Principles of Homeostasis and Negative Feedback

These practice questions can be used by students and teachers and is

Suitable for AQA A Level 7402 Biology Topic Question

Level: AQA A LEVEL 7402

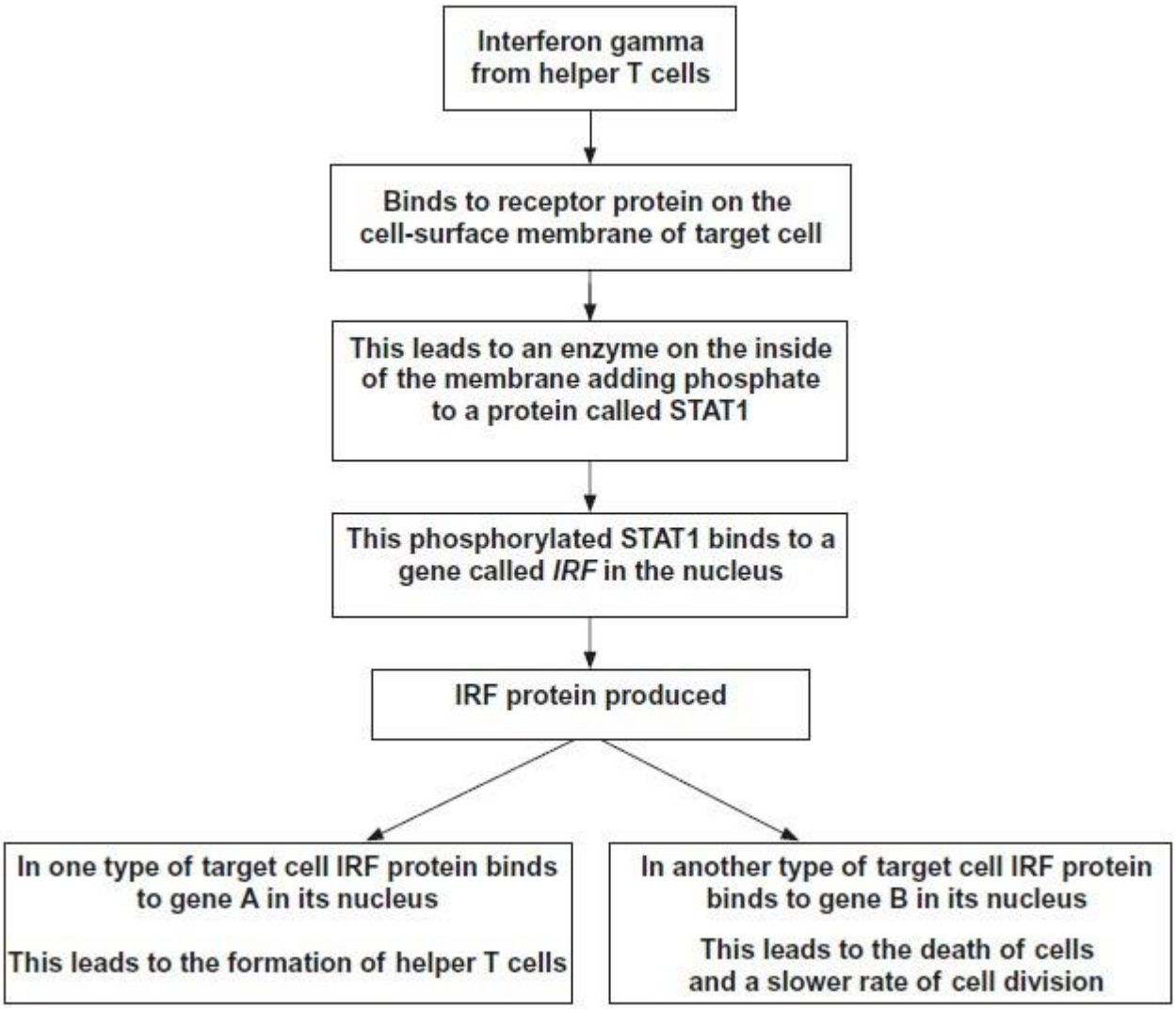
Subject: Biology

Exam Board: AQA A Level 7402

Topic: Principles of Homeostasis and Negative Feedback

1 Interferon gamma is a substance secreted by some types of white blood cells, including helper T cells. It regulates the production of a number of proteins by target cells. Which protein is produced depends on the type of target cell.

The diagram shows how interferon gamma regulates three genes.



(a) Use information in the diagram to suggest how the binding of interferon gamma to itsreceptor protein leads to the production of phosphorylated STAT1.

_____

_____

_____

_____

(2)

(b) Name the **two** transcription factors in the diagram.

1. _____

2. _____

(2)

(c) The regulation of the formation of helper T cells by interferon gamma is an example ofpositive feedback.

Explain why it is an example of positive feedback.

_____

_____

_____

_____

(2)

(d) The *IRF* gene can be a tumour suppressor gene.

Use the information in the diagram to explain how the *IRF* gene acts as a tumour suppressor gene.

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(3)

(Total 9 marks)

Scientists investigated the control of blood glucose concentration in mice. They kept a group of

2

normal mice without food for 48 hours. After 48 hours, the blood glucose concentrations of the mice were the same as at the start of the experiment.

(a) Explain how the normal mice prevented their blood glucose concentration falling when they had **not** eaten for 48 hours.

