SL Paper 2

a. The pumping of blood is a vital process. Explain the roles of the atria and ventricles in the pumping of blood. [4]

b. Explain how the structure of an artery allows it to carry out its function efficiently. [5]

c. Describe the inheritance of ABO blood groups. [9]

Markscheme

a. atria collect blood from veins (vena cava/pulmonary);

collect blood while ventricles are contracting;

atria pump blood into ventricles/ensure ventricles are full;

ventricles pump blood into arteries/out of the heart;

ventricles pump blood at high pressure because of their thicker, muscular walls;

mention of heart valves working with atria and ventricles to keep blood moving;

left ventricle pumps blood to systems and right ventricle pumps blood to lungs;

Both left and right ventricles with correct function required for mark to be awarded.

b. thick wall to withstand high blood pressures/avoid bursting/leaks;

many muscle fibres to help pump blood;

many elastic fibres to stretch and pump blood after each heart beat;

narrow lumen to maintain high pressure/because blood flows along rapidly;

thick outer layer of collagen to give strength/prevent aneurism;

no valves as pressure is high enough to prevent backflow;

endothelium/smooth inner lining to reduce friction;

c. one gene determines (ABO) blood groups / one gene for ABO blood groups;

genes have different/alternative forms called alleles;

there are three alleles (I^A, I^B and i) of the gene for (ABO) blood groups;

(ABO) blood groups are an example (of the effect of) multiple alleles (in this instance three alleles can result in four phenotypes);

each individual has two alleles of the gene but only one is passed to offspring;

alleles that are codominant both affect the phenotype in a heterozygote;

(alleles) I^A and I^B are codominant;

(alleles) I^A and I^B are dominant over i / i is recessive to I^A and I^B;

(genotypes) I^AI^A and I^Ai both give blood group A;

(genotypes) I^BI^B and I^Bi both give blood group B;

(genotype) I^AI^B gives blood group AB;

(genotype) ii/homozygous i gives blood group O;

example of a cross involving ABO blood groups;

Examiners report

a. Most candidates answered the question by trying to trace the blood flow through the heart rather than collectively explaining the roles of atria and ventricles. It was generally known that the right atrium collects blood from the body and pumps it into the right ventricle but the timing was misunderstood. Blood flow to and from the lungs was usually mentioned, including the pulmonary artery and pulmonary vein.

b. Valves were mentioned but not their prevention of backflow. The idea of ventricles generating high pressure due to thick walls was mostly lacking.

The only structural feature of an artery consistently mentioned in relation to its function was that the thick wall of an artery enables it to withstand high blood pressure. Many other important features such as muscle fibres to help blood movement or elastic fibres to allow an artery to stretch were ignored. Statements such as “arteries are the biggest blood vessels in the body” or “are bigger than other blood pathways” suggest that candidates lack an understanding that the relative sizes of blood vessels can vary. Very few candidates included mention of the role of a narrow lumen or smooth inner lining

c. Candidates often confused the term blood group with blood allele. The terms were used synonymously without distinction. Though the question called for a description of the inheritance of ABO blood groups, that whole realm of thought was often neglected.

Most marks were gained only because candidates gave the correct genotypes for the various blood groups. However, potential marks were lost here because candidates failed to use the standard notion I with superscripts and I to represent the alleles. Sometimes a Punnett square was used successfully to support an answer when inheritance was addressed. Much irrelevant information was given about universal blood donors or recipients and the related antigens and antibodies.

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a. Outline what is meant by homeostasis. [4]

b. Describe how body temperature is maintained in humans. [6]

c. Explain the need for a ventilation system and the mechanism of ventilation of the lungs in humans. [8]

Markscheme

a. maintaining (stable) internal environment/conditions;

within (narrow) limits;

example (*e.g.* body temperature / blood pH / blood glucose / water / CO_2 concentration);

levels of these variables are monitored (internally);

negative feedback mechanisms / *OWTTE*; (*reject if positive feedback included*)

involves hormonal / nervous control;

b. maintained close to 36.7/37°C/98.6°F ;

heat is transferred/distributed in body by blood;

hypothalamus contains thermoreceptors;

hypothalamus monitors temperature/sends message to effectors/causes response;

(vaso) dilation of skin arterioles warms skin/cools body;

(vaso) constriction of skin arterioles retains body heat;

skin/sweat glands produce sweat to cool the body when overheated;

removal of heat through evaporation of sweat;

shivering generates heat / increased metabolism / hair erection to retain heat;

example of behavioural change to warm/cool the body to thermoregulate;

c. (cellular) respiration drives the need for gas exchange/absorption of oxygen and removal of CO_2;

gas exchange depends upon a ventilation system;

lungs/alveoli provide surface area for gas exchange (with capillaries/blood);

ventilation system maintains a high concentration of oxygen in the alveoli;

bloodstream links alveoli to cells;

inhalation by contraction of diaphragm;

inhalation occurs with contraction of external intercostals/relaxation of internal intercostals;

(these) increase the volume/reduce the pressure in thorax, pulling air into lungs;

exhalation caused by relaxation of the diaphragm;

exhalation occurs with relaxation of external intercostals/contraction of internal intercostals;

(these) decrease volume/increase pressure in the thorax, forcing air out of lungs;

Examiners report

a. On question 7, candidates tended to score either high or low for the whole question. It was unfortunate that some did not read the whole question before beginning to answer it, as part (a) asking about homeostasis was followed by part (b) how body temperature is maintained. Candidates who answered (a) very thoroughly wasted time repeating themselves in (b). They may have been unconsciously drawn to the body temperature example of (b) when answering (a).

   Most candidates could give an example of homeostasis, even though many of their definitions for homeostasis were incomplete. Errors included forgetting to mention “internal” and “within limits.” The best answers included the concept of negative feedback and control through nerves and hormones

b. The majority of candidates had good knowledge of how sweating helps to control body temperature. They knew that sweat is released by the skin to cool an overheated body. In addition, some mentioned that heat removal occurs through evaporation of sweat. Since shivering, increased metabolism, and hair erection were all parts of one marking point, candidates were awarded a mark regardless of how many of these ideas were given. A common major misunderstanding involved the role of blood vessels. Too many suggested that blood vessels either moved closer or away from the skin surface for cooling or heating. Many candidates did not understand vasodilation and vasoconstriction of arterioles. Furthermore,

terminology was restricted to blood vessels, veins or capillaries. Only the rare candidate used the term arteriole. Other pertinent ideas often missed included normal body in degrees °C or °F, distribution of heat by the blood, and the importance of the hypothalamus with its thermoreceptors in monitoring body temperature and effecting needed responses.

c. Many candidates showed surprising command of the details in explaining the mechanism of ventilation. That understanding coupled with knowing the need for O_2 absorption and CO_2 removal was enough to gain most of the available marks. However, there were flaws. For example, the diaphragm was referred to as getting flattened or dome shaped with no reference to contraction or relaxation. The idea of the thoracic cavity increasing or decreasing was replaced with lungs increasing or decreasing with no reference to pressure. A number of candidates traced the respiratory system from mouth to alveoli. Some even included diagrams. All this was irrelevant since the mechanism of ventilation was not being addressed. The high surface area of the alveolicapillary interface was not often mentioned nor was the high concentration gradient of O_2 in the alveoli and the importance of blood to deliver O_2 to respiring cells.

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a. Define *pathogen*. [1]

b. Explain antibody production. [3]

c. Explain why antibiotics are effective against bacterial diseases but not against viral diseases. [2]

Markscheme

a. Organism (or virus) that causes a disease.

b. a. many types of lymphocytes (B and T) exist;
b. produced/ stored in the lymph nodes;
c. each type recognizes one specific antigen/pathogen;
d. each type responds by dividing to form a clone;
e. (a clone) (B) lymphocyte secretes (specific) antibody against the antigen;
f. antibodies are produced as part of a specific immune response;
g. some reference to plasma/memory cells;

c. a. antibiotics block metabolic pathways of bacteria / reference to a specific pathway;
b. viruses have no metabolic pathways / viruses reproduce using the host cell's metabolic pathways;
c. (host cell's) metabolic pathways are not affected by antibiotics / (antibiotics) do not affect host cells because they are metabolically different from bacteria;

Examiners report

a. A disturbing number could not give a definition for pathogen in part a. (6.3.1).

b. In b, some teachers seem to have over-taught antibody production including the HL components, with the result that the students were giving very confused answers and missing out the basics. There were a few G2 comments that the command term for part b should have been "describe" rather than explain.

c. The reasons why antibiotics are effective against bacteria and not viruses was quite well understood, by those students who had covered it.

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a. All organisms take in and also release carbon compounds. Draw a labelled diagram of the carbon cycle. [5]

b. Describe how the rate of photosynthesis can be measured. [6]

c. Explain the mechanism of ventilation in humans. [7]

Markscheme

a. CO_2 in atmosphere/air;

plants/producers linked to carbon in air/CO_2 with arrow labeled photosynthesis;

plants/consumers linked to animals/consumers with arrow labeled feeding;

plants/producers and animals/consumers linked to carbon in air/CO_2 with arrow labeled (cell) respiration;

plants/producers and animals/consumers linked to decomposers/bacteria/fungi with arrow labeled death;

decomposers/bacteria/fungi linked to carbon in air/CO_2 with arrow labeled (cell) respiration;

plants/producers connected to carbon in air/CO_2 with arrow labeled combustion/forest fire;

decomposers/bacteria/fungi linked to fossil fuels/coal/oil/natural gas with arrow labeled (partial) decomposition;

fossil fuels/coal/oil/gas linked to carbon in air/CO_2 with arrow labeled

combustion;

Award marking points only if arrows point in correct direction.

b. correct equation for photosynthesis in words or symbols;

measure production of oxygen;

example of method to measure oxygen production;

(eg count bubbles from water plant/collect oxygen data per unit of time using electronic sensors/probes)

measure uptake of CO_2;

example of method; *(eg method of measuring (aquatic) pH changes/shift per unit time)*

measure increase in biomass;

example of method; *(eg sample (dry) mass of crop before and after timed period)*

not possible to measure water uptake since water is transpired/used in turgidity/many chemical processes;
another valid method if concept of rate (measurements per time) is included;

c. air enters/exits lungs through trachea, bronchi and bronchioles;

during inspiration/inhalation external intercostal muscles contract;

causing ribs to move upwards/outwards;

during inspiration diaphragm contracts/flattens;

causes increase in volume of thorax/lungs;

decrease in pressure allows air to enter (passively);

during expiration internal intercostal muscles contract/external intercostal muscles relax;

causing ribs to move down/in;

diaphragm relaxes/returns to original domed position;

abdominal muscles contract to push diaphragm up;

causes decrease in volume of thorax/lungs;

increase in pressure forces air out of lungs;

Award [5 max] for inhalation or exhalation only.

(Plus up to [2] for quality)

Examiners report

a. Many candidates spent considerable time drawing beautiful trees, rabbits, and factories but labels on the arrows that connected the various components of the carbon cycle. Some candidates never showed CO_2/carbon in the air.

b. Many candidates could name production of O_2, uptake of CO_2, and an increase in biomass as methods to measure the rate of photosynthesis. This meant an easy three marks. Gaining marks beyond that became very difficult. The primary reason was that when candidates gave details about the method, they failed to mention rate, as in a unit of time for the measurement e.g. bubbles of O_2 released per minute. The equation for photosynthesis was rarely given by any candidate.

c. The mechanism of ventilation in humans was generally explained well. Some accounts were flawed when specific intercostals muscles contracting or relaxing were not identified. More serious problems occurred when candidates mixed up ventilation with gas exchange at the level of alveoli or dwelled on cell respiration.

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a. Draw a labelled diagram to show the human ventilation system. [4]

b. Outline anaerobic cell respiration in plant cells. [5]

c. Explain the concept of homeostasis, using the control of blood sugar as an example. [9]

Markscheme

a. *Award **[1]** for each structure clearly drawn and correctly labelled.*

trachea;

bronchi;

bronchioles;

lungs;

alveoli – shown enlarged as inset;

diaphragm;

intercostal muscles;

abdominal (wall) muscles;

*Award **[3 max]** for diagrams that do not show correct connections or proportions.*

b. anaerobic (cell) respiration in the absence of oxygen;

glycolysis / breakdown of glucose molecules;

leads to the production of pyruvate;

also known as fermentation;

production of small yield/two ATP (molecules per molecule of glucose respired);

produces ethanol;

produces carbon dioxide;

occurs in cytoplasm;

example of anaerobic respiration in plants (*e.g.* waterlogged roots);

c. maintaining the internal environment constant/between narrow limits;

example (other than blood sugar) of blood pH / oxygen and carbon dioxide concentrations / body temperature / water balance;

involves negative feedback;

where a variation from the normal (blood sugar level) triggers the correction mechanisms;

controlled by both nervous and endocrine systems;

blood sugar above normal stimulates insulin release;

insulin secreted by β cells in the (islets of the) pancreas;

insulin lowers blood sugar;

by converting to glycogen/fat / increased respiration;

blood sugar below normal stimulates glucagon release;

glucagon secreted by α cells in the (islets of the) pancreas;

glycogen converted to glucose; causes increased level of glucose in the blood;

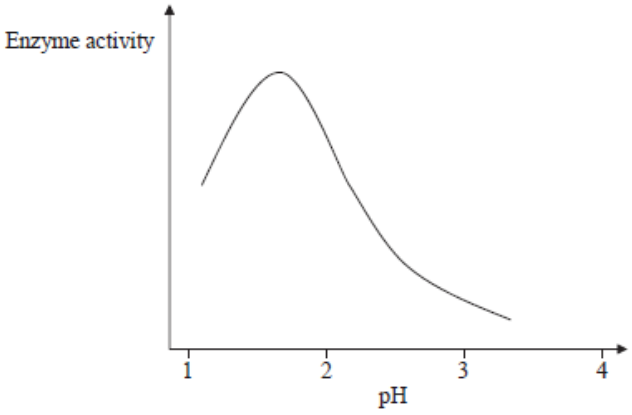
Examiners report

a. In the diagram of the human ventilation system, alveoli needed to be shown as an inset to gain their mark. This was consistent with the Teacher's notes for A.S. 6.4.4 in the Subject Guide. Many candidates included intercostal muscles but it was difficult to show them clearly. Abdominal (wall) muscles were not shown. The quality of the ventilation diagrams was generally lower than for the membrane diagrams. Correct labels must correspond to recognizable structures.

b. Uncertainty as to the type of anaerobic respiration found in plants may have put off some candidates since, for A.S. 3.7.3., the Teacher's notes only mention yeast and humans. Nonetheless, some candidates gained full marks knowing those aspects common to both pathways. Also, candidates may have associated yeast with plants, thereby describing the alcohol fermentation pathway. At least one candidate was able to cite waterlogged roots as a place where anaerobic respiration would occur in plant cells.

c. Many candidates did quite well on this question, showing good knowledge and understanding of homeostasis. The mark scheme provided ample opportunities for many high scoring answers. Negative feedback was frequently included but "controlled by both nervous and endocrine systems" was rarely seen.

Researchers extracted an enzyme from the human digestive system and tested its activity at different pH values on proteins extracted from the blood of cows. The results are shown in the graph below.



a. Deduce from where in the human digestive system this enzyme was extracted. [1]

b. Outline the need for enzymes in the digestive system. [2]

c. State **one** function of the large intestine. [1]

d. Explain how the structure of the villus is adapted for absorption. [3]

Markscheme

a. stomach

b. enzymes speed up the digestive processes;

(chemical) break down of food/food particles/large molecules;
make soluble products/molecules small enough to be absorbed;

c. to (re)absorb water/vitamins(s) (*e.g.* K and B12) / temporary storage of feces

d. ***N.B.*** *for each marking point, function should accompany structure.*

shape of villus has large surface area to improve absorption / microvilli increase surface area to improve absorption;

thin walls/epithelium to allow fast diffusion;

capillaries/rich blood supply (nearby) to absorb digested food products/ maintain concentration gradient;

lacteal in villus to absorb fatty acids/fats (and carry them away from small intestine);

protein pumps in membrane to carry on active transport / channel proteins in membrane to facilitate diffusion;

large number of mitochondria provide ATP for active transport;

Examiners report

a. The stomach was correctly mentioned by most students, but a few mentioned the pancreas and even the liver.

b. Many candidates gave generic descriptions of enzyme properties without any application to digestion, such as speeding up the process. Acceptable answers frequently included the breakdown of food particles/molecules and the notion that the products had to be soluble or small enough to be absorbed.

c. Not answered particularly well. For those who were correct, absorption of water/vitamins was usually cited. A few mentioned temporary storage of feces.

d. This question required an explanation involving structure and function. The problem for a number of candidates was that they gave accurate structural details, but neglected to include any reasoning, that is explaining how the structural feature aided absorption. For example, the pencil shape of the villus provides a high surface area to volume ratio which makes absorption easier/faster. For those candidates who supported their answers with reasoning, maximum credit was easily obtained.

Distinguish between type I and type II diabetes.

Markscheme

Must be genuine differences not descriptions of one type of diabetes followed by description of other type of diabetes. If two totally separate descriptions/no paired statements are written, award ***[2 max]****.*

Type I diabetes	Type II diabetes
early-onset/childhood diabetes / usually develops in those under 20 years old *Do not accept present at birth.*	adult-onset diabetes / usually occurs in those over 40 years old;
inability to produce sufficient quantities of insulin	inability to respond to insulin (due to insufficient receptors on target cells);
target cells remain sensitive to insulin	target cells less sensitive to insulin;
genetic predisposition/virus/autoimmune disorder / destruction of (pancreatic) beta cells involved	is linked with dietary/lifestyle factors / increased fatty acids in blood;
requires daily injections of insulin / beta cell transplant	controlled by diet/exercise/weight loss/medication but not insulin injections;

Examiners report

Information given here was frequently in error, incomplete, or just mixed up. Many candidates thought that Type I diabetes is present at birth.

Sometimes, if one correct idea was given about Type I or Type II there was no contrasting idea given for the other item. Few candidates earned full marks.

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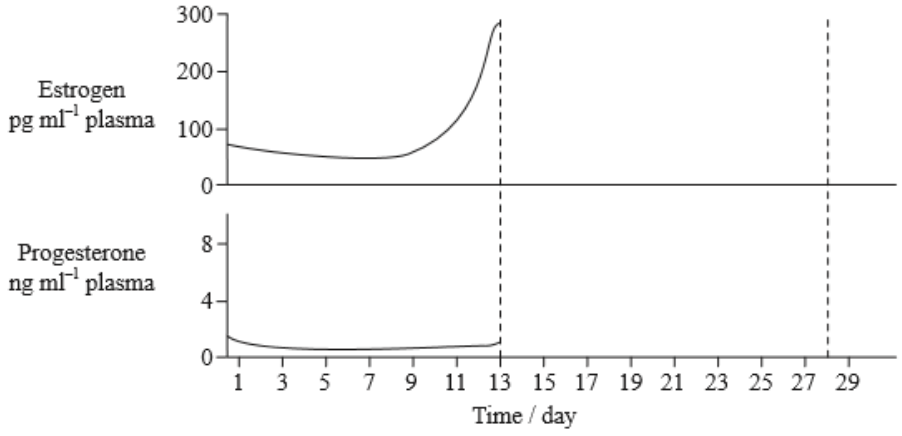
b. Describe the need for a ventilation system in humans. [2]

c. Sketch the hormone changes between days 13 and 28 on the graphs below for a woman in her normal menstrual cycle. [2]



[Source: adapted from www.mivf.com.au/ivf/infertility/images/cyclediagram.GIF]

Markscheme

b. most cellular respiration is aerobic/requires oxygen / produces carbon dioxide;

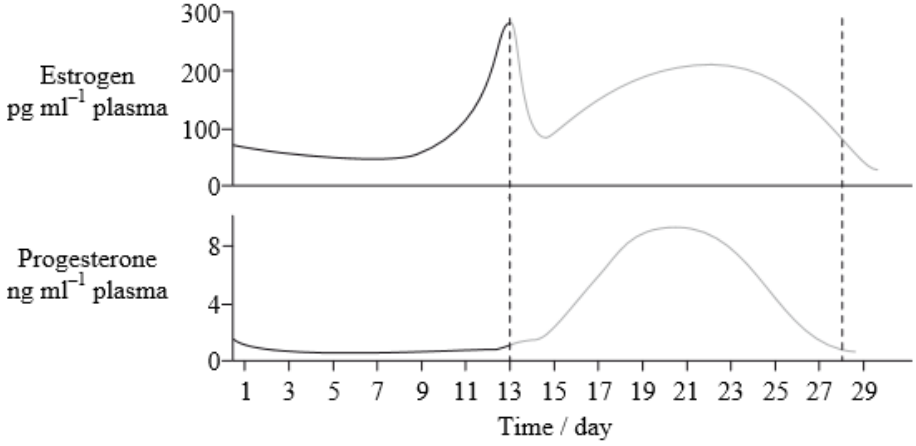
ventilation system exchanges gases between inhaled air and lungs/blood stream;

ventilation system maintains high concentration gradient of gases in alveoli/ lungs;

c. estrogen line should show sharp drop after day 13, followed by gradual rise to another peak (more rounded/stretched out and lower than day 13) followed by gradual drop to level similar to day 1;

progesterone line should gradually rise to rounded peak, followed by gradual drop to level similar to day 1;

example of diagram:

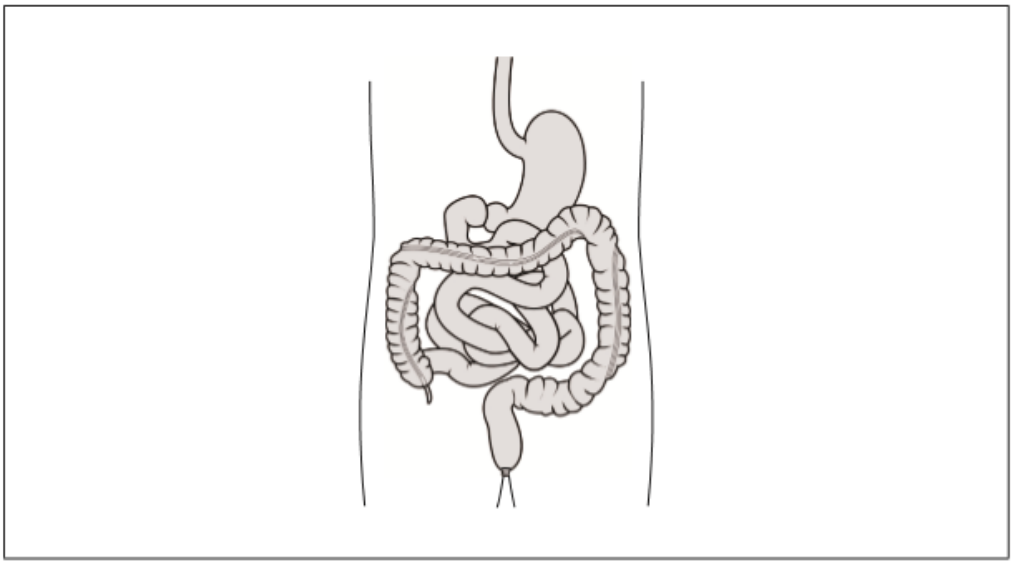


Examiners report

b. Many candidates found this question difficult and were unable to describe gas exchange or the high concentration gradient that results from a ventilation system.

c. Candidates generally found it difficult to sketch the changes in hormone levels in the second half of the menstrual cycle. Strictly speaking, candidates are required to annotate a graph rather than draw one. Examiners gave candidates a fair leeway in their responses to ensure that candidates who had a roughly appropriate graph drawn were not disadvantaged.

