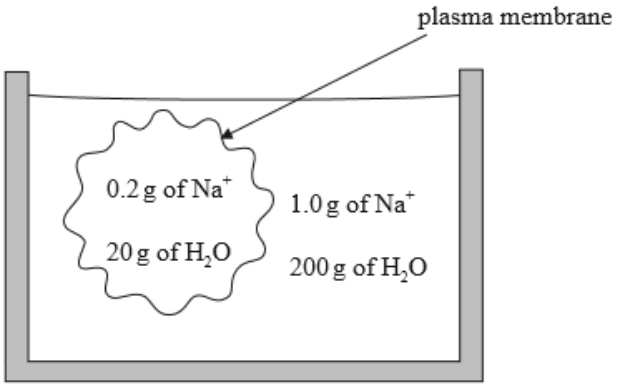
SL Paper 2

The diagram (not to scale) shows a cell which contains water and sodium ions. This cell is immersed in a salt solution of water and sodium ions.



a (i) State the mode of transport if water moves into the cell. [1]

a (ii) State the mode of transport if sodium ions move into the cell. [1]

b. Explain facilitated diffusion. [3]

c. State the name of the structures formed within a cell by endocytosis. [1]

Markscheme

a (i) osmosis

a (ii) active transport

b. movement down the concentration gradient / from high to low concentration;

through channel proteins/ion channels;

passive transport / it requires no energy from the cell / no ATP;

for molecules that cannot pass through the phospholipid bilayer;

channel is specific/selective to the ion/molecule being transported;

c. vesicles / vacuoles / endosome

Examiners report

a (i) N/A

a (ii) Candidates misinterpreted 2a(ii) as diffusion rather than active transport.

b. N/A

c. N/A

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a. State **two** differences in structure between plant and animal cells. [2]

b. Outline how molecules move across a membrane by simple diffusion. [2]

c. Explain the role of protein pumps in active transport. [2]

Markscheme

a.

Plant cells	*Animal cells*
chloroplasts/plastids	no chloroplasts/plastids;
cell wall	no cell wall;
large (central) vacuole	no large (central)vacuole;
no centrioles	centrioles;
no lysosomes	lysosomes;

Answers do not need to be shown in a table format.

b. membranes are porous/permeable allowing diffusion;

diffusion is (passive) movement (of particles) from high to low concentration;

due to random motion/kinetic energy of molecules / no ATP involved;

diffusion continues until concentrations are equal (across the membrane);

c. (can) move solutes against a concentration gradient;

using energy/ATP;

specific for the solute/molecule transported;

protein pumps change shape (as they transport molecules);

Examiners report

a. Most candidates knew structural differences between plant and animal cells. Answers usually mentioned that chloroplasts and cell walls exist in plant cells but not animal cells. That plants have chlorophyll and animal cells do not was unacceptable since chlorophyll is not a structure. Unless the wording was careless, some shocking misconceptions were revealed when candidates wrote that “plant cells have cell walls while animal cells have cell membranes” or that “plant cells have chloroplasts while animal cells have mitochondria.”

b. An easy 2 marks were gained by many candidates who mentioned that membranes are permeable/porous to allow diffusion and that diffusion is movement of particles from high to low concentration. Many candidates stated that diffusion happens without the need for energy instead of without the need for ATP.

c. Most candidates stated that active transport goes against the concentration gradient and requires ATP. Unfortunately, some candidates thought protein pumps produce/provide ATP and some confused change in the shape of protein pumps with exocytosis and endocytosis. Though candidates did give the example of the sodium potassium pump, they did not mention that protein pumps are specific for the solute/molecule they transport.

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a. Draw a labelled diagram showing the ultrastructure of a typical prokaryote. [4]

b. Outline how **three** different environmental conditions can affect the rate of photosynthesis in plants. [6]

c. Explain how the emission of gases, both naturally and through human activity, can alter the surface temperature of the Earth. [8]

Markscheme

a. *Award **[1]** for each structure clearly drawn and correctly labelled, up to **[4 max]**.*

cell wall – a uniformly thick wall;

pili – hair-like structures / flagellum – at least length of the cell;

plasma membrane – represented by a continuous single line; *May be labelled as the innermost wall line.*

ribosomes – drawn as small discrete circles/shaded circles;

nucleoid – region with DNA not enclosed in membrane;

plasmid – circular ring of DNA;

cytoplasm – the non-structural material within the cell;

*Award **[3 max]** if one eukaryote structure is shown, **[2 max]** for two eukaryote structures, **[1 max]** for three eukaryote structures and **[0]** if four or more eukaryote structures are shown.*

b. *light: **[2 max]***

rate increases with increasing light;

it reaches maximum then plateaus;

as all chloroplast molecules are working at optimal pace;

*temperature: **[2 max]***
rate increases with increasing temperature;
to a maximum/optimum temperature;
but then falls off rapidly;
as enzymes are denatured above the optimal temperature;

carbon dioxide: ***[2 max]***
rate increases with increasing carbon dioxide level;
it reaches maximum then plateaus;
as photosynthesis operating at optimal level;

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

c. increase in temperature is called global warming;

this is caused by the greenhouse effect;

a natural phenomenon that has occurred over millions of years;

main gas responsible is carbon dioxide;

other gases like methane/nitrous oxide also cause effect;

shortwave radiation from the Sun enters atmosphere;

warms the surface of the Earth;

longwave radiation emitted by the surface of the Earth;

is absorbed by carbon dioxide/greenhouse gases;

human use of fossil fuels has increased levels of atmospheric carbon dioxide;

rapid rise in temperatures over (approximately) hundred years;

cows/animals/peat bogs release methane;

greenhouse gases emitted by volcanic activity;

Examiners report

a. On the whole the diagrams of a prokaryotic cell were well drawn receiving full marks. A sizable number of candidates drew hybrid cells with features of prokaryote and eukaryotes. Contradictions in answers cannot be rewarded and such answers did poorly. As with other questions, some candidates squandered the opportunity for marks by drawing small or untidy diagrams

b. This question was straight from the subject guide but many candidates were unable to identify the relevant factors. Those who could generally did well. Many good answers used annotated graphs to illustrate the changing effect of the factor on photosynthesis.

c. The impact of gases on the Earth's temperature was, in most cases, not well answered with many candidates confusing the greenhouse effect with the hole in the ozone layer.

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a. State the property of stem cells that makes them useful in medical treatment. [1]

b. Explain how multicellular organisms develop specialized tissues. [2]

c. Outline some of the outcomes of the sequencing of the human genome. [3]

Markscheme

a. has the ability to differentiate (into specialized tissue)

b. only some genes are expressed in each cell type/tissue;

tissues therefore develop differently/become differentiated;

example of differentiated cell and the function of tissues;

c. knowledge of location of human genes / position of human genes on chromosomes;

knowledge of number of genes/interaction of genes / understanding the mechanism of mutations;

evolutionary relationships between humans and other animals;

discovery of proteins / understanding protein function / detection of genetic disease;

leads to the development of medical treatment/enhanced research techniques;

knowledge of the base sequence of genes/study of variation within genome;

Examiners report

a. Candidates either seemed very clear that differentiation was the process that produced specialized tissue or not aware of it at all.

b. Again, candidates found it difficult to explain how specialized tissue develops. The best answers explained how cells used genes selectively and gave specific examples of specialized tissue and their functions.

c. Many candidates confused the human genome project with karyotyping of individuals. However most candidates gained marks by mentioning that the project had been valuable in increasing our knowledge of and ability to treat diseases of genetic origin.

---

a. Draw a labelled diagram showing the structure of three water molecules and how they interact. [5]

b. Aquatic and other environments are being affected by a global rise in temperature. Outline the consequences of this on arctic ecosystems [6]

c. Cell membranes separate aqueous environments in cells. Explain how the properties of phospholipids help to maintain the structure of cell membranes. [8]

Markscheme

a. a. O connected to 2 H forming a V shape;

b. line between O and H of same molecule labelled as covalent bond;

c. three water molecules bonded together with dashed/dotted lines between O on one molecule and H on another;

d. dotted/dashed line labelled as hydrogen bond;

e. O labelled as partial negative charge/ □□ and H labelled as partial positivecharge/ □□ ;

b. a. warming results in melting (arctic/polar) ice (cap) / loss of ice habitats;

b. (warming) raises sea level / floods coastal areas / destroys coastal habitats;

c. (warming) of habitat would change species/flora/fauna that can be supported (named examples can be used);

d. decrease in size of population(s) / possible extinction of species;

e. temperate species move into area / arctic species adapt/move;

f. change in distribution of species/changes in migration patterns;

g. (ecological) changes will affect higher trophic levels/food webs/food chains;

h. increased rates of decomposition of detritus from (melting) permafrost;

i. increased success of pest species including pathogens;

c. a. (labelled) phospholipid consisting of head and two tails;

b. head is glycerol and phosphate;

c. tails are fatty acid chains;

d. head hydrophilic and tails hydrophobic;

e. hydrophilic molecules/heads attracted to/soluble in water;

f. hydrophobic molecules/tails not attracted to water but attracted to each other;

g. (properties of phospholipids leads to) formation of double layer in water;

h. stability in double layer because heads on outer edge are attracted to water and tails are attracted to each other in middle;

i. phospholipid bilayer in fluid/flexible state because of attraction of non-polar tails to each other;

j. (fluidity) allows membranes to change shape/vesicles to form or fuse with membrane/(fluidity) allows cells to divide;

k. non-polar amino acid side chains attracted to (hydrophobic) tails;

Marks may be earned using suitable labelled/annotated diagrams illustrating the points given above.

