SL Paper 2

The diploid number of chromosomes in horses (*Equus ferus*) is 64 and the diploid number in donkeys (*Equus africanus*) is 62. When a male donkey and a female horse are mated, the result is a mule which has 63 chromosomes.

a. State the haploid number for horses. [1]

b. Explain reasons that mules cannot reproduce. [2]

c. Discuss whether or not horses and donkeys should be placed in the same species. [2]

d. A mule was born at the University of Idaho in the USA with 64 chromosomes. Suggest a mechanism by which this could happen. [1]

Markscheme

a. 32

b. a. because the chromosome number is not an even number/63

b. (so) cannot divide by two during meiosis/cannot perform meiosis/chromosomes cannot pair up during meiosis

c. one chromosome has no homologue/WTTE

d. because unlikely to/cannot produce viable gametes/sperm/egg cells

c. a. to be in same species two organisms must have the same genes arranged on the same chromosomes

OR

must have the same number of chromosomes

b. members of same species produce fertile offspring and a mule is not fertile

d. non-disjunction

Accept description of non-disjunction.

Examiners report

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

In ecosystems, energy is used to convert inorganic compounds into organic matter. Energy enters ecosystems through producers.

a. Explain the processes by which energy enters and flows through ecosystems. [8]

b. Producers extract phosphates and nitrates from soil. Outline how these ions are used in the synthesis of organic molecules. [3]

c. Draw a labelled diagram of a pyramid of energy. [4]

Markscheme

a. a. light energy is the initial energy source for (all) organisms

b. producers/autotrophs change light/radiant energy into chemical energy
OR
producers/autotrophs convert/trap light/radiant energy by photosynthesis

c. producing $C_6H_{12}O_6$ /sugars/carbohydrates

d. carbon/organic compounds used for energy/growth/repair/storage

e. compounds/energy pass as food along food chains/trophic levels WTTE

f. cellular respiration releases energy as ATP from food

g. energy is lost as heat (during cellular respiration)

h. loss of energy at each trophic level
OR
only approximately 10% of energy is passed to the next trophic level / 90% is lost at each trophic level

i. energy lost in bones/hair when they die/not fully eaten by the next trophic level

j. energy lost in feces/urine

k. decomposers/saprotrophs remove energy from wastes/bodies

l. energy is not recycled

b. a. by photosynthesis / using energy from light

b. attached to carbon compounds

c. phosphates used to make phospholipids/nucleotides/nucleic acids/DNA/RNA/ATP

Other phosphorus-containing metabolites are acceptable if verified.

d. nitrates are used to make amino acids/proteins/nucleotides/nucleic acids/DNA/RNA/ATP

Other nitrogen-containing metabolites are acceptable if verified.

e. transported from roots to leaves (in xylem)

c. a. drawn in steps rather than triangle

b. drawn to scale (should be at least 1/5 of the box below it)
OR
annotated with appropriate numeric values

c. producer

d. primary consumer

e. secondary consumer

Award no marks if a drawing has not been made.

“Appropriate numeric values” should indicate scale so accept percentage or numbers.

Examiners report

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

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b. Describe what is meant by a food chain and a food web. [6]

c. Explain the relationship between rises in concentration of atmospheric gases and the enhanced greenhouse effect. [8]

Markscheme

b. *Accept examples of the points below, provided that the terms underlined are clearly identified.*

Accept only named examples (latin or common names) from natural ecosystems only.

Do not award marks for general names such as "fish" or "tree".

a. food chain shows transfer of nutrients/energy in an ecosystem / arrows <u>from</u> one trophic level <u>to</u> the next in examples;

b. between different <u>trophic levels</u> / shown in a correct chain or web;

c. starting with a <u>producer</u>;

d. followed by at least two levels of <u>consumers</u> / shown in a correct chain or web;

e. food web is the (branched) interaction of multiple food chains / cross arrows in examples;

f. using (multiple) <u>producers</u> as a source;

g. transferring nutrients/energy to consumers from different food chains;

h. same consumer could be at different trophic levels in a food web;

c. *Award **[2 max]** from the following list of greenhouse gases*:

a. water vapour;

b. carbon dioxide;

c. methane;

d. oxides of nitrogen;

e. all (of these gases) occur naturally;

f. and human activity has increased the normal level of these gases in recent years;

g. incoming shorter wave radiation <u>from the Sun</u>;

h. is re-radiated as longer wave radiation/infrared;

i. (mainly) in the form of heat;

j. captured by greenhouse gases;

k. which increases the atmospheric/ocean temperature;

l. at a higher rate than normal / creating a positive imbalance;

m. which threatens ecosystems/climatic patterns/ocean patterns;

n. Earth's history had many fluctuations in gas levels/global temperature / some scientists are skeptical about enhanced greenhouse effect;

Examiners report

b. In general, a poorly answered question. Candidates drew simplistic or inaccurate food chains and rarely connected the concept of trophic levels with transfer of energy or nutrients. Reference to multiple producers in food webs was usually lacking.

c. Many answers did not distinguish between atmospheric gases and greenhouse gases. Few candidates were able to write about the shorter radiation from the sun and the longer radiation that is re-radiated. Some answers classically confused the greenhouse effect with the ozone layer.

There was no clear understanding of the effect of an increase in global temperature in leading to imbalance and climate change. Many answers were based around emotional arguments about the state of the planet.

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a. Define *habitat*, *population, community* and *ecosystem.* [4]

b. Outline how energy flows through an ecosystem. [6]

c. Discuss the benefits and possible harmful effects of altering species by **one** example of genetic modification. [8]

Markscheme

a. *habitat*:

the environment in which a species normally lives / the location of a living organism / *OWTTE*;

population:
a group of organisms of the same species who live in the same/specific area at the same time/interact; (*some reference to common place and time is required*)

community:
a group of populations/species living and interacting with each other in an area / *OWTTE*;

ecosystem:
a community and its abiotic environment / *OWTTE*;

b. producers/plants/autotrophs convert light energy into chemical energy/make food by photosynthesis;

such as sugars/organic compounds;

producers eaten by primary consumers, these by secondary consumers, (these by tertiary consumers)/energy moves up trophic levels;

only a small percentage/10–20 % of the energy is passed along food chain;

energy lost in the form of heat;

energy lost by (cell) respiration;

energy lost as not digested/lost in feces;

energy lost through death of organisms;

passed to detritivores/saprophytes/decomposers;

energy is not recycled;

c. DNA is universal (genes can be transferred among species);

gene modification is the transfer of genetic material between species;

named example; (*e.g. glyphosate resistant crops*)

source of gene; (*e.g. bacteria*)

function of gene; (*e.g. resistance to herbicides*)

modified organisms; (*e.g. soya beans*)

argument in favour/benefit of named example; (*e.g. increase in crop yield*)
argument in favour/benefit of named example; (*e.g. reduction in use of herbicides)*
argument in favour/benefit of named example; *(e.g. glyphosate breaks down into naturally occurring components so glyphosate resistant crops are justified)*

argument against/risk of named example; *(e.g. (application of) glyphosate could cause cancer in future)*
argument against/risk of named example; *(e.g. could be transferred to wild plants)*
argument against/risk of named example; *(e.g. genetically modified crops may cause allergies)*

Examiners report

a. Many candidates were correct with all of their definitions in 6(a). Since these involved pure recall, it showed that candidates had studied the topic.

Where trouble occurred, it was confusion between population and community

b. Overall, 6(b) was well answered with very few outright errors. Energy flow was well understood with accurate terminology being used. The ideas most frequently missed were: sugars/organic compounds as products of photosynthesis and the loss of energy. The latter included loss by (cell) respiration, loss as undigested material/feces and loss through death of organism. Also, not many candidates wrote that energy is not recycled.

c. Although 6(c) asked for the benefits and possible harmful effects of genetic modification using one example, it was appropriate to begin the answer by explaining that genetic modification involves the transfer of genes among different species based on the universality of DNA. This was rarely done. When naming the example, the source of the gene was usually not included, whereas its function and the modified organism were often given. Several examples of non-existent GMOs were cited. Some have ceased to be manufactured while others have not got out of the research

laboratory. Pros and cons tended to be generic instead of true applications of the arguments to the named GMO. Some candidates used different examples for different points in favour and against as opposed to discussing with one relevant named example. Finally, a few candidates confused GMOs with selective breeding or cloning.

---

a. Define the terms *species*, *population* and *community*. [3]

Species:

Population:

Community:

b. Explain the shape of the pyramids of energy that are constructed by ecologists to represent energy flow in an ecosystem. [3]

Markscheme

a. *species:* group of organisms that can interbreed to produce fertile offspring;

population: group of organisms of the same species living in the same area at the same time;

community: group of populations living and interacting with each other in an area;

b. energy flows up from one trophic level to the next (in a community);

energy is lost at each stage by waste products/feces/not all the organism is consumed;

most energy is lost through respiration/heat;

each level on the pyramid is about 10% – 20% of the size of the one below it / 80% – 90% energy lost between levels;

labelled diagram of pyramid of energy (indicating trophic levels);

Examiners report

a. Candidates either knew these definitions well or did not. It is valuable to stress to candidates that many marks come from command term objective 1 questions, which are overwhelmingly “state” or “define”. These questions require commitment to learn these statements and definitions. Such commitment is always rewarded when candidates meet questions such as these in examinations

b. Many candidates were able to describe the flow of energy through ecosystems well with the best answers including diagrams of an energy pyramid with the tropic levels labelled.

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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. Describe the structure and function of starch in plants. [3]

b. Outline the production of carbohydrates in photosynthesis. [4]

c. Discuss the processes in the carbon cycle that affect concentrations of carbon dioxide and methane in the atmosphere and the consequences for climate change. [8]

Markscheme

a. *Structure*:

a. «starch» is a polysaccharide/is composed of glucose molecules

b. contains amylose which is a linear/helical molecule

c. contains amylopectin which is a branched molecule

Function:

d. storage of glucose/energy in plants

e. storage form that does not draw water

b. a. light is absorbed by chlorophyll

OR

chlorophyll absorbs more red and blue light

b. «absorbed» light energy is converted to chemical energy

c. some of the energy is used for production of ATP

d. water molecules are split/photolysis

e. produces oxygen «as waste product»/hydrogen/NADPH

f. plants absorb/fix CO_2 «from air or water»

g. ATP/energy is needed to produce carbohydrates/starch

c. a. CO_2 is produced from respiration in organisms/combustion of biomass/fossil fuels

b. CH_4 is produced by anaerobic respiration of biomass/«methanogenic» bacteria

c. CH_4 is oxidized to CO_2 and water

d. CO_2 is converted into carbohydrates/organic compounds by autotrophs/producers/photosynthesis

e. CO_2 can be converted to calcium carbonate/fossilized into limestone

f. «partially» decomposed organic matter/biomass can be converted into peat/coal/oil/gas/fossil fuels

g. CO_2 and CH_4 are both greenhouse gases/increase greenhouse effect

h. both absorb long-wave radiation from the earth and retain the heat in the atmosphere

i. increased CO_2 concentrations in the atmosphere correlate with increased combustion of fossil fuels

j. rising average global temperatures correlate with more greenhouse gases in the atmosphere

k. cattle production/rice paddy/defrosting of tundra increase CH_4 in the atmosphere
OR
increasing CO_2 leads to acidification of marine/aquatic environments

l. the global temperature increase influences/disrupts climate patterns

OWTTE

Examiners report

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

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a. Distinguish between bryophyta and coniferophyta. [5]

b. Outline the consequences of a global temperature rise on arctic ecosystems. [6]

Markscheme

a.

bryophyta	*coniferophyta*
(reproduced by) spores	(reproduced by) seeds;
(carried in) capsules	(carried in) cones;
non-woody stems	woody stems;
smaller (less than 2 cm)	larger (meters tall);
rhizoids	roots;
no cuticle on leaves	cuticle on leaves;
no xylem/phloem	have xylem/phloem;

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

b. increasing rates of decomposition of detritus previously trapped in permafrost;

expansion of the range of habitats available to temperate species;

loss of ice habitat;

changes in water salinity;

changes in distribution of prey species affecting higher trophic levels;

increased success of pest species;

loss of ice increases absorption of solar radiation increasing warming of atmosphere;

extinction of species adapted to arctic/cold conditions;

humans can/should take steps to reduce/slow losses in habitat / given example of measure taken;

statement applying the precautionary principle to this issue;

Examiners report

a. Many answered this question very poorly. They did not identify bryophytes as mosses, liverworts or hornworts instead they identified them as angiosperms. They could write about conifers but not distinguish between the two.

b. The knowledge of consequences of a global temperature rise on arctic ecosystems tended to be very general and simplistic (certainly not specific enough). Many candidates wrote in great length about how the polar bear population is decreasing but forgot to mention any other consequence of global warming on the arctic ecosystem. As well, many candidates incorrectly wrote about increasing sea levels as this applies to all coastal ecosystems not just the arctic. Many candidates believed that penguins were arctic.