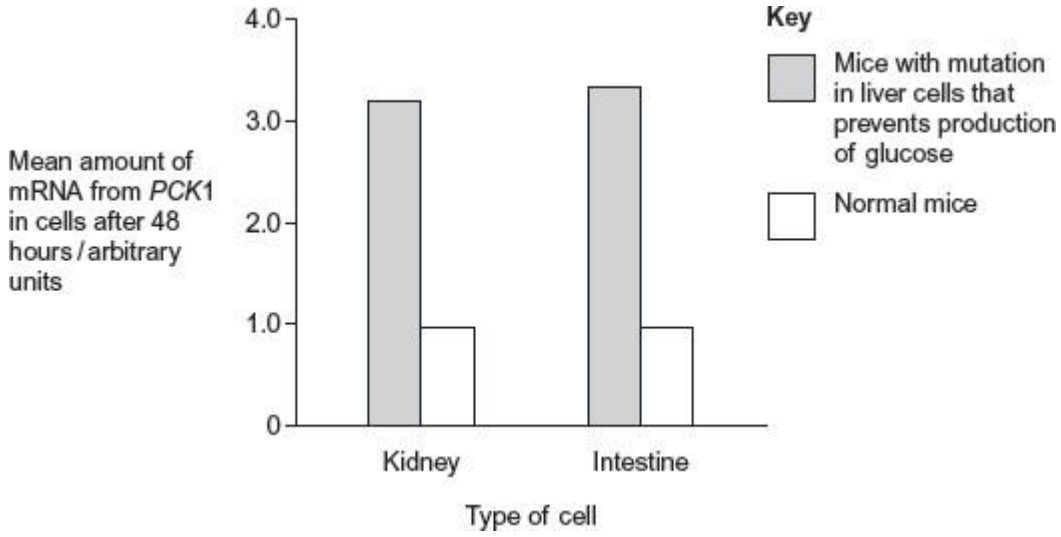
[Extra space]

(3)

The scientists then investigated mice with a mutation that prevents their liver cells making glucose. They kept a group of these mice without food for 48 hours. After 48 hours, the mean blood glucose concentrations of the mutant mice and the normal mice were the same.

The scientists investigated how blood glucose concentration is controlled in these mutant mice. An enzyme required for synthesis of glucose is coded for by a gene called *PCK*1. The scientists measured the mean amount of mRNA produced from this gene in cells from the kidneys and intestines of normal mice and mutant mice. They did this with mice that had previously been without food for 48 hours.

The scientists' results are shown in the graph.



(b) Use information from the graph to suggest how blood glucose concentration is controlled inthe mutant mice, compared with the normal mice.

[Extra space]

(3)

(c) The scientists performed statistical tests on the data shown in the graph, to see whetherthe differences in the amount of mRNA in cells from normal and mutant mice were significant. Both the probability values they obtained were $p<0.01$.

Explain what this means about the differences in the amounts of mRNA produced.

[Extra space]

(2)

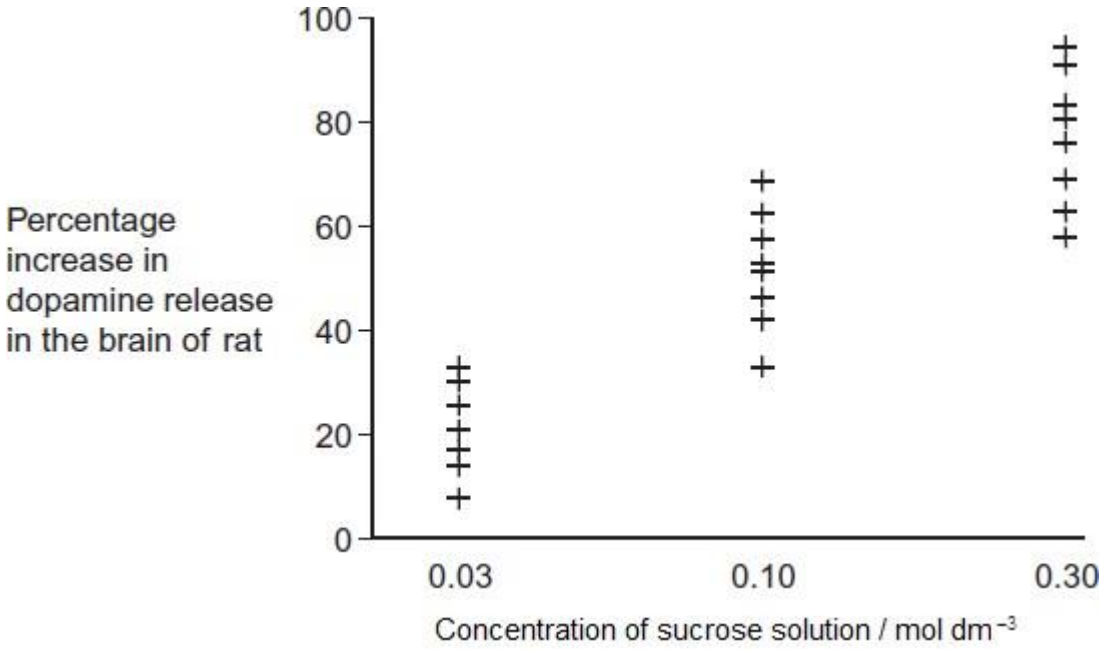
(Total 8 marks)

3 The release of a substance called dopamine in some areas of the brain increases the desire to eat.

Scientists measured increases in the release of dopamine in the brains of rats given different concentrations of sucrose solution to drink.

Sucrose stimulates taste receptors on the tongue.

The graph shows their results. Each point is the result for one rat.