The structure of part of the digestive system is shown in the diagram below.



[Source: http://commons.wikimedia.org/wiki/File:Intestinesall.svg
Created by Wikipedia user: Madhero88.]

a (i) Label the diagram to show the structure that is involved in digestion of proteins in acid conditions (using the letter A). [1]

a (ii) Label the diagram to show the structure where **most** absorption of water to prevent dehydration occurs (using the letter B). [1]

a (iii) Label the diagram to show the structure where **most** absorption of nutrients occurs (using the letter C). [1]

b (i) Explain how the structure of veins is adapted to their function. [2]

b (ii) Cells defend the body against pathogens. Outline how some of these cells ingest pathogens in the blood and in body tissues. [2]

Markscheme

a (i) *Award **[1]** for each of the following correctly labelled.*

stomach (*labelled A*)

a (ii) *Award **[1]** for each of the following correctly labelled.*

large intestine (*labelled B*)

a (iii) *Award **[1]** for each of the following correctly labelled.*

small intestine / ileum (*labelled C*)

b (i) valves to avoid backflow;

thin wall allows them to be pressed flat by muscles to move/carry blood under low pressure;

wide lumen (for a given blood vessel diameter) for slow flowing blood;

b (ii) attraction to foreign protein/pathogen / chemotaxis;

membrane invaginates / engulfs foreign matter / phagocytosis/endocytosis;

formation of vacuole/vesicle;

(phagocytes) can squeeze out of walls of capillaries;

Accept clearly annotated diagrams.

Examiners report

a (i) Candidates knew the role and location of the stomach.

a (ii) Marks were lost when candidates mixed up the identity and role of the small and large intestine (A.S. 6.1.4, 6.1.5).

a (iii) Marks were lost when candidates mixed up the identity and role of the small and large intestine (A.S. 6.1.4, 6.1.5).

b (i) This was similar to past exam questions about structure and function of veins (A.S. 6.2.5). An easy mark, gained by most candidates, was that valves in veins prevent backflow of blood. Thin walls allowing muscle pressure to move blood or wide lumens to accommodate slow moving blood were cited less often. There was also glaring confusion with capillaries such as “veins have thin walls for diffusion of oxygen molecules” or “veins have walls of one cell thickness so exchanges can occur.”

b (ii) This question required an outline of how some cells can ingest pathogens in the blood and in body tissues (A.S. 6.3.4). “Outline” meant only a brief account or summary, with or without a diagram. Quite a few candidates scored the maximum of two marks. They knew that phagocytes can detect/recognize/identify foreign protein or pathogens which can then be engulfed through phagocytosis. Unfortunately, more than a few candidates thought that antibodies engulf pathogens.

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a. Draw a labelled diagram of the human heart showing the attached blood vessels. [6]

b. Describe the action of the heart in pumping blood. [5]

c. Nerves connecting the brain and heart contain neurons that control heart rate. Explain how a nerve message passes from one neuron to another neuron. [7]

Markscheme

a. *Remember, up to TWO “quality of construction” marks per essay.*

NB: *Drawings must be correctly proportioned and clearly drawn showing connections between structures. The drawing may show the heart without contraction or in any stage of contraction. Award [1] for any correctly labelled part that has been drawn to the stated standards.*
a. atria/right atrium/left atrium – *shown above the ventricles and must not be bigger than ventricles*;
b. ventricle/left ventricle/right ventricle – *shown below the atria, must have thicker walls than atria*;
c. vena cava/superior vena cave/inferior vena cava – *connected to right atrium*;
d. pulmonary artery – *shown from right ventricle (to lungs);*
e. pulmonary vein(s) – *shown (from lungs) to left atrium*;
f. aorta – *shown as large artery from left ventricle out of heart*;
g. AV valves/atrioventricular valves / mitral/bicuspid and tricuspid – *named correctly and shown between both atria and ventricles and labelled at least on one side*;
h. semilunar valves – *shown in aorta/pulmonary artery*;
Valves need to open in correct direction.

b. *Remember, up to TWO "quality of construction" marks per essay.*

a. (both) atria collect blood (from veins);
b. sinoatrial/SA node sends impulses to muscle/fibres initiating contraction;
c. blood is pushed to ventricles by contraction of atria/atrial systole;
d. AV (atrioventricular) valves are open (as atria contract);
e. semilunar valves are closed so that ventricles fill with blood;
f. ventricles contract / ventricular systole;
g. AV (atrioventricular) valves close (and preventing backflow);
h. blood is pushed out through the semilunar valves/into pulmonary artery and aorta;
i. when ventricles relax/diastole, semilunar valves close preventing backflow of blood;
Do not accept the description of blood flow without a clear action.
Do not accept general statements such as systole = heart contraction and diastole = heart relaxation.

[4 max] *if suggests that left and right sides are contracting at different times or simultaneous contraction not indicated.*

c. *Remember, up to TWO "quality of construction" marks per essay.*

a. nerve impulse reaches the end of the presynaptic neuron;
b. (depolarization causes) calcium channels in membrane (to) open;
c. calcium diffuses into the presynaptic neuron;
d. vesicles of/containing neurotransmitter move to and fuse with presynaptic membrane;
e. (neurotransmitter) released (by exocytosis) into synaptic space/cleft;
f. (neurotransmitter) diffuses across the space/synapse;
g. (neurotransmitter) attaches to receptors on postsynaptic neuron;
h. receptors cause ion channels to open and sodium diffuses into the postsynaptic neuron;
i. the postsynaptic neuron membrane is depolarized;
j. (depolarization) causes a new action potential;
k. (neurotransmitter) on postsynaptic membrane is broken down;
l. (neurotransmitter) is reabsorbed into the presynaptic neuron;

Examiners report

a. There were some G2 comments that the whole of this question could be answered with only SL knowledge. This is true. However part c proved difficult for all but the top students.

The diagrams of the heart were of very varied quality. A diagram was asked for, i.e. the chambers and correctly positioned blood vessels, not an artistic impression with the blood vessels mysteriously floating outside the heart. Very few showed the atria with thinner walls than the ventricles.

b. There were some G2 comments that the whole of this question could be answered with only SL knowledge. This is true. However part c proved difficult for all but the top students.

Perhaps it is the fault of descriptions of the heart action in terms of how a blood cell would pass through the heart, but very few were able to explain that both atria contract at the same time etc. Weaker candidates seemed to think that the blood just flowed through the heart, instead of explain the movement in terms of muscle contraction.

c. The question writer was obviously trying to show the connection between the heart and nerves with the opening sentence. Unfortunately weaker students did not read beyond the first line and did not realise that the question was about synapses. There were many irrelevant essays about nerve impulse propagation and also the action of the SAN and AVN. Well prepared candidates could explain concisely the train of events triggered by the arrival of the nerve impulse at the presynaptic knob. The word "message" was questioned by several teachers. It was presumably used to imply that it does not pass across the synapse as an impulse.

Explain the propagation of electrical impulses along a neuron including the role of myelin.

Markscheme

Neurotransmitter attaches to receptor site, initiating transmission

Nerve impulses are action potentials propagated along the axons of neurons

Resting potential is more negative inside/–70 mV/ more positive outside the membrane
OR
a resting potential has greater concentration of Na ions outside than K ions inside the axon

«volted gated» channels open and Na ions diffuse in

Causes depolarization of the membrane/–70 mV to +40 mV

Local currents affect adjacent channels/cause action potential

Depolarization is followed by repolarization of the neuron

«voltage gated» channels open and K ions diffuse out/repolarize the membrane

Na-K pumps restore Na/K balance/resting potential

Myelin around the neuron insulates the axon
OR
speeds the transmission

Myelin permits saltatory conduction
OR
permits jumping from node to node

*Award **[6 max]** if no mention of the role of myelin.*

Examiners report

Nerve impulses – Most candidates knew the purpose of myelin. Unfortunately many could explain little else. Well prepared candidates gave very clear answers. The confusions between sodium and potassium and diffusion and pumps were rife.

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a. Distinguish between ventilation, gas exchange and cell respiration. [4]

b. Outline the process of aerobic respiration. [6]

c. Respiration and other processes in cells involve enzymes. Explain the factors that can affect enzymes. [8]

Markscheme

a. ventilation is moving air into and out of lungs/inhalation and exhalation;

involves (respiratory) muscle activity;

gas exchange involves movement of carbon dioxide and oxygen;

between alveoli and blood (in capillaries) / between blood (in capillaries) and cells;

cell respiration is the release of energy from organic molecules/glucose;

(aerobic) cell respiration occurs in mitochondria;

*To award **[4 max]** responses must address ventilation, gas exchange and cell respiration.*

b. during glycolysis glucose is partially oxidized in the cytoplasm;

(small amount/yield of) ATP produced;

(two) pyruvate formed by glycolysis;

pyruvate absorbed into/broken down in the mitochondrion;

requires oxygen;

carbon dioxide is produced;

water is produced;

large amount/yield of energy/ATP molecules (per glucose molecule);

c. collisions between enzyme/active site and substrate;

enzyme activity increases as temperature rises;

more frequent collisions at higher temperatures;

each enzyme has an optimum temperature / enzymes have optimal temperatures;

high temperatures (above optimum) denature enzymes;

each enzyme has an optimum pH / enzymes have optimal pHs;

increase or decrease from optimum pH decreases rate of reaction/activity;

extreme pH alters/denatures the tertiary/3D protein/enzyme structure;

increasing substrate concentration increases the rate of reaction;

higher substrate concentration increases chance of collision;

until plateau;

when all active sites are busy;

Accept clearly annotated graph.

Examiners report

a. As candidates distinguished between ventilation, gas exchange and cell respiration (A.S. 6.4.1), certain ideas keep reappearing and others were infrequently expressed. Among the former were inhalation and exhalation; movement of carbon dioxide and oxygen; and release of energy from organic molecules. Less common were involvement of muscle activity for ventilation; exchange between alveoli and blood or between blood and cells; and that cell respiration occurs in mitochondria. “Ventilation is moving air into the lungs” was not enough for a mark, nor was “cell respiration is release of energy from food” which was too general.

b. With this question on aerobic respiration (A.S. 3.7.2, 3.7.3), many candidates easily earned four of the six available marks. These were that aerobic respiration requires oxygen, produces carbon dioxide, produces water and produces a large yield of energy/ATP. Additional marks were earned with commentary on glycolysis, since it produces the pyruvates that are eventually broken down aerobically.

c. Factors that affect enzyme activity (A.S. 3.6.1-3.6.4) is another topic that has appeared repeatedly on past IB exams. Furthermore, the topic is often visited during IA investigations. Details on how changes in temperature and pH affect enzyme activity formed the heart of most answers. Denaturation of enzyme structure that alters the active site was usually included in those answers. The effect of substrate concentration on enzyme activity was less common. Higher quality answers mentioned collisions between enzyme and substrate and linked enzyme activity to the frequency of collisions at different temperatures or substrate concentrations. Many written passages were supported with annotated graphs that also earned marks. However, some candidates confused the graph for enzyme activity vs temperature with the graph of enzyme activity vs. substrate concentration. They show a plateau in the temperature curve and declared that the plateau represented denaturation of the enzyme at that temperature.

---

a. State **four** molecules transported by the blood. [4]

b. Outline the control of the heartbeat. [6]

c. Discuss the cause, transmission and social implications of AIDS. [8]

Markscheme

a. a. example of a nutrient *e.g. glucose*;

b. oxygen/O_2;

c. carbon dioxide/CO_2;

d. nitrogen/N_2;

e. hormones;

f. antibodies;

g. urea;

b. a. is myogenic;

b. pacemaker / SA node / *OWTTE*;

c. stimulates atria to contract;

d. leading to contraction of ventricles;

e. (autonomic) nerves can alter the pace;

f. (by secretion of) epinephrine/adrenaline/norepinephrine/noradrenaline increase the pace;

g. (by secretion of) acetylcholine reduces the pace;

h. adrenal glands release epinephrine/adrenaline;

i. carried by blood to heart;

j. to increase pace;

c. *cause: [4 max]*

a. AIDS caused by HIV;

b. penetrates (T) lymphocytes;

c. (envelope) (glyco)protein and cell receptors involved;

d. reverse transcriptase enables DNA to be produced from viral RNA; *(reject DNA transformed into RNA)*

e. number of lymphocytes reduced over years;

f. results in lower immunity;

g. other illnesses develop (as result of lower immunity);

h. AIDS is the observed syndrome when final stages of infection develop / *OWTTE*;

transmission: [3 max]

i. HIV transmitted through blood/sexual contact/body fluids/placenta/childbirth/ breastfeeding;

j. distribution/transmission uneven around the world;

k. transmission risk increased depending on society's traditions/beliefs/behaviour;

l. (rare minority of) individuals do not have cell receptors and do not develop AIDS;

m. condoms/latex barriers only protection against transmission through sexual contact;

social implications: [3 max]

n. treatment expensive;

o. discrimination against victims;

p. moral obligation of wealthy countries to help poorer countries;

q. economic consequences / loss of wage earners *etc.*;

r. increase in the number of orphans;

s. comment on traditions/beliefs/behaviour; *(if not already awarded in transmission) [8 max]*

Examiners report

a. Generally this question was answered well. Weaker candidates did not give an example of a nutrient. The weakest candidates wrote about red blood cells, white blood cells and water being carried in the blood.

b. Some candidates mentioned that the heart is myogenic but most based heartbeat control on the pacemaker. Answers included stimulation of the atria but not the subsequent contraction of ventricles. Many did not seem to understand that the two atria contract simultaneously followed by simultaneous contraction of the two ventricles. Descriptions of neural control and hormonal control varied greatly. The idea that secretion of

acetylcholine by nerves can reduce the pace was never given. A few candidates only knew heart anatomy so drew a diagram and described flow of blood through the heart, to no avail.

c. The AIDS question was generally answered well. Though the marks gained were spread over cause, transmission and social implications, there were gaps. Many candidates did not seem to understand how HIV affects lymphocytes. There was almost no mention of reverse transcriptase enabling DNA to be produced from RNA. Despite much detail about how the virus is transmitted, few candidates mentioned the uneven transmission of HIV throughout the world. Many candidates wrote in depth about the social implications of AIDS. Often, the ideas were exceptionally well-expressed.

---

b. Describe the relationship between the structure and function of blood vessels. [6]

c. Explain the mechanisms involved in the ventilation of the lungs. [8]

Markscheme

b. arteries carry blood under high pressure;

they have a thicker elastic wall/narrower lumen;

they have muscles that control pressure / help move the blood;

veins carry blood under lower pressure;
they have thin walls with less elastic tissue/muscle/wider lumen;
have valves to prevent back flow;

capillaries have walls which are one cell thick;
to allow easy diffusion across their wall / ultrafiltration;
(some) capillaries have pores/clefts;
*Award **[5 max]** if capillaries are not referred to.*

c. external intercostal muscles contract;

internal intercostal muscles relax;

pulling the rib cage upwards;

diaphragm contracts and flattens;

increase in volume of thoracic cavity;

this reduces pressure;

so air enters the lungs;

internal intercostal muscles contract / external intercostal muscles relax;

diaphragm relaxes;

abdominal muscles/organs/liver push diaphragm upwards;

decrease in volume of thoracic cavity;

increases the pressure;

so air leaves the lungs;

Award any of the above points if clearly drawn in a diagram.

Examiners report

b. The structure of the blood vessels was outlined well, though some candidates lost marks here as they referred to e.g. the arteries, rather than the artery walls as being thick. A number of answers simply listed the features of the vessels without linking these to their function as required by the question.

c. This section was generally very well done with candidates outlining the sequence of events in the ventilation of lungs. Weaker answers did not distinguish between internal and external inter-costal muscles which have opposing roles in ventilation.

The human circulatory system is structured to serve the organs and tissues of the body efficiently.

a. Outline the exchange of materials between capillaries and tissues. [3]

b. Explain the structures and functions of arteries and veins. [8]

c. Describe what happens in alveoli. [4]

Markscheme

a. a. molecules move by <u>diffusion</u> / move down a concentration gradient

b. nutrients move into tissues

c. gas exchange / Oxygen and carbon dioxide exchange between tissues and blood/capillaries

d. (nitrogenous) wastes/excess water move from cells/tissues into blood/capillaries

e. hormones leave capillaries in target tissues/to attach to receptors on cells / (endocrine) organs/gland tissues release hormones into the bloodstream

b. a. arteries and veins have three layers in their walls

OR

walls of arteries and veins have tunica externa, media and intima

b. pressure is high in arteries/pressure is low in veins

c. arteries receive blood from ventricles/heart / carry blood away from heart

d. lumen of artery is small to keep pressure high

e. arteries have thick (muscular) walls (with elastic fibres) to withstand pressure

f. elastic fibres recoil in response to ventricle/heart contraction

g. muscle / elastic fibres help maintain pressure between heartbeats

OR

muscle / elastic fibres help propel blood toward capillary beds

h. veins receive blood from capillaries/capillary beds / carry blood to heart

i. large lumen of veins so there is less resistance to blood flow

j. valves in veins keep blood flowing toward heart/prevent backflow

c. a. gas exchange

b. oxygen diffuses from air to blood and carbon dioxide diffuses from blood to air

c. oxygen binds to hemoglobin in red blood cells

d. pressure inside/volume of alveoli increases/decreases / air enters/exits alveoli during inspiration/expiration/ventilation

e. blood flow through capillaries / concentration gradients of gases/oxygen/CO_2 maintained

f. type II pneumocytes secrete fluid/surfactant / secretion of surfactant to prevent sides of alveolus adhering

Accept answer in a clearly annotated diagram.

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

---

b. Outline the control of the heartbeat by the nervous and endocrine systems. [6]

c. Explain the principles of synaptic transmission. [8]

Markscheme

b. myogenic muscle contraction;

contracts without stimulation;

pacemaker/sino-atrial node/SAN in (wall of) right atrium;

pacemaker/sino-atrial node/SAN initiates contraction;

nerves (from brain) transmit messages to pacemaker;

to alter/increase/decrease the rate of the pacemaker;

medulla of the brain controls heart rate/beat;

epinephrine/adrenaline is hormone produced by adrenal gland;

epinephrine/adrenaline accelerates heart rate/beat;

c. Ca^{2+}/calcium ions enter presynaptic neuron;

release of neurotransmitter/acetylcholine;

from pre-synaptic membrane/neuron;

diffusion/movement across cleft/gap;

to post-synaptic membrane/neuron;

binding of the neurotransmitter to receptors/binding sites;

change in membrane permeability;

sodium ions flow into post-synaptic neuron;

depolarization of post-synaptic membrane;

initiation of an action potential;

removal of the neurotransmitter;

by enzyme / cholinesterase;

inactivated neurotransmitter returns to pre-synaptic neuron;

Examiners report

b. The terms myogenic and pacemaker were clearly explained on occasion in 7(b). However, there was also confusion about the concept of being "myogenic" and the pacemaker as the structure which initiates the heartbeat. Sometimes candidates traced the pathway of the control signals through the heart in great detail rather than explaining how the nervous system and endocrine systems can control the heartbeat. When addressed, correct reference was made to adrenaline but usually not to the role of the medulla or nerves

c. Part 7(c) was generally answered well, sometimes with nicely annotated diagrams. Most candidates had a good understanding of pre and post synaptic neurons, the role of Ca^{2+} ions and the concept of polarization/depolarization. Very few candidates mentioned removal of the neurotransmitter by enzyme or cholinesterase. Otherwise, accurate detail showed good knowledge and understanding.