Plants have widespread influences, from food chains to climate change.

a. Draw a diagram of a palisade mesophyll cell labelling only the structures that would not be present in a pancreatic cell. [3]

b. Explain the process of photosynthesis. [8]

c. Describe the process of peat formation. [4]

Markscheme

a. a. cell wall

Must be shown as a double line

b. large vacuole

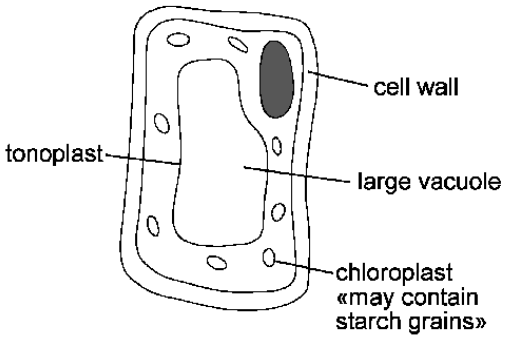
Labelled either inside or on the membrane

c. chloroplast/plastid

d. starch grain

e. tonoplast

*Allow **[2 max]** if any features common to both plant cells and animal cells are labelled*



[Max 3 Marks]

b. a. autotrophs perform photosynthesis

b. carbon dioxide and water are the reactants/raw materials required for «photosynthesis»

c. light splits water molecules/causes photolysis

d. «photolysis» releases oxygen as a «waste» product

e. light energy is converted into chemical energy

f. «photosynthesis» produces organic compounds/glucose/carbohydrates

g. photosynthesis occurs in chloroplasts

h. chlorophyll «photosynthetic pigment» absorbs light

i. different pigments absorb different wavelengths «of light»

j. chlorophyll absorbs red and blue light/ends of the spectrum

k. carbon dioxide concentration/temperature/light intensity are limiting factors

*Award only **[1]** for correct display of equation unless further annotated or explained*

*Allow up to **[2]** for correct use of understandings specified as AHL topic 8*

[Max 8 Marks]

c. a. formed from dead plant material/leaves/mosses/Sphagnum

b. formed in waterlogged sites/bogs/mires/swamps

c. where bacteria/fungi/saprotrophs are not active/are inhibited

d. organic matter not fully decomposed

e. «occurs» in acidic conditions

f. «occurs» in anaerobic conditions

Reject anaerobic respiration

g. «very» slow process/takes a long time

[Max 4 Marks]

Examiners report

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

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a. Outline the difference in absorption of red, blue and green light by chlorophyll. [4]

b. Explain how the process of photosynthesis affects carbon dioxide concentrations in the atmosphere during a typical year **and** the likely consequences on Earth of the yearly rises in carbon dioxide concentrations. [8]

Markscheme

a. a. blue and red light absorbed (the most);

b. greatest absorption in blue light;

c. red light absorbed in high amounts;

d. least/no absorption of green light / green light is reflected/transmitted;

Allow answers shown in an annotated diagram/graph.

b. *Relationship between photosynthesis and carbon dioxide concentration:* ***[4 max]***

a. photosynthesis uses carbon dioxide;

b. CO_2 fixed/made into organic molecules/compounds by photosynthesis;

c. lowering carbon dioxide level in atmosphere;

d. annual/seasonal fluctuations of carbon dioxide levels could be related to photosynthesis;

e. caused by increased photosynthesis during spring/summer;

Consequences: ***[5 max]***
f. enhanced greenhouse effect caused by raised levels of carbon dioxide;
g. causing global warming;
h. rising of ocean levels / melting of polar ice caps/glaciers;
i. changes in weather (patterns);
j. ocean acidification;

k. alter food webs;
l. changes/loss of habitat;
m. changes in distribution of plants and animals;
n. may lead to extinction;

Examiners report

a. Question 6 appeared to be the most difficult question for candidates.

Most candidates knew that chlorophyll absorbs blue and red light and virtually no green light which is consequently reflected. Very few candidates knew that blue light is absorbed most and that red light is absorbed in high amounts.

b. Question 6 appeared to be the most difficult question for candidates.

Candidates frequently began with the idea that plants take in CO_2 through photosynthesis and that levels of atmospheric CO_2 can be lowered as a result. After that changes in atmospheric levels as a result of seasonal fluctuation was left undeveloped or confused with human production of CO_2 through deforestation etc. Candidates did know about global warming resulting from rising levels of CO_2. They knew a variety of consequences related to global warming which reflected awareness of similar IB questions on past exams. Some candidates still think that CO_2 weakens the ozone layer. It seems that no candidate knew about the enhanced greenhouse effect.

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

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

Markscheme

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

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

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

d. the first/lowest trophic level is producers;

e. second level is primary consumers/herbivores;

f. third level of secondary consumers/carnivores;

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

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

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

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

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

b. regulated by negative feedback/homeostatic mechanisms;

c. hypothalamus is the centre of thermoregulation;

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

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

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

g. heat is transferred by blood;

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

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

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

k. shivering increases heat production (in muscles);

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

Examiners report

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

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

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a. Outline **two** possible consequences of global warming for organisms living in arctic ecosystems. [2]

b. The changes that result from global warming may lead to evolution. Define *evolution*. [2]

c. Explain how sexual reproduction promotes variation in a species. [3]

Markscheme

a. reduced space/habitat (for ice-dwelling species) / valid example;

increased competition (from temperate species);

arctic species forced to migrate (in search of suitable habitats/food);

changes in patterns of (seasonal) migration;

extinction of some species due to inability to adapt quickly/compete successfully;

increased activity of decomposers;

increased success of pest species including pathogens;

changes in the distribution of prey species;

b. (cumulative) change in heritable/genetic characteristics of a population;

new species arise from pre-existing species;

change/adaptation of a population due to natural selection / descent with modification;

c. sexual reproduction involves interbreeding/genetic material from two parents;

new combinations of paternal and maternal chromosomes/alleles/genes / (random) fertilization;

which leads to new genetic combinations/greater variation;

meiosis creates a great variety of gametes;

by crossing-over / by random orientation of alleles (during meiosis);

Examiners report

a. Most candidates performed well here, but a significant number of candidates lacked the appropriate vocabulary (habitat, competition, and extinction). Some poor answers focused on the effect of warming on the environment rather than the organisms in the arctic. Others focused only on the problems posed for polar bears. Answers that did not earn credit were release/increase in greenhouse gases, rising water levels, and references to animals “dying out” which was vague.

b. Given the pivotal position of evolution in biology, it is disturbing that so many definitions missed the mark. Candidates who did well were familiar with the Teacher's notes in the Biology syllabus (p. 66) which accompany A.S. 5.4.1. The concept of change in the heritable characteristics of a population was often expanded to include adaptation through natural selection. Others candidates expanded their answer with the idea of species arising from pre-existing species. Candidates who performed poorly did not specify change in terms of heritable/genetic characteristics. Many weak answers stressed mutation rather than natural selection as the basis for adaptation.

c. Among all candidates as a group, every marking point for the question about the promotion of variation in a species through sexual reproduction was eventually awarded. However, most candidates could only produce one or two creditable ideas in their answers. Most common was the involvement of two parents leading to new genetic combinations which cause variation in offspring. Many candidates mentioned crossing-over and/or random orientation during meiosis. A few candidates mentioned random fertilization. Some weak answers talked about interbreeding of different species because the candidates misread the question and overlooked “in a species.” Also, many candidates talked about the genes of an organism or adaptation of an organism when the discussion should have been on a species or population. Finally, some candidates mixed up meiosis with mitosis while other made irrelevant comparisons to asexual reproduction.

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

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

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

Markscheme

a. $\underline{CO_2}$ in atmosphere/air;

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

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

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

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

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

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

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

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

combustion;

Award marking points only if arrows point in correct direction.

b. correct equation for photosynthesis in words or symbols;

measure production of oxygen;

example of method to measure oxygen production;

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

measure uptake of CO_2;

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

measure increase in biomass;

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

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

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

during inspiration/inhalation external intercostal muscles contract;

causing ribs to move upwards/outwards;

during inspiration diaphragm contracts/flattens;

causes increase in volume of thorax/lungs;

decrease in pressure allows air to enter (passively);

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

causing ribs to move down/in;

diaphragm relaxes/returns to original domed position;

abdominal muscles contract to push diaphragm up;

causes decrease in volume of thorax/lungs;

increase in pressure forces air out of lungs;

Award [5 max] for inhalation or exhalation only.

(Plus up to [2] for quality)

Examiners report

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

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

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

---

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.

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

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

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

Markscheme

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

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

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

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

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

to allow diffusion / to make food soluble;

so foods can be absorbed into the bloodstream/body;

so foods can move from bloodstream into cells;

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

hydrolysis is aided by enzymes;

hydrolysis requires water;

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

proteins/polypeptides (hydrolysed) to amino acids;

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

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

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

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

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

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

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

primary consumer/herbivores obtain energy from plant food;

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

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

some energy is lost as heat through respiration;

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

Examiners report

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

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

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

---

a. Describe the movement of energy and nutrients in an ecosystem. [6]

b. Explain how sexual reproduction can eventually lead to evolution in offspring. [8]

c. Using simple external recognition features, distinguish between the plant phyla bryophyta and angiospermophyta. [4]

Markscheme

a. ecosystem is a community and its abiotic environment;
solar energy collected by autotrophs/plants (via photosynthesis);
moves through trophic levels via food;
only 5 to 20% transferred from one trophic level to next / never 100% efficient;
lost as metabolic heat/organic waste;
energy flow can be illustrated by pyramid shape;
organisms absorb nutrients from food/environment;
nutrients occur as complex organic matter in living organisms;
after death, saprotrophic bacteria and fungi (decomposers) breakdown complex organic matter;
breakdown products are simpler substances;
absorbed into plants for resynthesis into complex organic matter/recycled;

b. offspring vary in traits;

variation results from sexual reproduction;

independent assortment of alleles (during meiosis of spermatogenesis/ oogenesis) contributes to variation;

meiosis is the cellular process that produces gametes;

crossing over (during meiosis) increases variation;

fertilization (combination of different genomes) contributes to variation;

more offspring may be produced than the environment can hold;

struggle for existence can occur;

offspring whose traits best adapt them to environment will survive/survival of fittest;

change in environment will lead to survivors with new/different traits;

correct use of term natural selection/selective pressure;

variation is heritable / over time more offspring born with new trait;

change in gene pool;

when entire population (of a species) exhibits new trait, evolution has occurred;

c.

bryophyta	angiospermophyta
nonvascular/unspecialized tissue / no veins	vascular/specialized tissue / veins;
small / height up to 7 cm	tall / height up to 100 m;
exist as organized masses of cells / "leafy" appearance	contain water-conducting cells (tissue)/food-conducting tissue/ support tissue;
reproductive structures / capsules appear on stalks	have flowers;
microscopic spores	covered seeds/fruits;
sometimes hair-like extensions below growing surface/rhizoids	roots;

Examiners report

a. Candidates demonstrated a good understanding of the movement of both energy and nutrients in ecosystems. The best responses were illustrated with energy pyramids or nutrient diagrams.

b. The role of sexual reproduction in evolution was well answered in general. The best answered laid out a step-wise sequence of events that explained how sexual reproduction leads to evolution with real life examples such as Galapagos Island Finches.

c. Few candidates could recall any detail of the characteristics of the plant phyla bryophyta and angiospermophyta. Many did use a table to distinguish between the two phyla, which was an appropriate way to approach the answer, however the lack of detail let most candidates down.

