protozoans **A** and **B** were exposed to different dilutions of sea water for one hour and the number of vacuolar contractions counted. The following results were obtained.

Concentration of sea water(%)	**Number of vacuolar contractions**	
	Species A	**Species B**
100	0	0
80	0	0
65	0	0
50	6	0
35	20	25
25	42	45
20	56	58
15	64	65
10	63	74
5	20	82
0	22	90

(a) Represent the information on a suitable graph.
(b). Explain the effect of decreasing concentration of sea water on the number of vacuolar contractions in;
 (i) Species **A**
 (ii) Species **B**
(c) State **one** advantage of species **A** over species **B.**
(d) Explain what would happen if small quantities of a mercury compound were added to the 15% concentration of sea water

Possible solutions.



(a).

(b).(i) Decreasing concentration of sea water from 100% to 65%; has no effect on the number of vacuolar contractions; because external osmotic pressure is higher than internal osmotic pressure; water molecules are drawn out of the vacuoles/protozoa by osmosis; Decreasing concentration of sea water from 65% to 35%; gradually increases number of vacuolar contractions; because internal osmotic pressure is slightly higher than the external osmotic pressure; allowing small quantities of water to enter the protozoa/vacuoles by osmosis; Decreasing concentration of sea water from 35% to 15%; rapidly increases the number of vacuolar contractions to a

peak ; because internal osmotic pressure is much higher than the external osmotic pressure; large quantities of water is thus drawn into the protozoa/vacuole by osmosis;
Decreasing concentration of sea water from 15% to 10%; gradually decreases the number of vacuolar contractions; because little salt is actively extruded by protozoa; lowering the internal osmotic pressure slightly below the external osmotic pressure; amount of water entering the protozoa/vacuoles by osmosis gradually decreases;
Decreasing concentration of sea water from 10% to 5%; rapidly decreases the number of vacuolar contractions; because much salt is actively extruded by protozoa; lowering the internal osmotic pressure; far below the external osmotic pressure; allowing much water to leave the protozoa/vacuoles by osmosis. Also osmotic pressure gradient between sea water and protozoa decreases rapidly; reducing the amount of water entering protozoa/vacuoles by osmosis;
Decreasing concentration of sea water from 5% to 0%; slowly increases the number of vacuolar contraction; because internal osmotic pressure is slightly higher than the external osmotic pressure; allowing little quantity of water to enter the vacuoles/protozoa by osmosis again;
(ii) Decreasing concentration of sea water from 100% to 50%; has no effect on the number of vacuolar contractions; because external osmotic pressure is higher than internal osmotic pressure; water molecules are drawn out of the vacuoles/protozoa by osmosis; thus no need to functioning of vacuoles;
Decreasing concentration of sea water from 50% to 0%; rapidly increases the number of vacuolar contractions; to the highest; because internal osmotic pressure is much higher than the external osmotic pressure; large quantities of water is thus drawn into the protozoa/vacuole by osmosis;
(c)Species A can survive in both sea and fresh waters above 5% concentration of sea water because can osmoregulate in decreasing external osmotic pressure/increasing dilutions of sea water; but species B cannot osmoregulate in decreasing external osmotic pressure/increasing dilution of sea water; thus cannot survive in fresh waters; as it may die at minimum external osmotic pressure;
(d) Vacuolar contractions stops; killing both species of protozoa; because mercury a metabolic poison; inhibits enzyme activity during respiration; no energy is produced to power the process of vacuolar contraction;

14. An individual with **juvenile diabetes** was injected with insulin or allowed to inhale insulin (a recent product administered using a nasal spray).
Figure .1.1 shows the concentration of insulin in the blood plasma in the 480minutes after injecting or inhaling insulin. In both cases insulin was of the same type obtained from a genetically engineered *Escherichia coli.*
Figure .1.2 shows the concentration of glucose in the blood plasma in the 480minutes after injecting or inhaling insulin.
Study both graphs and use them to answer the questions that follow.