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

Examiners report

a. Almost all candidates knew the V shape for water molecules but few labeled covalent bonds and still fewer were exact in describing the negative charge on O as partial or the positive charge on H as partial. The mark scheme assumes a stick model of water. Answers often used a bubble diagram, undercutting one possible mark. Even so, full marks could be earned. Bonding within and among water molecules was the part most often neglected.

b. This question was generally well answered displaying good knowledge of the effect of global warming on arctic ecosystems. Often this answer was reasonably well started, but often did not have enough follow-through. Weak answers included some odd understandings. It is not melting glaciers that are the issue, it is the melting ice cap and the sea ice. Some answers were glib, repeating the cases made by the public media rather than research-based information regarding the plight of endangered animals. There are no penguins in the Arctic.

c. This question expected students to approach the topic from a slightly different position than the usual. As such, it discriminated well between stronger and weaker candidates. Many students misinterpreted what was being asked and wrote long detailed answers on structure of the cell membrane and how transport occurs through the proteins - rather than concentrating on the properties of the phospholipids which give the cell membrane its structure. Answers needed more attention to interaction of phospholipid with water. Few knew that the phospholipid head is glycerol and phosphate and virtually nobody mentioned anything about non-polar amino acid side chains being attracted to (hydrophobic) tails.

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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]

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a. State **three** processes occurring in a cell during interphase of the cell cycle but not in mitosis. [3]

1. .....
2. .....
3. .....

c. Explain how sexual reproduction can allow evolution to occur. [3]

Markscheme

a. a. growth (of cells);

b. transcription/protein synthesis/translation;

c. DNA replication / genetic material copied;

d. production of organelles/mitochondria/chloroplasts;

e. named normal activity of cell (*eg active transport, movement, secretion*);

NB *Do not accept G1, S, G2 unless linked to correct process.*

c. a. sexual reproduction promotes variation in species;

b. independent assortment of genes / random orientation of chromosomes in metaphase/meiosis;

c. crossing-over provides new combinations of alleles;

d. production of great variety of gametes (by meiosis) / different combinations of chromosomes in gametes;

e. (random) combination of gametes from both parents (in fertilization);

f. (genetic) variation allows natural selection which leads to evolution;

Examiners report

a. Various cellular processes occur during interphase. Any three of the following were accepted: growth (of cells), protein synthesis/translation, DNA replication, production of organelles or named normal activity (e.g. active transport, movement, secretion etc.). It was not necessary to name the sub phases such as G1, S or G2. If that was done the sub phase had to be linked to a correct process to achieve a mark. It should be noted that cells grow in all three phases by producing proteins and organelles. DNA replication, however, only occurs in the S phase.

c. Explaining how sexual reproduction can lead to variation and then evolution challenged many candidates. Some candidates began with the premise that sexual reproduction produces variation, but did not explain how the variation occurs.This was the heart of the question. Others tried to answer what evolution is, instead of explaining how sexual reproduction allows it to occur. Too many answers just stated the terms independent assortment, crossing over, random fertilization and natural selection without further developing them, i.e. their effect on genes, allele combination or gametes. Sometimes mutation was mixed into the answer gaining no credit.

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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.

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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.

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

b. Explain the importance of surface area to volume ratio as a factor limiting cell size. [7]

Markscheme

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

phospholipid bilayer – with head and tails;

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

integral protein – embedded in hydrophobic region of the phospholipid bilayer;

channel protein – integral protein showing clear channel/pore;

peripheral protein – on the surface (not embedded in hydrophobic region) can be attached to integral protein;

glycoprotein – with carbohydrate attached on outside;

cholesterol – shown embedded in bilayer;

b. as volume of a cell increases, the ratio of its surface area to volume decreases;

food/oxygen enters through the surface of cells;

wastes leave through the surface of cells;

the rate of substance crossing the membrane depends on surface area;

more metabolic activity in a larger cell means more food and oxygen required;

large volume means longer diffusion time;

(large volume) means more wastes produced;

excess heat generated will not be lost efficiently (with low surface area to volume ratio);

eventually surface area can no longer serve the requirements of the cell;

this critical ratio stimulates mitosis;

(thus) the size of the cell is reduced and kept within size limits;

Examiners report

a. Most candidates correctly answered this question with diagrams that were well done and appropriately labelled. If one or two labels were incorrect many candidates still had at least 5 correctly done. In most cases, the incorrect structure of cholesterol was drawn or they did not label carbohydrate part of glycoprotein. A common error was the peripheral protein drawn embedded in hydrophobic region.

b. Many candidates could describe how surface area and volume changed as a cell gets bigger but they did not mention how the ratio between the two decreases. Many candidates understood surface area to volume ratio with increasing size, but were unable to relate this to 'limiting cell size' which was needed in this question. As well, many candidates did not understand what happens to the metabolic activities of the cell when the ratio changed. They wrote about this in general terms but did not go into specifics in terms of food/oxygen entering and wastes leaving the cell via the surface and having a larger volume means longer diffusion time.

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a. Outline the bonding between DNA nucleotides. [2]

b. Explain how chemical bonding between water molecules makes water a valuable coolant in living organisms. [2]

c. Describe the movement of water across membranes. [2]

d. Outline the role of water in photosynthesis. [2]

Markscheme

a. hydrogen bonds between nucleotides of opposite strands/complementary bases/adenine and thymine and cytosine and guanine;

covalent bonds between nucleotides within strands/between sugar/deoxyribose and phosphate;

b. hydrogen bonding between water molecules;

breaking (hydrogen bonds) needs/removes energy/heat;

hydrogen bonds must break when water evaporates/vaporizes;

c. osmosis / moves passively;

from regions of low solute/high water potential/concentration to high solute concentration / low water potential/concentration;

passes through protein channels/aquaporins/selectively-permeable membrane;

d. water molecules undergo photolysis/are split by light energy;

forms oxygen as a by-product;

hydrogen helps power the fixation of carbon (into organic molecules);

Examiners report

a. This question was well answered with the best responses clearly indicating the location of both hydrogen and covalent bonds. Almost all candidates discussed hydrogen bonding, but many did not discuss the use of covalent bonds.

b. Again, this was generally well answered with the best responses indicating that the breaking of hydrogen bonds occurs when water evaporates and removes a great deal of energy.

c. Many candidates answered this well, demonstrating a good knowledge of the movement of water across membrane.

d. Many candidates did not appear to be aware that water played a role in the reaction of photosynthesis. Better answers used the term photolysis and explained it appropriately.

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a. Explain why DNA must be replicated before mitosis and the role of helicase in DNA replication. [4]

b. Explain how the base sequence of DNA is conserved during replication. [5]

c. Describe the events that occur during mitosis. [9]

Markscheme

a. two genetically identical nuclei/daughter cells formed during mitosis (so hereditary information in DNA can be passed on);

two copies of each chromosome/DNA molecule/chromatid needed;

helicase unwinds the DNA/double helix;

to allow the strands to be separated;

helicase separates the two (complementary) strands of DNA;

by breaking hydrogen bonds between bases;

b. DNA replication is semi-conservative;

DNA is split into two single/template strands;

nucleotides are assembled on/attached to each single/template strand;

by complementary base pairing;

adenine with thymine and cytosine with guanine / A with T and C with G;

strand newly formed on each template strand is identical to other template strand;

DNA polymerase used;

Marks may be awarded for any of the above points if clearly presented in a well-annotated diagram.

c. sequence of stages is prophase → metaphase → anaphase → telophase;

chromosomes condense/supercoil/become shorter and fatter in prophase;

spindle microtubules grow (from poles to equator) in prophase/metaphase;

nuclear membrane breaks down in prophase/metaphase;

spindle microtubules attach to the centromeres/chromosomes in metaphase;

chromosomes line up at equator in metaphase;

centromeres divide / (paired) chromatids separate / chromosomes separate into two chromatids in metaphase/anaphase;

(sister) chromatids/chromosomes pulled to opposite poles in anaphase;

spindle microtubules disappear in telophase;

nuclear membrane reforms around chromosomes/chromatids in telophase;

chromosomes/chromatids decondense in telophase;

Examiners report

a. Practically everybody knew the role of helicase in DNA replication. Extremely few could clearly explain the need for mitosis.

b. The question was often confused with other details of DNA replication, transcription and even translation. Though DNA replication was correctly described as semiconservative, further expansion of that term became muddled. Most knew A-T and G-C base pairing but the idea of complementarity was not always included. Diagrams were drawn but lacked labels and annotations most of the time. Occasionally, candidates mentioned that DNA polymerase was used

c. Of all the parts in Section B, this one (describe the events of mitosis) was answered best. Many candidates earned close to the maximum number of marks. A few candidates thought that interphase is a part of mitosis.

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]

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a. Describe the characteristics of stem cells that make them potentially useful in medicine. [5]

b. Outline the inheritance of a **named** sex-linked condition in humans. [5]

c. Explain the use of karyotyping in human genetics. [8]

Markscheme

a. (stem cells) have/retain the capacity to divide;

can be used to produce cell cultures/large number of identical cells;

can be used to repair/replace damaged/lost cells/tissue;

(stem cells) are undifferentiated / have not yet differentiated/specialized;

can differentiate/specialize in different ways / are pluripotent/totipotent;

can be used to form a variety of different tissues / form organs;

used in medical research;

used in treatment of (named) disease;

b. genes that are located on just one of the sex chromosomes/X or Y are sex-linked;

(sex-linked) genes present on the X chromosome are absent from the Y chromosome / *vice versa*;

named recessive X-linked condition (e.g. colour blindness / haemophilia / other valid example);

sex-linked conditions tend to be more commonly expressed in males;

female can be homozygous or heterozygous/carrier for a sex-linked/X-linked condition;

affected males have only one copy of the gene / have carrier daughters but cannot pass the condition on to sons;

carrier/heterozygous females can have affected sons/carrier daughters;

for a female to be affected (homozygous recessive) the father must be affected;

If the example used is of a recessive X-linked condition, use marking points c–h.
Make appropriate adjustments if the example is of a dominant X-linked trait or a Y-linked trait.
Accept any of the above points shown in a suitable diagram/chart/Punnett square/pedigree.

