HL Paper 2

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 from one trophic level to the next in examples;

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

c. starting with a producer;

d. followed by at least two levels of consumers / 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) producers 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 from the Sun;

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. Food chains and webs seem to be concepts that candidates had come across, but had great difficulties explaining them. Examples given should be realistic and contain specific animals and plants (5.1.4 to 5.1.8), not just “insect” and “bird”.

c. An alarming number of candidates still think that the greenhouse gases are kept in by the ozone layer or are part of the ozone layer. Most could identify some greenhouse gases, but few were able to explain the difference between the short wave solar radiation and the much longer re-radiated waves from Earth which are trapped by the gases.

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a (i) The greenhouse effect is a naturally occurring process. [1]

State **one** greenhouse gas.

a (ii) The greenhouse effect is a naturally occurring process. [2]

Explain how radiation of different wavelengths is involved in the greenhouse effect

b (i) The enhanced greenhouse effect can cause a rise in atmospheric temperature. [2]

Outline **two** consequences of a global temperature rise on arctic ecosystems.

1.

2.

b (ii) The enhanced greenhouse effect can cause a rise in atmospheric temperature. [1]

Outline **one** effect of a temperature rise on plants.

Markscheme

a (i) carbon dioxide / methane / oxides of nitrogen / water vapour / ozone / CFCs

a (ii) incoming shorter-wave radiation/UV/visible passes through Earth’s atmosphere;

converted to longer-wave radiation/heat/infrared;

atmosphere absorbs/traps longer-wave radiation/infrared/heat;

Answers can be given in the form of an annotated diagram.

Answers must specify long wave/infrared/heat and short wave radiation.

b (i) increased rates of decomposition (of detritus in permafrost);

expansion of the range of habitats available to temperate species;

loss of ice habitat;

changes in distribution of prey species affecting higher trophic levels;

increased success of pest species/pathogens;

rise in sea levels;

Mark only the first two answers given.

b (ii) rate of photosynthesis increases as temperature increases;

rate of transpiration increases as temperature increases;

shift in plant distribution / *OWTTE*;

Examiners report

a (i) Nearly all candidates could name a greenhouse gas.

a (ii) The explanations of the greenhouse effect in (a) (ii) were on average better than when this question had been asked before. Some candidates were still confused between the greenhouse effect and the effects of the ozone layer but many successfully described the difference between short and long wave radiation in penetration of the atmosphere. The absorption of short wave radiation by the Earth's surface and emission of longer wavelengths by the heated surface were less well described

b (i) Part (b) (i) was an easy question and many candidates scored both marks. Candidates should be encouraged to write more than a short phrase as an answer to an "outline" question as in some cases too little had been stated for one of the points on the mark scheme to have been earned.

b (ii) Part (b) (ii) is another question where it was safer to write one or two sentences than just a word or short phrase. Many candidates outlined the effect of global temperature rises on photosynthesis. Only those who stated that photosynthesis rates would rise were given a mark. Those that predicted a fall, based this on a prediction that enzymes used in photosynthesis would be denatured. The temperature rise due to the enhanced greenhouse effect is unlikely to be large enough to cause this. Smaller temperature rises might cause an increase in photorespiration but this was not the reason for a fall that candidates were giving.

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a. Distinguish between autotrophs and heterotrophs. [2]

b. Define *saprotroph*. [1]

c (i) State an external feature that is different in: [1]

Cnidaria and Mollusca.

c (ii) State an external feature that is different in: [1]

Mollusca and Annelida.

Markscheme

a. autotrophs make their own food/organic molecules/organic matter and heterotrophs feed on/obtain their food/organic molecules from other organisms;

autotrophs use/require inorganic molecules/CO_2 and heterotrophs require (complex) organic molecules;

b. an organism that lives on/in non-living/dead (organic) matter and secretes digestive enzymes/digestive juices into it / *OWTTE*

c (i) Cnidaria have radial symmetry while Mollusca have bilateral symmetry;

Cnidaria have tentacles/nematocysts/stinging cells while Mollusca do not;

Mollusca (may) have a (hard) shell while Cnidaria do not;

Mollusca have a mouth and anus while Cnidaria have only one opening;

Mollusca have a muscular/large foot while Cnidaria do not;

other valid external difference;

c (ii) Annelida are segmented while Mollusca are not (visibly segmented);

Annelida may have bristles/chetae/chaetae while Mollusca do not;

Mollusca (may) have a (hard) shell while Annelida do not;

Mollusca have a muscular/large foot while Annelida do not;

other valid external difference;