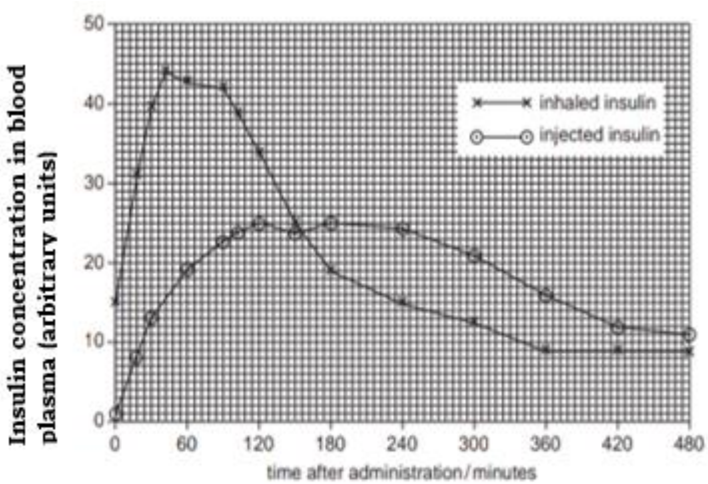


Fig 1.1

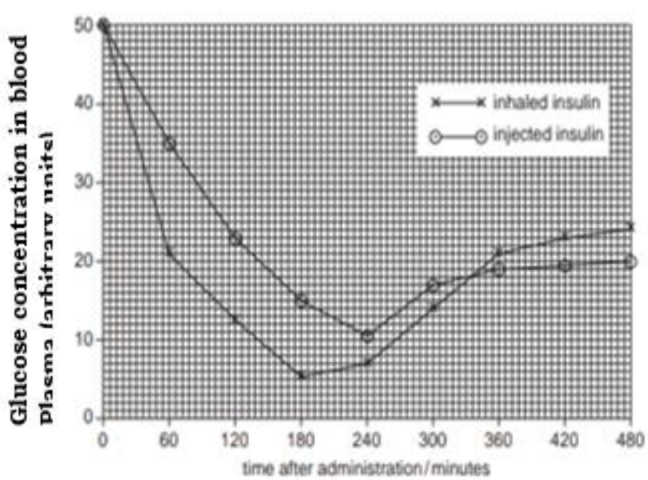


Fig 1.2

(a) What are causes and symptoms of juvenile diabetes?
(b) Compare the levels of injected insulin and inhaled insulin in the blood plasma.
(c) Explain the effect of injected insulin on the blood glucose concentration
(d) Suggest the advantages and disadvantages of inhaling insulin rather than injecting insulin.
(e) Explain the need for regulation of blood glucose concentration

Possible solutions

(a) Majorly caused by autoimmune destruction of $\beta - \text{cells}$ of the islets of Langerhans in the pancreas; thus insufficient quantities of insulin are secreted;
Also caused by Viral infection; and genetic factors;
Its characterized by increased thirst; frequent urination; fatigue; blurred vision; unintended weight loss; bed wetting in children who previously could not wet the bed;

(b) Similarities

In both injected and inhaled insulin,

- **Peak is attained**
- **Blood plasma concentration increases first, then decreases;**
- **Blood plasma concentration remains constant from 420minutes to 480minutes;**

Differences

Inhaled blood insulin concentration	Injected blood insulin concentration
Higher peak attained	**Lower peak attained**
Peaks earlier	**Peaks later**
Higher from 0minutes to 156minutes	**Lower from 0minutes to 36minutes**
Lower from 156minutes to 480minutes	**Higher from 156minutes to 480minutes**
Increases rapidly to a peak from 0minutes to 42minutes	**Increases gradually from 0minutes to 42minutes**
Decreases gradually from 42minutes to 90minutes	**Increases gradually from 42minutes to 90minutes**
Decreases rapidly first the gradually from 90minutes to 240 minutes	**Remains almost constant from 90minutes to 240minutes**