(a) The scientists concluded that drinking a sucrose solution had a positive feedback effect on the rats' desire to eat.

How do these data support this conclusion?

*(Extra space)*_____

(3)

(b) In this investigation, the higher the concentration of sucrose in a rat's mouth, the higher thefrequency of nerve impulses from each taste receptor to the brain.

If rats are given very high concentrations of sucrose solution to drink, the refractory period makes it impossible for information about the differences in concentration to reach the brain. Explain why.

(2)

(c) In humans, when the stomach starts to become full of food, receptors in the wall of thestomach are stimulated. This leads to negative feedback on the desire to eat. Suggest why this negative feedback is important.

*(Extra space)*_____

(3)

(Total 8 marks)

Different substances are involved in coordinating responses in animals.

4

(a) Synapses are unidirectional. Explain how acetylcholine contributes to a synapse beingunidirectional.

_____

_____

_____

_____

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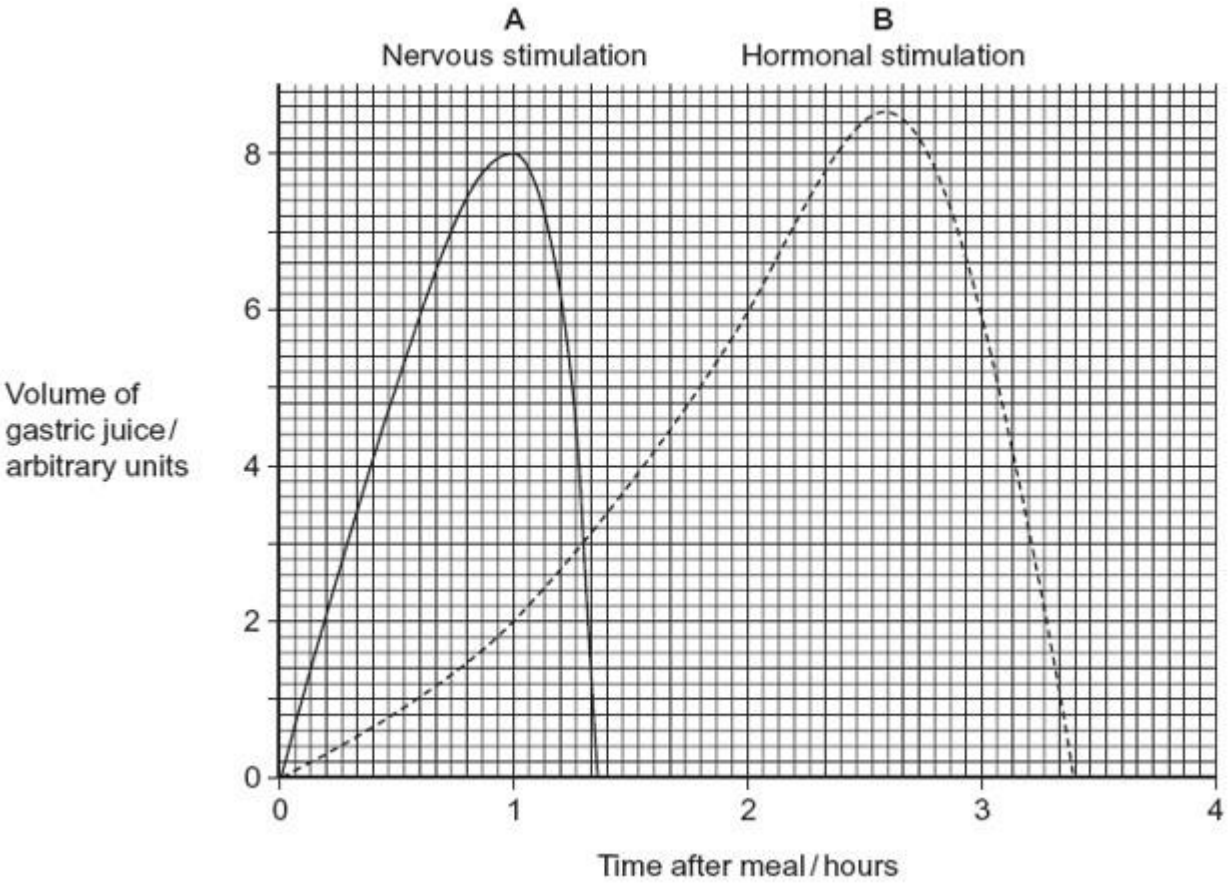
(2)

(b) Cells in the stomach wall release gastric juice after a meal. The graph shows how thevolumes of gastric juice produced by nervous stimulation and by hormonal stimulation change after a meal.



(i) Describe the evidence from the graph that curve **A** represents the volume of gastric juice produced by nervous stimulation.