Examiners report

a. Nearly all candidates knew something about autotrophs and heterotrophs but answers tended to be too loose to score many marks. A common error was to suggest that plants make energy.

b. Fewer than half of candidates were able to state what a saprotroph is. Answers had to make it clear that saprotrophs feed on dead organic matter by external digestion, to exclude detritivores that ingest dead matter.

c (i) Candidates were evenly divided between those who had no idea of the external features of Cnidaria, Annelida and Mollusca, those who knew some of their features but failed to score marks because they did not give both sides of the comparison and those who gave correct and full comparisons.

c (ii) Candidates were evenly divided between those who had no idea of the external features of Cnidaria, Annelida and Mollusca, those who knew some of their features but failed to score marks because they did not give both sides of the comparison and those who gave correct and full comparisons.

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a. Describe the relationship between the rise in the concentration of atmospheric carbon dioxide and the enhanced greenhouse effect. [5]

b. Outline the precautionary principle. [5]

c. Antibiotic resistance in bacteria is an example of evolution in response to environmental change. Using another example, explain how an environmental change can lead to evolution. [8]

Markscheme

a. CO_2 is a greenhouse gas;

increases in CO_2 increase/enhance the greenhouse effect;

greenhouse effect is a natural phenomenon but not its increase;

Earth receives short wave radiation from the sun;

reradiated from Earth as longer wave radiation/infra red/heat;

CO_2 /greenhouse gases trap/absorb longer wave radiation/infra red/heat;

global warming happened during same time/period as CO_2 rise;

CO_2 concentration correlated (positively) with global temperature / global temperature increases as CO_2 concentration increases;

(causal) link accepted by most scientists;

no proof that man-made increases in CO_2 have caused global warming;

b. those proposing something must prove that it causes no harm;

before they start to do it;

objectors do not have to prove that there will be harm;

activities that risk/threaten/may cause harm are banned;

trials/tests must be done first;

precautionary principle is applied when possible consequences are severe;

precautionary principle should be used in the case of global warming;

action should be taken to reduce CO_2 emissions before proved it is the cause;

another example of implementation of the precautionary principle;

c. natural selection (in correct context);

better-adapted individuals survive/more likely to survive;

more reproduction/genes passed on by better adapted individuals;

name of species; (*accept even if remainder of answer is invalid*)

description of original/decreasing phenotype;

type of environmental change that led to evolution;

consequence of environmental change

description of new/increasing phenotype;

genetic basis of phenotypes;

reason for new phenotype being better adapted;

detail of reason for adaptedness of new phenotype;

The following has been provided as an example answer.
great tit;
bird that lays its eggs in spring;
global warming/climate change;
more caterpillars (on trees) in early spring;
laying eggs earlier in spring;
time of egg laying is (partly) genetically controlled;
eggs laid early hatch at start of period of greatest food abundance;
more young can be fed/young grow faster/fewer deaths;

Examiners report

a. Answers to part (a) were varied but mostly were rather weak, with confusion about long wave and short wave radiation and between the greenhouse effect and ozone depletion. Most answers explained the greenhouse effect in general terms and only a few really described the relationship between the rise in atmospheric carbon dioxide and the enhanced greenhouse effect. The best answers explained that the greenhouse effect is a natural phenomenon but that there was been an anthropogenic increase in carbon dioxide concentrations that is positively correlated with global warming. Although not proven, almost all climate scientists accept that there is a causal link.

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b. Part (b) was also poorly answered on the whole, with much evidence of guesswork rather than secure understanding. The term precautionary principle has been used in different ways and a teacher‟s note was therefore inserted in the current IB Biology programme, to make clear what is expected in answers to IB Biology questions. Teachers are encouraged to follow the guidance in that note.

c. Part (c) of this question was also poorly answered. Fewer than half of candidates gave an acceptable example of evolution in response to environmental change. Candidates were expected to give a real and well documented example, with the species named and the precise environmental change explained. Resistance to a named pesticide in a named pest species was acceptable for example, but not accounts of how resistance might develop in general. Giraffes were not accepted as an example, as their evolution cannot be tied in to any proven and specific environmental change. The human examples that were seen in candidates' answers were also not accepted.

Many candidates' answers were vague and confused and in some cases were based on guesswork, in the hope that examiners might not realise. It is of course unacceptable to fabricate examples and evidence in science, whether in an exam or any other situation. Particularly with evolution, any assertion that we make should be based on reliable evidence. Despite these negative comments about the quality of answers, some were excellent with a clear explanation of how the characteristics of a species can change by natural selection when the environment of a species has changed.