c. *Definition and construction of karyotypes:*

karyotype is the number and type / image of chromosomes in a cell;

cells collected from chorionic villus / by amniocentesis;

requires cells in metaphase / stimulate cells to divide and reach metaphase;

burst cells and spread chromosomes / photo taken of chromosomes;

chromosomes are arranged in pairs;

according to size/structure/position of centromere/banding pattern;

Uses for karyotypes:
karyotypes used to identify sex/gender;
male is XY and female XX;
used to identify chromosome mutations/abnormal numbers/non-disjunction;
Down syndrome due to extra chromosome 21 / other trisomy/aneuploidy example;
used for pre-natal diagnosis of chromosome abnormalities;
may lead to a decision to abort the fetus;
prepare for consequences of abnormality in offspring;

Examiners report

a. Many candidates knew that stem cells retain the capacity to divide and can differentiate into different tissues. It was frequently mentioned that stem cells can replace damaged cells and form a variety of tissues. Candidates knew about medical applications for stem cells such as in treatment for leukemia and for growing skin to help burn victims.

b. Many candidates showed excellent knowledge about sex linked inheritance, using hemophilia as their example. Although many candidates gained the max of 5 marks, the importance of the X chromosome in sex-linked conditions was not always understood. There was a lack of understanding of “carrier” vs “affected.” A few candidates gained marks with annotated Punnet Squares. For those who failed this question, there was an inability to explain the genetics of inheritance and the inaccurate choice of sickle cell anemia as the example. Some regarded alleles as chromosomes. There appears to be weakness in the learning of Topic 4 among more than a few candidates.

c. There were many strong answers to this question. The technique and the uses of karyotypes were well stated. Collectively, candidates answered all the marking points. Some candidates failed to point out the obvious e.g. XY is male and XX is female. Some candidates referred to Down syndrome as inherited on chromosome 23. Others did not use the term chromosome for the abnormality and referred to genes instead. As mentioned earlier in this report, karyotyping was confused with a variety of other laboratory procedures from DNA fingerprinting to gel electrophoresis.

---

a. Describe the genetic code and its relationship to polypeptides and proteins. [5]

b. Outline the role of proteins in active and passive transport of molecules through membranes. [5]

c. Many cell functions, like synthesis of macromolecules and transport, require energy in the form of ATP. Explain how ATP is generated in animal cells. [8]

Markscheme

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

a. (the genetic code is based on) sets of three nucleotides/triplets of bases called codons;
b. bases include adenine, guanine, cytosine and thymine in DNA / adenine, guanine, cytosine and uracil in RNA; (do not accept ATCG)
c. each codon is code for one amino acid;
d. some codons are (start or) stop codons;
e. DNA is transcribed into mRNA by base-pair matching/complementary base pairing;
f. mRNA is translated into a sequence of amino acids/polypeptide;
g. each gene codes for a polypeptide;
h. polypeptides may be joined/modified to form proteins;

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

a. channel proteins allow diffusion/osmosis/passive transport;
b. large/polar molecules cannot cross the (hydrophobic) membrane freely;
c. facilitated diffusion involves moving molecules through proteins down their concentration gradient/without requiring ATP;
d. aquaporins (specific integral membrane proteins) facilitate the movement of water molecules/osmosis;
e. some proteins (for facilitated diffusion) are specific to molecule/ions;
f. active transport involves moving molecules through proteins against their concentration gradient/requiring ATP;
g. (some) proteins in the membrane are pumps / pumps perform active transport / sodium potassium pump;

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

a. ATP is a form of energy currency/immediately available for use;
b. ATP is generated in cells by cell respiration (from organic compounds);
c. aerobic (cell respiration) requires oxygen;
d. anaerobic (cell respiration) does not require oxygen;
e. glycolysis breaks down glucose into pyruvate;
f. glycolysis occurs in cytoplasm;
g. (by glycolysis) a small amount of ATP is released;
h. ADP changes into ATP with the addition of a phosphate group/phosphoric acid / accept as chemical equation;
i. in mitochondria/aerobic respiration produces large amount of ATP / 38 mols (for the cell, per glucose molecule);
j. oxygen/aerobic respiration is required for mitochondrial production of ATP;
k. in mitochondria/aerobic respiration pyruvate is broken down into carbon dioxide and water;

Examiners report

a. Many mentioned codons and anticodons, but few explained what they are. Most gained marks from stating that one gene codes for one polypeptide, and that polypeptides can be linked or modified to form proteins.

b. Many were confused by the differences between channel proteins (passive) and protein pumps (active).

c. There were several comments about how the students could gain 8 marks on a question about ATP. It was obvious that some students had studied option C, but this should not really have given them an advantage. In fact the students found this question much easier than the teachers thought, scoring well in this section.

---

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. Draw a labelled diagram to show the structure of membranes. [6]

c. Explain passive transport and active transport across membranes. [8]

Markscheme

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

phospholipid bilayer – with head and tails;

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

integral/intrinsic protein – embedded in the phospholipid bilayer;

protein channel – integral protein showing clear channel/pore;

peripheral/extrinsic protein – on the surface;

glycoprotein with carbohydrate attached; (*carbohydrate should project outwardly from membrane protein*)

cholesterol – shown embedded in bilayer; (*must appear in hydrophobic region*)

thickness indicated (10 nm); (*allow answers in the range of 7 nm to 13 nm*)

c. diffusion/facilitated diffusion and osmosis are passive;

do not require energy/ATP;

diffusion is movement from high to low concentration/down a (concentration) gradient;

facilitated diffusion uses (protein) channels/carrier proteins;

osmosis is water movement from lower to higher solute concentration / from higher to lower water potential/concentration;

across a partially permeable membrane;

active transport/formation of vesicles require energy;

in the form of ATP;

active transport moves materials up/against the (concentration) gradient/from low to high concentration;

protein pumps required;

endocytosis into cells / exocytosis out of cells;

example of active or passive transport; (*e.g. sodium potassium pump for active transport / oxygen exchange in alveoli for passive transport*)

Examiners report

a. Candidates knew their hydrophilic heads and hydrophobic tails! Overall performance on this question was good. As noted earlier, improvement was seen in the quality of the drawings. However, some details needed to be more exact: peripheral/extrinsic protein should have appeared on the membrane surface, not fully embedded and flush with the surface; channel proteins, by definition, required a channel or pore.

c. Explanations of passive and active transport (A.S. 2.4.5, 2.4.6) involved many ideas that candidates seemed to know. Responses were generally well organized. Easy marks were gained for knowing which type of transport required ATP and for knowing details about different concentration gradients. Candidates did stumble when they confused protein pumps needed in active transport for protein channels used in facilitated diffusion. Some candidates also forgot that osmosis involves the movement of water molecules, not just “particles,” from lower to higher solute concentration gradients across semi-permeable membranes. Instead of explaining osmosis in terms of solute concentration, other candidates correctly wrote about movement of water molecules from higher to lower water potential.

---

a. Explain how materials are moved across membranes of cells by active transport. [2]

b. Explain the effects of pH on enzyme catalysed reactions. [3]

c. Distinguish between the process of anaerobic respiration in yeast and humans. [2]

Markscheme

a. transport against a concentration gradient / from low to high concentration;

through protein pumps;

uses energy/ATP;

b. enzymes have a pH optimum;

active site works best at this pH;

activity decreases above and below the optimum;

by interfering with H-bonding/active site structure;

denaturing by extremes of pH so enzyme activity/reaction stops;

c. *yeast*: pyruvate to ethanol and carbon dioxide;

humans: pyruvate to lactic acid;

*Award **[1 max]** if products are appropriately linked to organisms without the mention of pyruvate.*

Examiners report

a. Knowledge of the characteristics of active transport was generally well expressed. Many candidates understood that protein pumps, requiring energy were required as opposed to protein channels that may be used in facilitated diffusion.

b. This question was answered well with candidates aware of the concept of an optimal pH with activity trailing off on either side. The best answers liked this to the structure of the enzyme active site being changed by the changing pH.

c. Most candidates had no difficulty indicating the end products of respiration. A large number of answers indicated that pyruvate was a common source in each case of respiration, though weaker answers did not.

---

a. Outline the use of human embryonic stem cells (hESC) to treat Stargardt's disease. [2]

b. The most common form of Stargardt's disease is known to be autosomal recessive. Using a Punnett grid, deduce the probability of a child inheriting Stargardt's disease, if both of the parents are carriers of the disease but do not have the disease themselves. [3]

Markscheme

a. a. «an inherited form of» degeneration of retinal layer/photoreceptor cells/blindness

OR

eye genetic disorder

OWTTE

b. «hESC/stem cells» can provide/differentiate into healthy <u>retinal</u> cells

c. injecting «hESC/stem cells» into the retina/eye can restore vision in animal/human trials

b. a. correct allele identification

«eg: S=dominant/normal; s=recessive/disease»

b. correct Punnett grid

c. correct phenotypic ratio/outcome

example:
s =recessive, disease-causing form of gene,
S =dominant,
normal form parents =Ss.
Any letter can be used as capital and lower case but a legend/key is not required if correct notation is used.

	S	*s*
S	*SS*	*Ss*
s	*Ss*	*ss*

Do not award mp b if the gametes do not show heterozygous organisms

phenotypic ratio:
normal : with disease
OR
3 normal : 1 with disease
OR
«75 % normal :» 25 % disease

Examiners report

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

---

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.

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.