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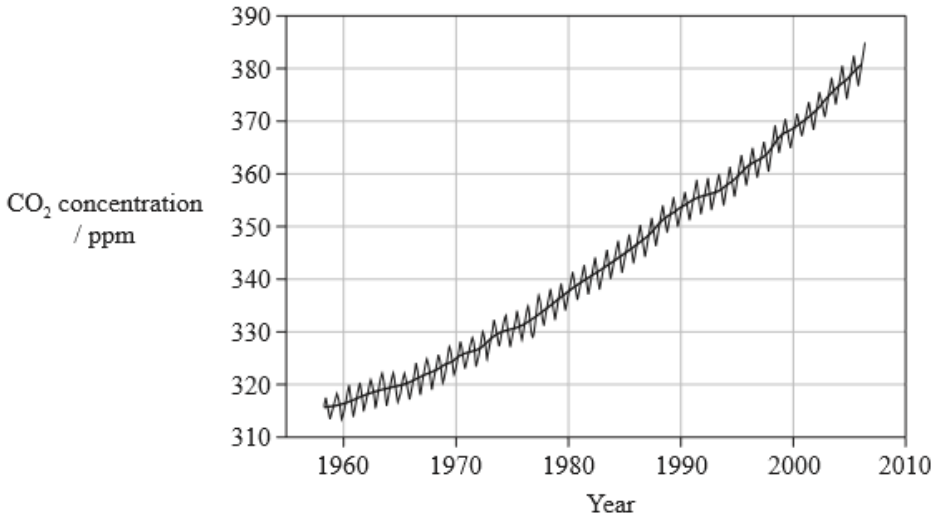
a. Below is a graph of atmospheric CO_2 levels measured at Mauna Loa Observatory, Hawai'i. [3]



[Source: adapted from Dr P Tans, NOAA Earth System Research Laboratory]

Explain the observed changes in atmospheric CO_2 concentration from 1960 to 2005.

b. Outline the precautionary principle. [2]

Markscheme

a. (from 1960–2005) atmospheric CO_2 concentration increases/strong positive trend / increase between 1960–2005 of 65 ppm/figures to that effect;

CO_2 released by human activities contributes to the increase;

examples of human activities *e.g.* combustion of fossil fuels / deforestation;

seasonal/annual fluctuations (do not prevent long-term increase);

b. some human-induced change can be very large/perhaps catastrophic;

those responsible for the change must prove it will cause no harm before proceeding;

appropriate (environmental/medical *etc.*) example *e.g.* companies must immediately reduce emission of greenhouse gases even though proof of human impact on global warming is still debated;

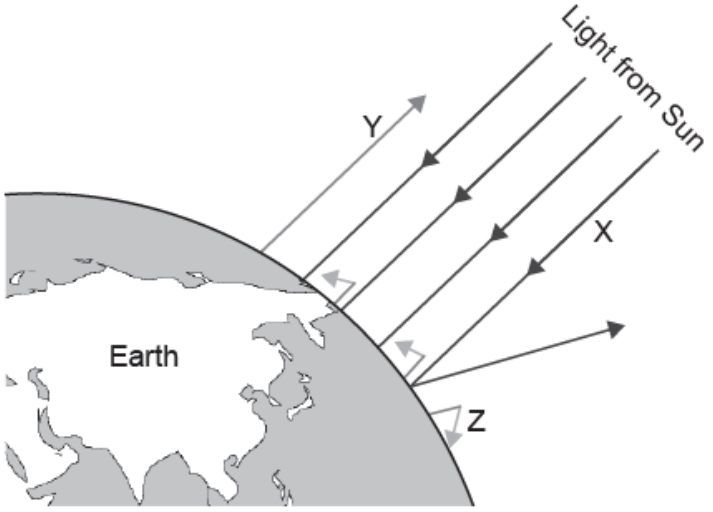
is reverse of historical practice / previously those concerned about change had to prove it will do harm to prevent such changes from going ahead / paradigm shift;

Examiners report

a. Few candidates gained three marks. The increasing trend of atmospheric CO_2 was commonly given with the combustion of fossil fuels as the reason. Sometimes, there was no explanation at all. Many candidates reported the seasonal/annual fluctuations in the trend.

b. It was clear that many candidates had never heard of the precautionary principle and guessed at the answer. Conversely, there were candidates who wrote terrific answers which got at the heart of the answer, i.e. that those responsible for change must prove it will cause no harm before proceeding. Good examples were limited.

The diagram shows the greenhouse effect.



[Source: © International Baccalaureate Organization 2017]

a. State the type of wavelength of the radiation labelled X and Y. [2]

X:

Y:

b. Outline reasons for the change occurring at Z. [2]

c. The short-tailed albatross (*Phoebastria albatrus*) nests and breeds on remote low-lying coral islands in the Pacific Ocean. Predict how global warming may threaten the survival of such an ocean bird. [1]

Markscheme

a. X: short-/ultraviolet/UV/visible/EMR/electromagnetic radiation

Y: long-/infrared/IR

b. a. greenhouse gases present (at Z)

b. greenhouse gases «CO_2, methane, nitrous oxide, water vapour» absorb long-wavelengths/infrared
OR
long wavelengths/infrared waves blocked from leaving the atmosphere

c. (long-wavelengths/infrared absorbed and) reradiated/re-emitted (heat Earth)

c. a. rising ocean levels/more extreme weather «due to global warming» may destroy breeding/nesting sites

OR

rising sea level may put island underwater causing young birds/chicks to drown

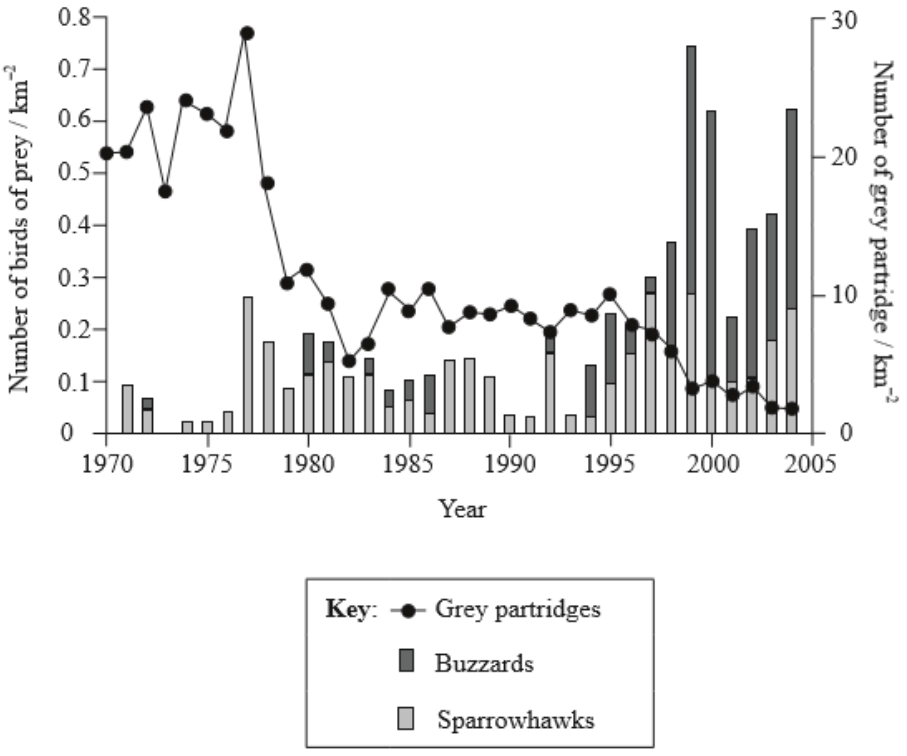
b. populations may not find/adapt to new colony sites

c. warming seas may affect the food supply

Examiners report

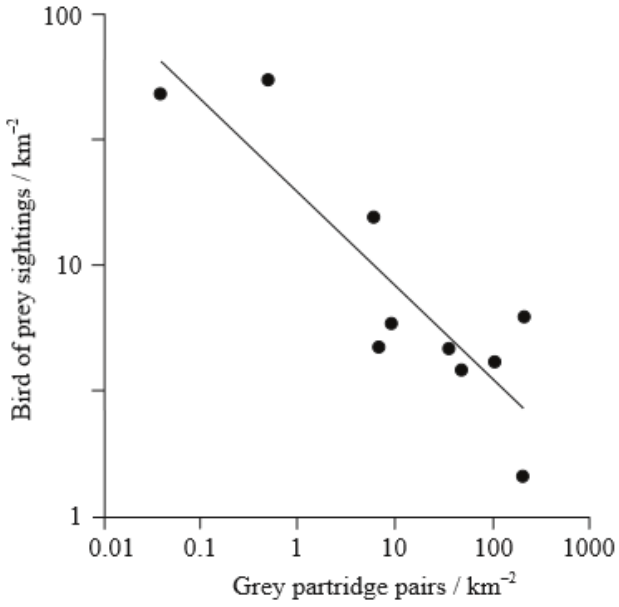
a. [N/A]
b. [N/A]
c. [N/A]

The grey partridge (*Perdix perdix*) is a species of bird that is found on farmland. Sparrowhawks (*Accipiter nisus*) and buzzards (*Buteo buteo*) are birds of prey that kill and feed on birds, including grey partridge. The number of grey partridges in a region of southern England was monitored from 1970 to 2004. The numbers of sparrowhawks and buzzards, seen from sampling positions during regular observation periods, were counted. The results are shown in the graph below.



[Source: M Watson, *et al.*, (2007), *Journal of Applied Ecology*, **44**, pages 972–982]

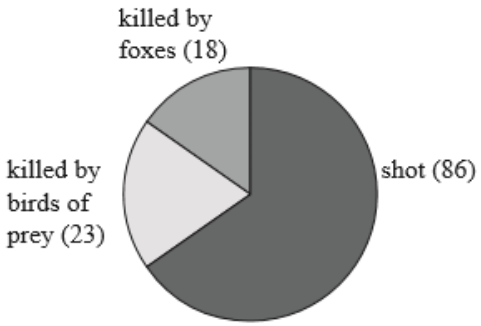
The density of grey partridge (number per square kilometre) varied considerably in different areas within the study region. The graph below shows the correlation between the density of grey partridges and the density of birds of prey.



[Source: adapted from M Watson, *et al.*, (2007), *Journal of Applied Ecology*, **44**, pages 972–982]

The highest density of birds of prey was found in areas used for recreational shooting. In these areas, other species of partridge were bred and released. Food and shelter were provided for the released birds. These measures tended to increase the number of both released and wild birds.

The causes of death of grey partridge were investigated in one of the areas that was used for recreational shooting. The pie chart below shows the causes of death.



a. Outline the trends, over the period of time shown in the graph, in the number of grey partridges, buzzards and sparrowhawks. [3]

Grey partridges: .....

Buzzards: .....

Sparrowhawks: .....

b (i) Identify the correlation between the density of grey partridges and birds of prey. [1]

b (ii) Suggest a hypothesis to account for this correlation. [2]

c (i) Calculate the percentage of deaths due to birds of prey. [1]

c (ii) Using the data provided, discuss the causes of the correlation between the density of grey partridges and the density of birds of prey. [3]

Markscheme

a. grey partridge numbers/pairs reduced;

buzzard numbers increased;

sparrowhawk numbers no clear trend/no overall rise or fall/constant/stable/ fluctuates;

b (i) negative correlation/inverse proportion/bird of prey density falls as partridge density rises

b (ii) partridges eaten by birds of prey;

fewer partridges present where more birds of prey present / more partridges present where fewer birds of prey present;

partridges move to areas with fewer birds of prey;

fewer birds of prey enable growth (by reproduction) of grey partridge population;

c (i) 18%/18.1% (*18 needed but no penalty if significant figure error*)

c (ii) birds of prey attracted from outside to shooting areas because of abundant food (grey and released partridges) / birds of prey living in shooting areas increase in numbers because of abundant food;

non-hunting human involvement (food and shelter) influenced the correlation between the densities;

more grey partridges shot than killed by birds of prey / many grey partridges shot in shooting areas;

correlation not only due to birds of prey eating grey partridges/human involvement;

grey partridges compete with released partridges for food and shelter (decreasing the density of grey partridges);

Examiners report

a. The answers here were usually fine, but sometimes candidates faltered because they never summarized an overall trend or reached any conclusion about a trend. Just noting yearly population fluctuations for individual bird species was not enough to gain marks.

b (i) Answers were divided between giving the term negative correlation or inverse proportion or using a sentence such as "birds of prey density goes down as grey partridge density rises." Either style was acceptable.

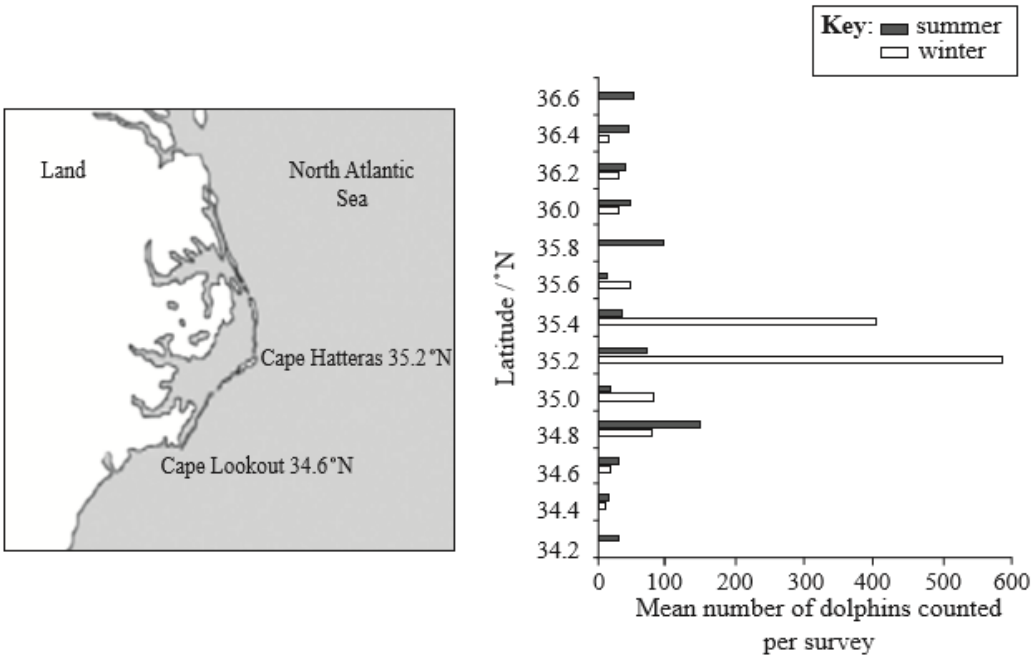
b (ii) Those answers that gained the maximum of two marks provided a prediction/observation supported by some reasoning. For example, “fewer partridges are present when more birds of prey are seen because partridges are eaten by birds of prey.” Another acceptable reason was that the partridges moved to areas with fewer birds of prey. Converse accounts also gained credit such as “more grey partridges can exist (through reproduction) when fewer birds of prey are around.” Some candidates just repeated their response from 1(b) (i) and gained no credit.

c (i) A correct percentage was usually calculated. Although it was not required, many candidates applied significant figures rules in determining their answer.

c (ii) Answers were quite varied. Many candidates had difficulty using the data provided. The discussions of some candidates covered more than the maximum number of marks while others wrote vague and ambiguous explanations for no credit. Many candidates showed some sort of reasoning. All the marking points eventually appeared over the range of scripts. Often, candidates mentioned that birds of prey were attracted from outside to

the shooting area because of the abundant food i.e. the released partridges and grey partridges.