(c) From 0minutes to 240minutes, increase in injected blood insulin concentration, rapidly decreases blood glucose concentration to a minimum; because transportation of injected insulin to the liver; stimulates liver cells to increase rate of glucose oxidation to release energy; convert excess glucose to glycogen and fats; stored in the liver, muscle and adipose tissue beneath the skin respectively; subsequently lowering the blood glucose concentration;
From 240minutes to 420minutes, decrease in injected blood insulin concentration, gradually increases blood glucose concentration because it lowers the uptake of glucose by cells;

(d) Advantages

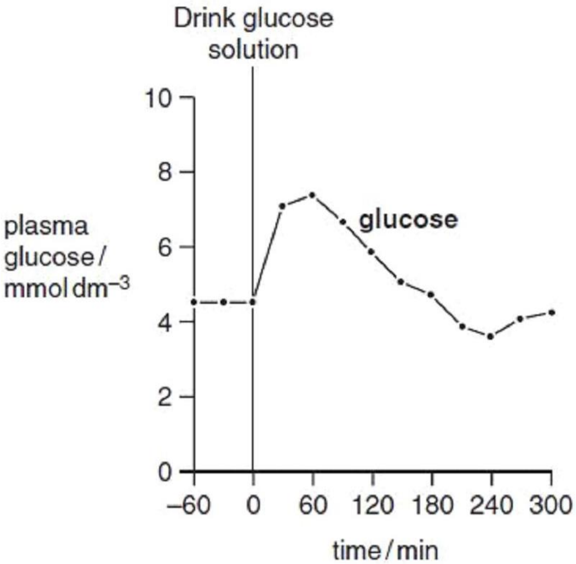
- **faster response time**
- **less chance of infection/contamination**
- **applicable for people with needle phobia**

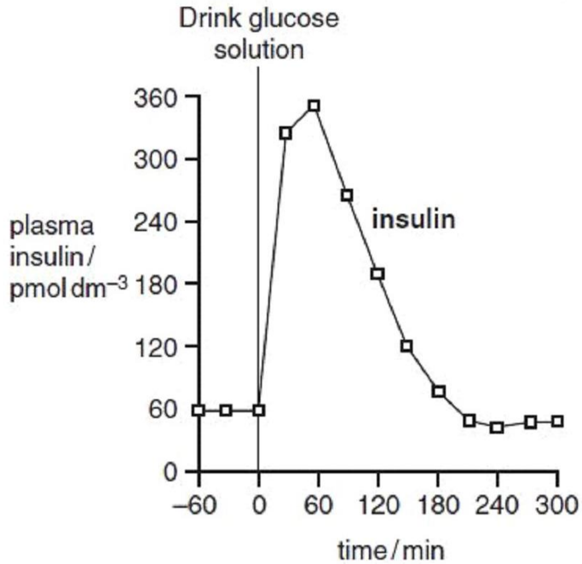
disadvantages

- **could cause larger swings in blood glucose concentration**
- **not long lasting; thus need to be taken frequently**
- **possible variability of the dose**

(e) Glucose is a respiratory substrate for cells e.g. brain cells; thus decrease in blood glucose concentration below norm deprives the cells of energy; resulting into fainting/ketosis;
Excess of glucose in blood above norm; increases the osmotic pressure of blood beyond that of the surrounding cells; drawing water from the cells into blood; dehydrating the cells of the body; enzymatic activities are hindered; impairing cellular metabolism;

15. Figures **6.1** and **6.2** show the concentration of glucose and insulin in blood plasma before and after a glucose drink. Study them carefully and answer the questions that follow.