_____

_____

_____

_____

(2)

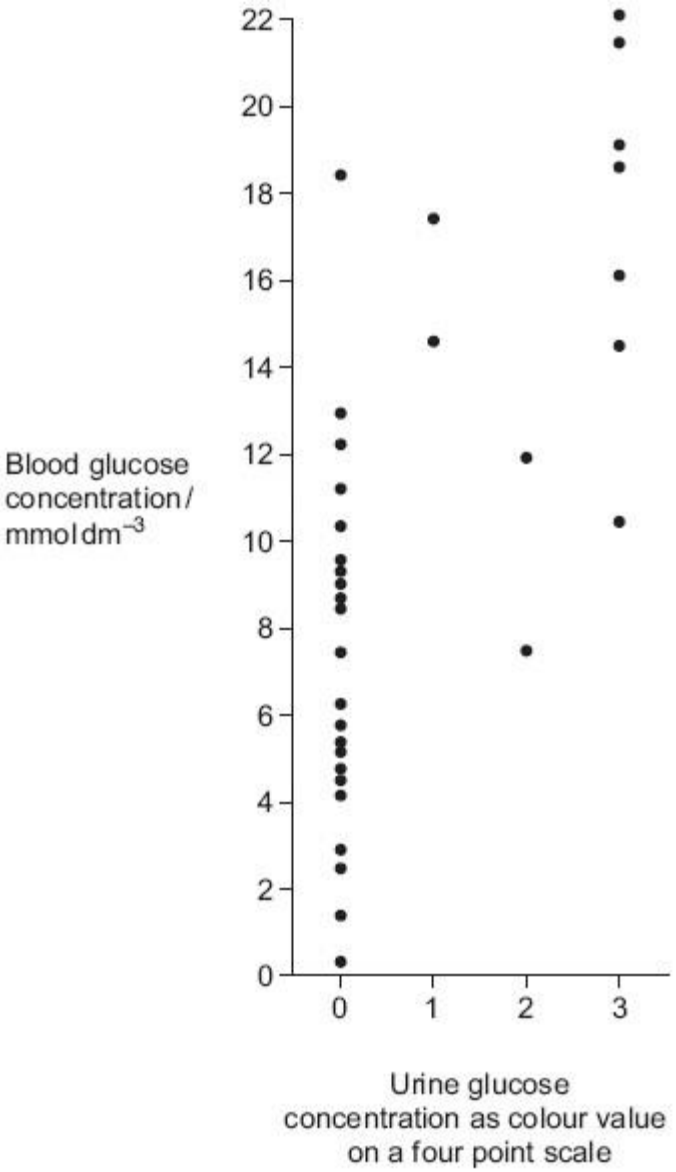
(ii) Complete the table to show the percentage of gastric juice produced by nervousstimulation at the times shown.

	Ti ne after meal / ho ırs		
	1	**2**	**3**
Percentage of gastric juice produced by nervous stimulation			

(1)

(Total 5 marks)

5 (a) Technicians in a hospital laboratory tested urine and blood samples from a girl with diabetes at intervals over a one-year period. Each time the technicians tested her urine, they also measured her blood glucose concentration. Their results are shown in the graph.



(i) The girl who took part in this investigation was being successfully treated with insulin.The graph shows that on some occasions, the concentration of glucose in her blood was very high. Suggest why.

_____

_____

_____

_____

(2)

(ii) Use the graph to evaluate the use of the urine test as a measure of blood glucoseconcentration.

_____

_____

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(3)

(b) Diabetic people who do not control their blood glucose concentration may become unconscious and go into a coma. A doctor may inject a diabetic person who is in a coma with glucagon. Explain how the glucagon would affect the person's blood glucose concentration.

_____

_____

_____

_____

(2)

(Total 7 marks)

6 (a) The control of water balance in the body involves negative feedback.

(i) Describe what is meant by *negative feedback*.

_____

_____

_____

(1)

(ii) Water is removed from the body via the kidneys. Give **two** other ways in which water is removed from the body.

1. _____

2. _____

(2)

(iii) Name the part of the brain which acts as the coordinator in the control of water balance.

_____

(1)

(b) **Figure 1** shows the cells lining the collecting duct in a human kidney. ADH molecules bind to the receptor proteins and this triggers the vesicles containing aquaporins to bind with the plasma membrane next to the lumen. **Figure 2** shows an aquaporin which is a large channel protein.

Figure 1

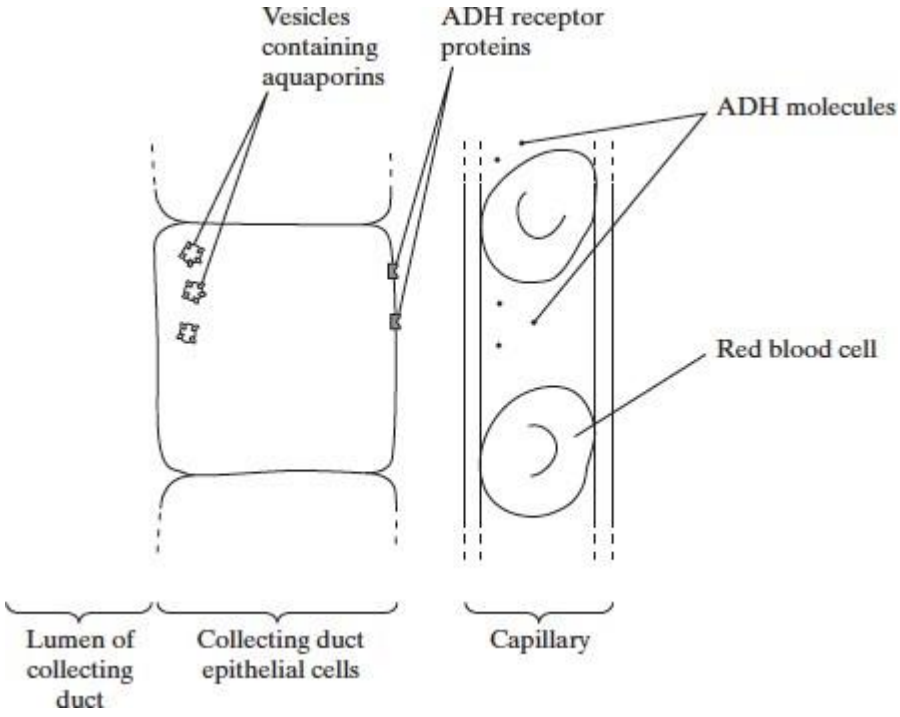
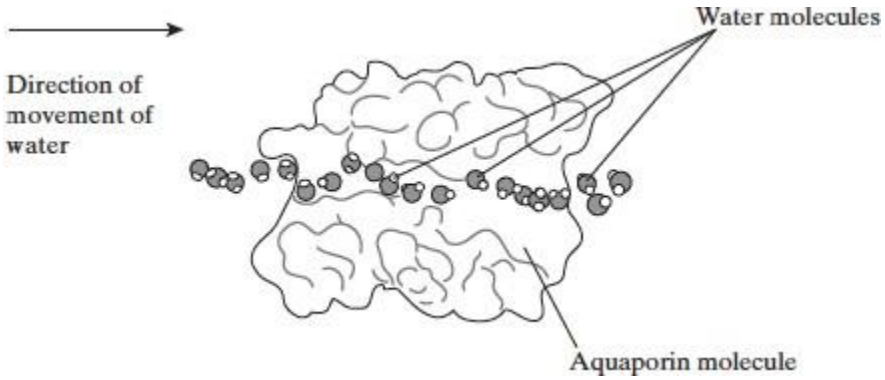