Bottlenose dolphins (*Tursiops truncatus*) inhabit almost all tropical and temperate oceans between 45°N and 45°S. Over a two-year period, aerial surveys were carried out to investigate the seasonal distribution of these animals along the mid-Atlantic and eastern coastal waters of the USA. Sightings were recorded using a global positioning system (GPS) while flying parallel to the coast approximately 500 m offshore. The diagram below shows a map of the section of coast surveyed. The bar graph shows the seasonal data for summer and winter at the corresponding latitudes (°N). A total of 5431 bottlenose dolphins were sighted during these surveys.



[Source: adapted from Leigh G. Torres, William A. McLellan, Erin Meagher and D. Ann Pabst (2005) 'Seasonal distribution and relative abundance of bottlenosedolphins, *Tursiops truncatus*, along the US mid-Atlantic Coast.' *Journal of Cetacean Research and Management*, 7 (2), pp. 153–161.]

a. State the largest number of dolphins counted in a single summer survey. [1]

b. Compare the distribution of dolphins in summer and winter. [2]

c. Suggest **one** reason for the differences in distribution. [1]

Markscheme

a. 150 (*allow answers in the range 140–160*)

b. more evenly distributed in summer than in winter (across latitudes);

many near Cape Hatteras/35.0/2–35.4/6°N in winter/more than in summer;

more dolphins overall in the survey area in winter than in summer;

wider summer range / reaches 36.6 and 34.2°N/ less far N and S in winter;

unimodal distribution in winter versus bimodal in summer / *OWTTE*;

c. seasonal variation in food supply/prey/predators/water temperatures;

migration to find food/prey/warmer water/mates;

migrating dolphins rest/congregate near Cape Hatteras/35.2 – 35.4°N;

Cape Hatteras/35.2 – 35.4°N may be a mating area in the winter;

seasonal variation in human activity / valid example;

more food/warm water between mainland and Cape Hatteras in winter;

Examiners report

a. Most answers were correct, although some gave the highest overall number in winter.

b. Many candidates recognized the more even distribution of dolphins in summer than in winter and that more dolphins congregated near Cape Hatteras in winter than in summer. Some candidates just quoted data. Instead of saying “many” dolphins they would state a number and let the reader interpret the meaning.

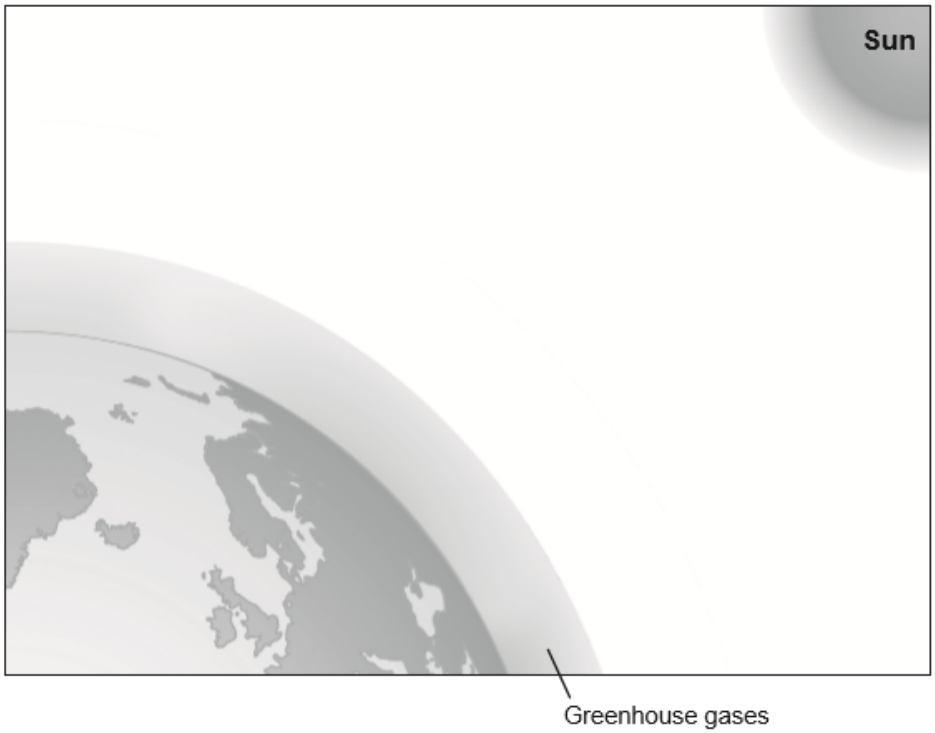
c. By far, the most common answer identified seasonal variation in food supply or water temperature. Some candidates did not earn the mark because they had no reference to season. In 1(b) candidates had been asked to compare the distribution of dolphins in summer and winter and in 1(c) they were asked to suggest one reason for the differences in distribution. It was expected that some reference to seasonality would accompany any answer in 1(c).

---

a. (i) Distinguish between the thermal properties of water and methane. [4]

(ii) Explain the reasons for the unique thermal properties of water.

b. Using the diagram, explain the interaction of short and long wave radiation with greenhouse gases in the atmosphere. [3]



[Source: © International Baccalaureate Organization 2016]

Markscheme

a. (i)

Boiling point of water is greater than methane

Melting point of water is greater than methane

Latent heat of vaporization of water is greater than methane
OR
specific heat capacity of water is greater than methane

(ii)

Water is polar
OR
O atom more negative
OR
H atoms more positive

This causes «strong» hydrogen bonds to form between the molecules

Which require more/high amount of energy to break

Which increases the melting/boiling/latent heat properties

b. Short wave radiation/UV «shown as» having its origin in the Sun gives off light as short radiation

Short wave radiation/UV «shown as» passing through the greenhouse gases «some reflected»

Some short wave radiation/UV is absorbed by the Earth and some is reflected

The reflected radiation is long wave radiation «reflected as heat»

Long wave radiation/IR «shown as» being unable to pass through/being absorbed/reflected by the greenhouse gases

Award marks for diagrammatic explanations of these marking points.
Accept UV and IR as long as they are drawn with the correct wavelength.

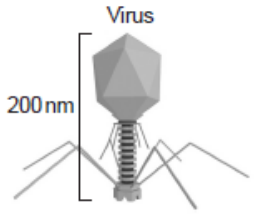
Examiners report

a. (i) The expression ‘thermal properties’ seemed to confuse weaker candidates, who looked ahead to part b and tried to compare them as greenhouse gases. Perhaps the use of ‘physical properties’ might have been better. Many were able to state, for example, that water has a high boiling point, but did not get the mark as they did not continue to say that it was much higher than methane.

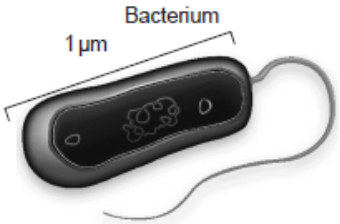
(ii) Most remembered about hydrogen bonds, but lost the mark for forgetting to state that they are between molecules.

b. The writer of this question presumed that the more visual learners would use the diagram to produce an annotated response. In fact, very few used the diagram at all. The difference between long and short wavelengths was very confused, and weaker candidates were obsessed with explaining the composition of the greenhouse gases, and the role of the ozone layer (usually incorrectly). As a major problem affecting the planet, there seemed to be a lot of confusion.

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

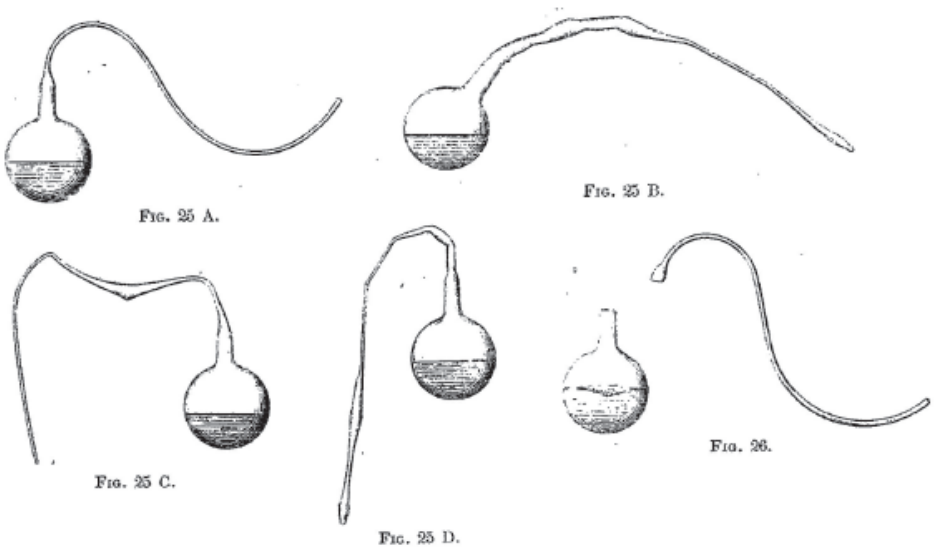


Fig. 25 A.

Fig. 25 B.

Fig. 25 C.

Fig. 25 D.

Fig. 26.

[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]
[N/A]

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

Male Lepidoptera (butterflies and moths) commonly drink from pools of water or from moist soil. This behaviour, called puddling, was investigated in an undisturbed area where male tiger swallowtails, *Papilio glaucus*, had been seen puddling.

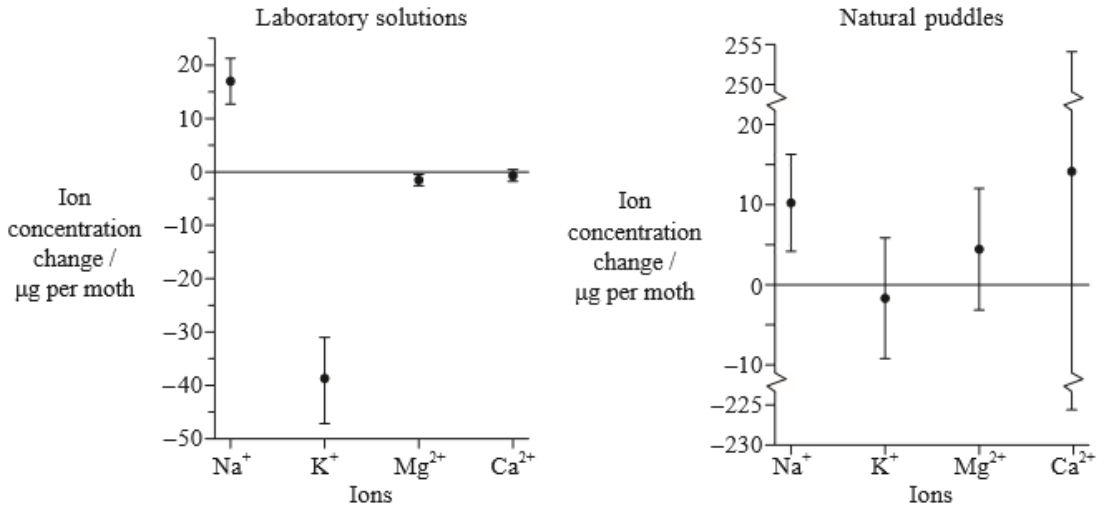
Four successive sets of experiments were performed under similar conditions of temperature and humidity. In each set, equal samples of sand were spread out evenly on trays and then treated differently. Except for one dry sample (in the first set), all others were saturated with a different liquid. Results of the observations are given in the table below.

Numbers of visits (V) and time in minutes (T) spent puddling by male *Papilio glaucus* adults on sand treated in different ways.