(a) Describe the changes in the blood glucose concentration after a glucose drink
(b) From figures above, explain how changes in blood glucose concentration cause
  (i) an increase in concentration of insulin in plasma
  (ii) a subsequent fall in concentration of insulin in plasma
(c) Describe the role of the hormone glucagon in maintaining the concentration of blood glucose.
(d) Why is it significant to regulate the blood glucose level?
(e) Other than the concentration of glucose in blood, what other factors must be regulated in the internal environment?

Possible solutions

(a) From 0minutes to 60 minutes, blood glucose concentration increases first rapidly; then gradually to a peak;
From 60minutes to 240minutes, blood glucose concentration decreases rapidly;
From 240minutes to 300minutes, blood glucose concentration increases gradually; to norm;

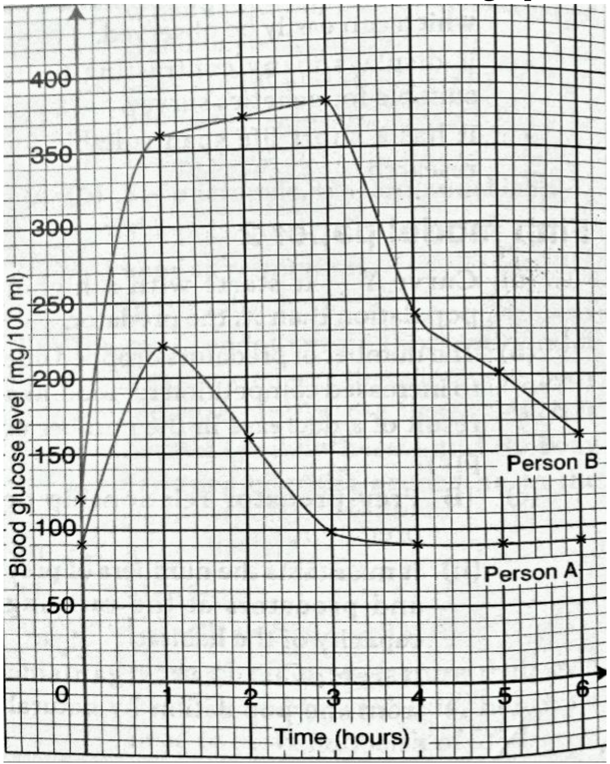
(b) **(i) From 0minutes to 60 minutes, insulin concentration in plasma increases first rapidly; then gradually to a peak because increase in blood glucose concentration above the norm (90mg/100cm^3); due to absorption from the gut; stimulates secretion of insulin hormone by β-cells of the islets of Langerhans; in the pancreas; into the blood stream, to lower the glucose concentration back to the norm;**
(ii) From 60minutes and 240minutes; insulin concentration in plasma decreases rapidly; because lowering of glucose concentration to norm; due to its conversion to glycogen or fats, oxidation by tissues; inhibits secretion of insulin hormone by the by β-cells of the islets of Langerhans; and insulin is broken down;

(c) Decrease in blood glucose concentration below norm; stimulates secretion of glucagon hormone by ∝-cells of the islets of Langerhans; in the pancreas; into the blood stream, transported to the liver; stimulating the liver cells to convert the glycogen into glucose; synthesis of glucose from amino acids and fatty acids (non-carbohydrate sources) by gluconeogenesis; decreased metabolism; all increasing the blood glucose concentration back to norm;

(d) Glucose is a respiratory substrate for cells e.g. brain cells; thus decrease in blood glucose concentration below norm deprives the cells of energy; resulting into fainting/ketosis;
Excess of glucose in blood above norm; increases the osmotic pressure of blood beyond that of the surrounding cells; drawing water from the cells into blood; dehydrating the cells of the body; enzymatic activities are hindered; impairing cellular metabolism;

(e) Carbon dioxide concentration of blood; temperature of the body; blood pressure; pH of blood; concentration of ions; and osmotic pressure of blood and tissue fluid.

16. In an investigation, two persons **A** and **B,** drunk the same amount of glucose solution. Their blood sugar levels were determined immediately and thereafter at intervals of one hour for the next six hours. The results are shown in the graph below.