Blood transports molecules throughout the body. State where the blood absorbs oxygen.

Markscheme

alveoli / lungs

Examiners report

Most of the candidates obtained the mark for this answer.

---

a. List **two** functions of membrane proteins. [2]

b. Explain why digestion of large food molecules is essential. [1]

c. Outline why antibiotics are effective against bacteria but not against viruses. [2]

d. Outline the use of polymerase chain reaction (PCR) to copy and amplify minute quantities of DNA. [2]

Markscheme

a. a. hormone binding sites / receptors;

b. (immobilized) enzymes;

c. cell adhesion;

d. cell (to cell) communication;

e. passive transport/channels;

f. active transport/pumps;

g. facilitate diffusion;

h. carry electrons;

b. a. many molecules are too large to be absorbed (by the villi) / small molecules are soluble and can be absorbed;

b. large food molecules are broken down so they can be reorganized/rearranged;

c. a. antibiotics block/inhibit specific metabolic pathways/cell functions found in bacteria;

Accept specific examples of inhibition such as cell protein synthesis, cell wall formation

b. viruses must use host/eukaryotic cell metabolism / viruses do not have their own metabolic pathways;

c. host/eukaryotic cell metabolism/pathways not blocked/inhibited by antibiotics;

d. a. strands of DNA (fragments) split/denatured with heat;

b. complementary nucleotides added to split stands (when cooling);

c. with the use of (DNA) polymerase (and primers);

d. process/heating and cooling cycle is repeated (until enough DNA is obtained);

Accept example of PCR application e.g. paternity cases or forensic investigations.

Examiners report

a. Functions were asked for, not named structures. “Channels” and “pumps” by themselves were too vague to gain marks.

b. The idea of food breakdown to a small enough size for absorption was the easier mark achieved by many. Some candidates wrote that food had to be “digested” but “digestion” was written in the stem of the question and too vague for credit.

The idea of food breakdown for eventual reorganization/rearrangement rarely appeared in any answer, perhaps indicating a conceptual gap in candidate understanding of digestion.

c. There was a complete misunderstanding of this question. Almost no candidate seemed to realize that the question was asking for how the PCR can copy and amplify minute quantities of DNA. Thus, the process was either unknown or ignored so marking points were immediately lost. In contrast, almost every candidate knew forensic science as a use of PCR, thereby salvaging one mark.

d. [N/A]

---

a. State **one** disaccharide and the **two** monomers from which it can be synthesized. [2]

Disaccharide:

1:

Monomers:

1:

and 2:

b. Discuss the roles of the enzymes secreted by the pancreas during digestion. [3]

c. Compare and contrast cis-fatty acids and trans-fatty acids. [2]

Markscheme

a. a. disaccharide name

eg: lactose, glucose and galactose

b. both monomers that make up mpa

eg: maltose, glucose and glucose

eg: sucrose, glucose and fructose

b. a. amylase breaks down/catalyzes/hydrolyses starch to maltose

b. lipase breaks down/catalyzes/hydrolyses fats to fatty acids and glycerol

c. proteases/peptidases break down/catalyze/hydrolyze proteins into smaller polypeptides/dipeptides/amino acids

Award [2] if all three enzymes and substrates named correctly and one further mark for all three products named correctly.

Allow specific enzymes

c. a. both are unsaturated fatty acids

OR

both have two carbon atoms joined by a double bond

b. in cis-fatty acids the two H atoms are on the same side while in trans-fatty acids they are on opposite sides

OR

cis-fatty acids are healthier than trans-fatty acids

OR

cis-fatty acids have a lower boiling/melting point than trans

OR

cis-fatty acids have a kink «in the chain» but trans do not

Accept answer in an annotated diagram

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

---

a. Outline the role of hydrolysis in the relationships between monosaccharides, disaccharides and polysaccharides. [4]

b. Describe the use of biotechnology in the production of lactose-free milk. [6]

c. Explain the importance of enzymes to human digestion. [8]

Markscheme

a. monosaccharides are single sugars and disaccharides are two sugars and polysaccharides are multiple sugars;

hydrolysis is the addition of water to split a molecule into smaller fragments;

–OH and –H are added to the fragments;

disaccharides are split/digested into two single sugars;

polysaccharides are broken/digested into smaller fragments (*e.g.* diasaccharides);

process depends on enzyme control (in organisms);

b. a particular yeast (growing in natural milk) contains lactase;

biotechnology companies can grow/culture the yeast;

lactase (an enzyme) is extracted from the yeast;

natural milk contains lactose/milk sugar;

when added directly to milk, lactase converts lactose into simpler forms;

same effect when milk is passed past immobilized (on surface or beads) lactase;

simpler forms of sugar (glucose and galactose) are easily absorbed (in the small intestine);

a commercial market exists for lactose-free milk / lactose-free milk is example of biotechnology's economic impact;

some people are lactose intolerant/cannot digest lactose in milk/have lost lactase activity in intestinal cells;

consuming lactose-free milk allows lactose intolerant people to be nourished by milk without discomfort (abdominal cramps and diarrhoea);

many Asians are lactose intolerant whereas less common among other groups (northern Europeans and some Africans);

biotechnology produced in one part of world is more useful in another;

c. food must be in a small enough form to leave the gut and enter the bloodstream;

physical breakdown is not enough / chemical breakdown is necessary;

enzymes are required for the chemical breakdown of food;

enzymes increase the rate of digestion;

enzymes are biological catalysts;

enzymes allow digestion to occur at body temperature;

enzymatic digestion is a sequential process *e.g.* from protein to peptide to amino acid;

specific location for each reaction with specific conditions/environments *e.g.* stomach high acidity;

most enzymes work extracellularly / some enzymes work intracellularly;

variations in pH throughout digestive tract promote the activity of different digestive enzymes / different enzymes have different optimal pHs;

amylases digest carbohydrate to monosaccharides;

proteases digest proteins to amino acids;

lipases digest fats to fatty acids and glycerol;

Examiners report

a. Candidates generally understood the process of hydrolysis but had difficulty applying it to the relationship between monosaccharides, disaccharides and polysaccharides.

b. The production of lactose free milk was well understood by many candidates, but most left out basic points such as the fact that lactose is found in milk and that lactase is the enzyme that breaks it down. Sometime these fundamental points, which are worth marks, are skipped. Candidates should fully explain their answers and not take any response for granted as "too obvious for a mark".

c. This section was generally well done with candidates demonstrating a good understanding of enzyme function in the context of the human digestive tract. The best responses named specific enzymes, the location of release and the substrate and products of the reaction catalysed. As in 5 (b), many candidates did not indicate that enzymes are biological catalysts and that they increase the rate of digestion. Candidates should fully explain their answers and not take any response for granted as "too obvious for a mark".

a. Describe the properties of water that make it a useful component of blood. [4]

b. Explain the relationship between structure and function of arteries, capillaries and veins. [8]

c. Outline how leucocytes defend the body against pathogens. [6]

Markscheme

a. a. water is a polar molecule / hydrogen bonding;

b. (makes it) (versatile) solvent;

c. example of dissolved substance (eg salts/proteins or other example);

d. (water is) fluid/liquid at body temperature;

e. example of transported material (eg nutrients/metabolic wastes/gases/hormones/blood cells or other example);

f. high heat capacity/specific heat allows water to carry heat without warming up;

g. (allows) blood to move heat (for warming/cooling/homeostasis);

b. *Arteries:* **[3 max]**

a. thick walls to withstand high pressure/maintain blood flow/pressure;

b. collagen fibres/elastic fibres/connective tissue (in outer layer) give wall strength/flexibility/ability to stretch and recoil;

c. (smooth) muscle layer (contracts) to maintain pressure;

d. narrow lumen maintains high pressure;

e. smooth endothelium for efficient transport/reduced friction;

Capillaries: **[3 max]**
f. wall has one layer of cells allowing (fast) diffusion of substances;
g. pores to allow lymphocytes/plasma to exit / to increase permeability;
h. extensive branching increases surface area for exchange of materials;
i. small diameter allows them to fit between cells/perfuse tissue;
j. narrow diameter increases oxygen diffusion from RBC;

Veins: **[3 max]**
k. thin walls allow (skeletal) muscles to exert pressure on veins;
l. thin outer layer of collagen/elastic/muscle fibres provide structural support;
m. wide lumen allows great volume of blood to pass;
n. valves prevent backflow;
NB *Every structure requires a function for the mark.*

c. a. leucocytes/phagocytes/macrophages can recognize pathogens/foreign matter;

b. (phagocytes) engulf pathogens by endocytosis/phagocytosis;

c. migration to tissues/squeezing out of capillaries;

d. each pathogen has specific antigens;

e. leukocytes/lymphocytes produce antibodies by reacting to specific antigen/ pathogens;

f. antibody joins to (specific) antigen inactivating/destroying them;

g. lymphocyte makes a clone/copies itself;

h. thus increasing the total number of (specific) antibodies;

Examiners report

a. This question troubled the rote learner who was unable to apply a general idea to a specific case. Candidates knew key properties of water but could not specifically relate them to blood. Most candidates correctly answered that the polarity of water molecules makes water a good solvent but forgot to give examples of dissolved substances in blood or materials that blood transports. High specific of water was cited but not how blood temperature can remain steady because of it.

b. Many candidates only wrote about the direction of blood flow through arteries, the heart veins. They completely missed out on the link between structure and function. Other candidates who did write about structural features of blood vessels failed to relate the features to function. Many confused the size of lumen with the degree of pressure in the vessels. Understanding of capillary structure and function appeared to be less than that of arteries or veins. Pores to increase permeability and allow lymphocytes to escape, extensive branching to increase surface area for exchange, and small diameters to allow capillaries to penetrate spaces between cells are examples of ideas often missed.

c. Many candidates knew that leucocytes can recognize pathogens and engulf them by phagocytosis/endocytosis. More knowledgeable candidates mentioned production of antibodies with specificity to antigens on pathogens. Further details about antigen inactivation and lymphocyte cloning to amplify antibody production were seen only in the very best answers.

---

b. Ecologists sometimes display data from an ecosystem using a diagram called a pyramid of energy. Describe what is shown in pyramids of energy. [6]

c. Explain the control of body temperature in humans. [8]

Markscheme

b. a. pyramid of energy shows the flow of energy from one trophic level to the next (in a community);

b. units of pyramids of energy are energy per unit area per unit time/kJ m^{-2} yr^{-1};

c. bar width is proportional to the energy stored (in the biomass) in that trophic level;

d. the first/lowest trophic level is producers;

e. second level is primary consumers/herbivores;

f. third level of secondary consumers/carnivores;

g. only a small amount (10 to 20 %) of energy of one level is passed to the next;

h. bar width/energy stored in the trophic level decreases (proportionally) as you go up each level;

i. pyramid shows that there is a limit to the length of food chains;

Award any of the above marking points to a correctly drawn and clearly labelled pyramid.

c. a. normal body core temperature constant/36.5 to 37.5°C; (*accept single values within this range*)

b. regulated by negative feedback/homeostatic mechanisms;

c. hypothalamus is the centre of thermoregulation;

d. hypothalamus sends impulses to the body to increase/decrease temperatures;

e. release of sweat (by sweat glands in the skin) if skin temperature rises;

f. evaporation of water cools the body; (*concept of evaporation must be mentioned*)

g. heat is transferred by blood;

h. transfer of heat from body core in blood to surface;

i. if temperature rises, increased flow of blood/heat to the skin/vasodilation of skin blood vessels/arterioles; (*do not accept veins, arteries or capillaries*)

j. if temperature drops, decreased flow of blood/heat to the skin/vasoconstriction of skin blood vessels/arterioles; (*do not accept veins, arteries or capillaries*)

k. shivering increases heat production (in muscles);

l. example of one behavioural mechanism; *(eg reducing activity (to lower body temperature) / reducing exposed surfaces (to reduce heat loss)*

Examiners report

b. The pyramids of energy were not always shown in the correct energy proportions for each step. As in many of the text books this error is also found, we decided to accept it and award the corresponding mark. Many of the marks were awarded for correctly drawn and clearly labelled pyramids.

c. Among the most common errors were to mention dilation of arteries capillaries or veins instead of arterioles and shivering was not always associated to heat production. The concept of evaporation was not always mentioned. Few were able to account for the role of the hypothalamus.

---

a. Draw a labelled diagram of the adult male reproductive system. [5]

b. Describe the role of sex chromosomes in the control of gender and inheritance of hemophilia. [7]

c. Discuss the ethical issues associated with IVF. [6]

Markscheme

a. *Award **[1]** for each of the following structures clearly drawn and correctly labelled.*

Adjacent structures mentioned in each marking point must be recognizable in the drawing for the mark to be awarded, but need not be correctly labelled.

testes/testis – shown inside scrotum;

scrotum – shown around testes;

sperm duct/vas deferens – shown connected to urethra;

penis/erectile tissue – penis shown with erectile tissue inside;

urethra – shown linking bladder / upper side of prostate gland to end of penis;

epididymis – shown connected to sperm duct;

seminal vesicle – shown branched off sperm duct (not off the urethra);

prostate gland – shown positioned where sperm duct connects with urethra;

bladder – showing urethra leading away;

b. two sex chromosomes are X and Y;

one sex chromosome inherited from each parent;

XX results in female;

XY results in male;

sex determined by sperm/father;

sex-linked genes are those located on the sex chromosomes / usually refers to genes on X chromosome;

recessive sex-linked traits appear more frequently in males since they only have one X chromosome;

hemophilia is an example of a gene located on the X chromosome/sex-linked;

female carriers are heterozygous / X^HX^h;

males with hemophilia are X^hY / normal males are X^HY;

sons (of carrier females) have 50 % probability of showing the trait (even if father is normal);

daughters (X^hX^h) of hemophiliac father and carrier mother can be affected / daughters who receive an affected X from each parent will have hemophilia;

The points above can be gained by annotated Punnett squares.

Candidates may introduce a lettering system for haemophilia genotypes which does not include H and h. Accept other letters for superscripts, but same alphabetical letter should be used throughout, dominant form should appear as upper case letter and recessive as lower case letter.

c. *To award full marks, discussion must contain both pro and con considerations.*

*pros/positive considerations: **[3 max]***
chance for infertile couples to have children;
decision to have children is clearly a conscious one due to difficulty of becoming pregnant;
genetic screening of embryos could decrease suffering from genetic diseases;
spare embryos can safely be stored for future pregnancies/used for stem cell research;

*cons/negative considerations: **[3 max]***
IVF is expensive and might not be equally accessible;
success rate is low therefore it is stressful for the couple;

it is not natural/cultural/religious objections;
could lead to eugenics/gender choice;
could lead to (unwanted) multiple pregnancies with associated risks;
production and storage of unused embryos / associated legal issues / extra embryos may be used for (stem cell) research;
inherited forms of infertility might be passed on to children;
Accept any other reasonable answers.

Examiners report

a. The drawings of the male reproductive system were generally poor. Organs were suspended and not connected to one another in many drawings, while in others they were improperly connected. The relative sizes of structures showed little sense of proportion.

b. Candidates usually knew the role of sex chromosomes in controlling gender but were weak explaining how sex-linkage affects the inheritance of hemophilia. Some stated that dominance changed depending on the gender of the person; others put the gene on the Y chromosome. Punnett squares were evident but had irrelevant crosses. Confusion was apparent over whether hemophilia was a recessive trait, and subsequent lettering systems for genotypes were unclear and muddled.

c. Since this question involved a discussion of ethical issues associated with IVF, both positive and negative arguments should have been included. This did not always happen. Some candidates limited their answers to only negative arguments such as why IVF was not natural or why it was against religious beliefs and did not expand this. Several candidates wrote about the process of IVF while others confused IVF with artificial insemination or even cloning. Fortunately, there were a few candidates who wrote thoughtful and balanced discussions.

---

a. State the source, substrate, products and optimal pH condition for lipase in the human digestive system. [4]

b. Outline the use of **named** enzymes in gene transfer using plasmids. [6]

c. Explain the effect of changes of pH, substrate concentration and temperature on enzyme activity. [8]

Markscheme

a. *eg source:* pancreas;

substrate: triglycerides / lipids / fats / oils;

product: glycerol and (three) fatty acids; (*both needed*)

optimal pH: 8; (accept answers in the range of 7 to 8)

Accept other correct examples.

b. a. plasmids are removed/obtained from bacteria;

b. endonuclease/restriction enzymes cut the plasmids at target sequences;

c. DNA fragments of other organism are cut with the same restriction enzymes;

d. in both DNA and plasmid, complementary sticky ends/staggered cut are produced;

e. DNA segment added to the opened plasmid;

f. spliced together by ligase;

g. reverse transcriptase makes DNA copies of mRNA / DNA polymerase to increase the amount of DNA;

h. recombinant plasmids inserted into new/host cells;

i. cultured/cloned to produce the new genes/more genetically modified cells;

Award [3 max] if no specific enzyme names are given.

Do not accept the word "enzyme" on its own.

c. *pH:*

a. enzymes have an optimal pH/work best at a given pH;

b. activity increases as pH gets closer to optimal pH;

c. extreme pH denatures enzymes;

d. by breaking bonds / changing enzyme shape/structure / active site shape/structure;

substrate:
e. as substrate concentration increases, activity increases;
f. as substrate concentration increases, the collisions between substrate and enzyme increase;
g. up to a maximal level of action / reaching a plateau;
h. all active sites are saturated/occupied;

temperature:
i. enzymes have an optimal temperature (where they work most effectively);
j. activity increases as it gets closer to optimal temperature;
k. high temperatures stop enzyme activity due to irreversible changes in structure / denaturation;
l. by breaking bonds / changing enzyme shape/structure / active site shape/structure;
Award any of the above points in an annotated graph.
*Award up to **[8]** if all three addressed and **[6 max]** if only two addressed.*

Examiners report

a. Clear answers were given by most of the students that had the knowledge.

b. Some students got confused with other biological techniques, making reference to PCR for example, apart from explaining correctly some steps in gene transfer. There was often no mention of reverse transcriptase.

c. Most of the students scored marks for this answer, some of them confused the graphs of temperature and pH with the one of substrate concentration, consequently their explanations were incorrect. A number of students incorrectly wrote that the enzyme denatures once it reaches its optimal temperature or pH, so marks were not awarded.

---

a. Draw a labelled diagram to show the molecular structure of a membrane. [4]

b. Some proteins in membranes act as enzymes. Outline enzyme-substrate specificity. [6]

c. Membranes of pre-synaptic and post-synaptic neurons play an important role in transmission of nerve impulses. Explain the principles of synaptic transmission. [8]

Markscheme

a. *Award [1] for each of the following clearly drawn and correctly labelled.*

phospholipid bilayer; *(double row of opposing phospholipids, tails to inside)*

hydrophilic/phosphate/polar (heads) and hydrophobic/hydrocarbon/fatty acid/nonpolar (tails) labeled;

integral protein; *(embedded in the phospholipid bilayer)*

protein channel/channel protein; *(integral protein showing clear channel/pore)*

peripheral protein; *(shown on surface or slightly embedded on either side)*

glycoprotein*; (with carbohydrate attached on outer side)*

cholesterol; *(shown embedded in bilayer and smaller than the hydrophobic tail)*

b. enzyme shape is specific to (particular) substrate;

lock and key analogy/model;

example of specific enzyme and substrate;

has specific 3-D/tertiary configuration/3-D/tertiary shape essential to functioning;

active site on enzyme binds to substrate;

substrate and active site complementary/fit together;

(substrate and active site) are complementary due to structure/chemical attraction;

enzyme-substrate complex forms;

denaturation changes enzyme's binding ability (to specific substrate);

Award [6] for the above points clearly shown in an annotated diagram.

c. synapse is gap between adjacent neurons;

(arriving) action potential depolarizes pre-synaptic membrane;

opens (voltage-gated) calcium channels in membrane;

causes influx of calcium ions;

causes synaptic vesicles to fuse with pre-synaptic membrane;

vesicles release/exocytose neurotransmitter into the synaptic cleft;

neurotransmitter diffuses/moves across synaptic cleft;

neurotransmitter binds to receptors on post-synaptic membrane;

opens channels allowing sodium ions/potassium ions to diffuse;

initiation of action potential/depolarization in post-synaptic membrane;

removal/breakdown of neurotransmitter stops effect on post-synaptic membrane;

Award any of the above points for a clearly drawn correctly annotated diagram.

(Plus up to [2] for quality)

Examiners report

a. There were many clear diagrams showing the molecular structure of a membrane. A labelled phospholipid bilayer always seemed to be shown. 'Intrinsic and extrinsic proteins' are terms still used by candidates. The marking criteria for glycoprotein and cholesterol discriminated against some who included them. Cholesterol molecules were sometimes incorrectly placed next to the phosphate heads rather than being embedded in the bilayer and appearing smaller than the hydrophobic tails. Overall, however, candidates earned maximum credit for this question.

b. The topic of enzymes has been visited many times on exams and is usually studied in depth. Though the question was narrowed to an outline of enzyme-substrate specificity, many candidates were able to get three of the six available marks. Specificity of enzyme shape to substrate, the lock and key model and the binding of enzyme active site to substrate were the marking points frequently awarded. Sometimes irrelevant information was given, as when enzyme activity under different environmental conditions was described.

c. Unfortunately, candidates who showed thorough understanding of the principles of synaptic transmission were few and far between. Insufficient accurate detailed information was a common problem, along with an incorrect sequence of events. Other answers were laden with generalities, vagueness, or confusion. Many candidates scored poorly on this question.