Experiments	Visits and times on sand plus substance:									
	V	T	V	T	V	T	V	T	V	T
1	*Dry sand alone*		*Distilled H_2O*		*Casein hydrolyzate*		*5% Sucrose*		*NaCl (0.17 M)*	
	26	0	47	0.5	27	205.5	60	0.5	74	320.5
2	*KCl (0.1 M)*		*$MgCl_2$ (0.1 M)*		*$CaCl_2$ (0.1 M)*		*Na_3PO_4 (0.1 M)*		*NaCl (0.1 M)*	
	33	0	36	0	48	1.5	43	79.5	65	362.0
3	*NH_4Cl (0.1 M)*		*KNO_3 (0.1 M)*		*K_3PO_4 (0.1 M)*		*Na_3PO_4 (0.1 M)*		*$NaNO_3$ (0.1 M)*	
	9	0	6	0	6	0	3	0.5	86	279.5
4	*Distilled H_2O*		*NaCl (10^{-5} M)*		*NaCl (10^{-4} M)*		*NaCl (10^{-3} M)*		*NaCl (10^{-2} M)*	
	2	0	7	1.5	16	27.5	32	172.5	22	195.5

[Source: adapted from K Arms, *et al.*, (1974), *Science*, **185**, pages 372–374]

Study of the male moth *Gluphisia septentrionis* revealed that their puddling behaviour can last for hours. Though drinking results in the uptake of hundreds of gut-loads of fluid, this fluid becomes rapidly expelled from the digestive system through frequent anal ejections. In this experiment, the ion concentration change was calculated by subtracting ions ejected from ions taken in. The following data was collected from males drinking laboratory solutions and from natural puddles.



[Source: adapted from S R Smedley and T Eisner, (1995), *Science*, **270**, pages 1816–1818]

a. Identify the dissolved element always present in the three samples with most puddling time. [1]

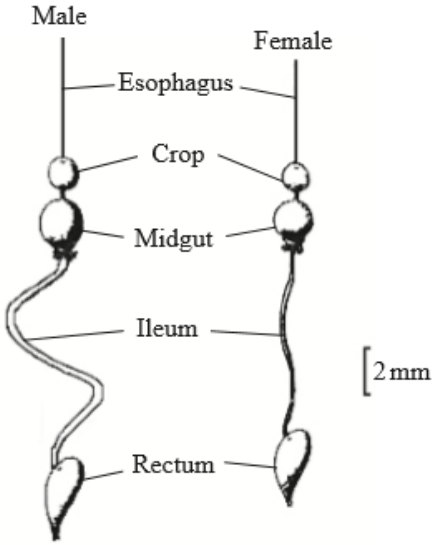
b. Discuss the relationship between sampling visits (V) and puddling time (T) in experiments 1, 2 and 3. [2]

c. Analyse the results for experiment 4. [2]

d (i) Identify which ion the moths are retaining in their body from the laboratory solutions. [1]

d (ii) Compare the gain and loss of ions in the male moths which have drunk from laboratory solutions with the changes in those that have drunk from natural puddles. [3]

e. The diagram below shows the digestive system anatomy of the male and female moth. [2]



[Source: adapted from S R Smedley and T Eisner, (1995), *Science*, **270**, pages 1816–1818]

Using the diagram above, evaluate the hypothesis that male moths are better adapted than female moths to benefit from puddling behaviour.

Markscheme

a. sodium/Na

b. unclear correlation between V and T;

depends on the nature of the substrate and its concentration;

sometimes high V with low T (*e.g.* experiment 1 for sucrose) / sometimes high V with high T (*e.g.* experiment 2 for NaCl);

c. higher salt/NaCl concentrations increase T and V;

increase in puddling with increase in salt/NaCl;

no clear relationship between the number of visits and the concentration of salt/NaCl;

d (i) sodium/Na

d (ii) retention of sodium/Na from laboratory solutions and natural puddles;

definite loss of potassium from laboratory solutions but loss/gain uncertain from natural puddles;

slight loss of magnesium from laboratory solutions and uncertain gain/loss from natural puddles;

calcium uncertain in both cases / variation in data for calcium;

more conclusive results in laboratory solutions / conditions more reliable in laboratory solutions / greater variation in natural puddles;

Accept reference to error bars/ranges in data in place of uncertainty.

e. males have longer/wider digestive tracts for greater absorption of fluid;

ileum of males has greater surface area;

which allows faster/more absorption in males than in females;

Examiners report

a. Many candidates answered NaCl instead of Na when asked to identify the dissolved element.

b. Many candidates were unable to discuss correctly the relationship between sampling visits (V) and pudding time (T) in experiments 1 2 and 3.

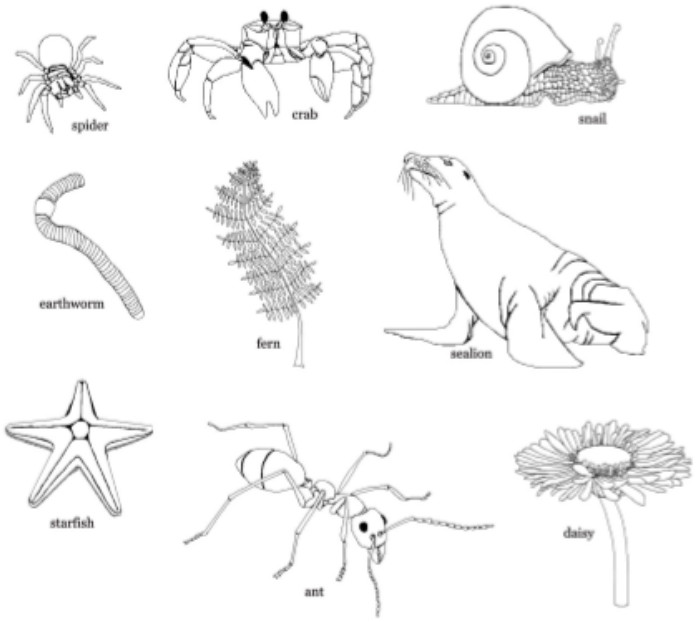
c. Many candidates were unable to see the relationship between the NaCl concentration, the sampling visits (V) and the pudding time (T).

d (i) N/A

d (ii) In part (ii), the majority of the candidates did not compare the gain and loss of each ion between moths which drank from laboratory solutions and moths which drank from natural puddles.

e. In the case of many candidates, no discussion or analysis was included, only description.

The diagrams below show different organisms (not drawn to scale).



a. State **all** the organisms shown above that belong to the following phyla. [3]

Filicinophyta:
Arthropoda:
Mollusca:

b (i) Construct a possible food chain using **three** of the organisms shown opposite, stating the trophic level to which they belong. [2]

b (ii) State the initial energy source of the food chain constructed in (b)(i). [1]

Markscheme

a. *filicinophyta:* fern;

arthropoda: spider, ant, crab; *(all three needed to award the mark)*

mollusca: snail;

b (i) e.g.

daisy/fern → ant → spider;
daisy/fern → snail → crab/sea lion/ant;
producer primary consumer secondary consumer;
*Award **[1 max]** for correct trophic levels. Award **[1]** for the correct sequence of organisms which includes a producer.*

b (ii) sun / solar energy/light

Examiners report

a. Widespread weakness was seen as many candidates could not identify which organisms belonged to which phyla (A.S. 5.5.3, 5.5.4). One correctly matched organism was often mixed with one that didn't belong, resulting in no mark.

b (i) Unrealistic food chains were given; for example, daisy→ant→snail. Arrows showing energy flow did not always lead from producer to primary consumer etc. or were shown leading in both directions. Finally, the food chain had to include a producer, a primary consumer and a secondary consumer.

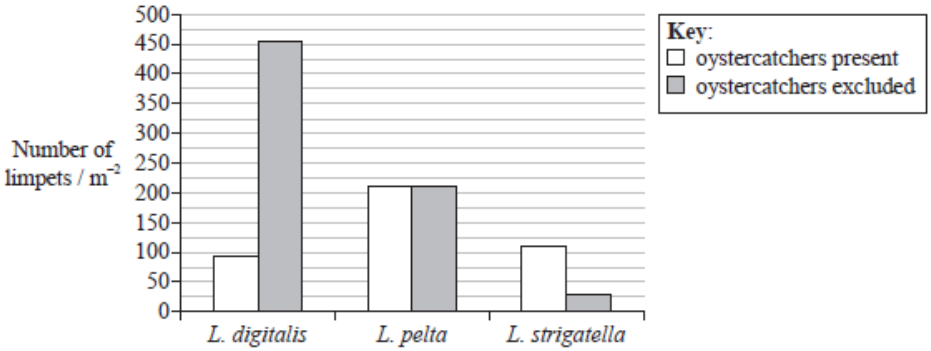
b (ii) Although the food chain in 3(b)(i) had to begin with either daisy or fern, the initial source of energy should have been (sun)light. Either plant was unacceptable for the mark.

Limpets are small animals that feed on the green algae which grow on rocks on seashores. Oystercatchers (*Haematopus bachmani*) are birds that feed on limpets.

Limpet

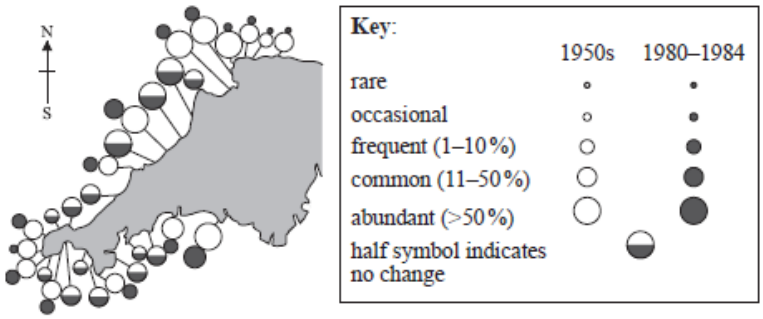
Oystercatcher

In a study on the north-west coast of the USA, where three limpet species are common (*Lottia digitalis*, *Lottia pelta* and *Lottia strigatella*), the limpets were protected from the oystercatchers by large wire cages. After two years the number of limpets in this area was compared with the number of limpets in an area without cages, where oystercatchers were present.



[Source: J T Wootton, (1992), *Ecology*, **73**, pages 981–991]

There is evidence to show that both air and water temperatures have increased over a period of time. An investigation was undertaken to determine the effect this change in climate had on the populations of another species of limpet, *Patella depressa*, around south-west England. The population of the limpet was recorded in many locations and around 30 years later, this study was repeated. The chart below compares the population in each of the locations.



[Source: M A Kendall, *et al.*, (2004), IBIS, **146**, pages 40–47]

a. State the effect that the exclusion of the oystercatchers had on the total number of limpets per m^2. [1]

c. Suggest reasons for the difference in numbers of *L. strigatella* between the areas where oystercatchers were present and where oystercatchers were excluded. [3]

d. On the map above label **one** location, [2]

(i) with the letter X, where the limpet population was abundant in the 1950s and occasional in the 1980s (1980–1984).

(ii) with the letter Y, where the limpet population was abundant in both the 1950s and in the 1980s (1980–1984).

e. Outline, using the data, the overall trend in the limpet population from the 1950s to the 1980s (1980–1984). [2]

f. Suggest **two** reasons for the change in limpet population between the 1950s and the 1980s (1980–1984). [2]

Markscheme

a. total number of limpets increased

c. *L. strigatella* decrease when oystercatchers excluded;

could be due to increase in number of *L. digitalis*;

increased competition/predation (for *L. strigatella*);

less food/green algae (for *L. strigatella*);

less habitat available (for *L. strigatella*);

d. (i) X at 4th location going anticlockwise from top right

(ii) Y at 8th, 9th or 11th location going anticlockwise from top right

e. (overall) decline in limpet population;

in no location has the population increased;

greatest decrease in numbers at most northern/western locations;

in many/some/quantitative value locations the population has not changed;

f. more predation of the limpets than before;

less food available;

less habitat available;

more competition from other species;

water/air too warm for their metabolic activities/other specific reason;

water pollution / toxins;

Examiners report

a. Weaker candidates often missed the reference to “total”. This oversight resulted in answers about changes in individual limpet species rather than a single answer describing the effect on all the species added together.