(a)Compare the levels of blood glucose between diabetic and normal individual.

(b) Account for the observed pattern of the levels of blood glucose in the two individuals.

(c) Why is it significant to regulate the blood glucose level

Possible solutions

(a) <u>similarities</u>.

In both persons A and B,

Blood glucose concentration increases; to a peak; and then decreases;

Both have same blood glucose concentration initially

<u>Differences.</u>

Person A	Person B
Blood glucose concentration increases rapidly from 0hours to 1hour;	**Blood glucose concentration increases rapidly first the gradually; from 0hours to 3hours**
Lower peak is attained	**Higher peak is attained**
Peak is attained earlier/ at 1hour;	**Peak is attained later/ at 3hours**
Blood glucose concentration is lower throughout the time of experiment	**Blood glucose concentration is higher throughout the time of experiment**
Blood glucose concentration decreases rapidly from 1hour to 3hour;	**Blood glucose concentration increases gradually/slowly from 1hour to 3hour;**
Blood glucose concentration decreases gradually from 3hours to 4hours; to the norm;	**Blood glucose concentration decreases rapidly from 3hours to 4hours;**
Blood glucose concentration remains constant from 4hours to 6hours;	**Blood glucose concentration decreases gradually from 4hours to 6hours**

(ii) From 0hours to 1hour, blood glucose concentration increases due to absorption after digestion;

Higher peak is attained in person B because of lack of regulatory mechanisms/insulin/malfunctioning pancreas.

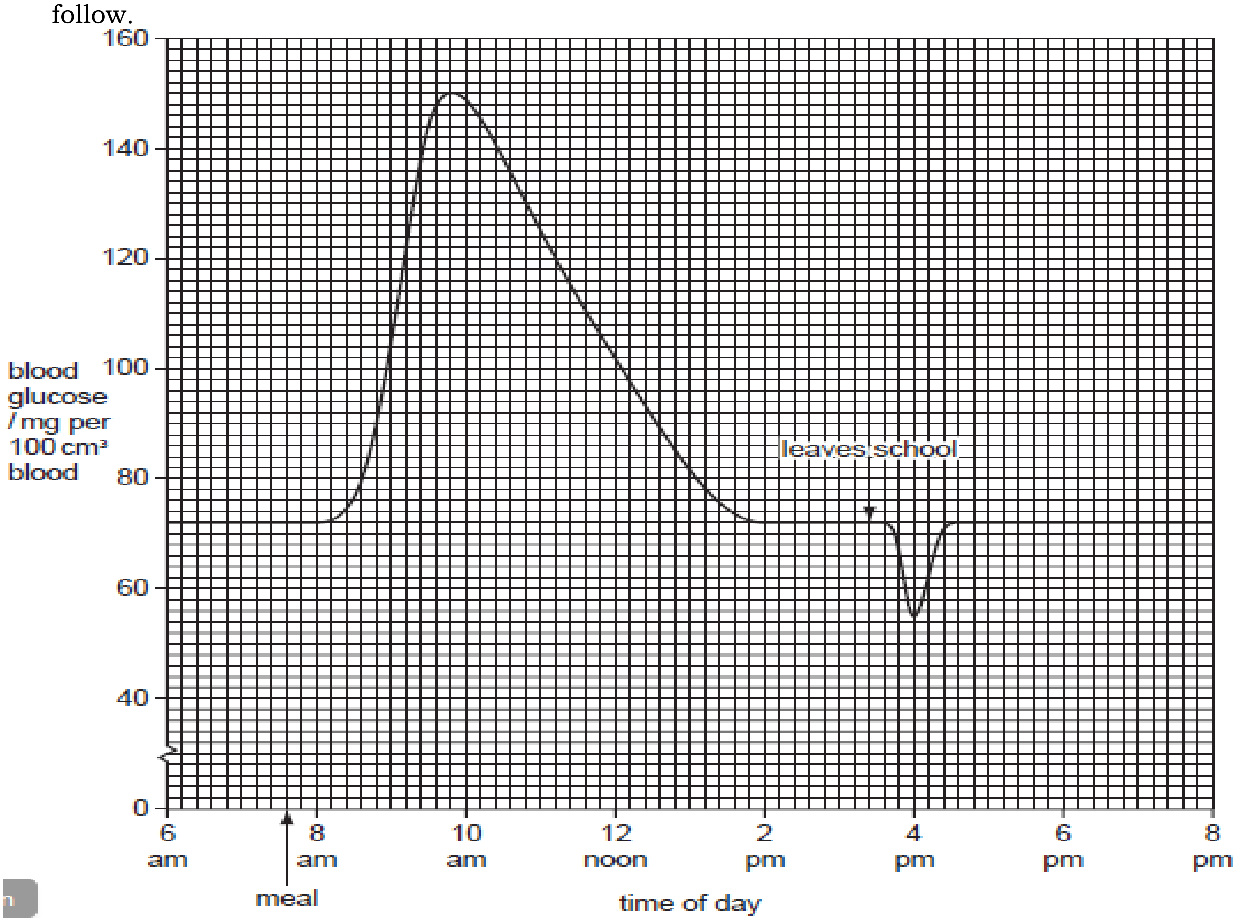
From 4hours to 6hours, blood glucose concentration in person A remains constant; because of its regulation by negative feedback mechanism/ release of insulin that stimulated the liver to effect correct measures to maintain a constant glucose concentration;