---

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

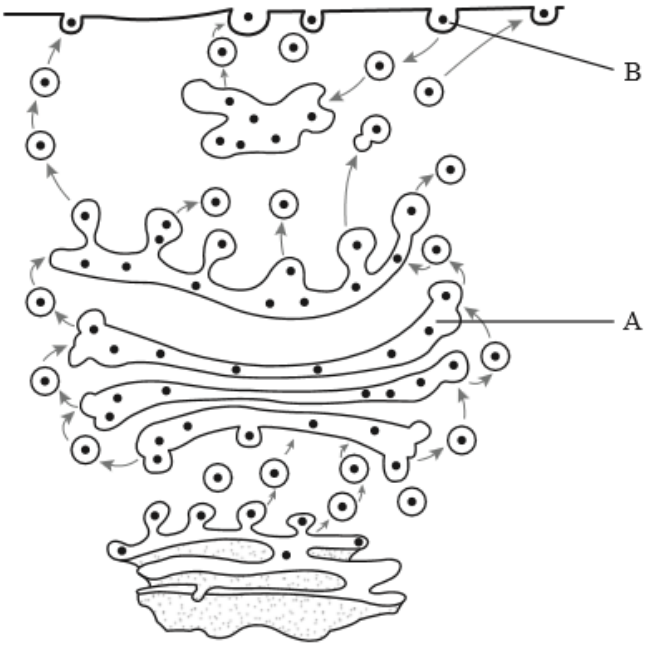
a. Question 6 was the most popular to answer.

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 diagram shows how vesicles are used to transport materials in a cell.



a (i) State the name of organelle A. [1]

a (ii) State the process occurring at B. [1]

b. Describe how the structure of the membrane allows the formation of vesicles. [2]

c. Explain active transport across membranes. [3]

Markscheme

a (i) Golgi apparatus/complex/body

Reject Golgi vesicle and Golgi unqualified.

a (ii) endocytosis/phagocytosis/pinocytosis

Reject exocytosis.

b. a. fluidity of membrane allows change of shape/invagination/formation of vesicles;

b. phospholipids can move / phospholipid bilayer makes membrane fluid/flexible;

c. weak bonding between phospholipid tails;

d. bends/kinks in the phospholipid tails prevent close packing;

e. cholesterol affects membrane fluidity;

c. a. moves substances up/against a concentration gradient / from lower to higher concentration;

b. protein/pump (in membrane) that moves material; (*reject channels*)

c. ATP is used; (*reject energy alone*)

d. example/labeled diagram showing mechanism;

Examiners report

a (i) Most candidates correctly identified the organelle as Golgi apparatus; otherwise, it was usually mistakenly labelled as rough ER.

a (ii) Instead of answering “endocytosis”, candidates often stated “exocytosis” and lost the mark.

b. This follow-up question involved application of knowledge about membrane structure. Sadly, candidates had trouble linking fluidity in membranes to vesicle formation. Though the phospholipid bylayer was sometimes mentioned it was not seen as giving fluidity/flexibility. Weak bonding between the phospholipid tails was rarely included. A few candidates did mention the presence of cholesterol in membranes but not much on their role in membrane fluidity. The idea that bends/kinks in the phospholipid tails prevents close packing, thereby contributing to flexibility, was never given. Some candidates confused fluidity with permeability.

c. Many candidates gained partial or full marks on their explanations of active transport across membranes. Movement up/against a concentration gradient was often mentioned, along with the necessity of ATP. Energy, by itself, was rejected. There was confusion over protein pumps/carrier proteins and channel proteins. The latter were unacceptable since they are used in passive transport to enable solutes to diffuse down concentration gradients.

The diagram shows a human karyotype.

[Source: http://en.wikipedia.org/wiki/File:NHGRI_human_male_karyotype.png, courtesy of the National Human Genome Research Institute.]

a. (i) State the technique used to collect cells for pre-natal testing. [3]

(ii) State the method used to arrange the chromosomes in a karyotype.

(iii) State at what stage in the cell cycle the cells would be when this photograph was taken.

c. Albinism is inherited as a recessive trait; the alleles of the gene involved are A and a. An individual with albinism produces little or no pigment in the eyes, skin and hair. In a family, one sister has albinism while the parents and other sister have normal pigmentation. [3]

(i) Determine, using a Punnett grid to show your reasoning, the possible genotypes of the sister with normal pigmentation.

(ii) Deduce the probability that the next child of this couple will have albinism.

Markscheme

a. (i) amniocentesis/sampling amniotic liquid/fluid (via needle)/chorionic villus sampling

(ii) chromosomes are grouped by pairs according to size and structure/band pattern/location of centromeres

(iii) metaphase/late prophase of mitosis

c. (i) Punnett grid shows the gametes (A and a) on one axis and the gametes (A and a) on the other axis and genotypes (AA, Aa, Aa, and aa) of offspring;

AA/homozygous dominant and Aa/heterozygous (show normal pigmentation); *Both needed*

Do not award marks to any answer suggesting sex linkage.

(ii) 1/4 /25 %/0.25 probability of albinism / 1 in 4 chance

Examiners report

a. (i) A broad range of inaccurate answers were given, e.g. karyotyping, polymerase chain reaction, or just no response at all.

(ii) This question proved to be difficult because three components (pairs, size, structure/banding) were needed for the one mark. Many candidates forgot that chromosomes are placed in pairs in a karyotype. Some just mentioned 'karyotyping'. In this case, candidates should realize that just repeating a term (karyotyping) from the question stem will not get them credit.

(iii) Few mentioned metaphase; interphase, which was commonly given, lost the mark. Several answers suggested meiosis.

c. i) A Punnett grid usually given with correct genotypes and correct genotypes of sister with normal pigmentation. Confused answers gave pedigree charts or introduced sex linkage.

ii) Often the correct percentage or ratio was given. In some cases, this occurred despite an incorrect Punnett grid in (i).

---

a. Draw a labelled diagram to show the fluid mosaic structure of a plasma membrane, indicating the hydrophilic and hydrophobic regions. [5]

b. Distinguish between active and passive movements of materials across plasma membranes, using **named** examples. [4]

c. Explain how the properties of water are significant to living organisms. [9]

Markscheme

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

phospholipid bilayer – with head and tails;

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

integral protein – embedded in hydrophobic region of the phospholipid bilayer;

protein channel – integral protein showing clear channel/pore;

peripheral protein – on the surface;

glycoprotein with carbohydrate attached on outside;

cholesterol – shown embedded in bilayer; thickness indicated (10 nm); *(allow 7 nm to 13 nm)*

b.

passive	active
diffusion / osmosis / facilitated diffusion	active transport / ion pumps / exocytosis / pinocytosis / phagocytosis
a second passive method *(from above)*	a second active method; *(from above)*
does not require energy	requires energy/ATP;
down concentration gradient	against concentration gradient;
no pumps needed	requires protein pumps;
oxygen across alveoli / other example	glucose absorption in ileum / other example;

Both the passive and active movements must be contrasted to receive a mark.

*Award **[3 max]** if no examples are given.*

Responses do not need to be shown in a table format.

c. water is transparent / light passes through water;

this allows organisms to live below the surface / plants to photosynthesize;

hydrogen bonds between water molecules make water cohesive;

this gives water a high surface tension allowing animals to live on the surface / maintains lung structure (pleural membranes);

helps in water movement through plants/transpiration;

water has a high latent heat of vaporization / *OWTTE*;

evaporation/sweating/transpiration leads to cooling;

water has a high specific heat capacity / *OWTTE*;

this provides a stable environment for water organisms;

water is a universal solvent; can transport materials around organisms/plants/animals;

can be a solvent for chemical reactions in organisms;

ice is less dense than water / water has a maximum density at 4°C surface (pond/lake/ocean) freezes first, allowing organisms to survive in the water below;

Accept hydrogen bonds between water and other substance makes water adhesive from AHL.

Examiners report

a. Many drawings were of reasonably good quality and gained at least three marks. Glycoprotein was a challenging structure for candidates to draw.

Often the glycoprotein did not show anything resembling a carbohydrate chain attached to the protein. Also, the phospholipid bilayer was

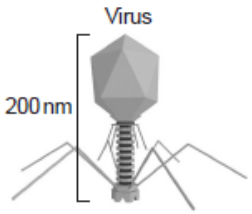
somewhat problematic. Sometimes, peripheral proteins were drawn in the hydrophobic region and, quite often, cholesterol molecules which should

have appeared in the hydrophobic region were not totally embedded there. It was good to see that candidates almost always showed two-tailed phospholipid molecules. It was a rare candidate who indicated any reference to membrane thickness.

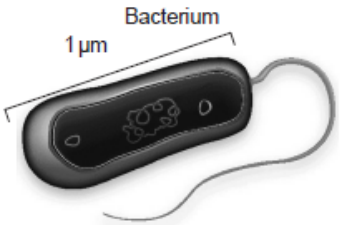
b. A few candidates did well on this question, but it was disappointing to see the lack of comparison skills among most candidates. Interpretation of the command terms distinguish and compare needs clarification for students, so that clear answers with opposing criteria are given and expected. Virtually all candidates wrote separate paragraphs about active and passive movement with indirect or incomplete pairings of ideas.

c. Candidates showed a wide range of understanding of how the properties of water are significant to living organisms. Every marking point was eventually awarded by the examiners. There was limited use of the terms latent heat of vaporization and specific heat, though candidates could receive the mark using other wording. Those who did use the terms only gained credit if the terms were qualified such as “high specific heat”. Just saying that water has specific heat was insufficient. Unfortunately, mistakes such as “water is soluble” were seen too often. Sometimes, a named property of water was linked to a wrong significance.

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 nutrients / 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 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;

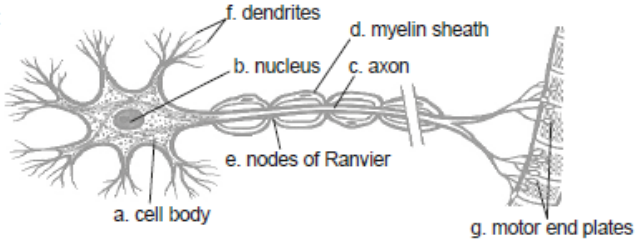
e. nodes of Ranvier – shown in axon;

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.