Figure 2



(i) From which gland is ADH released?

_____

(1)

(ii) Use the information given to explain how ADH increases the movement of water fromthe lumen of the collecting duct into the blood.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(c) The gene for the ADH receptor proteins is found on the X chromosome. One allele of this gene causes a non-functioning receptor protein to be made. This allele is recessive and is one cause of the condition called diabetes insipidus.

(i) What would be the most obvious symptom of diabetes insipidus?

_____

(1)

(ii) Suggest why diabetes insipidus is more common in males.

_____

_____

_____

_____

(2)

(iii) A recessive allele which has harmful effects is able to reach a higher frequency in apopulation than a harmful dominant allele. Explain how.

_____

_____

_____

_____

_____

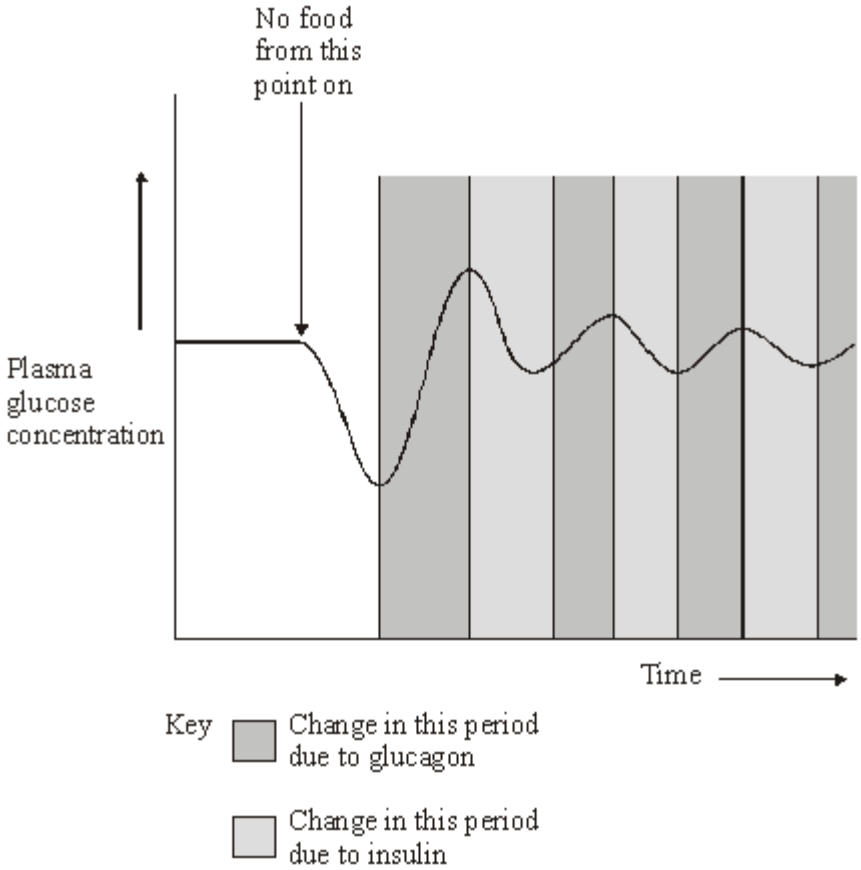
_____

(3)

(Total 15 marks)

7 Homeostatic mechanisms maintain a constant environment in the body.

(a) The graph shows changes in plasma glucose concentration that occurred in a person who went without food for some time.



Use evidence from the graph to explain the role of negative feedback in the control of plasma glucose concentration.

(5)

(b) How does maintaining a constant body temperature allow metabolic reactions in cells to proceed with maximum efficiency?

(5)

(Total 10 marks)

8 (a) What is homeostasis?

(1)

(b) Describe the role of the hormone glucagon in the control of blood sugar concentration.

_____

_____

(4)

(c) The kidney removes various substances from the blood plasma. The clearance value for asubstance is the volume of blood cleared of that substance by the kidney in one minute. This clearance value can be calculated using the equation.

$$C = \frac{U \times V}{P}$$

where the concentration of a substance in the blood is P g cm^{-3}

the concentration of a substance in the urine is U g cm^{-3}

the volume of urine produced is V cm^3 per minute

(i) Use the equation to work out the clearance value of glucose.