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b. Most of the surface of the Earth is covered with a wide diversity of ecosystems. Outline **two** general characteristics of all ecosystems. [2]

c.i. Vascular plants can be found in a wide variety of ecosystems. [2]

Outline active transport in phloem tissue.

c.ii. Vascular plants can be found in a wide variety of ecosystems. [3]

Explain how a plant replaces the water it loses in transpiration.

Markscheme

b. a. organisms/community plus the environment / biotic and abiotic «components»

b. interactions

c. ecosystems show sustainability

d. nutrients are recycled in ecosystems

e. energy flows through ecosystems

f. producers «are part of all ecosystems»

g. decomposers/saprotrophs «are part of all ecosystems»

c.i. a. active transport/pumps used to load sugars/sucrose into phloem/companion cells/sieve tubes

b. loading in sources/unloading in sinks
OR
sucrose/sugars moved from source to sink

c. active transport moves H^+ out of phloem/sieve tubes «to make H^+ gradient in the leaf/source»

d. H^+ gradient used for co-transport of sucrose into phloem/sieve tubes/companion cells

Accept protons or hydrogen ions instead of H+ ions.

Accept the equivalent of mpc and mpd for unloading in the sink.

c.ii. a. transpiration/evaporation of water causes suction/tension

b. water sucked/drawn out of xylem «in leaf»

c. water moves up in xylem

d. due to suction/tension/pulling forces

e. cohesion of water/hydrogen bonds between water molecules

f. movement from roots to leaves

g. water enters root by osmosis/due to higher solute concentration inside root

Examiners report

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

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a. Describe how plants carry out gas exchange in the leaves. [5]

b. Outline the causes and consequences of the enhanced greenhouse effect. [5]

c. Explain the role of limiting factors in photosynthesis. [8]

Markscheme

a. gases/O_2 and CO_2 enter/exit the leaf through the stomata;

by diffusion / down the concentration gradient;

photosynthesis maintains concentration gradients/high O_2 and low CO_2 in the leaf;

guard cells open the stomata during the day / close the stomata at night;

gases/O_2/CO_2 move through air spaces in the spongy (mesophyll);

CO_2 dissolves in moisture in (mesophyll) cell walls;

b. burning of (fossil) fuels/coal/oil/gas releases carbon dioxide;

deforestation/loss of ecosystems reduces carbon dioxide uptake;

methane emitted from cattle/livestock/melting permafrost/waste dumps;

heating of the atmosphere/global warming/climate change;

melting of ice caps/glaciers/permafrost / sea level rise / floods / droughts / changes in ocean currents / more powerful hurricanes / extreme weather events / other abiotic consequence;

changes in species distributions/migration patterns / increased decomposition rates / increases in pest/pathogen species / loss of ice habitats / other biotic consequence;

c. factor nearest its minimum/furthest from its optimum is limiting;

increasing a limiting factor with other factors constant increases the rate;

increasing a non-limiting factor with other factors constant has no effect on rate;

light intensity is limiting in dim/low intensity light / at night;

photosynthesis (directly) proportional to intensity up to plateau / graph to show this;

light intensity affects the light-dependent reactions/production of ATP/NADPH;

temperature limiting at low and high temperatures;

optimum temperature with lower rates above and below plateau / graph to show this;

low temperatures limit the rate of light-independent reactions/Calvin cycle;

RuBP carboxylase/rubisco does not fix carbon dioxide at high temperatures;

carbon dioxide concentration is limiting in bright light and warm temperatures;

photosynthesis is (directly) proportional to CO_2 concentration up to plateau / graph to show this;

low CO_2 concentration limits carbon fixation/reaction between CO_2 and RuBP;

Examiners report

a. This question was based on assessment statement 9.1.3, which includes the relationship between the structure of the leaf and its role in gas exchange. All that was needed was an outline of the structure of the spongy mesophyll, guard cells and stomata, in relation to the diffusion of carbon dioxide into the leaf and oxygen out. Scores were typically poor, with many candidates missing the basic points. More candidates for example for example seemed to state that CAM plants open their stomata for gas exchange at night than that most plants open their stomata in the day.

b. Scores were mostly much better in this part of the question, with nearly all candidates at least mentioning warming due the enhanced greenhouse effect and an example of the abiotic and biotic consequences. The cause of the enhanced greenhouse effect was less well understood, with vagueness about what is causing carbon dioxide levels to increase and other greenhouse gases often not mentioned. There was considerable confusion, as so often, between ozone depletion and the greenhouse effect. It is easy to assume that candidates will be able to distinguish between these two phenomena easily and that little teaching is required, but all those who marked this exam will know that careful teaching is very much required.