---

a. Outline the stages of the cell cycle. [5]

b. Explain the process of translation in cells. [8]

c. Outline the production of a dipeptide by a condensation reaction, showing the structure of a generalized dipeptide. [5]

Markscheme

a. a. interphase is the longest phase;

b. interphase includes G_1, S and G_2;

c. in G_1 and G_2 /G phases, cell performs normal functions/protein synthesis/cell grows/organelles are replicated;

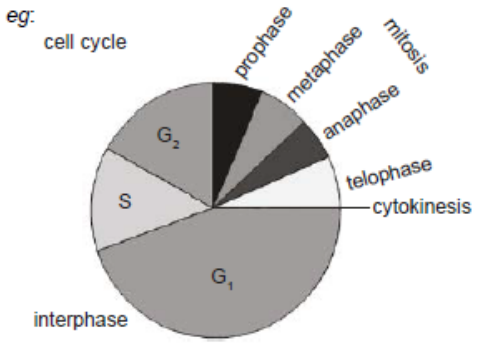
d. S/synthesis phase when the DNA replicates;

e. mitosis is when nucleus/genetic material divides;

f. named/described stages of mitosis;

g. cytokinesis: the division of the cytoplasm / formation of two daughter cells;

*Award **[3 max]** if all three stages (interphase, mitosis and cytokinesis) are not mentioned.*



b. a. translation is the conversion of base sequence on mRNA into an amino acid sequence / *OWTTE*;

b. messenger/mRNA attaches to ribosome (small unit);

c. many ribosome/polyribosomes bind to same mRNA;

d. (mRNA) carries codons/triplet of bases each coding for one amino acid;

e. transfer/tRNA each have specific anticodon;

f. tRNA carries specific amino acid;

g. tRNA anticodon binds to codon in the mRNA;

h. to corresponding triplet base/codon by complementary base pairing / *OWTTE*;

i. a second tRNA (anticodon) binds to next codon;

j. two amino acids bind together / peptide linkage is formed;

k. first tRNA detaches;

l. ribosome moves along mRNA;

m. another tRNA binds to next codon;

n. continues until stop codon is reached;

o. stop codon has no corresponding tRNA (anticodon)/amino acid/causes release of polypeptide;

c. a. condensation is joining together two amino acids to form a dipeptide;

b. carboxyl/COOH group of one amino acid reacts with amine/NH_2 group of another / diagrams of two (generalized) amino acids correctly shown;

c. water/H_2O is eliminated;

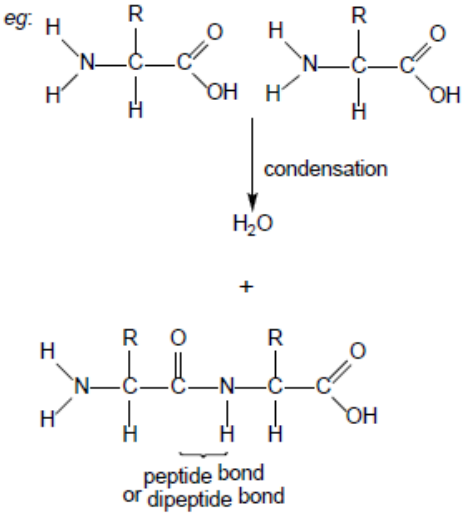
d. diagram of dipeptide correctly shown;

e. peptide/covalent bond is produced / peptide bond correctly labelled;

f. occurs at the ribosomes;

The above marking points can be award to a clearly annotated diagram.

eg:



Examiners report

a. Few managed to state that mitosis is the division of the nucleus/ genetic material and also lumped in cytokinesis as a part of mitosis.

b. Better candidates were able to explain the process of translation in very clear detail. It was good to see that very few candidates confused transcription and translation.

c. Most gained the mark for stating that water is eliminated in a condensation reaction. Unfortunately they could not explain the process in sufficient detail to gain any more marks. Even although the stem was about dipeptides, weaker candidates wrote about carbohydrates. There were some G2 comments that asking SL candidates to draw a dipeptide was beyond expectations. It is indeed on the limit of what could be expected from 3.2.2 and 3.2.5. However the candidates did have a choice of Section B questions.

The following sequence of pictures, made using an electronic imaging technique, shows a cell undergoing division.

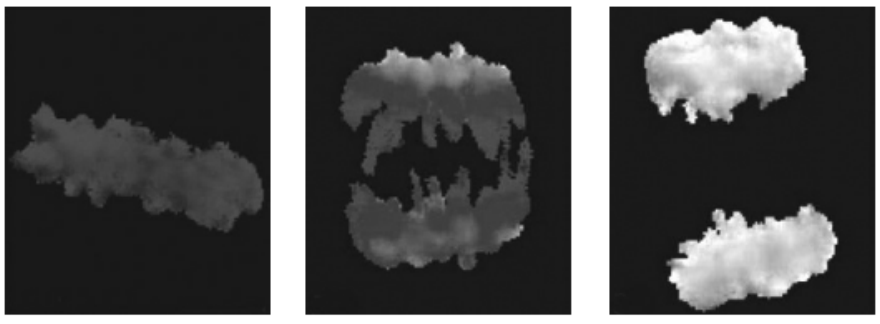


Image I Image II Image III

[Midzone activation of aurora B in anaphase produces an intracellular phosphorylation gradient, Brian G. Fuller, Michael A. Lampson, Emily A. Foley, Sara Rosasco-Nitcher, Kim V. Le et al. Nature, vol 453, issue 7198, 2008 Nature Publishing Group. Reproduced with permission.]

a. State the stage of mitosis typified by image II. [1]

b. List **two** processes that involve mitosis. [2]

c. State the process that results in tumour (cancer) formation or development. [1]

d. Explain, using **one** example, how non-disjunction in meiosis can lead to changes in chromosome number. [2]

Markscheme

a. anaphase

b. a. growth (through increasing cell number);

b. embryonic development;

c. tissue production/repair;

d. (asexual) reproduction;

c. uncontrolled mitosis/cell division

d. a. pair of homologous chromosomes moves in same direction/does not separate during anaphase I / chromatids move in same direction/do not separate during anaphase II;

b. leaving a cell with an (some) extra chromosome(s)/missing chromosome(s);

c. an example; *(e.g. Down syndrome where there is an extra chromosome number 21);*

Examiners report

a. Anaphase was usually given, perhaps Image II had not been studied in relation to Images I and III.

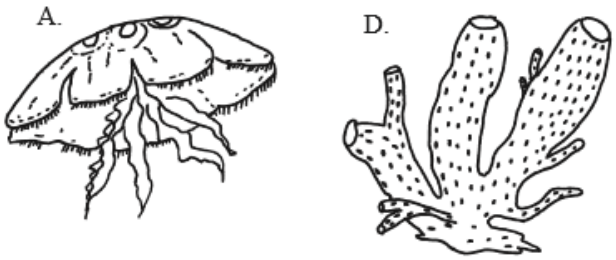
b. Some candidates understood the question to mean phases of mitosis. Others wrote ambiguous answers such as “repair” instead of “tissue repair”.

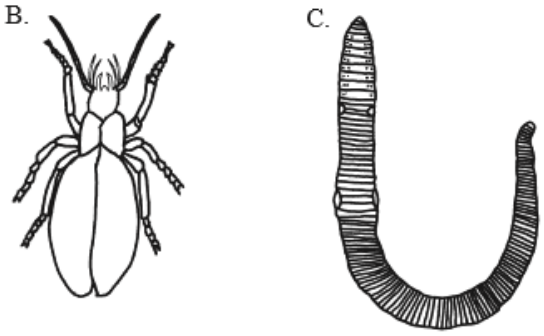
c. Mainly correct. It was essential to include the term “uncontrolled”. A few candidates were unclear about tumour formation and answered “mutation”.

d. There were very few descriptions of how non-disjunction in meiosis can produce a change in the chromosome number. However, the example of Down syndrome where there is an extra chromosome 21 was almost always given.

---

a. Parts of a dichotomous key to organisms A, B, C and D are shown. Design missing parts of the key using features visible in the following diagrams. [2]





1.

Body with tentacles .....A

Body without tentacles ..... go to 2

2.

.....B

.....go to 3

3

.....C

.....D

b. All of these organisms belong to the animal kingdom. State **two** structural differences between animal cells and plant cells [2]

Markscheme

a. any <u>visible</u> characteristic that distinguishes between B and the rest; (*eg. three pairs of legs/no legs*)

characteristic that distinguishes between C and D; (*eg. body divided into many segments / body not divided into many segments*)

characteristic specific to C <u>and</u> different characteristic specific to D; (*eg. C had cylinder shape and D has pores*)

b. cell wall only in plant cells;

starch granules only in plant cells;

chloroplasts only in plant cells;

centrioles only in animal cells;

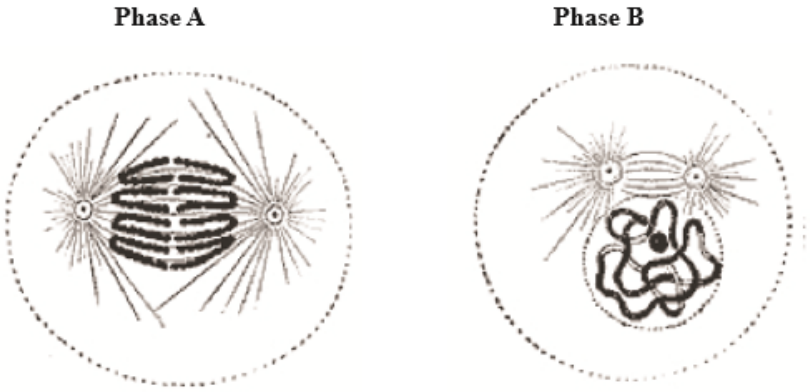
(large) vacuole in plant cells;

Examiners report

a. Despite the simplicity of 2(a), this dichotomous key question drew out some remarkable weaknesses. Too often, answers included internal or physiological characteristics as opposed to visible features of the organisms. Those candidates who did not have the proper knowledge of how to design a dichotomous key were the ones who gave a varied range of incorrect answers. Exoskeleton was accepted.

b. Most candidates correctly answered question 2(b). Some sloppy answers that gained no credit were: “Plant cells have chloroplasts. Animal cells have mitochondria” or just “Plant cells have chloroplasts” and nothing said about animal cells.