_____

_____

(1)

(ii) Explain how the activity of the kidney results in this clearance value for glucose.

_____

_____

_____

_____

_____

_____

(3)

(Total 9 marks)

9 (b) (i) What is meant by homeostasis?

_____

_____

(1)

(ii) Giving **one** example, explain why homeostasis is important in mammals.

(2)

(c) Cross-channel swimmers may suffer from muscle fatigue during which the contractionmechanism is disrupted. One factor thought to contribute to muscle fatigue is a decrease in the availability of calcium ions within muscle fibres. Explain how a decrease in the availability of calcium ions could disrupt the contraction mechanism in muscles.

(3)

(Total 6 marks)

10 (a) *Salmonella typhimurium* causes food poisoning in humans but not in other mammals.

Explain why these bacteria attach to human cells but not to the cells of other mammals.

(2)

S (b) Salmonella bacteria release toxins that cause the body temperature to rise. Although a small increase in body temperature can be beneficial, a large increase can cause serious harm.

Explain how a large increase in a person's body temperature can cause harm.

_____

_____

_____

_____

(2)

S (c) Some species of bacteria, which live in soil and decompose organic material, release exotoxins. Suggest how the release of exotoxins benefits the bacteria.

_____

_____

(1)

(d) Washing hands with anti-bacterial soap reduces the risk of transmission of the bacteria that cause food poisoning. Tea tree oil is a plant extract used in soaps. It is claimed to have anti-bacterial properties. Outline a method for investigating this claim.

_____

_____

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_____

_____

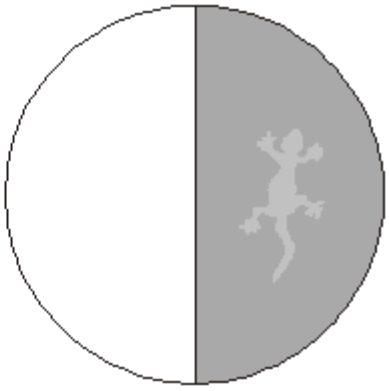
(4)

(Total 9 marks)

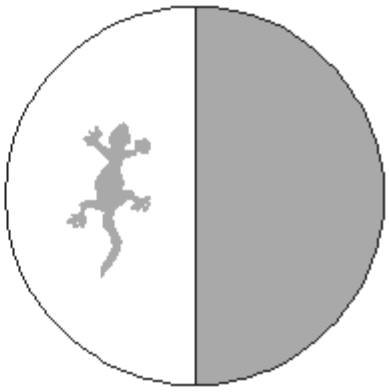
11 The body temperature of desert-living lizards is greatly affected by the temperature of their environment. A lizard was placed in a chamber where one half was maintained at 20 °C and the other at 40 °C. The lizard was free to move from one half to the other. The lizard's behaviour was observed using an infra-red camera, which records 20 °C surfaces as black and 40 °C surfaces as white. Temperatures between 20 °C and 40 °C appear as shades of grey. A series of photographs was taken.

40°C side 20°C side

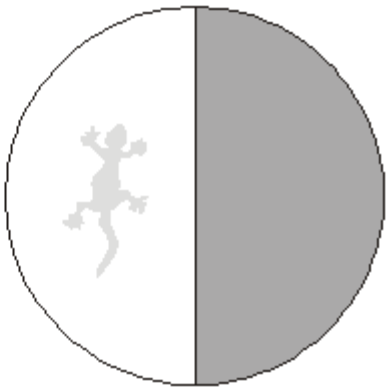
Photograph **1**
The lizard had been in the
20°C side for several minutes



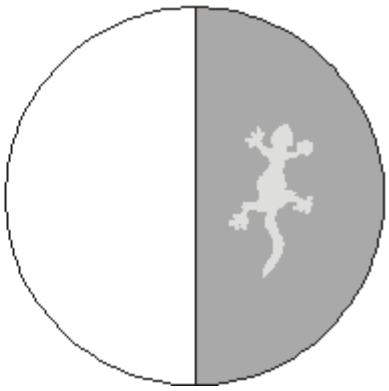
Photograph **2**
The lizard then moved
to the 40°C side



Photograph **3**
The lizard had been in the
40°C side for several minutes



Photograph **4**
The lizard then moved
to the 20°C side



(a) The position and appearance of the lizard, as recorded by the infra-red camera, changedduring the experiment. Describe and explain these changes.

(3)

(b) Suggest the advantage to the lizard of the behaviour shown.

(2)

(Total 5 marks)

12 (a) **Figure 1** shows the structure of a molecule of glycerol and a molecule of fatty acid.

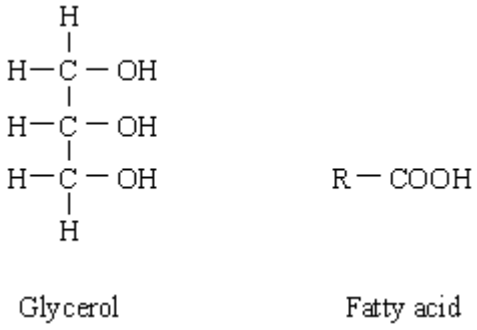


Figure 1

Draw a diagram to show the structure of a triglyceride molecule.

(2)

(b) Explain why triglycerides are **not** considered to be polymers.

_____

_____

(1)

(c) **Figure 2** shows two types of fat storage cell. Mammals living in cold conditions have more brown fat cells than mammals living in tropical conditions.