---

a. Plants are a diverse group of eukaryotic organisms. Describe the different characteristics of the bryophyta, filicinophyta, coniferophyta and angiospermophyta. [9]

b. Plants store carbohydrate in the form of starch. Explain the reasons for starch being digested by the human digestive system. [4]

c. Compare the structure of prokaryotic and eukaryotic cells. [5]

Markscheme

a. (*At least one characteristic from each group is needed for maximum credit*.)

bryophyta have no roots / only have rhizoids;

bryophyta have simple leaves/stems / only a thallus;

bryophyta produce spores in capsule;

byrophyta are nonvascular;

bryophyte exhibit (pronounced) alternation of generations / a significant gametophyte generation;

filicinophyta have roots, stems and leaves;

filicinophyta (often) have divided/pinnate leaves;

filicinophyta produce spores in sporangia/spores on the undersides of leaves;

filicinophyta exhibit alternation of generations;

filicinophyta have primitive vascular tissue / no true xylem and phloem;

coniferophyta have woody stems;

coniferophyta (often) have narrow leaves/needles/scales;

coniferophyta produce seeds in cones/unenclosed seeds;

angiospermophyta have flowers;

angiospermophyta have ovules in ovaries;

angiospermophyta produce seeds (with hard coats) in fruits;

b. starch is a large molecule;

large molecules/starch cannot be absorbed by the intestine/villi/epithelial cells;

glucose produced by digestion of starch can be absorbed;

starch/glucose is a useful source of energy;

starch is not used in humans;

glucose is stored as glycogen not starch;

starch is not soluble/could not be transported by blood;

c. (In the table below, information from both boxes on same line is needed for 1 mark.)

*Differences **[max 4]**:*

Prokaryotic cells	Eukaryotic cells
no nucleus	nucleus;
naked DNA	DNA associated with histone/protein;
loop of DNA	strands of DNA;
no mitochondria	mitochondria;
70S/ smaller ribosomes	80S/ larger ribosomes;
no/few internal membranes / no organelles	internal membranes/organelles/ Golgi/ER/lysosomes;
smaller in size (approx. 1-10μm)	larger in size (approx. 10-100μm);
cell wall (glycoprotein) present	sometimes present/not in animal cells;

Similarities: (*Award 1 mark for any combination of two different items **[max 2]***)

cytoplasm/plasma membrane/contains DNA/contains ribosomes

Examiners report

a. Only a few candidates could mention more than one distinguishing characteristic for each plant group. Within this category, there were a few elite candidates who earned maximum or close to maximum marks. They wrote comprehensive answers, full of detailed knowledge. For example, in terms of reproduction, they stated that bryophyta produce spores in capsules, that filicinophyta produce spores on the undersides of leaves (in sporangia), that coniferophyta produce seeds in cones or that angiospermophyta produce seeds in fruits.

b. That starch is useful for energy was the only idea candidates seemed to know about starch. Few candidates realized that starch molecules are large and must be digested to the size of glucose before being absorbed in the intestines of humans.

c. There were some good attempts to distinguish the types of cells, but all points were not described to gain full marks. Sometimes diagrams were drawn with no differences pointed out. There was general confusion about bacteria having a cell wall while eukaryotes not having it.

James Beard, a famous chef, once said “Food is our common ground, a universal experience.”

a. Explain how the small intestine moves, digests and absorbs food. [8]

b. Distinguish between the structures of the different types of fatty acids in food. [4]

c. Outline how leptin controls appetite. [3]

Markscheme

a. a. contraction of muscle «layers»/peristalsis helps move food

OR

circular muscle contraction prevents backward movement of food

OR

longitudinal muscle contraction moves food along gut

b. peristalsis/muscle contractions mix food with intestinal enzymes

c. enzymes digest macromolecules into monomers

Accept an example for mp c

d. pancreatic enzymes/amylase/lipase/endopeptidase «chemically» digest food in«lumen of» small intestine

e. «pancreatic» amylase digests starch
OR
lipases digest lipids/fats/triglycerides
OR
endopeptidases/dipeptidases digest proteins/polypeptides

f. bile/bicarbonate secreted into the small intestine creates favorable pH for enzymes
OR
bile emulsifies fat

g. some final digestion into monomers is associated with epithelial cells/epithelium «of small intestine»

h. mucosa layer/inside surface/lining of small intestine contains villi/finger-like projections

i. villi/microvilli increase surface area for better absorption

j. villi absorb products of digestion/monomers/mineral «ions»/vitamins

k. glucose/amino acids enter blood «capillaries»
OR
lipids enter lymph vessels/lacteals

l. absorption involves active transport/diffusion/facilitated diffusion

m. different nutrients are absorbed by different transport mechanisms

b. a. fatty acids can be saturated or unsaturated

b. unsaturated can be monounsaturated or polyunsaturated

c. saturated fats have no double bonds/have maximum number of hydrogen atoms
OR
unsaturated fatty acids have «at least one» double C=C bond
OR
polyunsaturated fatty acids have more than one double bond / OWTTE

d. cis-form has hydrogen atoms on same side of carbon double bond
OR
cis-form has bend at carbon double bond

e. trans-form has hydrogens on opposite sides of carbon double bond
OR
trans-form makes a straight carbon chain

f. length of hydrocarbon chain can vary
OR
position/number of carbon double bonds can vary

Accept labeled diagrams that illustrate these marking points

c. a. leptin suppresses/inhibits appetite

b. is secreted by adipose tissue/fat «storage» tissue

c. level is controlled by amount of adipose tissue/«ongoing» food intake

d. leptin targets cells in hypothalamus/appetite control centre in brain

e. causes hypothalamus/control centre in brain to inhibit appetite

f. if amount of adipose tissue increases, blood leptin concentration rises

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

---

a. Draw a molecular diagram of an amino acid to show its general structure. [3]

b. Outline the role of ribosomes in translation. [4]

c. Some blood proteins are involved in defence against infectious disease. Explain the roles of **named** types of blood proteins in different defence mechanisms. [8]

Markscheme

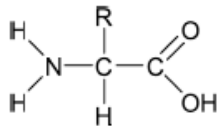
a. a. COO^- ***or*** COOH group at one end

b. NH_2 ***or*** NH_3^+ at the other

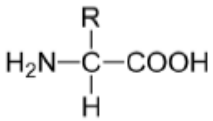
c. CH in middle with H or R group attached

If shown expanded, then carbonyl oxygen must attach to C
If shown non-expanded, N of amine group must attach to C

eg:



OR



b. a. translation is the production of polypeptides/proteins

b. mRNA binds to the ribosome

c. tRNA binds to the ribosome

d. at the site where its anti-codon corresponds to the codon on the mRNA

OWTTE

e. amino acids of «consecutive tRNAs» bind by a peptide link «in the ribosomes»

f. the ribosome moves along the mRNA
OR
continues with elongation of polypeptide chain

Accept annotated diagrams of the process.

c. a. clotting factors «are proteins» that initiate the clotting cascade/process

b. fibrin «is a protein that» permits blood clotting
OR
allows the formation of a clot

c. «the protease» thrombin converts fibrinogen to fibrin

OWTTE

d. fibrin forms a mesh/clot that prevents the entry of pathogen/antigen into the blood

e. antibodies are «specific» proteins that lymphocytes make

f. each antibody corresponds to a specific pathogen/antigen
OR
antibodies are specific «to certain pathogens/antigens»

g. antibodies create specific immunity

h. plasma cells produce large amounts of «specific» antibodies
OR
memory cells retain the ability to produce «specific» antibodies

i. immunoglobulins are antibodies against pathogens

j. enzymes in phagocytic white blood cells may digest pathogens

Accept annotated diagrams of the process.

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

Reproduction in eukaryotes can be sexual or asexual.

a. Describe the origin of eukaryotic cells according to the endosymbiotic theory. [4]

b. Explain how hormones are used to control the human menstrual cycle. [8]

c. Outline natural methods of cloning in some eukaryotes. [3]

Markscheme

a. a. mitochondria and chloroplasts are similar to prokaryotes

b. «host» cell took in another cell by endocytosis/by engulfing «in a vesicle»

Allow "taking in" in place of "engulfing"

c. but did not digest the cell/kept the «ingested» cell alive

OR

symbiotic/mutualistic relationship «between engulfed and host cell»

d. chloroplasts and mitochondria were once independent/free-living «organisms»

e. DNA «loop» in chloroplast/mitochondrion

f. division/binary fission of chloroplast/mitochondrion

g. double membrane around chloroplast/mitochondrion

h. 70s ribosomes «in chloroplast/mitochondrion»

*Award up to **[2]** for evidence from mpe to mph*

[Max 4 Marks]

b. a. FSH stimulates the development of follicles

b. follicles produce estrogen

c. estrogen stimulates the repair of the uterus lining

d. estrogen stimulates LH secretion

e. LH causes/stimulates ovulation

f. LH causes/stimulates the development of the corpus luteum

g. corpus luteum secretes progesterone

h. progesterone causes/stimulates thickening of the uterus lining

OR

prepares uterine lining for implantation

OR

maintains the endometrium

i. progesterone/estrogen inhibits the secretion of LH/FSH

j. falling progesterone levels at the end of the cycle allow FSH production/menstruation

k. negative/positive feedback «control» described correctly

l. LH/FSH are pituitary hormones

[Max 8 Marks]

c. a. clones are genetically identical organisms

OR

group of cells derived from a single parent cell

b. asexual reproduction in plants such as tubers/runners/bulbs

Allow other verifiable examples of plants

c. common in non-vertebrates such as budding in hydra

Allow other verifiable examples of invertebrates

d. budding in yeast/fungi

Allow other verifiable examples of fungi

e. identical twins «in humans» are clones because they originate from the same cell

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

---

a. Outline, with examples, the types of carbohydrate found in living organisms. [4]

b. Describe the importance of hydrolysis in digestion. [6]

c. Explain the flow of energy between trophic levels in ecosystems. [8]

Markscheme

a. (mono-, di- and polysaccharides) consist of one, two and many units;

example of monosaccharide (*e.g.* glucose/ribose/galactose/fructose);

example of disaccharide (*e.g.* maltose/lactose/sucrose);

example of polysaccharide (*e.g.* starch/glycogen/cellulose);

b. digestion is the breakdown of large molecules into small molecules;

to allow diffusion / to make food soluble;

so foods can be absorbed into the bloodstream/body;

so foods can move from bloodstream into cells;

small molecules can be joined to form the organism's (unique) macromolecules;

hydrolysis is aided by enzymes;

hydrolysis requires water;

polysaccharides (hydrolysed) to disaccharides/monosaccharides/specific example;

proteins/polypeptides (hydrolysed) to amino acids;

fats/lipids/triglycerides (hydrolysed) to fatty acids and glycerol;

c. sunlight is the initial source of energy for (most) ecosystems;

sunlight (energy) is converted (through photosynthesis) into chemical/potential energy by producers/plants/autotrophs;

energy escapes from an ecosystem (as heat) / is not recycled;

flow of energy through an ecosystem can be represented as a pyramid of energy; (*allow a suitable diagram*)

energy flow in an ecosystem is measured as energy per unit area/volume, per unit time, for example kJ m^{-2} yr^{-1}/ kJ m^{-3} day^{-1} / other valid unit;

(chemical) energy is passed along the food chain/trophic levels;

primary consumer/herbivores obtain energy from plant food;

secondary/tertiary consumer/carnivores obtain energy by eating other (animals);

energy transfer between trophic levels is not 100 % efficient / is only about 10% efficient;

some energy is lost as heat through respiration;

decomposers obtain energy from waste products/dead bodies/leaf litter;

Examiners report

a. Well answered except for the absence of understanding about the prefixes: mono-, di-, and poly- when preceding the word saccharide.

b. Candidates who did well understood that hydrolysis falls within the context of digestion rather than thinking that hydrolysis is synonymous with digestion. Their answers began with the notion that only small molecules can diffuse and be absorbed into the bloodstream and that hydrolysis is a step in the digestive process. Often those candidates went on to describe that hydrolysis requires water and gave examples of how polysaccharides or proteins are hydrolyzed to named sub-units. Even among stronger responses, lipid hydrolysis was not mentioned very often nor was the idea that hydrolysis is aided by enzymes. This question was an interesting link between Topic 3.2 and Topic 6.1

c. The best answers started out with the sun as the ultimate source of energy and how light energy is converted to chemical energy through photosynthesis by autotrophs/plants. This led naturally to how energy passes from one tropic level to the next. By including that energy transfer is only about 10% efficient and that it is not recycled, candidates gained the max of 8 marks. Some candidates included pyramids of energy. Less commonly mentioned was the loss of energy through metabolic heat or that decomposers obtain energy from waste products, dead bodies/leaf litter. Only the rare candidate mentioned how energy flow is measured in energy per unit area/volume per unit time.

---

a. Draw a labelled diagram of a prokaryotic cell. [5]

b. Bacteria are prokaryotes that sometimes act as pathogens. Describe how the body can defend itself against pathogens. [7]

c. Explain the evolution of antibiotic resistance in bacteria. [6]

Markscheme

a. a. cell wall – *uniformly thick and drawn outside the plasma membrane*;

b. plasma membrane – *a continuous single line*;

c. cytoplasm/cytosol;

d. nucleoid/(naked) DNA – *shown as a tangle of thread or irregular shape without a nuclear membrane*;

e. (70S) ribosomes – *drawn as a small circle or dark dot*;

f. pili – hair like structures / flagellum – *shown to be longer than any pili*;

g. plasmid – *circular ring of DNA*;

h. capsule – *drawn outside the cell wall*;

*Award **[1]** for each structure clearly drawn and labelled which conforms to the italicized guidelines given above.*

b. **Remember, up to TWO "quality of construction" marks per essay.**

a. skin/mucus membranes act as barrier (to pathogens);
b. sebaceous glands secrete lactic acid/fatty acids/sebum / make surface of skin acidic;
c. (skin/stomach) acid prevents growth of many pathogens;
d. lysozyme in mucus can kill bacteria;
e. pathogens caught in sticky mucus and removed from body;
f. inflammatory response/inflammation can cause swelling/redness/fever (to inhibit the pathogen);
g. phagocytes/macrophages/leucocytes/white blood cells (non-specifically) identify (pathogens/bacteria/fungi/viruses) as foreign;
h. (phagocytes macrophages/leucocytes/white blood cells) ingest pathogens;
i. specific lymphocytes recognize one specific antigen;
j. (antigen-specific) lymphocytes clone themselves;
k. lymphocytes/leucocytes produce antibodies;
l. antigen-antibody complex formed and stimulates destruction of pathogen;

c. a. antibiotics (are chemicals) used to treat bacterial diseases;

b. within populations, bacteria vary in their (genetic) resistance to antibiotics/fitness;

c. resistance arises by (random) gene mutation;

d. when antibiotics are used antibiotic-sensitive bacteria are killed;

e. (natural) selection favours those with resistance;

f. resistant bacteria survive, reproduce and spread the gene / increase allele frequency of resistant bacteria;

g. the more an antibiotic is used, the more bacterial resistance/the larger the population of antibiotic-resistant bacteria;

h. genes can be transferred to other bacteria by plasmids;

i. doctors/vets use different antibiotics but resistance develops to these as well;

j. multiple-antibiotic resistant bacteria evolve/it becomes difficult to treat some infections;

*(Plus up to **[2]** for quality)*

Examiners report

a. Those that drew a prokaryotic cell did well but there were also quite a few eukaryotic cells as the diagram showed and labeled organelles such as mitochondria, lysosome and endoplasmic reticulum.

b. There were a generous number of marking points for this question. However, candidates were expected to earn some of them describing the first and second lines of defence as well as some of them from the immune response. This answer was generally done well when students weren't confused by extra material, many students had been over taught this area and confused the functions of macrophages / B cells / T cells / memory cells. Terminology and concepts found in HL were presented by students. Those were not accepted in the mark scheme as there were sufficient marks allotted to show understanding of the broad picture expected at SL. Those who used the HL material successfully generally had most of the marks in the mark scheme plus HL information. Unfortunately many got muddled as stated above.

c. Capable candidates answered this question very well and with clear explanation. The best responses extended their answers to include the occurrence of multiple-antibiotic resistant bacteria. Weaker and mid-range candidates mentioned that bacteria evolve to gain resistance to antibiotics but rarely that it occurs through gene mutation or suggested that mutations that give resistance occurred because bacteria required them rather than randomly. There were many vague answers as candidates seemed to have some grasp of the mechanism but difficulty explaining it.

---

a. Outline the role of condensation and hydrolysis in metabolic reactions involving carbohydrates. [4]

b. Metabolic reactions are catalysed by enzymes. Explain how enzymes catalyse reactions and how a change in pH could affect this. [8]

c. Describe the digestion of food in the human digestive system. [6]

Markscheme

a. condensation is joining together molecules with the release of water;

(in general) two monosaccharides join to form a disaccharide / many mono-saccharides/disaccharides form polysaccharides;

example; (*eg. two glucose from maltose*)

hydrolysis is the breaking down of molecules with the addition of water;

(in general) disaccharides break into monosaccharides / polysaccharides break into disaccharides/monosaccharides;

example; (*eg. maltose forms two glucose*)

b. enzymes speed up the rate of chemical reactions;

lock and key model;

substrate fits into active site;

enzyme-substrate specificity;

enzymes work best at optimal pH/different enzymes have different optimal pHs;

increase/decrease from optimum pH decreases activity;

change in pH changes structure/charge of active site;

changing three-dimensional structure of enzyme/protein;

not allowing substrate to fit in active site;

enzymes can be denatured if change is extreme;

denaturing is loss of its biological properties;

sketch graph showing pH versus enzyme activity;

c. chewing food makes smaller particles/increases surface area of food;

starch digestion (begins) in the mouth/by saliva/(salivary) amylase/ptyalin;

digestion of proteins in stomach;

acid condition in stomach provides optimum pH for enzymes;

stomach muscle contraction causes mechanical digestion;

enzymes in small intestine complete digestion;

alkaline condition in small intestine provides optimum pH for enzymes;

bile salts help to emulsify fats;

example of amylase with source, substrate and products;

example of protease with source, substrate and products;

example of lipase with source, substrate and products;

Examiners report

a. In 5(a), most candidates clearly distinguished condensation and hydrolysis. A few candidates did not read the questions properly, giving examples of lipids or proteins instead of carbohydrates. Some marks were always scored.

b. Part 5(b) was an easy question for those who were well-prepared and most handled it well. Some candidates seemed to try to write everything they knew. They gave long explanations of factors beyond pH which can influence how enzymes catalyze reactions. In contrast, other candidates simply wrote that pH change can cause denaturation, without any further reference to change in active site or loss of biological function.

c. The weakest answers for question 5 appeared in 5 (c). The passage of food through various parts of the digestive system was frequently given rather than the breakdown of food. Accurate detailed information was scarce. Although digestion in the mouth was accurately discussed, there was a lack of clarity on digestion in the stomach and intestine. Most candidates discussed mechanical digestion without any attention to chemical digestion. Information on the conditions in each part of the digestion was sketchy. Very few candidates correctly included an example of enzyme source, substrate and product. The role of bile was not clear in most. Some made reference to absorption and egestion, instead of sticking to the question. Sadly, there were candidates who thought that as food progresses through the digestive tract, it stops at the pancreas.

Outline how nerve impulses are transmitted along a nerve fibre.

Markscheme

a. (sodium channels/voltage-gated channels open and) Na+ diffuse into neuron (down concentration gradient);

b. inside of neuron becomes positive compared to outside / potential is reversed / depolarization;

c. wave of depolarization moves (down the membrane);

d. (potassium channels open and) K+ diffuse out (down concentration gradient);

e. inside becomes negative compared with outside / potential across membrane restored / repolarization;

f. active transport of K+ (into neuron) and Na+ (out of neuron) restores resting potential;

Examiners report

Many low to medium scripts had answers which tackled this question from an anatomical or cytological rather than neurophysio point of view. There was confusion about the meaning of “along a nerve fibre.” Many thought that a “fibre” was more than a single neuron. This lead to outlines of a neural pathway rather than the changes that occur within a single neuron as an impulse passes. Several candidates outlined synaptic transmission. This question could have been set for more marks. Consequently, the strongest candidates often earned more marks than the maximum that could be awarded, while most earned no marks.