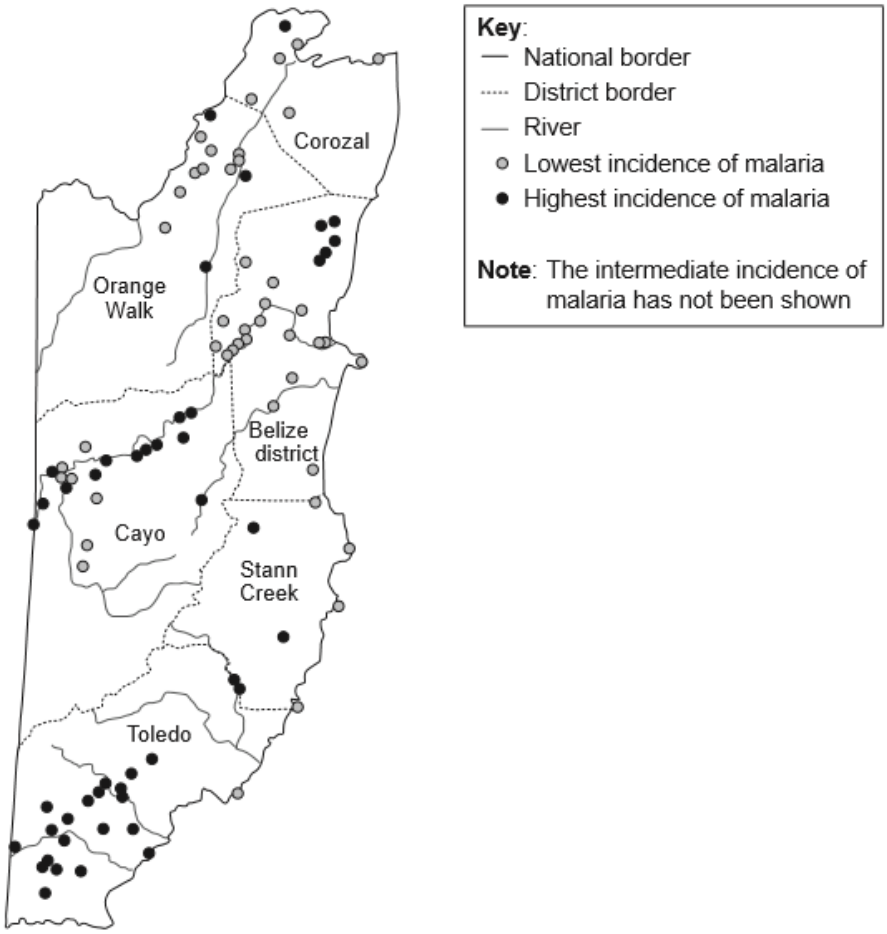
c. Very few candidates noted the decline in the population of *L. strigatella* when oystercatchers were excluded. Answers frequently mentioned the increase in the number of *L. digitalis* with reference to more predation and less food. Less habitat for *L. strigatella* was rarely, if ever, described.

d. Almost everybody correctly placed the X but much fewer the Y.

e. This question was answered well by most candidates. The popular answers were that the (overall) population declined and that in many locations the population had not changed. Only a few candidates mentioned that the population never increased or that the greatest decrease was in the most northern/western locations.

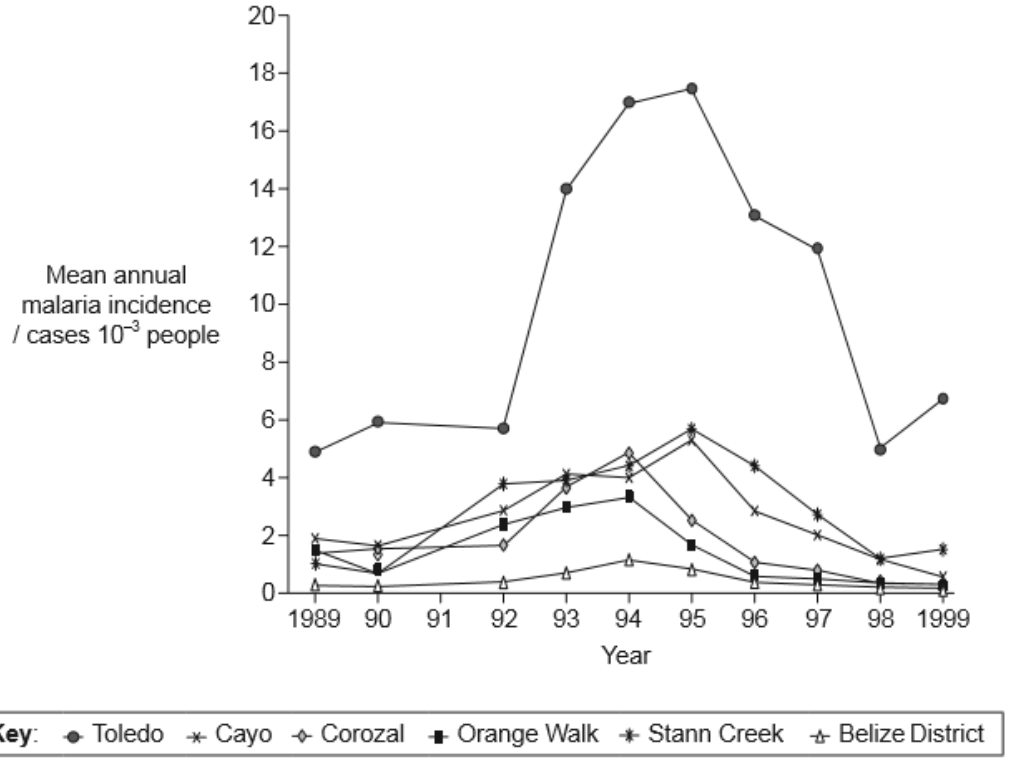
f. Again, this question was generally answered well. Most candidates mentioned greater predation of limpets, less availability of food or water pollution. Some talked about warmer air/water but then dropped the idea by not including any specific effect on limpets. In contrast, some candidates suggested that warmer water might inhibit reproductive behaviour, thus gaining a mark. A few other candidates gained a mark by suggesting loss of habitat.

Malaria is a mosquito-borne disease caused by a unicellular organism, *Plasmodium*. *Plasmodium* is a parasite that spends part of its life in a mosquito and part in a human. The mosquito transmits the *Plasmodium* to a human when it feeds on human blood. Mosquitoes hatch in water and are flying insects as adults. In the country of Belize, where malaria is a serious problem, studies have been made to determine what environmental factors affect the incidence of the disease. 156 villages were studied over a ten-year period.



[Source: adapted from S. Hakre *et al.* (2004) *International Journal of Health Geographics*, **3** (6). Spatial correlations of mapped malaria rates with environmental factors in Belize, Central America. Shilpa Hakre, Penny Masuoka, Errol Vanzie and Donald R. Roberts © 2004 Hakre *et al*; licensee BioMed Central Ltd]

Each of the six districts of Belize was studied from 1989 to 1999. The graph shows the mean number of people in each district to be affected by malaria per year per 1000 people.



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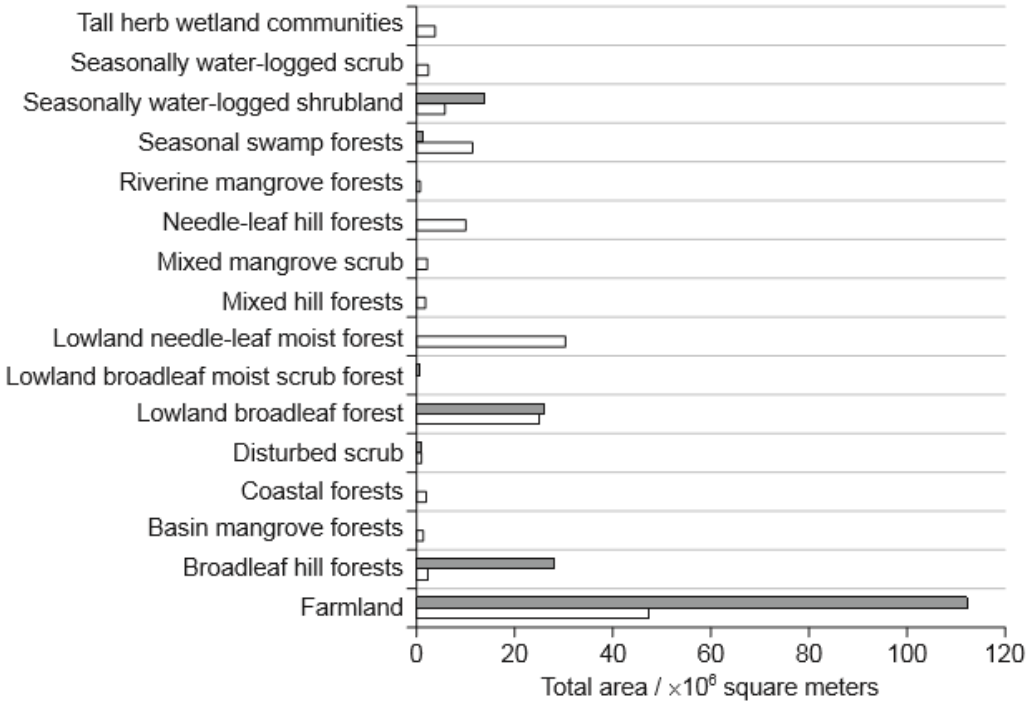
The country of Belize has many different ecosystems. These ecosystems are shown in the bar chart. The white bars indicate the total area within each ecosystem with the lowest incidence of malaria. The dark grey bars indicate the total area within each ecosystem with the highest incidence of malaria. The total area with an intermediate incidence of malaria is not shown.



[Source: adapted from S. Hakre *et al.* (2004) *International Journal of Health Geographics*, **3** (6). Spatial correlations of mapped malaria rates with environmental factors in Belize, Central America. Shilpa Hakre, Penny Masuoka, Errol Vanzie and Donald R. Roberts © 2004 Hakre *et al*; licensee BioMed Central Ltd]

a. State the district where there is the highest number of villages with the highest incidence of malaria. [1]

b. Analyse the data in the map to find whether there is an association between rivers and the incidence of malaria. [2]

c. Compare the trends in incidence of malaria for Toledo and Corozal. [3]

d (i) Suggest a reason for the decreases in the incidence of malaria from 1995 to 1999. [1]

d (ii) Suggest a reason why the incidence of malaria is so low in the Belize District. [1]

e. Besides farmland, identify which two ecosystems have the greatest total area with a high incidence of malaria. [1]

f. Predict with a reason, using the data, which district has most farmland. [1]

g. Discuss whether malaria could be reduced by replacing farmland with natural ecosystems and replacing broadleaf hill forest with mixed hill forest. [4]

Markscheme

a. Toledo

b. a. in Cayo and/or Toledo the high incidence seems to be associated with rivers;
b. however, along one river in Toledo there is no high incidence;
c. in Belize District there is low incidence along the river / high incidence away from the river;
d. Orange Walk/Stan Creek there is no clear association;
e. (consequently) association of rivers with high incidence of malaria is inconclusive OWTTE;

c. a. both are stable from 1989 to 1992;
b. both see upward spike in 1992;
c. Corozal reaches its peak (one year) earlier / vice versa;
d. Toledo rises after 1998 but Corozal continues to decline / Corozal at the end decreases almost to 0, while Toledo still have incidence at the end of the decade;
e. Toledo has a higher incidence (throughout the decade) / vice versa;
f. Toledo changes more rapidly than Corozal / vice versa;
Do not award numerical comparisons.

d (i) insecticides used to kill <u>mosquitoes</u> / more anti malarial drugs / drought/less water for mosquito breeding / increased drainage / improved education / more mosquito nets / other reasonable change in conditions
Do not accept vaccines as they do not exist.

d (ii) drier climate/less rainfall / more predators / vegetation/ecology not favourable to mosquitoes / higher rainfall so faster flowing rivers/more educated inhabitants so more aware of dangers.

e. lowland broadleaf forest and broadleaf hill forests *(both required)*

f. Toledo because it has the highest incidence of malaria in map/graph (and farmland has highest correlation to incidence of malaria in the table).

g. a. if farming provides habitat for mosquitoes, then reducing it could reduce malaria / *OWTTE*;

b. natural habitats provide predators, but farmland does not;

c. changing native vegetation is not practical since plants are adapted to their environment/organisms have specific adaptations to their environments;

d. might work to change broadleaf forest into mixed hill forest as much of broadleaf forest has high incidence of malaria and no part of mixed hill forest has high incidence of malaria / *OWTTE*;

e. loss of habitat/loss of biodiversity results in less stable environment;

f. the value of maintaining natural habitat must be balanced with the value of reduced malaria;

g. farmland feeds the population, so cannot be replaced / *OWTTE*

Examiners report

a. Some G2 comments seemed to think that Question 1 was too long, containing too many marks for one concept. Others felt that it was too biased towards geography due to the map analysis. Really the map reading required should have been within the capabilities of all students. Perhaps a geography student may have been at some advantage, but it could be argued that sometimes a chemistry student is advantaged in other years.

Nearly all students identified Toledo correctly.

b. Some G2 comments seemed to think that Question 1 was too long, containing too many marks for one concept. Others felt that it was too biased towards geography due to the map analysis. Really the map reading required should have been within the capabilities of all students. Perhaps a geography student may have been at some advantage, but it could be argued that sometimes a chemistry student is advantaged in other years.

Good candidates were able to analyse the data, quoting specific districts. Weaker ones did not mention any districts or tried to make the data fit the association.

c. Some G2 comments seemed to think that Question 1 was too long, containing too many marks for one concept.