The electron micrographs show mitosis in a cell at an early stage and an intermediate stage.



[Source: Phase A from: http://upload.wikimedia.org/wikipedia/commons/f/f5/Anaphase.jpg
Phase B from: http://upload.wikimedia.org/wikipedia/commons/d/db/Prophase.jpg]

a (i) State the name of each phase shown, recording whether each phase has taken place at an early or intermediate stage of mitosis. [2]

Phase A: . . . . . .occurs at an. . . . . stage
Phase B: . . . . . .occurs at an. . . . . stage

a (ii) Outline the events occurring in phase A. [2]

b. State what results when there is an uncontrolled division of cells in living organisms. [1]

c. DNA in chromosomes undergoes replication before mitosis. Outline how complementary base pairing is important in this process. [2]

Markscheme

a (i) *phase A*: anaphase (*occurs at an*) intermediate (*stage*); (*both needed*)

phase B: prophase (*occurs at an*) early (*stage*); (*both needed*)

a (ii) centromeres split/break;

(sister) chromatids/chromosomes separate;

dragged/pulled/movement to separate poles;

by shortening of spindle microtubules;

Do not allow events other than those in anaphase

b. tumours / cancer

c. conservation of the base sequence of DNA;

adenine pairs with thymine <u>and</u> cytosine pairs with guanine; (*do not accept initials only*)

both (daughter) cells/DNA strands produced have identical genetic information;

Examiners report

a (i). Many correctly identified Phase A in 3(a)(i) but often missed Phase B.

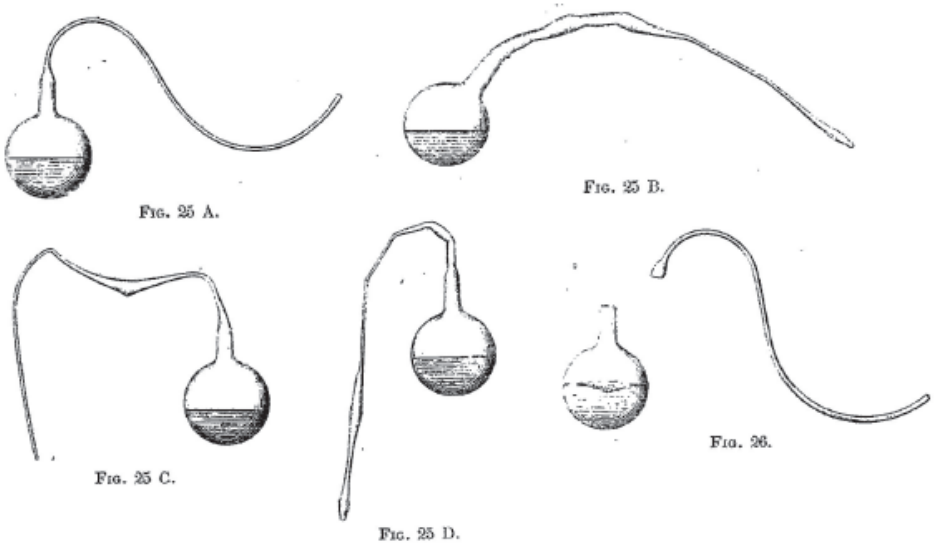
a (ii). Part 3(a)(ii) was usually well answered. Unfortunately, some candidates referred to homologous chromosomes when they meant sister chromatids; homologous chromosomes separate in Anaphase I of meiosis. Few mentioned centromeres splitting.

b. Part 3(b) was very successfully answered. No credit was given for “mutation.”

c. Some candidates just wrote that “an exact copy of DNA is made” in 3(c) which is ambiguous and gained no credit; it was not clear that they knew that replication is a semi-conservative process where each of the new DNA molecules has a parent strand (conserved) and a new strand made by complementary base pairing. Also, full names, rather than just letters were required for the nitrogenous bases and both pairs were required.

---

a. Pictured below are Louis Pasteur’s original drawings of swan-necked flasks. [3]



[Source: L Pasteur and L Pasteur Vallery-Radot, (1922), *Œuvres de Pasteur, Vol II Fermentations et générations dites spontanées*, pages 260–261]

Describe how Pasteur’s experiments provided convincing evidence to falsify the concept of spontaneous generation.

b.i. State the function of life in *Paramecium* that is carried out by: [1]

cilia.

b.ii. State the function of life in *Paramecium* that is carried out by: [1]

the contractile vacuole.

c. Discuss the advantages and disadvantages of the use of adult stem cells. [3]

d. Explain the role of decomposers in an ecosystem. [2]

Markscheme

a. a. spontaneous generation is life appearing from nothing / from non-living / cells only come from pre-existing cells/life

b. broth/culture medium (for bacteria) (used/placed) in flasks

c. broth boiled/sterilized «in some flasks» to kill microbes

d. no clouding/signs of bacterial growth/reproduction / microbes did not appear «in flasks of boiled broth»

Allow bacteria or organisms instead of microbes.

e. after necks of flasks were snapped boiled broth became cloudy/growth of microbes

f. because microbes from the air contaminated the «boiled» broth

g. curved necks allowed indirect exposure to air but prevented entry of microbes

b.i. movement/locomotion

OR

feeding/nutrition

b.ii. homeostasis

OR

maintain osmotic balance / expels «excess» water / maintains «cell» water content

c. *Advantages:*

a. «adult stem cells» can divide «endlessly» / can differentiate

b. «adult stem cells» can be used to repair/regenerate «tissues»

c. fewer ethical objections «than with embryonic stem cells»

d. adults can give «informed» consent for use of their stem cells

e. adult source is not killed / «source» would not have grown into new human / no death of embryos used to provide stem cells

f. no rejection problems / patient's own cells used

g. less chance of cancer/«malignant» tumor development «than from embryonic stem cells»

h. most tissues in adults contain some stem cells

Disadvantages:

i. difficult to obtain/collect/find in adult body/very few available

j. some «adult» tissues contain few/no stem cells

k. «adult stem cells» differentiate into fewer cell types «than embryonic cells» /OWTTE

d. a. saprotrophs/decomposers feed on/break down dead «organic» matter

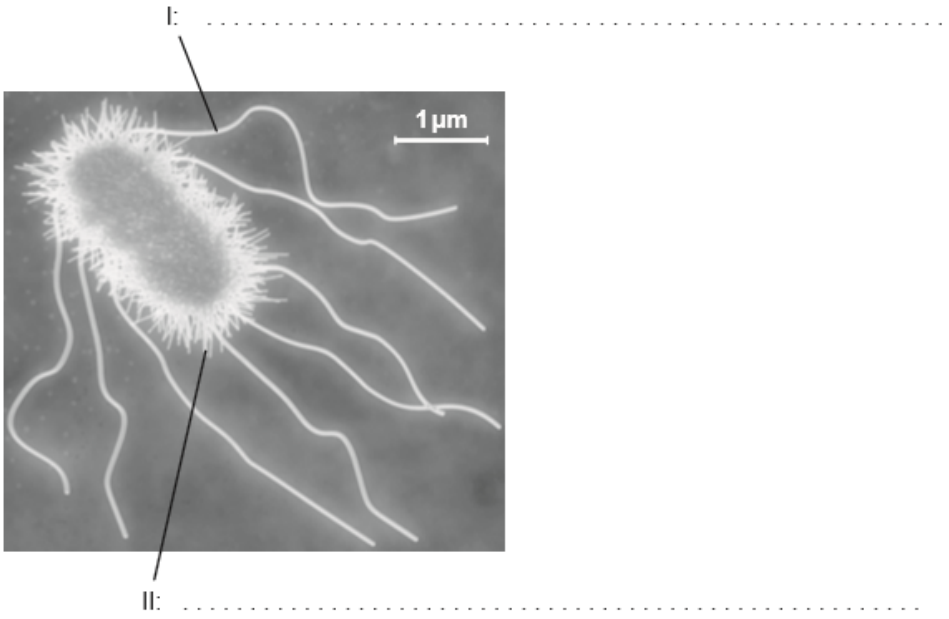
b. saprotrophs/decomposers release energy «heat» accelerating decomposition/warming soil

c. saprotrophs/decomposers recycle nutrients / make nutrients available (to producers)
OR
improves soil fertility / returns nutrients (minerals/nitrates/phosphates/carbon)to soil/water/environment

d. saprotrophs/decomposers detoxify waste

Examiners report

a. [N/A]
b.i. [N/A]
b.ii. [N/A]
c. [N/A]
d. [N/A]



a. Outline the cell theory [2]

b (i). Annotate the electron micrograph of the *Escherichia coli* cell with the function of the structures labelled I and II. [2]

b (ii). Calculate the magnification of the electron micrograph. [1]

Markscheme

a. a. living things are composed of cells;

b. cells are the basic/smallest unit of life;

c. cells come from pre-existing cells;

Do not accept cells are the "smallest organisms".

Do not accept "cells are the building blocks" of life on its own.

b (i) a. I: locomotion;

b. II: attachment to surfaces / holds bacteria together / conjugation;

Do not accept “exchange material” on its own.

If more than one function is given, mark the first answer only.

b (ii) ×15 000 *(accept answers in the range of × 14 000 to × 16 000)*

Examiners report

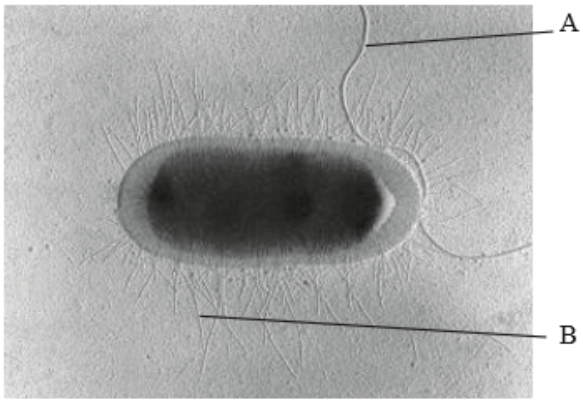
a. Most gained both marks for their knowledge of cell theory in part a.

b (i) Students who read the rubric correctly in b scored well. However approximately half of the students read "label" instead of "function".

b (ii) A disappointing number had no idea how to calculate the magnification (15000X) and some answers showed no concept of scale, with answers such as 0.15 X or $5x10^{-7}$ X.