---

a. Draw a labelled diagram to show the structure of a membrane. [5]

b. Outline how vesicles are used to transport materials secreted by a cell. [6]

c. Explain how the structure of a villus in the small intestine is related to its function. [7]

Markscheme

a. *Award **[1]** for each of the following clearly drawn and correctly labelled.*

phospholipid bilayer – double row of opposing phospholipids, tails to inside;

phospholipid – with head and two tails;

hydrophilic/phosphate/polar (heads) and hydrophobic/hydrocarbon/fatty acid/non-polar (tails) labelled;

integral protein – embedded in the phospholipid bilayer;

protein channel – integral protein showing clear channel/pore;

peripheral protein – on the surface;

glycoprotein – with carbohydrate attached on one side;

cholesterol – shown embedded in bilayer;

b. vesicles formed from rER transport proteins to Golgi apparatus;

these vesicles fuse with membranes of Golgi apparatus;

proteins are processed as they move through Golgi apparatus;

(transport) vesicles bud off/leave Golgi apparatus;

vesicles move through cytoplasm;

(vesicles) fuse with plasma membrane;

contents released to outside of cell / exocytosis;

cells use vesicles to secrete substances such as hormones/digestive enzymes/other appropriate example;

vesicles may contain cell products other than proteins;

Credit drawings which fully explain the points above.

c. *To achieve **[1]** answer must name the structure and relate it to its function.*

the villus has a large surface area to volume ratio;

microvilli increase surface area for absorption;

thin surface (epithelial) layer so products of digestion can pass easily through;

channel proteins located in plasma membrane used for facilitated diffusion;

network of capillaries inside each villus (so only short distance) for movement of absorbed products;

capillaries transport absorbed nutrients/sugars and amino acids away from small intestine;

blood flow in capillaries maintains concentration gradient;

central lymph vessel/lacteal to transport absorbed fats/fatty acids away from small intestine;

large number of mitochondria provide ATP needed for active transport;

protein pumps in membrane (of microvilli) carry out active transport;

pinocytosis occurs at surface (epithelial) layer;

Accept any of the points above shown in a drawing.

Examiners report

a. Many good membrane diagrams were seen. Phospholipids usually were shown with two tails. There was some uncertainty about the appearance of glycoproteins.

b. There were a variety of confused answers written about vesicles transporting materials produced by the cell. Some candidates mistakenly began with endocytosis and the formation of vesicles as the plasma membrane pinched inwardly. Only a few candidates stated that vesicles formed from rER and that proteins were carried to the Golgi apparatus.

Many candidates eventually stated that vesicles fuse with the plasma membrane but some thought that the vesicles again form around the cell product to transport materials outside the cell. Generally, candidates did not know this topic.

c. Candidates knew that villi increase the intestinal surface area for greater absorption. They also knew that the thinness of the villi surface layer facilitates the passage of digestive products into the villi. Explanations usually included the role of capillaries but less often the role of lacteals. There was little mention of mitochondria, ATP, protein pumps or active transport. A few candidates mistakenly thought that villi help pass food along the digestive tract.

---

a. State the functions of the following organelles of a eukaryotic animal cell: lysosome, Golgi apparatus, free ribosomes, plasma membrane, rough endoplasmic reticulum. [5]

b. Distinguish between anaerobic and aerobic cell respiration in eukaryotes. [4]

c. Explain the mechanism of ventilation in the lungs in order to promote gas exchange for cell respiration. [9]

Markscheme

a. *lysosome:*

a. (from Golgi apparatus) with digestive enzymes / break down food/organelles/ cell;

Golgi apparatus:
b. site that processes/modifies/packages and releases proteins;

free ribosomes:
c. site of synthesis of proteins (released to cytoplasm);

plasma membrane:
d. controls entry and exit of materials/substances in cell;

rough endoplasmic reticulum:
e. synthesis and transport of proteins; (*both needed*)

b.

	aerobic	anaerobic
a.	requires oxygen	no oxygen;
b.	(in cytoplasm and) mitochondria	in cytoplasm;
c.	Krebs cycle	no Krebs cycle;
d.	large yield of ATP/energy	small yield of ATP;
e.	CO_2 and water *(both needed)*	lactate (animals);
f.		ethanol + CO_2 (yeast/plants); *(both needed)*

*Award **[1]** for each contrasting characteristic.*

Table format is not necessary for the marks.

c. a. inspiration/inhalation brings air into lungs;

b. external intercostal muscles contract;

c. and move rib cage upwards and outwards;

d. diaphragm flattens/contracts;

e. increasing thoracic volume;

f. pressure decreases from atmospheric pressure so air rushes into lungs;

g. expiration/exhalation forces air out;

h. internal intercostal muscles contract / external intercostal muscles and diaphragm relax;

i. abdominal/abdomen wall muscles contract and push diaphragm upwards;

j. decreasing thoracic volume;

k. increasing pressure in lungs so air is forced out;

l. a concentration gradient between air sacs and blood needs to be maintained;

Examiners report

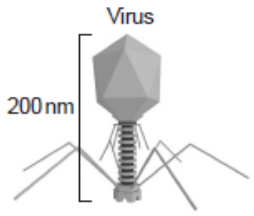
a. Question 6 was the most popular to answer.

The major confusions were found when explaining the functions of the Golgi Apparatus and the rough endoplasmic reticulum. Some candidates did not make any reference to proteins when explaining the function of the Golgi, for which they did not receive the mark.

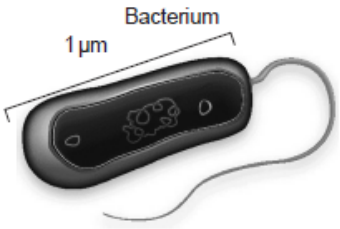
b. Marks were not awarded generally for incomplete answers. E.g. Not mentioning one of the end products of anaerobic respiration, either CO_2 or ethanol or in products of aerobic respiration, water was often omitted. The comparisons were sometimes difficult to spot, given that they did not use a chart or did not follow a proper order. Finally some candidates simply failed to compare, explaining only one type of cell respiration.

c. There were quite a few students who gave very good descriptions of gas exchange and even respiration in some cases, and the properties of the alveoli that made them well adapted for gas exchange. Unfortunately the question was "Explain the mechanism of ventilation in the lungs in order to promote gas exchange for cell respiration". Many candidates did not read the question correctly. Some candidates even gave more detail of aerobic respiration here than they did in part b. Among the most common errors found were to say that "...inspiration brings oxygen into the lungs" and that "...expiration releases CO_2". In some of the answers there was no differentiation between external and internal intercostal muscles. Some candidates referred to changes in the lung volume, instead of thoracic volume.

The diagrams show a virus and a bacterium.



[Source: adapted from http://cronodon.com]



[Source: adapted from www.microbiologyonline.org.uk]

a. Calculate the magnification of the bacterium. [1]

b. State the method that bacteria use to divide. [1]

c. Outline the effectiveness of antibiotics against viruses and bacteria. [1]

d(i). Saprotrophic organisms, such as *Mucor* species, are abundant in soils. [1]

Define *saprotrophic organisms*.

d(ii). State **one** role of saprotrophic organisms in the ecosystem. [1]

Markscheme

a. 45 000(x) ***or*** (x)45000 *(accept answers in the range of 44000 to 46 000)*

b. binary fission

c. effective against bacteria, but not viruses

d(i). an organism that secretes enzymes in dead organic matter and absorbs its nutrients/products of digestion

d(ii). decomposer / recycle <u>nutrients</u> / break down organic material into inorganic material

Do not just accept "recycle" alone.

Examiners report

a. Once again a simple calculation resulted in answers that were both incorrect and illogical. Better candidates gained the mark for 45000x. Some lost the mark for incorrect units.

b. ‘Binary fusion’ was the most common wrong answer.

c. Most knew that antibiotics are effective against bacteria, not viruses. An explanation was not required.

d(i). These were really definitions from the syllabus.

d(ii). These were really definitions from the syllabus.

a. Draw a labelled diagram showing the **interconnections** between the liver, gall bladder, pancreas and small intestine. [2]

b. Outline the role of glucagon in homeostasis of glucose. [2]

c. List **two** examples of polysaccharides. [1]

Markscheme

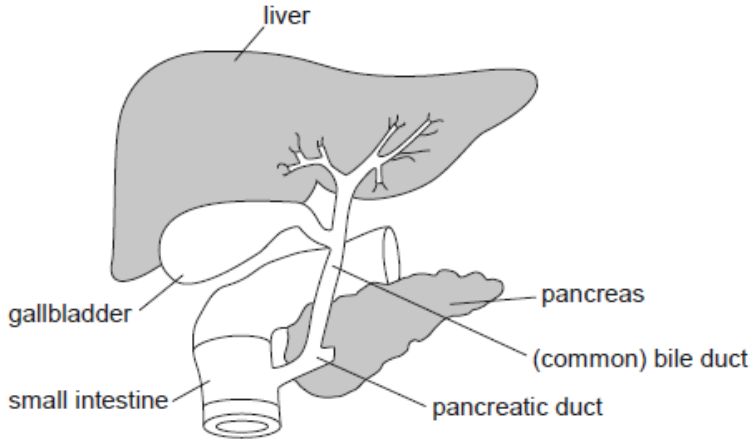
a. a. pancreas linked to small intestine by (pancreatic) duct (pancreas and small intestine both must be labelled);

b. gall bladder shown associated with liver and linked to small intestine by (bile) duct, (gall bladder and small intestine must be labelled);

c. showing (bile and pancreatic) ducts joined together before discharging in small intestine;

Ducts are to be drawn as double line structures.

eg:



b. a. (glucagon) released in response to low blood glucose levels;

b. (glucagon) increases blood glucose levels;

c. glucagon leads to conversion of polysaccharides/glycogen (in the liver) to glucose;

Do not accept implication that glucagon directly converts glycogen to glucose.

c. starch / glycogen / cellulose

*Award **[1]** for any two polysaccharides.*

Examiners report

a. "Well I will just draw a diagram of the gastro intestinal tract and hope for the best", seemed to be the idea of many, resulting in no marks. The connection from the pancreas and the gall bladder to the small intestine had to be shown clearly as ducts, not random lines. The indecision manifested itself in the fact that many candidates drew very feint diagrams, resulting in scanning problems. Point 6.1.4 from the guide states that the interconnections should be clearly shown.

b. Most well prepared candidates could outline the role of glucagon.

c. A disturbing number could not name two polysaccharides.

---

a. Compare simple diffusion with facilitated diffusion as mechanisms to transport solutes across membranes. [5]

b. Describe the process of endocytosis. [5]

c. Explain how an impulse passes along the membrane of a neuron. [8]

Markscheme

a. *Award **[1]** for each linked set of answers.*

	simple diffusion	facilitated diffusion
energy requirement	none	none;
direction of movement	down concentration gradient	down concentration gradient;
specificity	not specific	specific;
passage directly through phospholipid membrane	yes	no;
protein channels	not required	required;
solute	simple molecules / O_2 / CO_2	sugars/amino acids;
solute binding to carriers	no	yes;
speed of diffusion	slower	faster;

b. endocytosis occurs when a membrane encloses a target particle;

fluidity of membrane permits movement of membrane;

membrane sinks inwardly/forms pit/invaginates to enclose particle;

membrane seals back on itself / edges fuse;

one membrane layer / two phospholipid layers enclose particle making vesicle;

inner phospholipid layer of (original) membrane becomes outer phospholipid layer of vesicle membrane;

outer phospholipid layer of (original) membrane becomes inner phospholipid layer of vesicle membrane;

vesicle breaks away from membrane/moves into cytoplasm;

changes in membrane shape require energy;

specific example of endocytosis (*e.g.* pinocytosis, phagocytosis);

Accept any of the above points in an annotated diagram.

c. resting membrane is polarized;

interior is –70 mV/negative relative to outside;

more sodium ions outside than inside;

more potassium ions inside than outside;

disturbance of membrane opens sodium ion channels;

sodium ions rush to inside of cell;

causing depolarization;

sodium ion channels shut;

potassium ion channels open;

potassium ions rush out;

helping to restore polarized state of membrane;

sodium-potassium pumps maintain polarity;

process repeated along the length of neuron / sodium ions diffuse between region with an action potential and the region at resting potential;

Examiners report

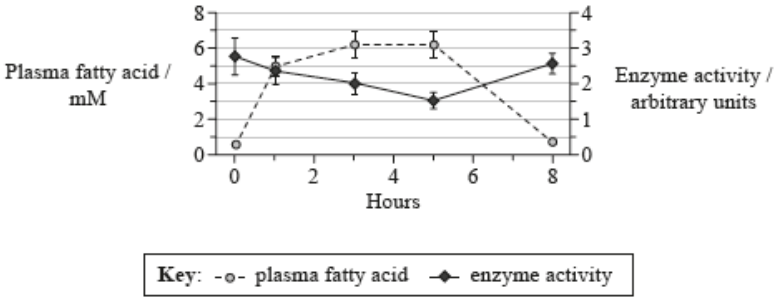
a. On the whole candidates appeared to understand the differences between simple and facilitated diffusion. However, whenever a question asks for a comparison, candidates must make a direct comparison or draw a table to make the comparison explicit. Lists of characteristics of both transport mechanism are not acceptable on their own. This is a case where many candidates were let down by lack of understanding of the implications of not understanding the implication of the command term beginning the question.

b. This question was generally well answered. Many good answers used annotated diagrams to illustrate the process of endocytosis.

c. Many candidates wrote about the movement of impulses from neurone to neurone (across a synapse) rather than answer the question to explain how the impulse passes along a neuron. Some very good responses used annotated diagrams to indicate the flow of ions as the action potential passes along the neurone.

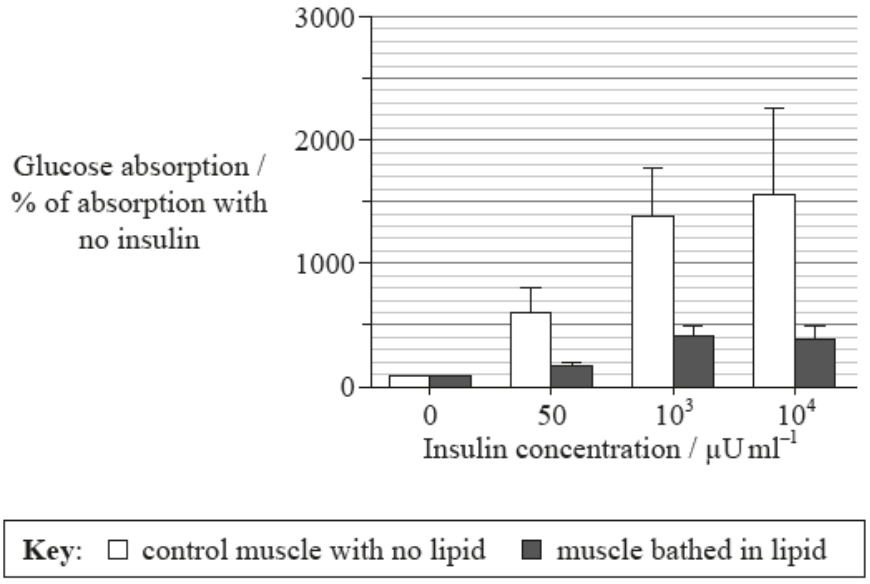
Skeletal muscle fibres normally respond to insulin by absorbing glucose. Failure of skeletal muscle to respond to insulin is a major factor in the development of type II diabetes.

A study was undertaken to investigate the effect of plasma lipids on the process of glucose absorption in response to insulin by muscle fibers. Muscle was bathed in a lipid solution for 5 hours. The lipid was then washed out over the next 3 hours. The graph shows the level of plasma fatty acids and the activity of an enzyme involved in glucose absorption in response to insulin over the period of the study. (Values are means ± standard error)



[Source: Chunli Yu, *et al.* (2002), *The Journal of Biological Chemistry*, **277**, pages 50 230–50 236]

A further study was undertaken to look at the effect of increasing the concentration of insulin on glucose absorption in muscle bathed in lipids. A wide range of insulin concentrations were used in the same type of muscle. Glucose absorption was then measured after 5 hours.



[Source: Chunli Yu, *et al.* (2002), *The Journal of Biological Chemistry*, **277**, pages 50 230–50 236]

a. Distinguish between type I and type II diabetes. [2]

b. State the relationship between plasma fatty acid level and enzyme activity. [1]

c. Calculate the percentage change of enzyme activity after 5 hours exposure to lipids. [1]

d. Discuss, using the data, whether the effect of lipids on this enzyme is reversible. [2]

e. Calculate the increase in glucose absorption when insulin is increased from 0 to 10^3 μU ml^{-1} for the muscle bathed in lipid. [1]

_____% of absorption with no insulin

f. Comment on the effect of increased insulin concentration on glucose absorption in the muscle bathed in lipid. [2]

g. Some investigators suggest that there is a strong relationship between high lipid diet and the body's response to insulin. Using the data provided, evaluate this hypothesis. [2]

Markscheme

a. type 1 caused by destruction of insulin secreting cells/beta cells (in pancreas) / insufficient insulin produced / genetic disorder resulting in failure to produce insulin;

type II caused by decreased response of body cells/receptors to insulin (that is produced);

type I early onset while type II adult onset;

type I treated with insulin while type II with diet (lifestyle changes);

b. negative/inverse relationship/negative correlation / as one variable increases the other decreases / as plasma fatty acid increases, enzyme activity decreases / *vice versa*

c. (a decrease of) 45 (%) *(accept answers in the range of 44 (%) to 47 (%))*

d. yes, effect is reversible as activity returns to (approximately) original level (when lipids/fatty acids decrease);

when lipid/fatty acids washed out enzyme is more active/activity increases;

difference between starting and final levels of enzyme activity is insignificant because of error bars;

three hours/experimental time may be insufficient to reverse the effect

e. 300

f. increased insulin concentration causes more glucose absorption (up to 10^3 μU ml^{-1});

glucose absorption in muscle bathed in lipid always less than control;

no further increase/slight decrease in glucose absorption beyond 103 (μU ml^{-1}) insulin;

g. *Referring to first graph*:

plasma lipids lower activity of enzyme (needed for glucose absorption);

Referring to second graph:
more/higher glucose uptake with higher insulin levels in muscles without lipids (compared to muscles bathed in lipids);
lipids reduce glucose absorption (even at raised insulin concentrations);
isolated muscle used in experiments so results may differ in whole organisms;

Examiners report

a. Distinction between type I and type II diabetes was easy for most; best answers included information on beta cells and insensitivity of cell receptors to insulin; some linked halves of different marking points for no credit, e.g. type I early onset while type II with diet (lifestyle changes) instead of type II early onset while type II adult onset or type I treated with insulin while type II with diet (lifestyle changes).

b. Usually correct, based on a generous markscheme; no mark for inverse proportion.

c. Many candidates could not calculate the percentage decrease in enzyme activity.

d. One of two marks was often awarded; the question asks for the effect of lipids on enzyme activity but some wrongly answered how enzyme activity affects lipid. Some thought the effect of lipids on the enzyme was irreversible because of enzyme denaturation. Virtually no candidate answered marking points c or d which showed a lack of critical thinking regarding experimental design.

e. The increase was wrongly calculated by many candidates who often said '400' but there was more success on this calculation than on 1c.

f. There was a major tendency to quote or describe the data instead of commenting on the data. For example, candidates said that when insulin concentration increased, glucose absorption in muscle also increased instead of saying that increased insulin concentration caused/resulted in increased glucose absorption.

g. Some candidates misinterpreted the second graph as showing the body's response to insulin with a high lipid diet. Again, candidates failed to consider experimental design so the fourth marking point was never awarded.

---

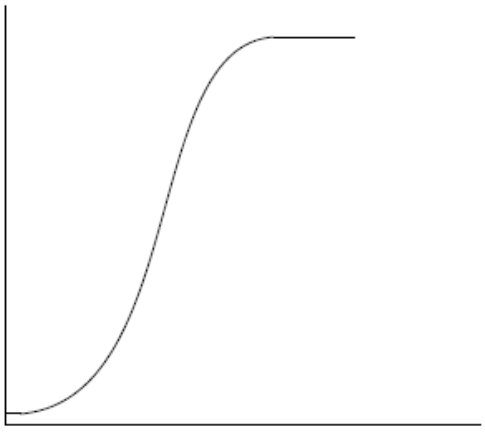
a. Reproduction can cause populations to increase rapidly. Draw a labelled graph showing a sigmoid population growth curve. [4]

b. Explain the various possible consequences of overproduction of offspring. [6]

c. Outline the role of hormones in the menstrual cycle. [8]

Markscheme

a. (a)



S-shaped curve correctly drawn; } *(eg does not fold back on itself)*

y-axis labelled as population/number of individuals and *x*-axis labeled as time/ years etc; } *(both axes must be correctly labelled)*

exponential/log growth indicated at point where rate is increasing;
transitional phase indicated at point where rate is decreasing;
plateau phase; *Do not accept carrying capacity* ***[4 max]***

b. overpopulation/overproducing (of offspring) leads to competition for limited resources/struggle for survival;

example of limited resource; *(eg water/space/food)*

not all can survive / less adapted will die/migrate;

some varieties/individuals more suited for environmental conditions;

they are more likely to survive and reproduce;

this is natural selection;

increase chances/spread of disease in population;

waste products of the population may reach toxic levels;

may exceed carrying capacity leading to population crash;
Do not accept references between species.

c. FSH (released from pituitary) stimulates follicle growth (in ovary);

oocytes/egg cells mature;

cells of growing follicle produce estrogen;

estrogen signals endometrium/lining of uterus to thicken;

causes final maturation of follicle;

high levels of estrogen stimulate secretion of LH;

LH spike stimulates ovulation/follicle ruptures releasing oocyte/ova/egg cells;

LH stimulates follicle (left behind in ovary) to develop into corpus luteum;

LH stimulates corpus luteum to secrete progesterone/estrogen;

progesterone/estrogen stimulates continued development/maintenance of lining of uterus (in preparation for implantation of embryo);

if no pregnancy then corpus luteum disintegrates;

drop in progesterone/estrogen hormone levels causes breakdown in uterine lining/menstruation;

progesterone/estrogen inhibit FSH/LH release;

(Plus up to [2] for quality)

Examiners report

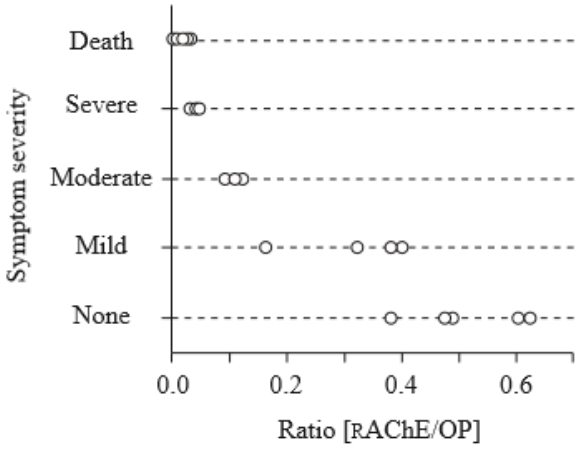
a. Growth curves often showed an S shape but, in some cases, the curve folded over itself. (Some even drew a log-linear plot.) Labelling was generally poor. Surprisingly, errors/omissions were seen in the X and Y labels. Although the plateau phase was usually clearly labelled, the exponential/log growth stage and the transitional phase were often vague. Many candidates did not earn full marks.

b. As consequences of overproduction of offspring, many answers only mentioned competition, limited resources, and survival problems. A common incorrect answer was ‘competition between species’. The spread of disease in a population, the accumulation of waste products to toxic levels, and exceeding the carrying capacity were infrequently mentioned. An increase in predators was not awarded a mark. Some answers digressed in the direction of evolution without gaining marks.

c. The role of hormones in the menstrual cycle was badly answered by many. The role of FSH was known but only partial knowledge of LH, estrogen, and progesterone was seen. Regarding estrogen and progesterone, candidates generally knew they are involved in the maintenance of the lining of the uterus but that was all. Often, the various hormones were stated but without any description of their effect.