Better students were able to compare the trends correctly and easily scored all three marks. Weaker students wrote about Toledo and then Corazol, hoping that the examiner would make the comparison for them. Very weak students just quoted numbers without considering trends. There were some G2 comments that it was difficult to make out the lines. However the students seemed to have no trouble, and some well organized students drew over it to highlight the correct line.

d (i) Some G2 comments seemed to think that Question 1 was too long, containing too many marks for one concept.

In part (i) an answer in terms of reducing the number of mosquitos or an increase in education about mosquitos was looked for. Simply "the mosquito population went down" was not deemed good enough; it needed a because… or due to…. Similarly in part (ii) "fewer mosquitoes" was too weak. Vaccines are nowadays near to becoming a reality, but certainly did not exist between 1995-1999. Similarly cures for malaria, and an increase in the number with sickle cell forest were discounted.

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e. Some G2 comments seemed to think that Question 1 was too long, containing too many marks for one concept.

Nearly everyone gave broadleaf forest and broadleaf hill forest.

f. Some G2 comments seemed to think that Question 1 was too long, containing too many marks for one concept.

Most correctly stated Toledo with the correct reason.

g. Some G2 comments seemed to think that Question 1 was too long, containing too many marks for one concept.

This proved to be a testing question, and as several pointed out, would have benefitted from a larger answer box as it was worth 4 marks. Many gained the mark for pointing out that if farming does provide the habitat for mosquitoes, then replacing would be beneficial, and that no part of mixed hill forest has high incidence, so that could work. Few got beyond these and discussed biodiversity and adaptation.

The diagram shows a leaf from Dryopteris arguta.

[https://commons.wikimedia.org/wiki/File:E20161208-0001%E2%80%94Dryopteris_arguta_(Reverse)%E2%80%94RPBG_(30698925004).jpg, E20161208-0001—Dryopteris arguta (Reverse)—RPBG Source: https://www.flickr.com/photos/john_d_rusk/30698925004/ (https://www.flickr.com/photos/john_d_rusk/30698925004/) Author: John Rusk from Berkeley, CA, United States of America, licensed under Creative Commons licence: https://creativecommons.org/licenses/by/4.0/legalcode]

a.i. State the phylum of this plant. [1]

a.ii. State **two** characteristics of plants from the phylum you stated in (a)(i). [2]

b. Outline why the number of trophic levels is limited in a food chain. [1]

Markscheme

a.i. Filicinophyta/Filicinophytes/Pteridophytes

Reject "ferns"

a.ii a. have roots, stem and leaves

All three, roots, stem and leaves required

b. pinnate leaves/leaves divided «repeatedly» into leaflets

c. have vascular tissue/xylem and phloem

d. produce spores/sporangia

OR

no flowers/fruits/seeds

[Max 2 Marks]

b. energy losses between trophic levels

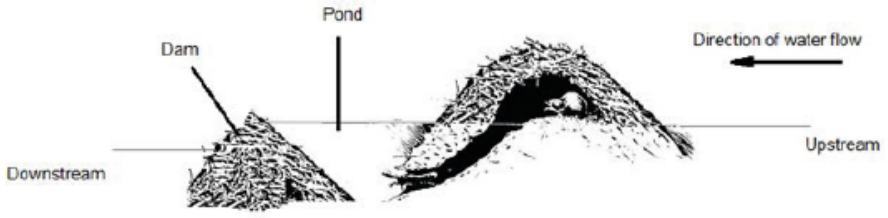
OR

only part of the energy in one trophic level will become part of the next trophic level

Examiners report

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

Beavers are large rodents that live in waterways throughout the northern hemisphere. Dams made by beavers change the temperature of the streams and affect the mayfly, *Baetis bicaudatus*. In the summer of 2008, beaver ponds in West Brush Creek and Cement Creek, Colorado, were studied to evaluate their impacts on mayflies. The study sites included streams flowing into (upstream) and out of (downstream) each beaver pond.



[Source: adapted from https://upload.wikimedia.org/wikipedia/commons/thumb/d/d4/Beaver_lodge.jpg/330px-Beaver_lodge.jpg]

Mayflies, including the species *B. bicaudatus*, are aquatic insects that hatch and spend their larval stages in water emerging from the water as adults. Larger females produce an increased number of better quality eggs.

The table shows the mean temperature differences (downstream – upstream) and mean dry mass for female and male mayflies.

	Beaver pond	Relative height of dam	Mean temperature differences / °C	Mean dry mass / mg					
				Female			Male		
				Up-stream	Down-stream	Difference	Up-stream	Down-stream	Difference
West Brush Creek	1	low	+0.1	1.97	1.83	−0.14	1.39	1.37	−0.02
	2	high	−0.3	1.43	1.51	+0.08	1.15	1.18	+0.03
	3	high	−0.2	1.55	1.67	+0.12	1.19	1.23	+0.04
	4	low	+0.4	2.27	2.15	−0.12	1.53	1.51	−0.02
Cement Creek	5	low	0.0	2.12	2.07	−0.05	1.39	1.33	−0.06
	6	high	−0.1	1.79	1.76	− 0.03	1.34	1.31	−0.03
	7	high	−0.2	2.10	2.14	+0.04	1.53	1.49	−0.04
	8	low	+0.2	2.14	2.10	−0.04	1.49	1.53	+0.04
	9	high	−0.3	2.05	2.09	… I …	1.57	1.45	… II …

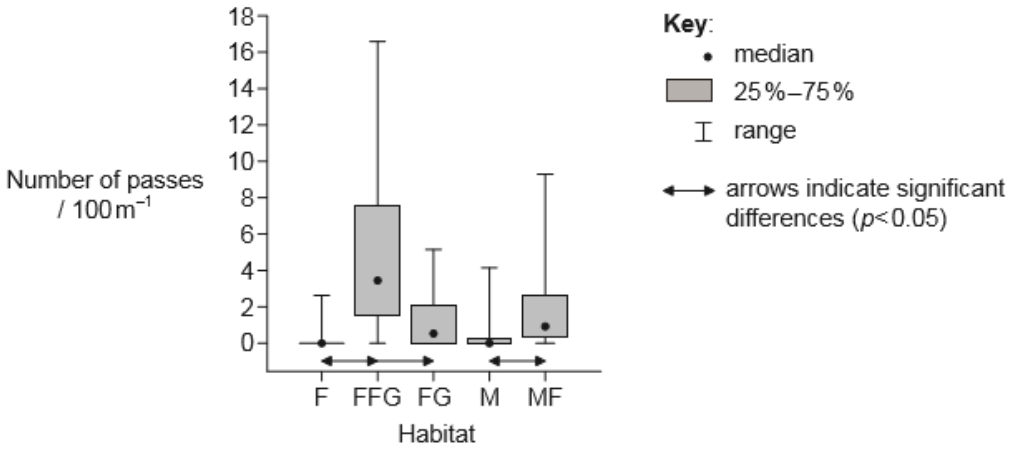
[Source: Fuller, M. R. and Peckarsky, B. L. (2011), Ecosystem engineering by beavers affects mayfly life histories. *Freshwater Biology*, 56: 969–979. doi:10.1111/j.1365-2427.2010.02548.x

The bat, *Pipistrellus nathusii*, feeds on insects including mayflies. A study was undertaken in Poland to see the effect of European beavers (*Castor fiber*) on the activity of bats. Beaver activity can affect forests that are covered by trees and meadows that are covered by grasses and have no trees.

The following habitats were studied:

- forest (F)
- flooded forest with canopy gaps created by beavers and flooding due to the presence of beaver dams (FFG)
- forest with canopy gaps created by beavers but no flooding (FG)
- meadow (M)
- meadow with flooding due to the presence of beaver dams (MF).

As bats feed they fly through the air catching insects. The number of feeding passes made by bats was counted. The graph shows differences in the bat activity between particular habitats.



[Source: adapted from Ciechanowski, M., Kubic, W., Rynkiewicz, A. et al. (2011), "Reintroduction of beavers *Castor fiber* may improve habitat quality for vespertilionid bats foraging in small river valleys". *European Journal of Wildlife Research*, Volume 57, Number 4, Page 737.]

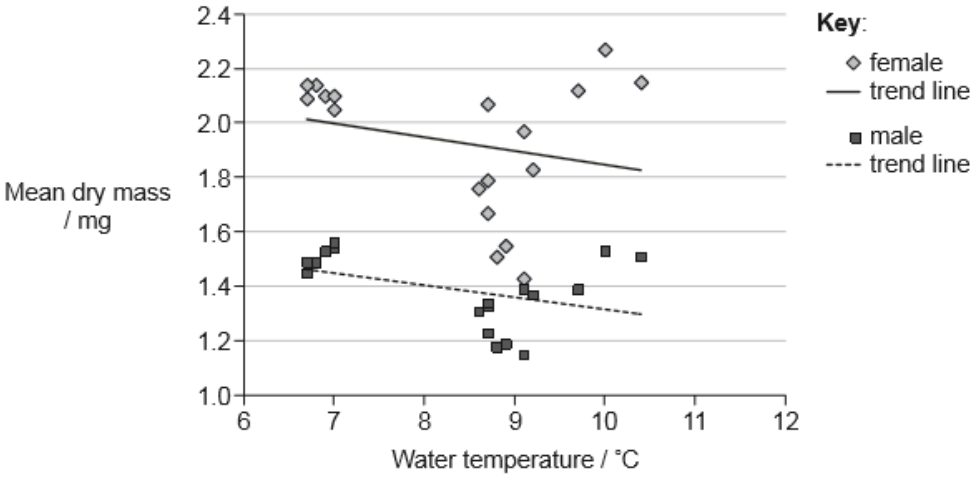
a. Calculate the difference in the mean dry mass of mayflies upstream and downstream of Cement Creek pond 9 for female and male mayflies. [1]

I. Female: ..... mg

II. Male: ..... mg

b. Describe the effect dams have on water temperature. [2]

c. The graph shows the mean dry mass of mayflies relative to the water temperature in their habitats. [2]



[Source: Fuller, M. R. and Peckarsky, B. L. (2011), Ecosystem engineering by beavers affects mayfly life histories. *Freshwater Biology*, 56: 969–979. doi:10.1111/j.1365-2427.2010.02548.x

Using the graph, discuss evidence for the hypothesis that mayflies grow to greater dry mass in cooler water.

d. Analyse the data to find the effect of flooding and tree felling by beavers on the activity of bats. [2]

e. The trout, *Oncorhynchus mykiss*, that live in West Brush Creek and Cement Creek also feed on the mayflies. Fishermen come to Colorado to catch and eat trout. Draw a diagram of part of a food web for the creeks in Colorado, including mayflies, humans, trout and bats. [2]

f. Identify an example of competition between organisms in this food web. [1]

g. The North American beaver (*Castor canadensis*) was introduced to islands adjacent to Argentina and Chile where they have become an invasive species. Discuss **one** ecological criterion (a basis for deciding) whether beavers are harmful **or** helpful to the ecosystems there. [2]

Markscheme

a. *I*. *female*: «+» 0.04 «mg»

AND

II. *male*: «–» 0.12 «mg»

Both needed.

b. a. height of dam affects the temperature

b. high dams tend to cool the water

c. low dams tend to warm the water

d. pond 5/one pond shows no change/stays the same

c. a. trend lines support «the hypothesis»

OR

trend shows a negative correlation shown «between increased temperature and size»

Do not credit answers with just numbers.
Accept "line of best fit" wtte.

b. the trend line is shallow / small slope
OR
there is a large amount of scatter at higher temperatures (reducing the certainty)
OR
wide/overlapping ranges so no significant difference «(at» 9°C)

Note that it is only the trend line that indicates support.

c. (hypothesis not supported because) females in water over 10°C have the highest «mean dry» mass

Words other than "hypothesis not supported" may be used: "as opposed to", "whereas", to express deviation from support.

d. a. both flooding and tree felling increases bat passes/activity / WTTE

b. flooding has greater/increase on bat passes/activity / WTTE
OR
flooding has the greater impact than tree felling on bat passes

c. supporting argument from the data

e. a. <u>arrow</u> pointing from trout to human

b. <u>arrows</u> pointing from mayflies to trout <u>and</u> bats

*Award **[1 max]** if answer does NOT show all 4 organisms*.

f. bats and trout compete for mayflies

g. a. criterion

b. reason that beavers damage

c. reason that beavers help

eg,

a. biodiversity

b. if indigenous species are eliminated biodiversity is reduced, then the beavers would be seen as damaging

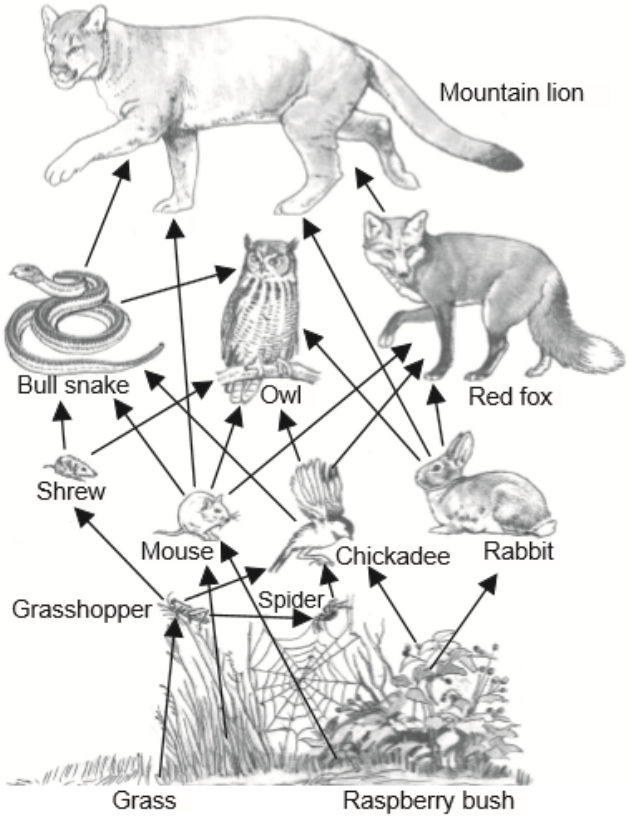
c. if biodiversity increases (due to the engineering of waterways), then beavers could be a benefit

Consider criteria something that may be dealt with from a range of perspectives.