From 3hours to 6hours blood glucose concentration in person b decreases because of its excretion/removal urine; and respiration;

(c)Glucose is a respiratory substrate for cells e.g. brain cells; thus decrease in blood glucose concentration below norm deprives the cells of energy; resulting into fainting/ketosis;

Excess of glucose in blood above norm; increases the osmotic pressure of blood beyond that of the surrounding cells; drawing water from the cells into blood; dehydrating the cells of the body; enzymatic activities are hindered; impairing cellular metabolism;

17. The graph in the figure below shows the blood glucose concentration of a boy over a 14-hour period. The boy was involved in a fight at 3.36pm on leaving school. Study it carefully and answer the questions that follow.



Possible solutions

(a) From 6am to 8:12am, blood glucose concentration remains constant;
From 8:12am to 9:48am, blood glucose concentration increases rapidly; to a peak;
From 9:48am to 1:48pm, blood glucose concentration decreases rapidly; to the norm/set point;

(b) (i) From 6am to 8:12am, blood glucose concentration remains constant because no absorption of glucose occurred;
From 8:12am to 9:48am, blood glucose concentration increases rapidly; to a peak; because of its absorption from the gut after the meal;
From 9:48am to 1:48pm, blood glucose concentration decreases rapidly; to the norm/set point; because absorption of glucose from the gut, increases the blood glucose concentration above the norm(90mg/100cm³); stimulating secretion of insulin hormone by β-cells of the islets of Langerhans; in the pancreas; into the blood stream, to lower the glucose concentration back to the norm;
(ii) On leaving school, blood glucose concentration decreases to a minimum; because the boy involved in a fight, a highly energy demanding activity; thus increased aerobic respiration of glucose /increased metabolism occurred; to generate energy for muscle contraction;

(c) Adrenaline (Epinephrine);
Increases rate and force of heartbeat;
Constriction of skin and blood capillaries;
Dilation of the arterioles of the heart and skeletal muscles;
Raises blood glucose level;

(d) Glucose is a respiratory substrate for cells e.g. brain cells; thus decrease in blood glucose concentration below norm deprives the cells of energy; resulting into fainting/ketosis;
Excess of glucose in blood above norm; increases the osmotic pressure of blood beyond that of the surrounding cells; drawing water from the cells into blood; dehydrating the cells of the body; enzymatic activities are hindered; impairing cellular metabolism;