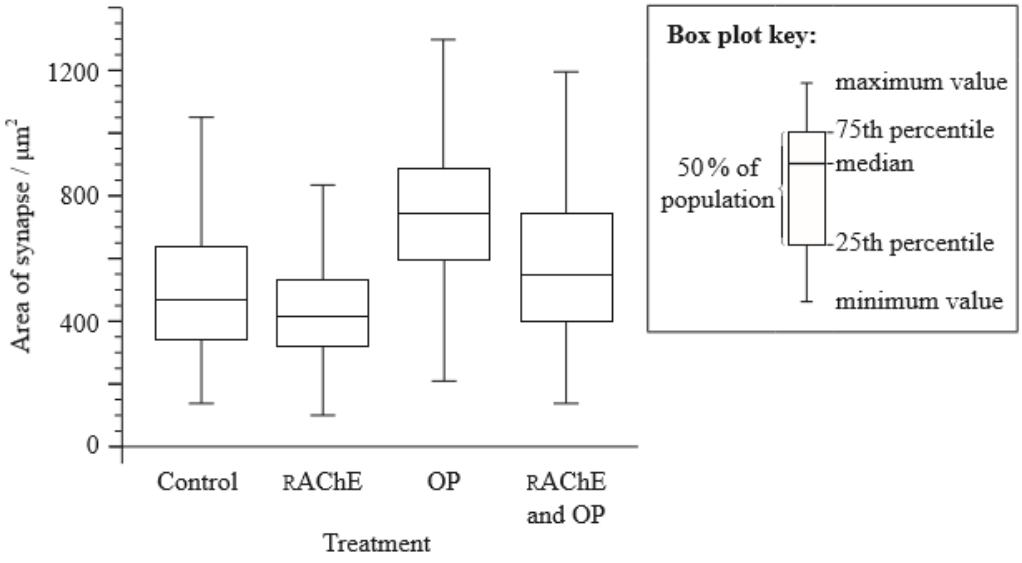
Exposure to organophosphorus pesticides (OP) is a cause of serious nerve damage. It disrupts synaptic transmission by inhibiting the enzyme acetylcholinesterase, causing death due to cardiovascular and respiratory failure.

Recombinant human acetylcholinesterase (rAChE) was obtained by genetic engineering and produced in *Nicotiana benthamiana* plants. It was tested as a new therapeutic treatment in mice that were exposed to OP. The following graph shows the severity of the symptoms shown by each mouse at different ratios of rAChE to OP.



[Source: T. Evron *et al.* (2007), "Plant-derived human acetylcholinesterase-R provides protection from lethal organophosphate poisoning and its chronic aftermath", *FASEB Journal*, 21 (11), pages 2961–2969: Figure 4a. Reprinted with permission.]

To test the effect of OP damage on synapses, mice were treated with rAChE, OP or both. Their diaphragms were dissected 10 days after treatment. The area of the synapse between axons and the diaphragm was measured. When the synapses are damaged by OP there is a greater area. The box plot shows the effect of different treatments on the area of the synapse.



[Source: Tama Evron, Brian C. Geyer, Irene Cherni, Mrinalini Muralidharan, Jacquelyn Kilbourne, Samuel P. Fletcher, Hermona Soreq and Tsafrir S. Mor (2007), "Plant-derived human acetylcholinesterase-R provides protection from lethal organophosphate poisoning and its chronic aftermath", *FASEB Journal*, 21 (11), pages 2961–2969: Figure 5b. Reprinted with permission.]

a. State the minimum ratio at which some mice showed no symptoms. [1]

b. Analyse the effect of increasing the ratio of rAChE to OP on the symptoms in mice. [3]

c. Predict what would happen if a mouse received 300 mg of rAChE and 600 mg of OP. [2]

d. Calculate the difference in median area of synapse between the control mice and mice treated with rAChE and OP, giving the units. [1]

e. Describe the evidence for damage to synapses by OP provided by data in the box plot. [2]

f. Using the data from **both** graphs, evaluate the hypothesis that plant-produced rAChE could be used to protect humans or other mammals from damage caused by exposure to OP. [2]

Markscheme

a. 0.38 (*allow any value in the range 0.37–0.39*)

b. a. as the ratio increases, the symptoms decrease;

b. between 0 and 0.16 *(accept 0.14 – 0.18)* symptoms decrease/are moderate;

c. between 0.16 *(accept 0.14 – 0.18)* and 0.4 *(accept 0.38 – 0.42)* symptoms are mild;

d. between 0.38 and 0.41 mice may have mild or no symptoms;

e. after 0.4 *(accept 0.38 – 0.42)* there are no symptoms;

c. a. (ratio would have been) 0.5/1 to 2;

b. no symptoms;

d. 90 μm^2 (*accept 75 – 100*) (*units required*)

e. a. higher/highest median area of synapses;

b. higher/highest maximum/minimum area of synapses;

c. higher/highest $25^{th}/75^{th}$ percentile;

f. a. the higher the RAChE, the milder the symptoms/damage (first graph);

b. with or without OP, RAChE decreases area of synapses / RAChE reduces the damage to synapses (second graph);

c. (but still) some increase in area/damage to synapses (with OP) even with RAChE;

d. the study was done on mice with no evidence that its results extend to humans;

Examiners report

a. Most candidates gave answers within the accepted range of 0.37-0.39. Those who gave 0.40 were not credited.

b. Many candidates recognized that as the RAChE to OP ratio increases, the symptoms decrease. Some others also saw that after a ratio of 0.4 (accept 0.38 - 0.42) there were no symptoms. Additional marking points were available but often not awarded because candidates did not think to give more details or were not precise enough when analyzing the graph. For example, for ratios between 0 and 0.16 (accept 0.14 - 0.18) the symptoms decrease; or, between 0.16 (accept 0.14 - 0.18) and 0.4 (accept 0.38 - 0.42) the symptoms are mild. The given tolerances provided adequate leeway to candidates who observed those features of the graph and made careful measurements.

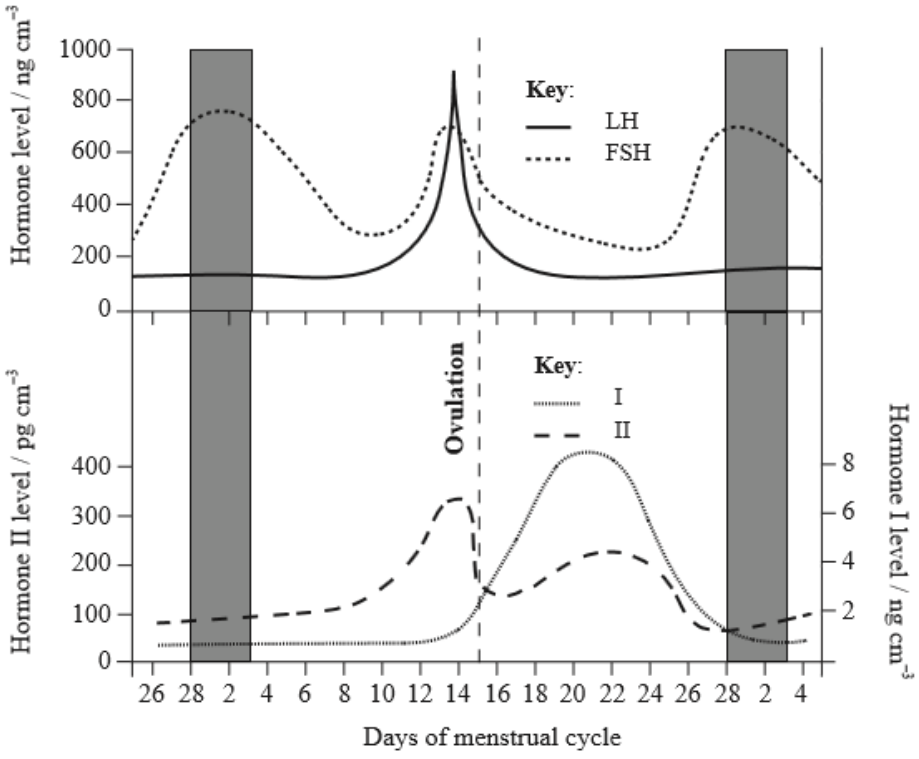
c. Much success was seen here. The prediction of 0.5 and “no symptoms” was very common. It was based on using the supplied data in a simple calculation.

d. This additional calculation for candidates also produced widespread success. It involved finding a difference using box plot data presented in the second graph. There was a generous acceptable range for the answer (from 75-100 μm2). Units were required.

e. Often, at least one mark was gained for describing the evidence. Candidates usually mentioned “highest median area of synapses” or “highest maximum area of synapses” or, sometimes, both for two marks

f. Again, many candidates gained at least one mark. In this case the task was to evaluate an hypothesis. True evaluative statements were not seen very often. A few candidates pointed out that the study was done on mice with no evidence that its results could extend to humans. Other candidates said that since humans and mice are mammals the RAChE might offer protection to humans. Both types of reasoning were accepted. The marks gained most frequently were for more descriptive answers such as “the higher the RAChE, the milder the symptoms” from the first graph or “RAChE decreases area of synapses” or “RAChE reduces the damage to synapses” from second graph.

The graph below shows the levels of hormones during the menstrual cycle.



a. Identify hormones I and II. [2]

I: .....

II: .....

b. Outline the roles of FSH in the menstrual cycle. [2]

c. FSH is secreted by the pituitary gland. During pregnancy, FSH secretion is inhibited. Suggest how FSH secretion could be inhibited during pregnancy. [1]

Markscheme

a. I: progesterone;

II: estrogen;

b. FSH stimulates follicle development;

FSH stimulates estrogen secretion (by the follicle/ovary);

c. high levels of progesterone/estrogen inhibit FSH production (during pregnancy)

Examiners report

a. Progesterone and estrogen were often interchanged. In an apparent effort to salvage one mark, some candidates named the same hormone for answers I and II. This attempt failed because of the contradiction. Some candidates used FSH or LH as labels.

b. Few candidates understood the role of FSH in the menstrual cycle. Often, it was described as stimulating the production of eggs or triggering ovulation.

c. Only a select few knew that FSH is inhibited by progesterone or estrogen during pregnancy. Some wrote that the embryo causes inhibition.

---

a. Draw a labelled diagram of a motor neuron. [5]

b. Explain how an impulse passes along the membrane of a neuron. [8]

c. Describe the process of endocytosis. [5]

Markscheme

a. *Award **[1]** for each of the following clearly drawn and correctly labelled.*

a. cell body – shown with a nucleus;

b. nucleus correctly labelled;

c. axon – shown as double line longer than the longest dendrite;

d. myelin sheath/Schwann cells – surrounding the axon;

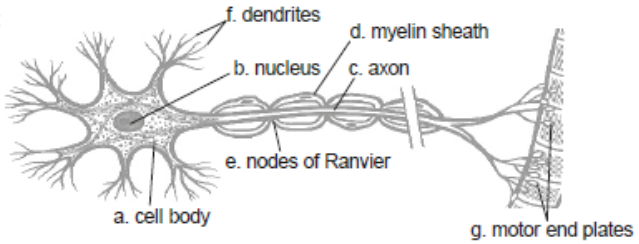
e. nodes of Ranvier – shown in axon;

f. dendrites – shown extending from the cell body;

g. motor end plates – not covered by myelin sheath and ending with buttons/dots;

Award any of the above marking points to clearly drawn annotated diagram.

eg:



b. a. resting potential is –70mV / relatively negative inside in comparison to the outside;

b. Na^{+}/K^{+} pumps maintain/re-establish (the resting potential);

c. more sodium ions outside than inside (when at the resting potential);

d. more potassium ions inside than outside (when at the resting potential);

e. nerve impulse is an action potential that stimulates a (wave of) depolarization along the membrane/axon;

f. if neuron is stimulated/threshold potential/–50mV is reached sodium ion channels open;

g. sodium ions diffuse/move in;

h. (Na^{+} move in) causing depolarization;

i. potassium ion channels open / potassium ions diffuse/move out;

j. (K^{+} move out) causing repolarization;

k. local currents / description of Na^{+} ion diffusion between depolarized region and next region of axon to depolarize;

Accept any of the above points clearly explained in an annotated diagram.

c. a. (plasma) membrane encloses/engulfs solid particles/droplets of fluid/molecules;

b. fluidity of the membrane allows endocytosis;

c. (plasma) membrane forms pit/forms indentation/pulled inwards/invaginates;

d. membrane pinches off /seals back on itself/edges fuse;

e. vesicle/vacuole formed;

f. inside of plasma membrane becomes outside of vesicle membrane / converse;

g. vesicle breaks away from plasma membrane/moves into cytoplasm;

h. active process / endocytosis/vesicle formation requires energy;

Accept any of the above points clearly described in an annotated diagram.

Examiners report

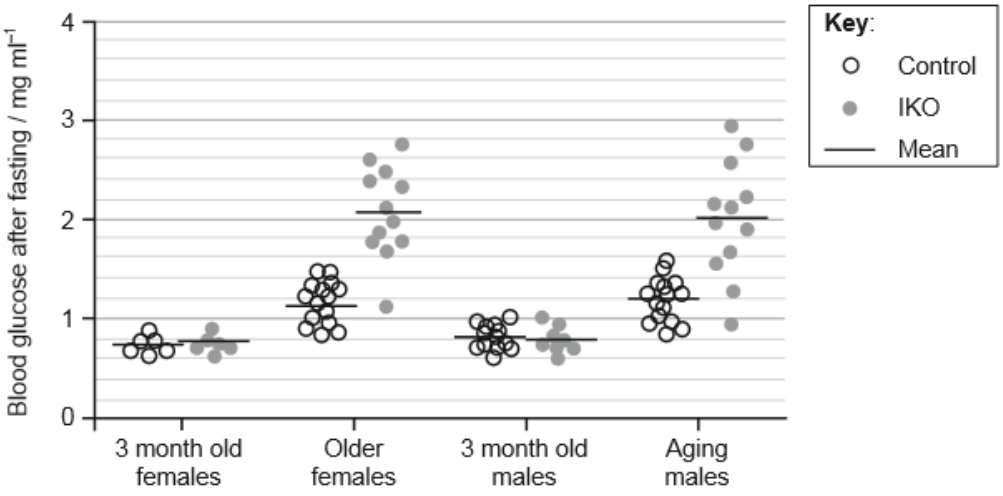
a. Most gained good marks for the diagram, which were generally of a good standard.

b. Most could explain the resting and action potential at a point on the axon. However only the best candidates could explain how it is propagated along the axon.

c. Better candidates could explain endocytosis in detail. Weaker candidates confused it with exocytosis or just described molecules passing through the membrane. The word vesicle should be used for the structure formed by the membrane.

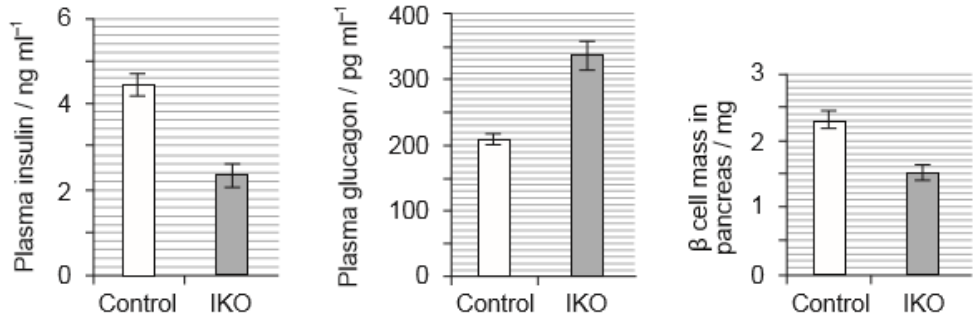
Diabetes is often associated with the failure of the β (beta) cells in the pancreas, but it is unclear what actually causes this failure. FoxO1 is a protein which acts as a transcription factor to regulate the expression of genes involved in cell growth. FoxO1 also regulates increase in number and differentiation in cells such as pancreatic β cells.

A study was conducted using mice lacking the gene for FoxO1 in β cells (IKO) as well as normal (control) mice. Blood glucose levels after fasting were compared for four groups of mice: young (3 months old) male mice, young (3 months old) female mice, older females (who have had several pregnancies) and aging males (16–20 months).



[Source: Chutima Talchai, Shouhong Xuan, Hua V. Lin, Lori Sussel, Domenico Accili, "Pancreatic β Cell Dedifferentiation as a Mechanism of Diabetic β Cell Failure", *Cell*, Volume 150, Issue 6, 14 September 2012, Pages 1223–1234.]

The levels of pancreatic hormones and β cell mass in older female control mice and older female IKO mice lacking FoxO1 were then investigated.



[Source: Chutima Talchai, Shouhong Xuan, Hua V. Lin, Lori Sussel, Domenico Accili, "Pancreatic β Cell Dedifferentiation as a Mechanism of Diabetic β Cell Failure", *Cell*, Volume 150, Issue 6, 14 September 2012, Pages 1223–1234]

a. Compare blood glucose levels after fasting in young control mice and young IKO mice without FoxO1. [2]

b (i) Estimate the difference between mean blood glucose levels in control and IKO older female mice. [1]

.....mg ml^{-1}

b (ii) Aging and having pregnancies are considered to be physiological stresses. Deduce the effect of stress on blood glucose levels. [2]

c. Outline the relationship between blood glucose levels after fasting and lack of FoxO1 in the mice studied. [2]

d. Calculate the percentage difference in β cell mass of the IKO mice compared to the control mice. [2]

e. State the correlation between lack of FoxO1 and pancreatic hormones in mice. [1]

f. Referring to the functions of insulin and glucagon, suggest how the differences in hormone levels help to explain the blood glucose levels. [3]

Markscheme

a. a. similar/same/nearly same (means)/very small difference/both at a low level;

b. means/averages (all) close to 0.8 mg ml^{-1};

c. difference not (statistically) significant;

d. similar/same/nearly same range of values/spread of data;

All marking points are comparisons between control and IKO mice. Do not award marks for comparisons between male and female mice.

b (i) 1 mg ml^{-1} (accept values between 0.8 – 1)

b (ii) a. stress causes increase in (mean) blood glucose/sugar;

b. older mice/males/females / aging mice show the increase;

*Reject answers that **only** compare control and IKO mice or **only** compare male and female mice.*

c. a. in young mice/3 month old mice lack of FoxO1/IKO/fewer beta cells does not affect/has little effect on blood glucose/sugar;

b. in older females/aging males blood glucose/sugar (much) higher with lack of FoxO1/IKO/fewer beta cells;

d. Award **[1]** for an answer:

a. accept either 35 / 34.8 / 34.78 (*this answer may be expressed as negative*) **OR** 53 / 53.3 / 53.33;

Do not award the mark if more than two decimal places shown or if the answer is incorrectly rounded up or down.