---

a. The electron micrograph below shows an *E. coli* cell. [2]



[Source: www.microbiology.umaryland.edu/images/bact_em.jpg]

Identify the structures labelled A and B in the electron micrograph above and state **one** function of each.

A: Name

Function

B: Name:

Function:

b. Compare prokaryotic and eukaryotic cells. [3]

Markscheme

a. *Both name and function required to achieve **[1]**.*

A: *name*: flagella/flagellum

function: used for locomotion / beats in whip-like action to propel cell;

B: *name*: pili/pilus
function: used for adhesion (to another cell/surface) / transfer of genetic material (between cells);
ECF, for one mark, can be applied if both parts of the pair are reversed.

b. *Award **[1]** for a similarity.*

both have a plasma/cell membrane/ribosomes/cytoplasm/genetic material;

*Award up to **[2]** for differences. Candidate must make a valid comparison, not simply describe each. Award **[2 max]** if features of prokaryotic and eukaryotic cells are not compared directly, item by item, although a table is not necessary.*

Prokaryote	Eukaryote
naked DNA	DNA associated with proteins;
DNA in cytoplasm / no nucleus	DNA enclosed in nuclear envelope/membrane / nucleus;
70S ribosomes	80S ribosomes;
no membrane-bound organelles	internal membranes that form membrane-bound organelles;
circular chromosome	linear chromosomes;
fission	mitosis;
no introns or exons	introns and exons;
smaller in size (approximately) 10 microns	larger in size up to (approximately) 100 microns;
cell wall present	cell wall only present in plants/fungi; *Do not accept cell wall sometimes present.*

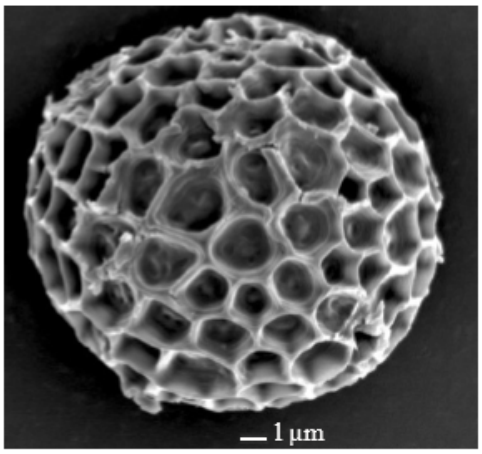
Examiners report

a. The flagella and its function were usually known. Although the pilus was often known, its function was not. Low achievers sometimes labeled the pili as cilia.

b. It was essential for candidates to make valid precise comparisons of the features for prokaryote and eukaryote. For example,

- "naked DNA" (prokaryote) was confused to mean DNA outside a nucleus so it was paired with "DNA enclosed in nuclear envelope
- (eukaryote) instead of "DNA associated with proteins" (eukaryote). For organelles, there had to be reference to membranes as in "no"
- membrane-bound organelles" (prokaryotes) paired with "membrane-bound organelles" (eukaryotes).
- When referring to differences in ribosomes or cell sizes, a quantified answer was required e.g. "70S ribosomes" (prokaryotes) paired with "80S ribosomes (eukaryotes)
- "smaller than 10 microns" (prokaryotes) paired with "larger in size, up to 100 microns (eukaryotes). Most candidates did not provide similarities,
- the command term "compare" includes similarities and differences. A few candidates produced tables which clearly represented similarities and differences.

a. The electron micrograph is of a spore of a fungus (Tilletia controversa) which affects wheat. [2]



[www.padil.gov.au/pbt/index.php?q=node/15&pbtID=163]

Determine the magnification of the spore in the electron micrograph. The scale bar represents 1 µm. Show your working.

b. Explain the importance of surface area to volume ratio as a limit to cell size. [2]

Markscheme

a. a. magnification □measured length of bar □ actual size bar represents/4 mm□ 1 µm

/ spore micrograph size □ real size / OWTTE;

b. □ 4000;

b. a. rate of exchange of materials/gas/energy is a function of its surface area;

b. rate of production of heat/waste/resource consumption is a function of its volume;

c. surface area to volume ratio decreases with increase in size / *OWTTE*;

d. at low surface area to volume ratios, exchange of materials takes longer/reduced efficiency of exchange / vice versa;

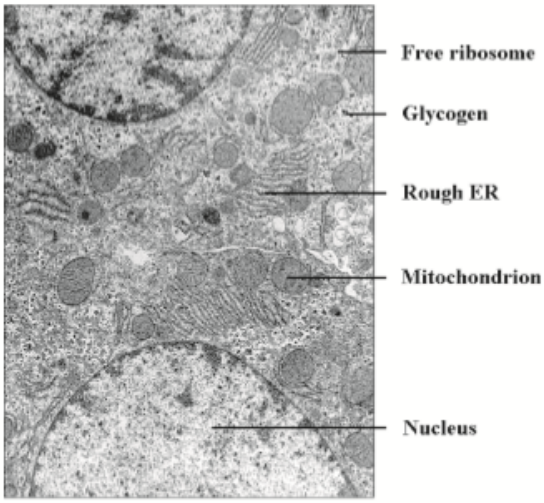
Examiners report

a. Candidates scored marks for a good working, but did not measure correctly, so failed to obtain the second mark. This question seemed to cause some confusion with candidates measuring the picture rather than the scale bar. Also, many wrote down very large magnifications without thinking about plausibility.

b. Confusing answers led to interpret that many candidates do not clearly understand this topic, writing wrong memorized concepts instead.

---

a. The image is an electron micrograph. [1]



[Source: http://image.wikifoundry.com/image/2/H1jghtjAjTutprovXh4VCA200205/GW720H652]

Determine, with a reason, whether the image is of a prokaryotic cell **or** eukaryotic cell.

b. (i) State the process that divides one nucleus into two genetically identical nuclei. [5]

(ii) Explain how the cell cycle is controlled.

Markscheme

a. eukaryotic because nucleus/membrane-bound organelles/named organelle other than ribosome «eg, mitochondria, vesicles» internal membranes

«ER»/multicellular

b. (i) mitosis

(ii)

a. cell cycle is a sequence of stages / cell cycle is G_1, S, G_2 and mitosis

b. (control of the cell cycle) by cyclins/cyclin

c. levels of cyclins rise (and fall)/fluctuate during the cell cycle/surge at different times/have to reach a certain concentration

d. conditions inside as well as outside the cell affect regulation

e. four cyclins/different cyclins to enter different stages of/events in the cell cycle / cyclins regulate the sequence/timing of the cell cycle / cyclins trigger the next stages

The idea of different cyclins acting at different phases must be clear.

f. cyclin-dependent kinases / cyclins bind to kinases and activate them

g. kinases phosphorylate other proteins

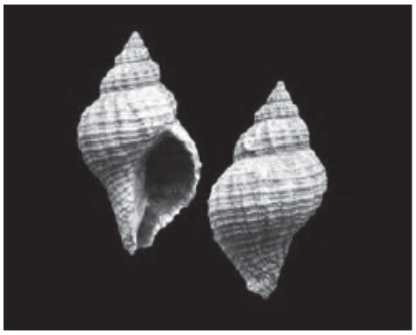
h. phosphorylated proteins perform specific functions in the cell cycle

Examiners report

a. [N/A]
b. [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*

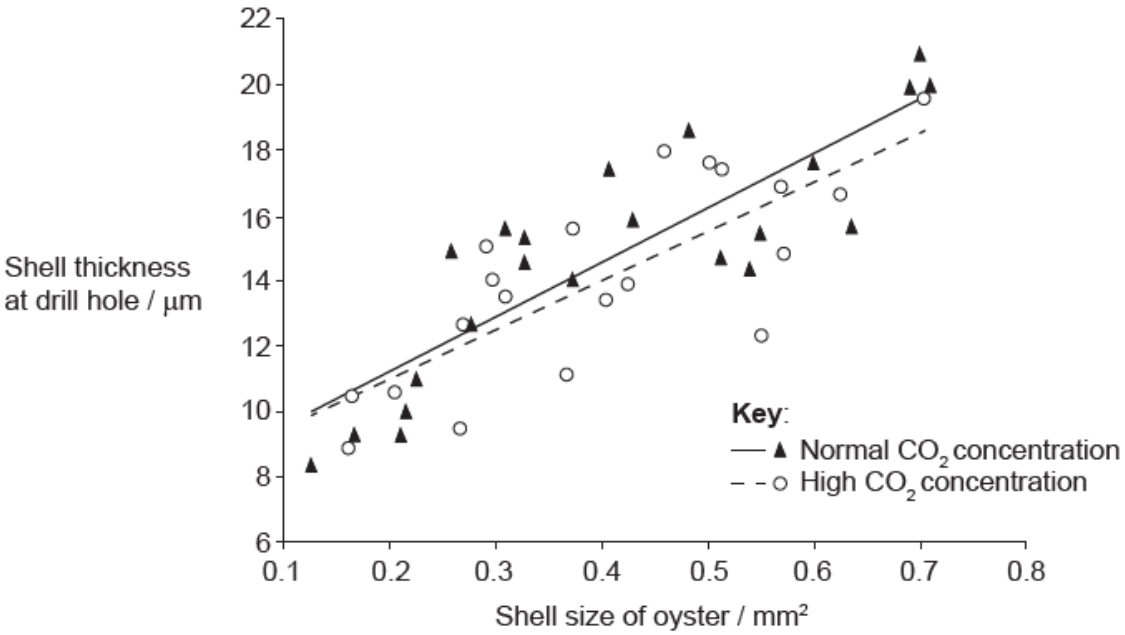


Adult gastropod shell, *Urosalpinx cinerea*

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.