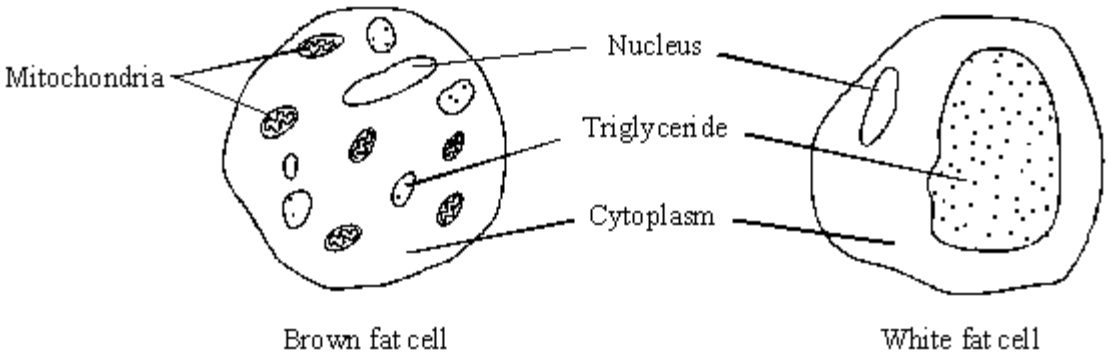


Figure 2

Using evidence from **Figure 2** to support your answer, suggest how the function of brown fat cells differs from that of white fat cells.

_____

_____

_____

_____

_____

(3)

(Total 6 marks)

Mark schemes

1

(a) 1. Binding (of interferon gamma) changes shape/tertiary structure of receptor (protein);

2. This activates/switches on the enzyme;

3. Use of ATP (to phosphorylate STAT1);

1. Accept reference to second messenger mechanism/process3.

Context is important

2 max

(b) 1. Phosphorylated STAT1;

2. IRF (protein);

Accept in either order

1. Must be phosphorylated but accept STAT1P

2. Ignore references to phosphorylated

2

(c) 1. Causes more helper T cells to form;

2. (So) more interferon (gamma) production (by helper T cells);

1. and 2. require idea of more

2

(d) 1. (Tumour suppressor gene) slows cell division/causes death ofdamaged/tumour/cancer cells;

2. *IRF* gene leads to formation of IRF (protein) that binds to gene B;

3. (Gene B protein) causes death of damaged/mutated cells ORslows division;

2. 'It' means IRF gene

3. Context is important

*3. If clearly stated **and** includes the protein, scores 2 marks because it subsumes point 1*

3

[9]

2

(a) 1. Release of glucagon;

2. Leads to formation of glucose in liver (cells);

Reject: glucagon breaks down glycogen, or any other biological molecule

3. From non-carbohydrates / amino acids / fatty acids.

Accept: gluconeogenesis / references to glycogen as source of glucose

3

(b) 1. Mutant mice (mRNA suggests) make a lot of (the) enzyme;*Accept: PCK1 made (for enzyme made)*

2. Mutant mice use kidney / intestine (cells) to make glucose;*Accept: use other organ (than liver)*

3. Normal mice do this much less / normal mice use liver cells.

3

(c) 1. Differences significant;

Reject: references to results being significant once

2. Probability of difference being due to chance less than 0.01 / 1% / 1 in 100 / probability of difference not being due to chance more than 0.99 / 99% / 99 in 100.

Ignore: references to 0.05 / 5% / 5 in 100

2

[8] (a) 1. Positive correlation between sucrose and dopamine concentrations / higher

3

concentration of sucrose, more dopamine;

***Q** NB question is 'How do these ...', not 'Do these ....*

1. Ignore simple statements of numbers from graph withoutdescription of trend

2. So (dopamine) makes them want to drink / eat more (sucrose);

3. Positive feedback because drinking / eating leads to wanting to drink / eat (even) more;

3. It must be a clear statement of why this example is positive feedback, not inferred from points 1 and 2

3

(b) 1. (Refractory period) leads to discrete / separate nerve impulses / time whenanother nerve impulse can't happen;

OR

(Refractory period) limits number of impulses per second / frequency of nerve impulses;

2. When maximum frequency reached / exceeded, no further increase in information / all (higher) concentrations of sucrose seem the same;

2

(c) 1. (Negative feedback) stops desire / wish to eat / appetite;

1. Accept stops dopamine release (in this context)

1. *Accept makes them feel full*

2. (This) limits amount eaten / stops eating;

2. *Accept prevents constant eating*

3. Prevents / reduces risk of obesity / too much energy intake;

3. Accept prevents vomiting

Accept descriptions based on what would happen in absence of the feedback mechanism - or if stomach empty for points 1 and 2

3

[8]

4

(a) 1. (Acetylcholine) released from / in presynaptic side;

2. Receptors in postsynaptic (side) / binds on postsynaptic (side);

2. Mark for diffusion only awarded in context of unidirectional movement.

2

(b) (i) 1. Rapid response;

2. Short duration;

Specific wording is not important. It is the principles that matter here.

Points may be made by referring to figures.

2

(ii)

	1	2	3
Percentage	80	0	0

Ignore % sign.

1

5

[5] (a) (i) Eaten;

Containing carbohydrate / sugar;

Glucose absorbed from intestine / into blood;

Long time after insulin injection / needs more insulin / has not taken insulin;

Does not convert glucose to glycogen / glucose not taken up from blood;

2 max

(ii) Shows positive correlation / directly proportional;

A range of results for a particular value / values (for different colours) overlap;

Urine test only an arbitrary scale / not directly related to concentration / colour is subjective / few colour values;

Accept description

3

(b) Glycogen to glucose / glycogenolysis by activating enzymes;

If name incorrect this disqualifies.