Other possible criteria: abiotic disturbance changes to food webs diversity

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]
d. [N/A]
e. [N/A]
f. [N/A]
g. [N/A]



[Source: adapted from *BSCS Biology: An Ecological Approach*, Figure 1.10, page 12]

The image shows a forest food web from North America.

a. Describe what is meant by a food chain. [2]

b (i). Identify a food chain with four or more organisms from the forest food web. [1]

b (ii). Deduce the trophic level of each organism identified in your food chain from (b)(i). [1]

c. State one reason that the population of mountain lions is smaller than the populations of other animals in the food web. [1]

Markscheme

a. a. food chain shows feeding/trophic relationships;

b. showing which organism/animal eats which organism;

c. showing the flow of energy from producer/autotroph to top consumer/top carnivore / through trophic levels;

b (i). example from the food web with four or more organisms, given in proper sequence with arrows showing flow of energy in the correct direction and starting with a producer.

Award [0] if any organism in the food chain is not in the web diagram.

b (ii). correct trophic levels

eg: raspberry bush⟶chickadee ⟶bull snake⟶mountain lion
producer primary consumer secondary consumer tertiary consumer

Accept ECF for mistakes in previous part. Do not accept "trophic level 1" etc.

c. mountain lions/highest trophic level receives less energy as energy is lost at each level / mountain lions are larger than other animals and require more (smaller) individuals for food.

Examiners report

a. Most gained at least 1 mark for their description of a food chain.

b (i) Most students were able to pick a suitable food chain from the web given. However a significant number seemed to ignore the web given and draw one from memory. There were a few with the arrows reversed and not starting with a producer.

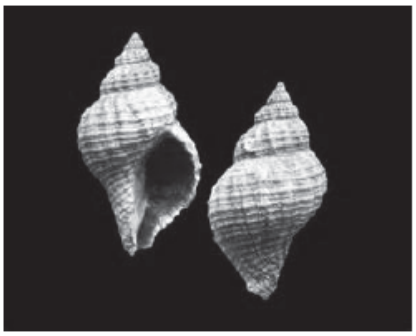
b (ii) The naming of the trophic levels is given in 5.1.7, and these are expected.

c. In c most were able to give a valid reason.

Native oyster populations are decreasing where rivers meet the ocean along the northwest coast of North America. These oyster populations are being attacked by a gastropod.

Adult oyster, *Ostrea lurida*

[Source: © International Baccalaureate Organization 2017]



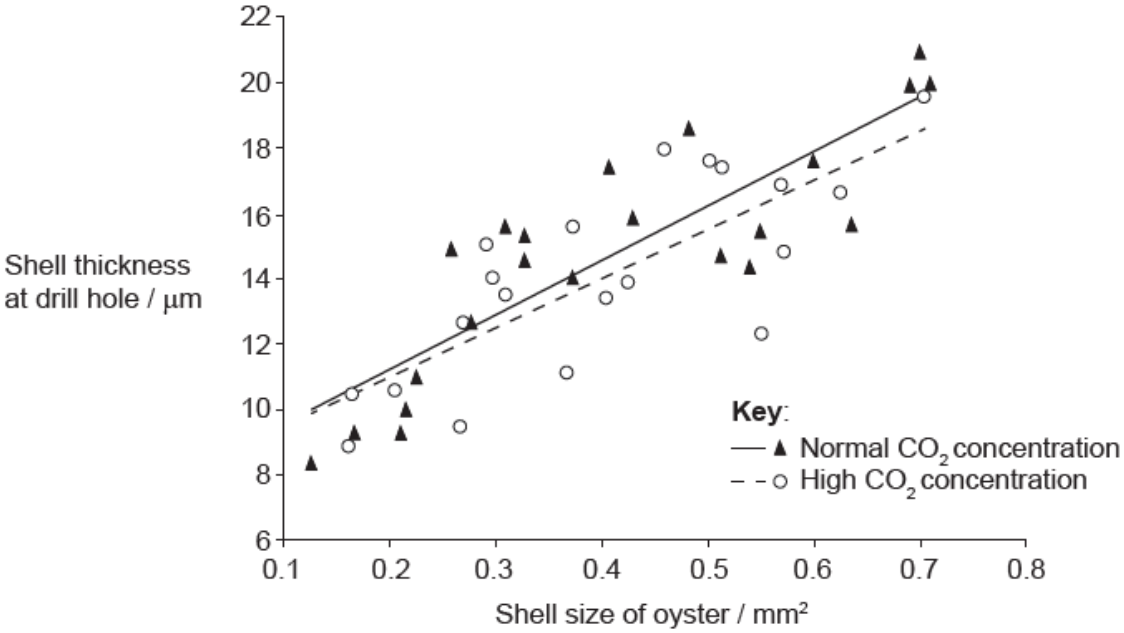
Adult gastropod shell, *Urosalpinx cinerea*

[Source: © International Baccalaureate Organization 2017]

It is known that oysters and gastropods have hard parts composed of calcium carbonate and that ocean acidification is increasing. Studies were carried out using juvenile oysters and gastropods to investigate the effects of acidification on the decrease in the population of oysters.

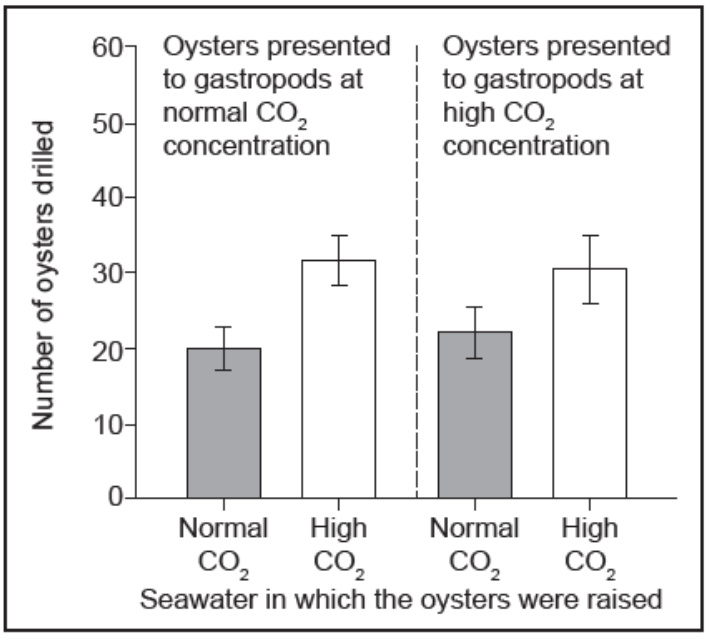
The first step was to raise oysters in two different mesocosms. One had seawater at a normal concentration of CO_2 and the other had sea water with a high concentration of CO_2. Gastropods were raised in two further mesocosms with normal and high CO_2 concentrations respectively.

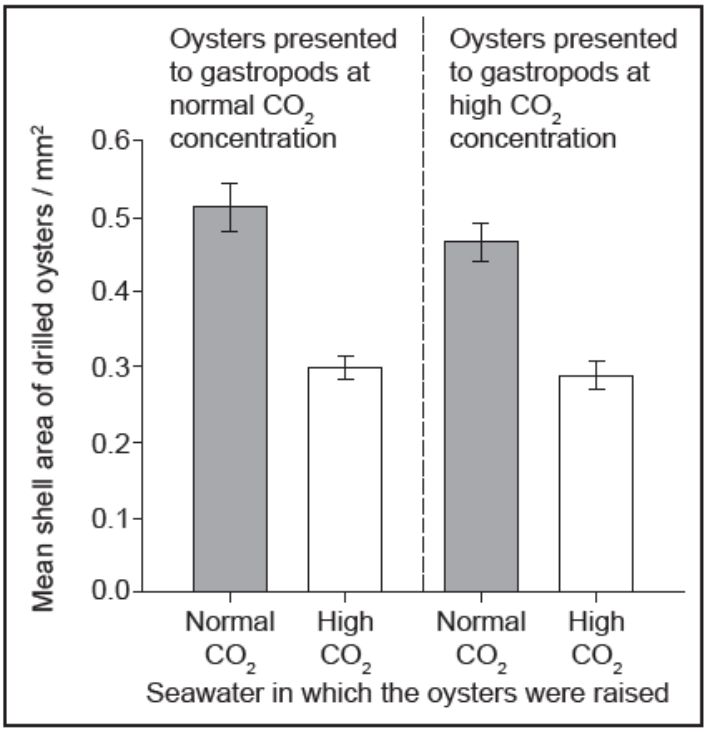
A juvenile gastropod will attack a juvenile oyster by using its tongue-like structure (radula) to drill a hole through the oyster shell. Once the hole has been drilled, the gastropod sucks out the soft flesh. Researchers investigated the shell thickness at the site of the drill hole in relation to the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



[Source: E Sanford *et al*. (2014) *Proceedings of the Royal Society B*, 281, by permission of the Royal Society.]

Equal numbers of oysters raised in seawater with a normal CO_2 concentration and in seawater with a high CO_2 concentration were then presented together to the gastropod predators in seawater with a normal CO_2 concentration. The same numbers of oysters from the two groups were also presented together to the gastropods in seawater with a high CO_2 concentration. The bar charts show how many of the oysters were drilled by the gastropods and the mean size of drilled oysters.





[Source: © International Baccalaureate Organization 2017]

a. Outline how acidified sea water could affect the shells of the oyster. [1]

b. Outline the trends shown in the data in the graph. [2]

c. Estimate how much smaller drilled oysters raised in seawater at a high CO_2 concentration were than drilled oysters raised in seawater at a normal CO_2 concentration. [1]

d.i. Deduce from the data in the bar charts which factors were and were not correlated significantly with the number of oysters drilled by the gastropods. [2]

d.ii. Suggest reasons for the differences in the numbers of oysters drilled, as shown in the bar charts. [2]

d.iii. The radula in a gastropod is hard but not made of calcium carbonate. Outline how this statement is supported by the drilling success of the gastropods in seawater with normal or high CO_2 concentrations. [2]

e. Using all the data, evaluate how CO_2 concentrations affect the development of oysters and their predation by gastropods. [2]

Markscheme

a. Shells might dissolve/deteriorate / become smaller/thinner/weaker / OWTTE

OR

shell formation reduced / more difficult

b. a. positive correlation between shell thickness and shell size

OR

as shell thickness increases, shell size «also» increases

b. (positive correlation) occurs at two different CO_2 concentrations / both high and normal concentrations

c. trend for thickness is «slightly» lower with high CO_2

c. «approximately» 0.2 mm^2

OR

«approximately» 40 % «smaller»

unit required

d.i. a. significant factor: concentration of CO_2 in which oysters were raised

b. insignificant factor: concentration of CO_2 at which oysters were presented to gastropods

d.ii. a. (because) shells are thinner/smaller when the oyster is raised in high CO_2/lower pH

OR

«because» lower pH/higher acidity prevents/reduces deposition of calcium carbonate

b. gastropods target smaller/thinner-shelled oysters more

c. gastropods can eat/drill thin-shelled/smaller oysters at a faster rate (and move onto another)

d. eating smaller oysters «from high CO_2 environments» means given population of gastropods require more oysters for same food intake

d.iii. a. data shows that similar numbers are drilled regardless of conditions

b. since radulas are not affected by acidification

OR

radulas not made of calcium carbonate so (remain) strong/successful at drilling

e. a. the data/trend lines indicate that a higher CO_2 concentration diminishes the shell thickness, making gastropod predation more successful

OR

the bar graphs suggest that oysters raised in a higher CO_2 concentration are smaller, making gastropod predation more successful

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

c. «limitation» no information about how exaggerated the CO_2 concentrations were
OR
«limitation» no information about numbers of gastropods used «in each setting»

Examiners report

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