Award **[1]** for working, accepting any of the following:

OR other credible alternatives for working;

e. lack of FoxO1 (correlates) with low/decreased insulin and high/increased glucagon levels.

f. a. insulin used to take up/reduce glucose levels (after eating/when blood glucose levels high);

b. decrease in insulin in FoxO1 lacking/IKO mice would cause increase in glucose levels (as less is removed);

c. glucagon (used to convert stored carbohydrate to glucose) to increase glucose levels;

d. increase in glucagon (as seen in second graph, where IKO level higher than control) would mean more glucose added to blood/increase in glucose levels (on first graph);

e. (on first graph) see older/stressed/adult female mice with much higher glucose levels than young mice;

Examiners report

a. Most candidates achieved one mark. This was an unusual compare question as the similarity was that the data showed only slight differences and the differences were actually not significant. The correct answers less often given included the added notation that there was no significant difference, the observation that the data were clustered around a mean value of 0.8 mg ml–1 and the observation that there is nearly the same spread of data (least often noted).

b (i) Most candidates achieved this mark.

b (ii) Many candidates got one or the other of the marks; better students got both by stating their answers as a formal deduction. The formality was not required for the mark, but seems to have been achieved by those who did

c. Many saw the relationship between older control and IKO mice but failed to comment on the relationship between younger control and IKO mice.

d. There are 2, possibly more, correct answers, depending upon the emphasis of the finding being discussed. So, the mark scheme limited acceptable answers to two possible numeric answers because, of the candidates who responded correctly, about half responded with 53% and the other half responded with 35%. There at least 5 ways to work through this problem correctly so the marking point for the working, was very generous. Partial working counted: all the way from extracting the correct data from the graphs (minimum) to display of all steps to an answer. All of these variations received marks for working. Numbers from the graph such as 2.3 and 1.5 were seen often but poor working. The mark was given anyway because necessary numbers were read from the graph. Working with percentages is an expectation given in the Mathematical Expectations in the course guide. Many candidates work with percentage change and percentage difference in their practical work. This is seen in the IA samples where schools are providing complex activities in the practical scheme of work.

e. As mentioned on the G-2 forms, this was an unusual format for asking candidates to detect correlations. However, where the answers really grappled with the idea of correlation, they usually performed well. They had to recognize that there are actually two correlations expected in the answer.

Wrong answers often described a causal relationship. Candidates did not seem to understand that when writing about correlation, causation should not be implied. A verb such as increases or decreases implies cause. However, the adjectives decreased insulin and increased glucagon are acceptable because the adjectives describe the conditions of the correlation. As such, the question assessed an authentic understanding of Topic 1 AS 1.1.6.

f. This question expected an application of information learned in Topic 6 (AS 6.5.11) to the data given. The command term is suggest which opens the door to reasonable analysis. Of the candidates who understood what was being asked, most earned two marks. They could gain one mark by recalling the function of insulin on blood glucose levels and another mark by recalling the function of glucagon. There were three additional marking points for interpreting the data as it would affect blood glucose levels because of the mutation. There were some excellent responses to this question, however, there were some really poor answers too. Candidates described when insulin and glucagon were released but not what the hormones would do. Many regarded insulin as an enzyme that breaks down sugar. Some students stated that glucagon was broken down into glucose. Some attempted to insert diabetes into the answer while others added the concept of stress.

Chronic Obstructive Pulmonary Disease (COPD) is characterized by progressive airflow limitation. Classification of COPD as mild, moderate or severe is based on measurement of Forced Expiratory Volume (FEV), which is the maximum volume of air that can be exhaled in one second.

The table shows the numbers of individuals in each COPD class and their mean FEV for a Swedish study of 349 people.

	Normal	Mild COPD	Moderate COPD	Severe COPD
Never smoked	96	12	6	0
Ex-smokers	95	29	19	3
Regular smokers	32	18	17	2
Occasional smokers	11	8	1	0
FEV / litres	2.9 ± 0.68	2.6 ± 0.60	2.0 ± 0.46	1.3 ± 0.24

[Source: Reproduced with permission of the © ERS 2012. European Respiratory Journal Apr 2012, 39 (4) 839–845; DOI: 10.1183/09031936.00064611]

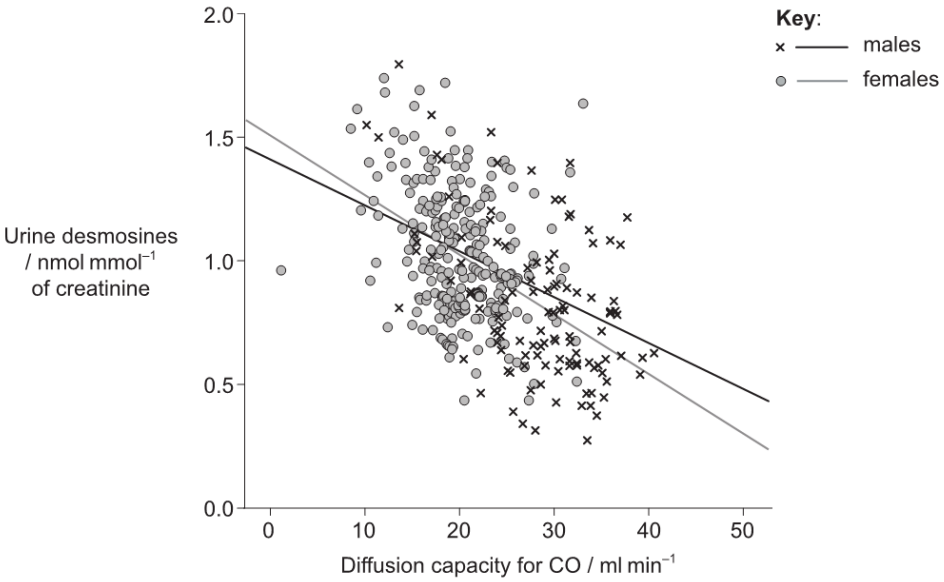
The elasticity and resilience of the lungs are mainly provided by the protein elastin. Degradation of elastin produces peptides called desmosines.

Desmosines in urine or blood plasma have been proposed as biomarkers of lung degradation. The relationship between urine desmosines, plasma desmosines and COPD severity in patients was assessed.

	Urine desmosines / nmol $mmol^{-1}$ of creatinine	Plasma desmosines / nmol L^{-1}
	Median	Median
Disease severity		
No disease	2.5 (1.3–5.7)	0.46 (0.16–1.4)
Mild COPD	2.6 (1.5–5.0)	0.49 (0.30–1.3)
Moderate COPD	2.9 (1.7–6.0)	0.55 (0.33–1.2)
Severe COPD	2.8 (2.0–4.1)	0.64 (0.47–1.1)

[Source: Reproduced with permission of the © ERS 2012. European Respiratory Journal Apr 2012, 39 (4) 839–845; DOI: 10.1183/09031936.00064611]

The graph shows the relationship between the diffusion capacity of the lungs for carbon monoxide (CO) and urine desmosines.



[Source: Reproduced with permission of the © ERS 2012. European Respiratory Journal Apr 2012, 39 (4) 839–845; DOI: 10.1183/09031936.00064611]

a. State the level of COPD that has the lowest FEV. [1]

b. Explain how a low FEV can be used to indicate emphysema. [2]

c. State the disease severity group that has the highest range of plasma desmosines. [1]

d. Evaluate which of the two biomarkers would be the most useful indicator of COPD severity. [2]

e. Elastin is also an important component of other tissues such as arteries and ligaments. Evaluate how these other sources of elastin could affect the interpretation of the biomarker as an indicator of COPD. [2]

f. State the relationship between diffusion capacity and urine desmosines. [1]

g. Other studies on pulmonary diseases have shown a wide variety of results. Apart from age, sex and severity of COPD, list **two** other factors that may explain the inconsistent results between studies. [2]

h. Discuss whether measurements of desmosine concentration would be useful for monitoring changes in the health of a patient. [3]

Markscheme

a. Severe

b. a. low FEV indicates inability to force out air/adequate volume of air

OWTTE

b. airflow limitation is the reason for inability to force out air/shortness of breath

c. inability to force out air/shortness of breath indicates emphysema

d. emphysema causes/involves breakdown of alveoli walls «so less elastin»

The idea that there are fewer alveoli to "push"

[Max 2 Marks]

c. No disease

d. a. plasma desmosines

b. neither is very good due to large overlaps of ranges

OWTTE

OR

the range of data for each category is less for plasma desmosines

OR

data are more reliable

c. the level of plasma desmosines increases with disease severity

d. easier/less invasive to take urine sample rather than a plasma sample

[Max 2 Marks]

e. a. degradation of elastin from other tissues may have contributed to the results

b. there is no guarantee that the concentrations of desmosines measured came from the lungs

OR

difficult to assess how much lung elastin constitutes the total

c. overlapping ranges makes interpretation difficult

[Max 2 Marks]

f. inversely correlated

OR

negative correlation

OR

the higher the «urine» desmosine concentration, the lower the diffusion «rate»

g. a. «small» sample size

OR

only studied in one country

b. methods used

c. environment/pollution/workplace exposure

d. race/genetic factors

e. health status/fitness/BMI of volunteers

[Max 2 Marks]

h. a. positive correlation with COPD severity «as seen in the table»

OR

negative correlation with «CO» diffusion capacity «as seen in the graph»

b. not directly proportional/other factors affect it

c. «but» if other factors stay the same in a patient it could be an effective indicator of change

d. because the ranges are high, only change in an individual is useful

e. the measurements may be more useful for one gender than the other as differences seen in the graph

[Max 3 Marks]

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]
d. [N/A]
e. [N/A]
f. [N/A]
g. [N/A]
h. [N/A]

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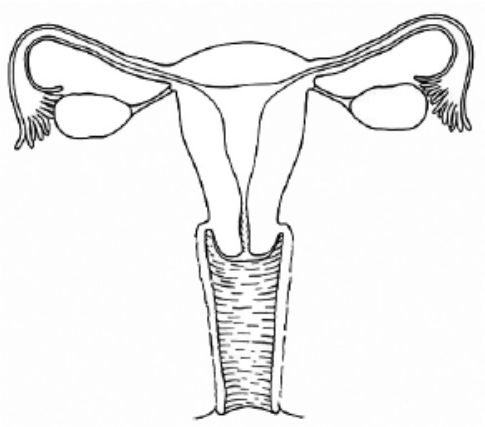
a. The diagram below shows the female reproductive system. [1]



Label the diagram above with the letter U to show the uterus.

b. Outline the role of luteinizing hormone (LH) **after** ovulation. [1]

c. Explain how sexual reproduction can lead to variation in a species. [3]

Markscheme

a. letter U marked/labelled on uterus

Accept in lumen or on wall.

b. formation of the corpus luteum

c. allows characteristics from both parents to appear in offspring;

crossing over (during prophase 1) changes chromosome composition;

produces gametes which are all different;

random chance of which sperm fertilizes ovum;

greater variation (resulting from sexual reproduction) favours survival of species through natural selection;

Accept independent assortment during meiosis from AHL.

Examiners report

a. Almost all candidates could identify the uterus.

b. An extremely difficult question for most candidates as evidenced by many blank answer spaces. The role of LH after ovulation was just not known. The corpus luteum was rarely mentioned.

c. A common knowledge among candidates was their understanding of independent assortment and crossing over. However, for the latter event, some candidates only mentioned the process without any comment on what it accomplished.

Male Lepidoptera (butterflies and moths) commonly drink from pools of water or from moist soil. This behaviour, called puddling, was investigated in an undisturbed area where male tiger swallowtails, *Papilio glaucus*, had been seen puddling.

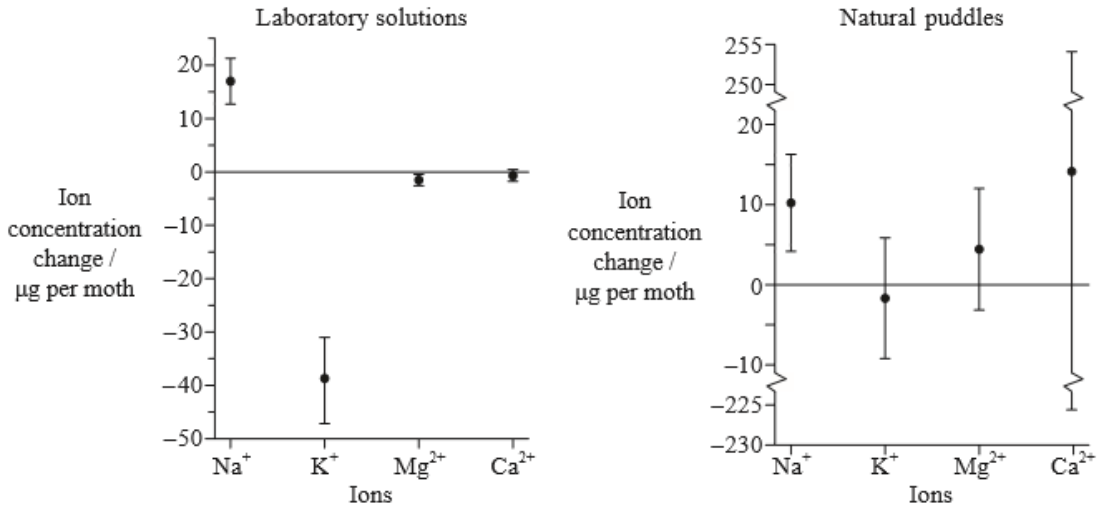
Four successive sets of experiments were performed under similar conditions of temperature and humidity. In each set, equal samples of sand were spread out evenly on trays and then treated differently. Except for one dry sample (in the first set), all others were saturated with a different liquid. Results of the observations are given in the table below.

Numbers of visits (V) and time in minutes (T) spent puddling by male *Papilio glaucus* adults on sand treated in different ways.

Experiments	Visits and times on sand plus substance:									
	V	T	V	T	V	T	V	T	V	T
1	*Dry sand alone*		*Distilled H_2O*		*Casein hydrolyzate*		*5% Sucrose*		*NaCl (0.17 M)*	
	26	0	47	0.5	27	205.5	60	0.5	74	320.5
2	*KCl (0.1 M)*		*$MgCl_2$ (0.1 M)*		*$CaCl_2$ (0.1 M)*		*Na_3PO_4 (0.1 M)*		*NaCl (0.1 M)*	
	33	0	36	0	48	1.5	43	79.5	65	362.0
3	*NH_4Cl (0.1 M)*		*KNO_3 (0.1 M)*		*K_3PO_4 (0.1 M)*		*Na_3PO_4 (0.1 M)*		*$NaNO_3$ (0.1 M)*	
	9	0	6	0	6	0	3	0.5	86	279.5
4	*Distilled H_2O*		*NaCl (10^{-5} M)*		*NaCl (10^{-4} M)*		*NaCl (10^{-3} M)*		*NaCl (10^{-2} M)*	
	2	0	7	1.5	16	27.5	32	172.5	22	195.5

[Source: adapted from K Arms, *et al.*, (1974), *Science*, **185**, pages 372–374]

Study of the male moth *Gluphisia septentrionis* revealed that their puddling behaviour can last for hours. Though drinking results in the uptake of hundreds of gut-loads of fluid, this fluid becomes rapidly expelled from the digestive system through frequent anal ejections. In this experiment, the ion concentration change was calculated by subtracting ions ejected from ions taken in. The following data was collected from males drinking laboratory solutions and from natural puddles.



[Source: adapted from S R Smedley and T Eisner, (1995), *Science*, **270**, pages 1816–1818]

a. Identify the dissolved element always present in the three samples with most puddling time. [1]

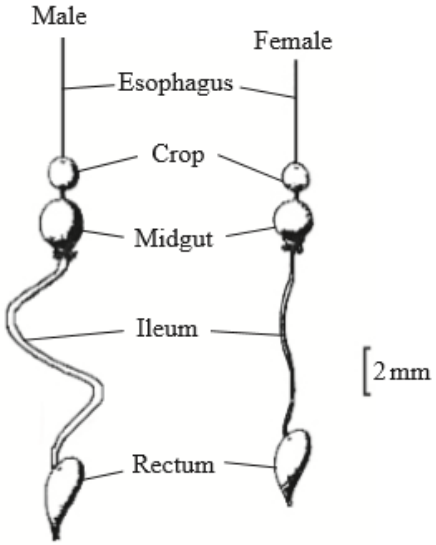
b. Discuss the relationship between sampling visits (V) and puddling time (T) in experiments 1, 2 and 3. [2]

c. Analyse the results for experiment 4. [2]

d (i) Identify which ion the moths are retaining in their body from the laboratory solutions. [1]

d (ii) Compare the gain and loss of ions in the male moths which have drunk from laboratory solutions with the changes in those that have drunk from natural puddles. [3]

e. The diagram below shows the digestive system anatomy of the male and female moth. [2]



[Source: adapted from S R Smedley and T Eisner, (1995), *Science*, **270**, pages 1816–1818]

Using the diagram above, evaluate the hypothesis that male moths are better adapted than female moths to benefit from puddling behaviour.

Markscheme

a. sodium/Na

b. unclear correlation between V and T;

depends on the nature of the substrate and its concentration;

sometimes high V with low T (*e.g.* experiment 1 for sucrose) / sometimes high V with high T (*e.g.* experiment 2 for NaCl);

c. higher salt/NaCl concentrations increase T and V;

increase in puddling with increase in salt/NaCl;

no clear relationship between the number of visits and the concentration of salt/NaCl;

d (i) sodium/Na

d (ii) retention of sodium/Na from laboratory solutions and natural puddles;

definite loss of potassium from laboratory solutions but loss/gain uncertain from natural puddles;

slight loss of magnesium from laboratory solutions and uncertain gain/loss from natural puddles;

calcium uncertain in both cases / variation in data for calcium;

more conclusive results in laboratory solutions / conditions more reliable in laboratory solutions / greater variation in natural puddles;

Accept reference to error bars/ranges in data in place of uncertainty.

e. males have longer/wider digestive tracts for greater absorption of fluid;

ileum of males has greater surface area;

which allows faster/more absorption in males than in females;

Examiners report

a. Many candidates answered NaCl instead of Na when asked to identify the dissolved element.

b. Many candidates were unable to discuss correctly the relationship between sampling visits (V) and pudding time (T) in experiments 1 2 and 3.

c. Many candidates were unable to see the relationship between the NaCl concentration, the sampling visits (V) and the pudding time (T).

d (i) N/A

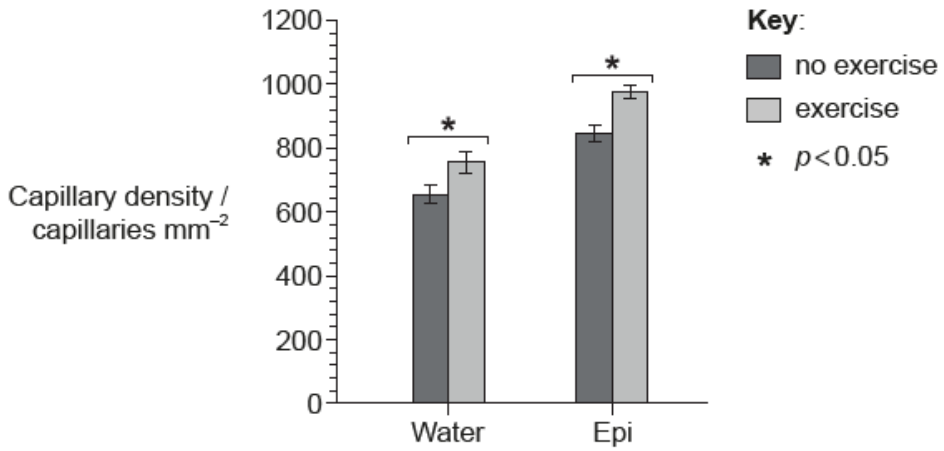
d (ii) In part (ii), the majority of the candidates did not compare the gain and loss of each ion between moths which drank from laboratory solutions and moths which drank from natural puddles.

e. In the case of many candidates, no discussion or analysis was included, only description.

Consumption of dark chocolate has been shown to have health benefits. A study was undertaken to see the effects of epicatechin (Epi), a substance in dark chocolate, on the aerobic capacity of leg muscles of mice.

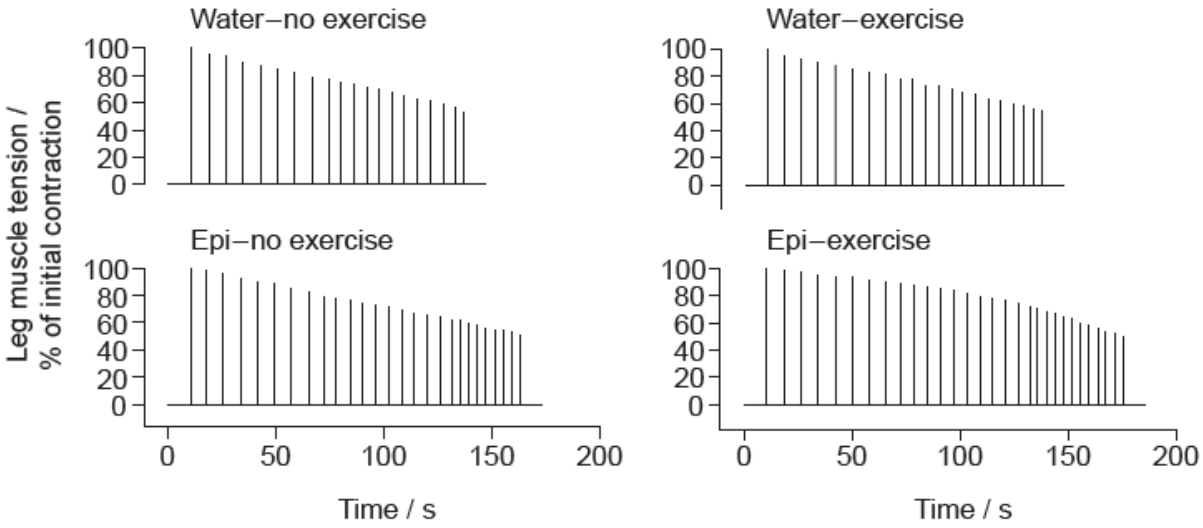
A group of adult mice was used to measure the effects of a low dose of Epi given over 15 days. The mice were divided into four groups and given either water or Epi and were either kept idle (no exercise) or made to exercise on a treadmill.