Gluconeogenesis;

Allow explanation in terms of glucose from a non-carbohydrate / named non-carbohydrate source.

2

[7]

6

(a) (i) where a change triggers a response which reduces the effect of a change;

1

(ii) e.g. sweating, breathing, defaecating, other valid example;

(reject respiration evaporation not acceptable as a 2nd mark if sweating or breathing given)

2 max

(iii) hypothalamus;

1

(b) (i) pituitary;

(ignore anterior pituitary)

1

(ii) 1. ADH causes vesicles containing aquaporins / aquaporins to be insertedinto membrane / collecting duct wall / plasma;
2. water enters cell through aquaporins;
3. by osmosis / diffusion / down a water potential gradient;
4. (from cell) to capillary;
5. via interstitial fluid;

4 max

(c) (i) excessive urination / drinking / diluted urine / thirst;

1

(ii) because males only have one X chromosome / do not have Y chromosome;a single copy of the recessive allele will be expressed;

2

(iii) recessive alleles can be carried by individuals without showing effects /dominant allele always expressed; organism that are carriers more likely to reproduce / affected organism less likely to reproduce; therefore recessive alleles are more likely to be passed on / dominant alleles less likely to be passed on;

3

[15]

Quality of Communication

7

The answers to all sections of this question require the use of continuous prose.
Quality of language should be considered in crediting points in the scheme. In order to gain credit, answers should be expressed logically and unambiguously, using scientific terminology where appropriate.

(a)
1. Deviation of a value from norm initiates corrective mechanisms;
2. fluctuations in plasma glucose concentration detected by hypothalmus / isletcells in pancreas;
3. initial decrease, no food given (in plasma glucose) stimulates (increased) secretion of glucagon;
4. increases (in plasma glucose) stimulate (increased) secretion of insulin from βcells as secretors;
5. correct ref. to interconversion of glycogen / glucose / increased / decreaseduptake of glucose by cells (as appropriate) / correct ref to change in membrane permeability;

5

(b)
1. Body temp. / 37 °C is optimum temp for enzymes;
2. excess heat denatures enzymes / alters tertiary structure / alters shape ofactive site / enzyme so substrate cannot bind / eq;
3. reactions cease / slowed;
4. too little reduces kinetic energy of molecules / moleculesmove more slowly;
5. fewer collisions / fewer ES complexes formed'

5

[10] (a) Maintaining a constant internal environment;

8

1

(b) Binds to (specific) receptor;
On muscle / liver cell;
Activation of enzymes (in liver);

Hydrolysis of glycogen;
(Facilitated) diffusion of glucose out of (liver cells) cells;
Increases blood glucose levels;

4

(c) (i) 0 / zero;

1

(ii) 1. Filtration, out of blood (plasma) / into renal capsule;
2. (Hydrostatic) pressure ;
3. PCT;
4. All reabsorbed;
5. Active transport;

3 max

[9]

9 (a) (i) maintaining a constant internal environment;

1

(ii) *one mark for example of factor kept constant; one mark for explaining its importance;*

e.g.
temperature / pH; optimum for enzymes / effect of pH / temperature on enzyme activity;

OR

water potential / blood glucose;
effect of osmotic / blood glucose imbalance on cells;

2 max

(b) cannot interact with / move tropomyosin from binding sites on actin;
(reject active sites) myosin(heads) do not bind /
actinomyosin not formed; does not activate ATPase /
energy not released from ATP;

3

[6]

10 (a) bacteria have ligands / antigens / proteins / glycoproteins / polysaccharides (on membrane / wall);

1

complementary to receptors / fits / binds / attaches to specific receptor

1

(b) enzymes denatured / tertiary / secondary structure altered / alteredactive sites / breaks hydrogen bonds;

1

prevents named chemical reactions / metabolic pathways;

1

(c) inhibits / kills other bacteria / fungi / decomposers / reduces competition;

1

(d) 1 prepare a bacterial lawn / culture / sample;
(accept mix bacteria with agar / medium)
2 with oil and one with control / water / range of concentrations; 3 appropriate method of standardising how sample applied, e.g. discs / wells;
4 appropriate measure of effectiveness / size / diameter of clear zone;
5 the larger the zone the greater the effectiveness;
6 use of aseptic technique;
(ignore haemocytometer)

4 max

[9]

11

(a) moves to 40 °C side, then later to 20 °C;

gets lighter in hot side and darker in cool side;
lighter as it absorbs heat / darker as it loses heat;
by conduction / convection / radiation;

3 max

(b) lizard finds favourable environment;
(helps it to) maintain constant body temperature;
advantage of this, e.g. for enzyme activity;

2 max

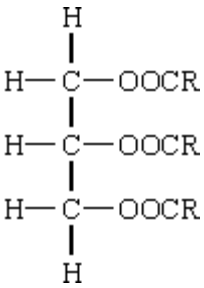
[5]

12

(a) 3 fatty acids attached;

ester bond correct;

(H on glycerol component, O attached to carbon, R at other end)



2

(b) not made of monomers / many repeating units;

1

(c) (many) mitochondria present in brown fat cells;mitochondria release heat / energy; (*ignore ATP*)
white fat cells for fat storage / reduced fat storage in brown fat cells;

3

[6]