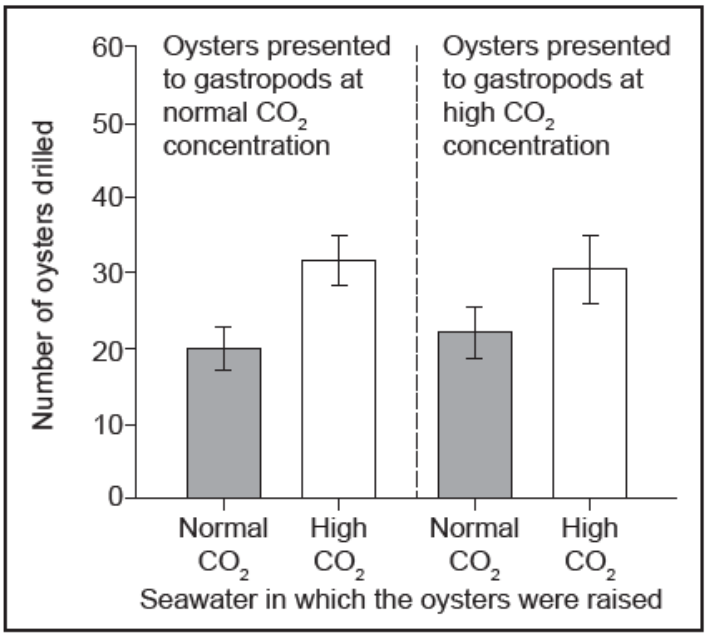
The first step was to raise oysters in two different mesocosms. One had seawater at a normal concentration of CO_2 and the other had sea water with a high concentration of CO_2. Gastropods were raised in two further mesocosms with normal and high CO_2 concentrations respectively.

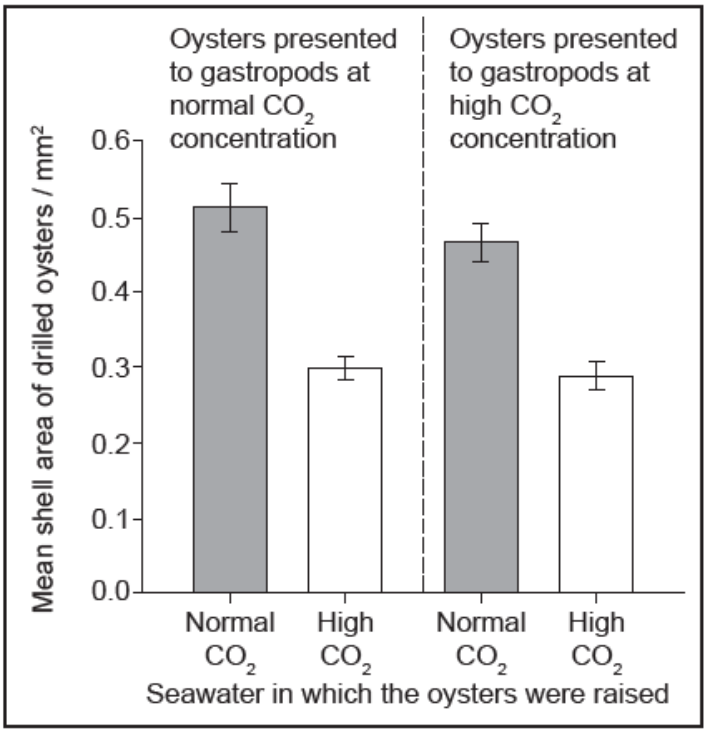
A juvenile gastropod will attack a juvenile oyster by using its tongue-like structure (radula) to drill a hole through the oyster shell. Once the hole has been drilled, the gastropod sucks out the soft flesh. Researchers investigated the shell thickness at the site of the drill hole in relation to the 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

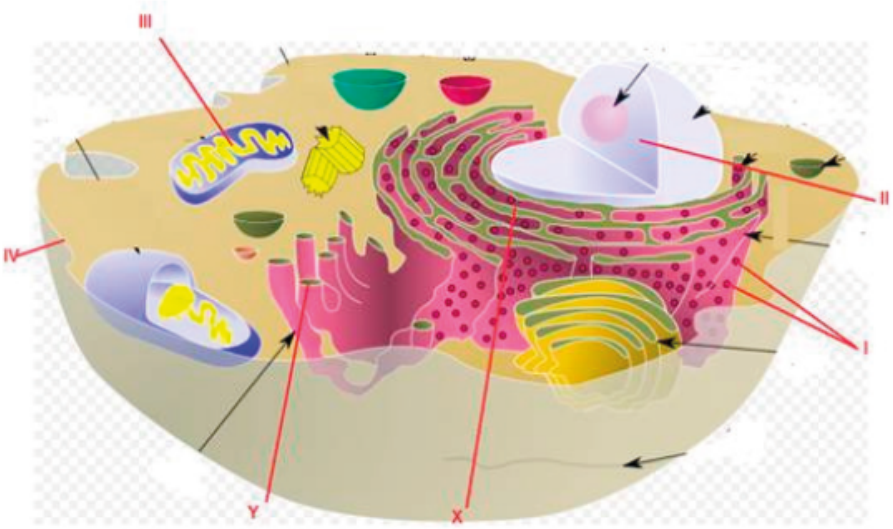
b. CO_2 concentrations «during feeding» do not change the occurrence of drilling/predation «by gastropods»

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 diagram shows some of the structures in an animal cell.



[Source: http://commons.wikimedia.org/wiki/File:Biological_cell.svg]

a. (i) Label structures I, II, III and IV. [3]

I.

II.

III.

IV.

(ii) State one function of structure III.

b. Explain how materials are transported within a cell between structures X and Y. [2]

Markscheme

a. (i) *Award [1] for any two of the following correctly labeled.*

I. ribosomes

II. nucleus (do not accept nuclear membrane)

III. mitochondrion

IV. plasma/cell membrane

(ii) ATP production/site of aerobic respiration *(do not accept energy production)*

b. (protein) material transported by vesicles;

from rER to Golgi apparatus/complex/body/membrane;

vesicles bud off from rER/fuse with Golgi membrane (due to membrane fluidity);

Do not accept vacuole(s).

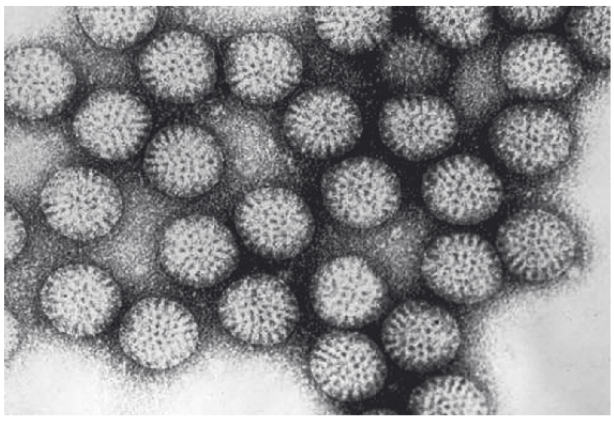
Examiners report

a. (i) Knowledge of basic cell structures usually earned at least one of two marks. Some confused nucleus with nucleolus or mentioned other incorrect organelles.

(ii) This was a discriminating question as most answers lacked detail; 'energy production' was too vague (should have been 'ATP production') and 'cell respiration' was incomplete (should have been aerobic cell respiration).

b. Sometimes X and Y were incorrect or ignored. A few gave 'endoplasmic reticulum' without specifying 'rough'. Many only mentioned transport by vesicles. Another problem was the use of 'vacuoles' instead of vesicles or the wrong direction for vesicle movement.

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

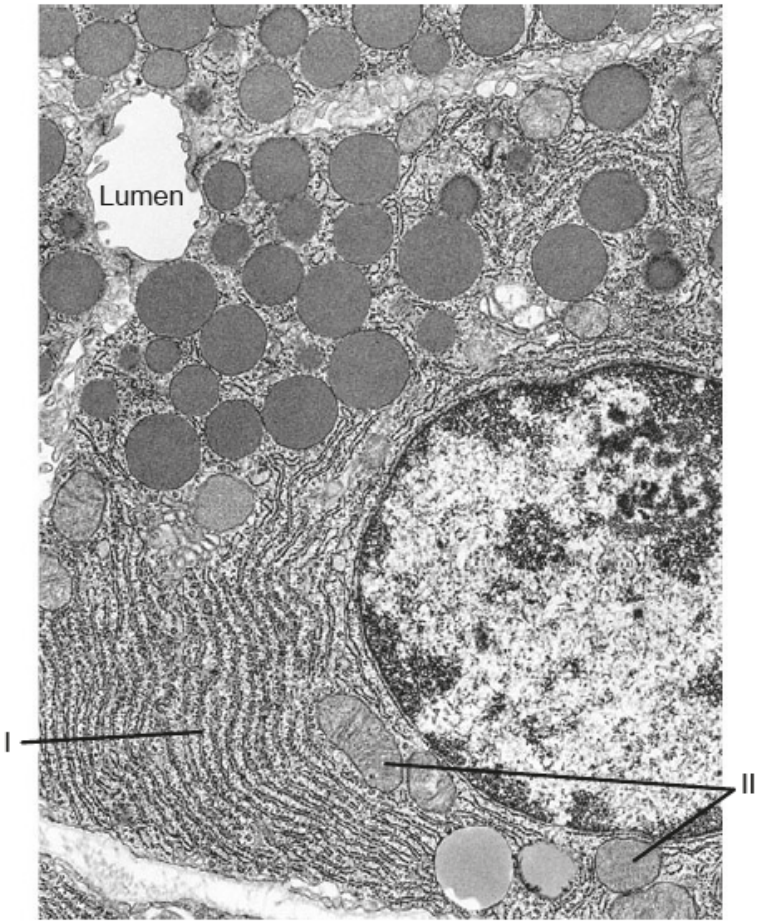
OR

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]