After 15 days, the results were analysed. The blood capillary density in leg muscle was measured under the light microscope.



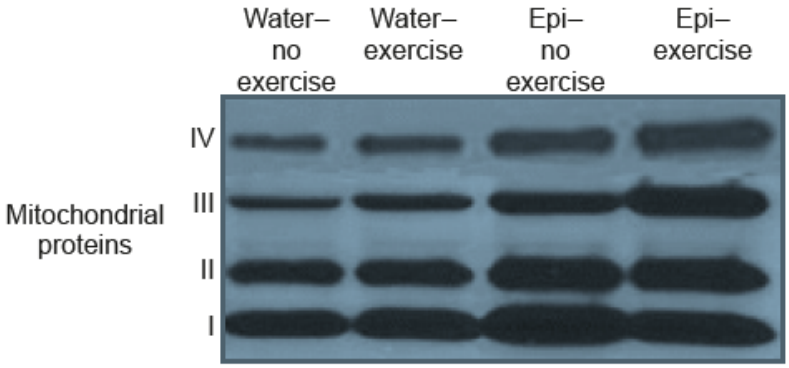
[Source: adapted from L Nogueira, *et al*., (2011), *The Journal of Physiology*, **589** (part 18), Wiley, pages 4615–4631]

Leg muscle tension was measured over time during a treadmill exercise in all four groups. The muscle is considered to reach a point of fatigue when there is a decrease in tension to 50 % of the initial tension.



[Source: adapted from L Nogueira, *et al*., (2011), *The Journal of Physiology*, **589** (part 18), Wiley, pages 4615–4631]

The scientists tested the expression of four different mitochondrial proteins. The protein samples were taken from leg muscles. The technique that was used to quantify the amount of protein expressed was Western blotting. In this procedure the thickness of the band is an indicator of the amount of protein.



[Source: adapted from L Nogueira, *et al.*, (2011), *The Journal of Physiology*, **589** (part 18), Wiley, pages 4615–4631]

a.i. State the significance of the statement: $p<0.05$. [1]

a.ii. Outline the trends in capillary density in the results of this experiment. [2]

b. Describe how increased capillary density could affect the aerobic capacity of muscle. [2]

c.i. State the time when the point of fatigue occurred in the Epi–exercise group. [1]

c.ii. Compare and contrast the results for the water–no exercise group and the Epi–no exercise group. [3]

d. Discuss the effect of exercise on the results of the experiment. [2]

e. Analyse the effect of exercise on the presence of the mitochondrial proteins in the leg muscle. [2]

f. Mitochondria are essential for aerobic respiration. Suggest **one** possible role of the proteins that were studied. [1]

g. The scientists concluded that Epi significantly increased aerobic capacity in leg muscle. [3]

Evaluate the strength of the evidence provided by all of the data for dark chocolate improving the aerobic capacity of athletes.

Markscheme

a.i. there is a significant «statistical» difference between two experimental values

OR

there is a less than 5 % chance that the difference is random

OR

95 % or more probability that results are due to the experiment «IV» and not random/can reject the null hypothesis

OR

there is a relationship/correlation between doing exercise and capillary density

OWTTE

a.ii. a. exercise «significantly» increased the density with both water and Epi

"both" or OWTTE must be mentioned

b. Epi «significantly» increased the density with and without exercise

c. Epi–exercise had the greatest increase in the density
OR
Epi increases the density more than exercise alone

b. a. increases amount of blood taken to the muscle

b. increases the delivery of oxygen/glucose/nutrients for aerobic respiration

c. increases the removal of carbon dioxide/wastes
OR
increased gas exchange

c.i. 175 «seconds»

Accept 170 to 180 «seconds».

c.ii. a. in both cases the tension decreased over time

b. Epi–no exercise lasts longer/more time until «onset of» fatigue «than water–no exercise»

c. the rate of decrease in tension is the same/similar in both

d. Epi–no exercise has more contractions per second before fatigue point «than water–no exercise»

Do not accept numerical comparisons without justification.

d. a. «exercise with» water has no impact

b. «exercise with» Epi promotes higher levels of tension for more time

c. «exercise with» Epi increases the time to fatigue

e. a. exercise has no/very little effect with water

b. exercise with Epi increased III/IV

c. «it appears that» exercise with Epi has no/very little effect on II
OR
Epi relative to water increases all 4
OR
exercise has little/no effect on protein I/II

d. exercise with Epi «appears to» decrease I

f. a. protein channels

OR

pumps in membranes of mitochondria

OR

hormone binding sites

b. structural/integral/peripheral/glyco/surface proteins

c. enzymes/catalysts

Accept verifiable names of specific membrane enzymes.

d. electron transport chain proteins

g. *Limitations*:

a. study done on mice and may not apply to humans

b. levels of Epi administered in experiment may exceed levels in a sample of dark chocolate
OR
levels of Epi administered in experiment may have different levels in a sample of dark chocolate
OR
chocolate may have other components with unknown effects on aerobic capacity

c. mitochondrial proteins may not improve aerobic capacity

Strengths:

d. data supports as dark chocolate contains EPI

e Epi improves capillary density and would therefore increase aerobic capacity

f. Epi improves fatigue resistance

g. Epi in combination with exercise improves it further

h. Epi increases mitochondrial proteins therefore/presumably increasing aerobic capacity

OWTTE

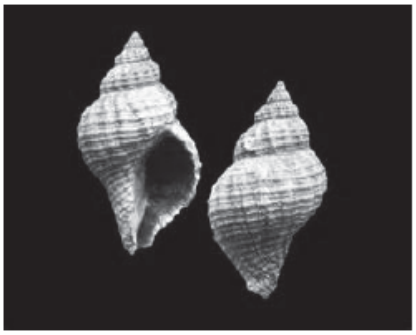
Examiners report

a.i. [N/A]
a.ii. [N/A]
b. [N/A]
c.i. [N/A]
c.ii. [N/A]
d. [N/A]
e. [N/A]
f. [N/A]
g. [N/A]

Native oyster populations are decreasing where rivers meet the ocean along the northwest coast of North America. These oyster populations are being attacked by a gastropod.

Adult oyster, *Ostrea lurida*

[Source: © International Baccalaureate Organization 2017]



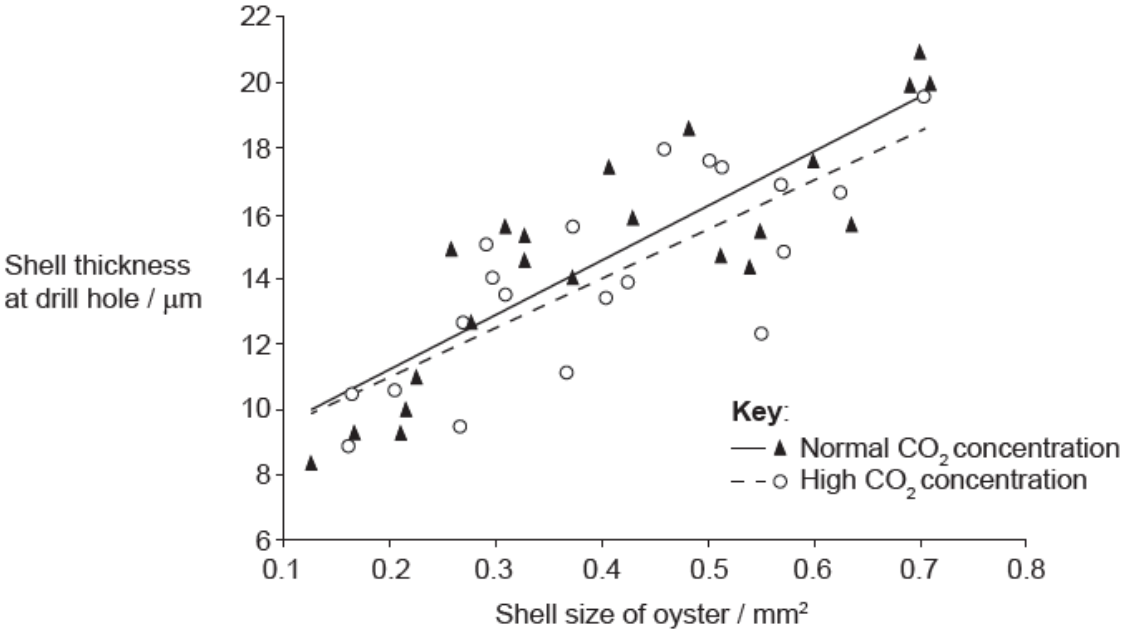
Adult gastropod shell, *Urosalpinx cinerea*

[Source: © International Baccalaureate Organization 2017]

It is known that oysters and gastropods have hard parts composed of calcium carbonate and that ocean acidification is increasing. Studies were carried out using juvenile oysters and gastropods to investigate the effects of acidification on the decrease in the population of oysters.

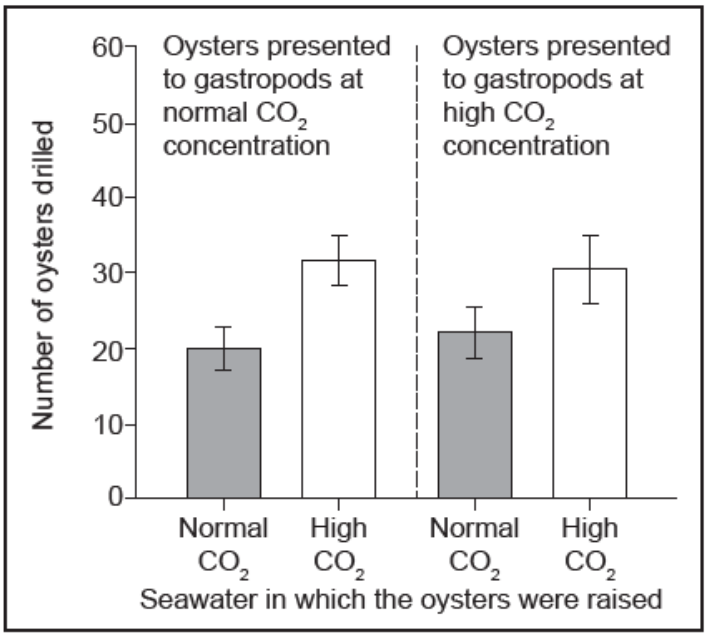
The first step was to raise oysters in two different mesocosms. One had seawater at a normal concentration of CO_2 and the other had sea water with a high concentration of CO_2. Gastropods were raised in two further mesocosms with normal and high CO_2 concentrations respectively.

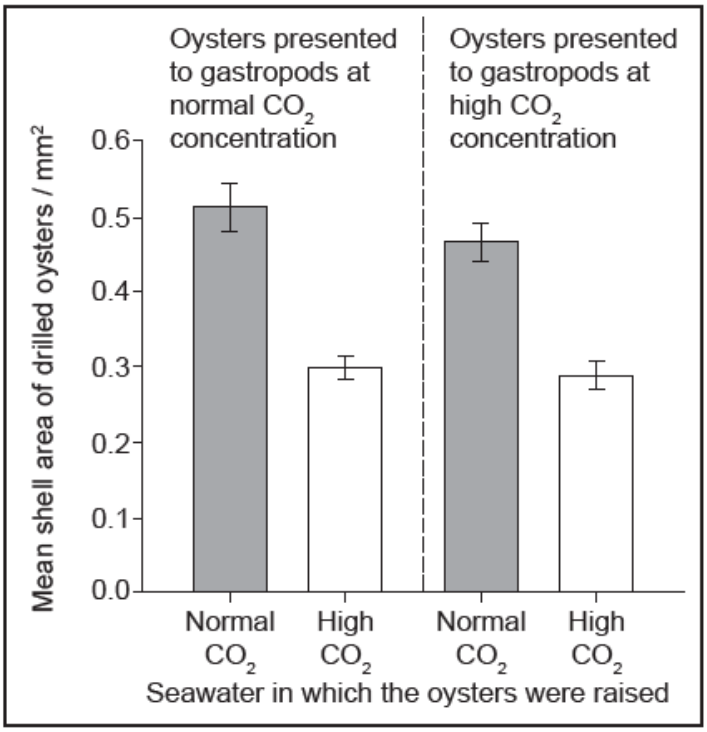
A juvenile gastropod will attack a juvenile oyster by using its tongue-like structure (radula) to drill a hole through the oyster shell. Once the hole has been drilled, the gastropod sucks out the soft flesh. Researchers investigated the shell thickness at the site of the drill hole in relation to the size of the oyster. The results are seen in this graph.



[Source: E Sanford *et al.* (2014) *Proceedings of the Royal Society B*, 281, by permission of the Royal Society.]

Equal numbers of oysters raised in seawater with a normal CO_2 concentration and in seawater with a high CO_2 concentration were then presented together to the gastropod predators in seawater with a normal CO_2 concentration. The same numbers of oysters from the two groups were also presented together to the gastropods in seawater with a high CO_2 concentration. The bar charts show how many of the oysters were drilled by the gastropods and the mean size of drilled oysters.





[Source: © International Baccalaureate Organization 2017]

a. Outline how acidified sea water could affect the shells of the oyster. [1]

b. Outline the trends shown in the data in the graph. [2]

c. Estimate how much smaller drilled oysters raised in seawater at a high CO_2 concentration were than drilled oysters raised in seawater at a normal CO_2 concentration. [1]

d.i. Deduce from the data in the bar charts which factors were and were not correlated significantly with the number of oysters drilled by the gastropods. [2]

d.ii. Suggest reasons for the differences in the numbers of oysters drilled, as shown in the bar charts. [2]

d.iii. The radula in a gastropod is hard but not made of calcium carbonate. Outline how this statement is supported by the drilling success of the gastropods in seawater with normal or high CO_2 concentrations. [2]

e. Using all the data, evaluate how CO_2 concentrations affect the development of oysters and their predation by gastropods. [2]

Markscheme

a. Shells might dissolve/deteriorate / become smaller/thinner/weaker / OWTTE

OR

shell formation reduced / more difficult

b. a. positive correlation between shell thickness and shell size

OR

as shell thickness increases, shell size «also» increases

b. (positive correlation) occurs at two different CO_2 concentrations / both high and normal concentrations

c. trend for thickness is «slightly» lower with high CO_2

c. «approximately» 0.2 mm^2

OR

«approximately» 40 % «smaller»

unit required

d.i. a. significant factor: concentration of CO_2 in which oysters were raised

b. insignificant factor: concentration of CO_2 at which oysters were presented to gastropods

d.ii. a. (because) shells are thinner/smaller when the oyster is raised in high CO_2/lower pH

OR

«because» lower pH/higher acidity prevents/reduces deposition of calcium carbonate

b. gastropods target smaller/thinner-shelled oysters more

c. gastropods can eat/drill thin-shelled/smaller oysters at a faster rate (and move onto another)

d. eating smaller oysters «from high CO_2 environments» means given population of gastropods require more oysters for same food intake

d.iii. a. data shows that similar numbers are drilled regardless of conditions

b. since radulas are not affected by acidification

OR

radulas not made of calcium carbonate so (remain) strong/successful at drilling

e. a. the data/trend lines indicate that a higher CO_2 concentration diminishes the shell thickness, making gastropod predation more successful

OR

the bar graphs suggest that oysters raised in a higher CO_2 concentration are smaller, making gastropod predation more successful

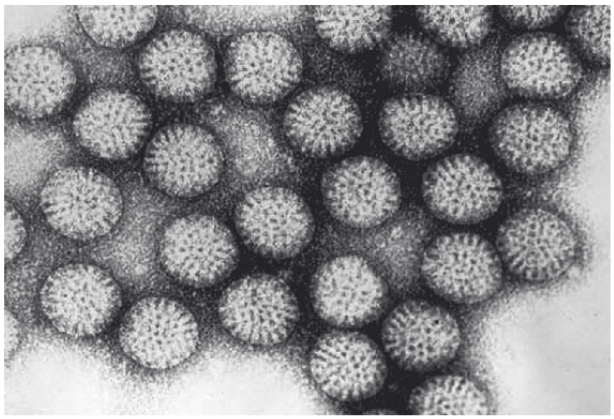
b. CO_2 concentrations «during feeding» do not change the occurrence of drilling/predation «by gastropods»

c. «limitation» no information about how exaggerated the CO_2 concentrations were
OR
«limitation» no information about numbers of gastropods used «in each setting»

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]
d.i. [N/A]
d.ii. [N/A]
d.iii. [N/A]
e. [N/A]

The figure shows a transmission electron micrograph of rotavirus particles. Each rotavirus is about 70 nanometres in diameter.



[Source: CDC / Dr. Erskine L. Palmer]

a. State a reason for using an electron microscope to view this virus rather than a light microscope. [1]

b. Rotavirus causes diarrhea and vomiting. Explain why viral diseases cannot be treated using antibiotics. [2]

c. State an application of plasmids in biotechnology. [1]

Markscheme

a. electron microscope has greater resolution/magnification

OR

70 nm is too small/viruses are too small to be viewed by a light microscope

b. a. viruses are not living

b. viruses lack metabolism/lack enzymes «for metabolism»/lack cell walls

c. antibiotics target metabolic «pathways»/cell wall production

[Max 2 Marks]

c. transfer/vector of genetic material/genes/DNA fragments

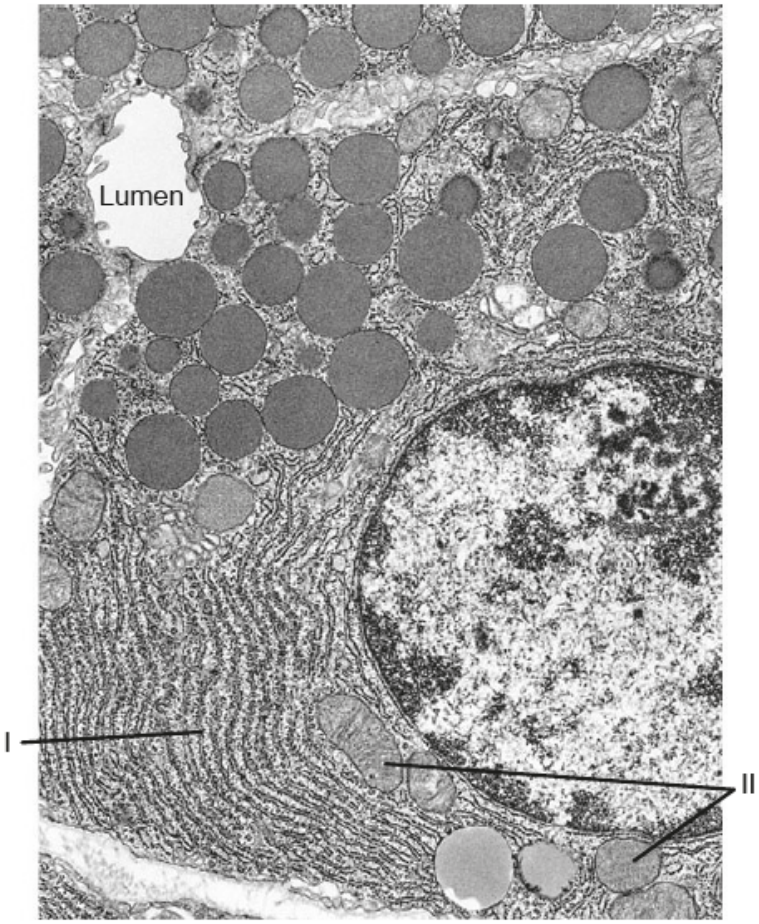
OR

to produce insulin/useful protein

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

The electron micrograph shows the structures in an exocrine gland cell of the pancreas.



[Source: Meschner AL, *Junqueira's Basic Histology: Text and Atlas*, 12th edition. Copyright McGrawHill Education.]

a. Glands are organs that secrete and release particular chemical substances. Melatonin is an important hormone secreted in the pineal gland in the brain. Describe its role in mammals. [2]

b.i. State the principal product of this cell. [1]

b.ii. Using the table, identify the organelles labelled I and II on the electron micrograph with their principal role. [2]

Organelle	Name	Principal role
I		
II		

Markscheme

a. a. controls circadian rhythms/biological clocks «in mammals»

b. production is controlled by amount of light detected by the retina

c. high production/secretion in the dark
OR
no production/secretion in the day
OR
production/secretion is directly proportional to night time duration

d. affects «seasonal» reproduction/sleep-wake cycles/jet lag

b.i. «digestive» enzymes

b.ii.

organelle	*name*	*principal role*
I	rough endoplasmic reticulum ***OR*** ribosome	protein production/synthesis «for excretion»
II	mitochondrion/mitochondria	aerobic «cell» respiration ***OR*** ATP/energy production

Examiners report

a. [N/A]
b.i. [N/A]
b.ii. [N/A]