c. This was another area of relatively poor understanding, perhaps because weaker candidates tended to choose question 7. A basic minimum was to know that light intensity, temperature and carbon dioxide concentration are the three main limiting factors of photosynthesis. Many failed at this first hurdle, omitting one or more of the main three and including instead pH, water availability or various other biotic and abiotic factors. Perhaps some candidates were confusing enzyme activity with photosynthesis. What was required for each of the three factors was a clear statement of the relationship between the level of the variable and the rate of photosynthesis, ideally by means of an annotated sketch graph, and then some details of the reasons for the rate of photosynthesis changing as the level of the variable changed. A common misconception was to say that the rate reduces at higher temperatures because of enzyme denaturation when in fact the rate reduction occurs at much lower temperatures than those at which this would happen. The problem at higher temperatures is due to RuBP carboxylase failing to fix carbon dioxide effectively.

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a. Outline how and where energy is stored in plants. [4]

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

a. a. glucose (from photosynthesis) stored as starch;
b. starch stored (as granules) in chloroplast/in plastids;
c. (starch stored) in seeds/storage roots/stem tubers;
d. stored as lipids/oils;
e. (lipid/oils storage) in seeds;
f. lipids store twice as much energy per gram as starch;

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

a. This was a popular question among candidates.

For part a, many did not earn full marks and this appeared to be due to a lack of knowledge of this part of the syllabus.

b. This was a popular question among candidates.

For b, many candidates easily earned the marks for parts d, e and f requiring them to identify examples of organisms that occupy the various trophic levels of organisms. A number lost marks due to poorly constructed diagrams especially in relation to the bars not being drawn proportionately. Few correctly indicated the correct units for productivity of the various trophic levels.

c. This was a popular question among candidates.

Part c was generally well done. Most used the term homeostasis and negative feedback in their answers. A number have a misconception regarding vasodilation and vasoconstriction as they are writing that arterioles move toward and away from the skin surface. Few discussed the role of the hypothalamus in regulated body temperature.

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a. Draw a labelled diagram of a eukaryotic plant cell as seen in an electron micrograph. [4]

b. Outline how the energy flow through food chains limits their length. [3]

c. In hot, dry conditions plants lose water rapidly due to transpiration. Explain how the structures and processes of the plant allow this water to be replaced. [8]

Markscheme

a. Cell wall shown with two continuous lines to indicate the thickness

Plasma membrane/cell membrane shown as a single continuous line

Accept inner line of wall as membrane if clearly labelled.

Nuclear membrane/nucleus shown with double membrane and nuclear pores

Vacuole «membrane»/tonoplast shown as a single continuous line

Chloroplast/plastid shown with a double line to indicate the envelope and thylakoids/grana

Mitochondrion shown with double membrane/cristae

b. Only a small proportion/20 %/10 % «of energy» can pass from one trophic level to the next *Accept named trophic levels or named stages in a food chain in place of "trophic levels"*.

OR

large proportion/80 %/90 % lost between one trophic level and the next *Accept if clearly shown in a diagram such as a pyramid of energy*.

Energy released by respiration ***AND*** lost as heat *Not just respiration or heat*.

Energy losses due to uneaten parts/undigested parts/feces/egestion

Not enough energy for 4th/5th/later stages of a food chain
OR
more energy available if feeding at an earlier stage in a food chain

c. Evaporation of water «in leaf/mesophyll» creates tension/low pressure/negative pressure «potential»/pulling force/transpiration pull

Water drawn through cell walls/out of xylem «in leaf» by capillary action/adhesion «to cellulose»

Low pressure/tension/suction/pulling force in xylem

Hydrogen bonds make water cohesive/allow water to be pulled up under tension/allow the transpiration pull «to move water»

Xylem resists tension/low pressure/collapse with thickened/lignified walls

Water travels from the roots to the leaves in xylem

Water absorbed in roots by osmosis

Active transport of ions/solutes into roots «enabling osmosis»

Deep/wide ranging/extensive root systems/taproots/many root hairs

Thick/waxy cuticle reduces transpiration/water loss/evaporation

Small/no leaves/reduced surface area of leaves/thorns instead of leaves

Few stomata/stomata in pits/rolled leaves

Hairs on leaf surface «to reduce air flow near the leaf/reflect sunlight»

Stomata open at night/CAM physiology to reduce water loss

Examiners report

a. Diagrams of plant cell structure were mostly rather poor and few candidates scored full marks. The question specified ‘as seen in an electron micrograph’. Many diagrams showed the appearance of plant cells in a light micrograph. This allowed marks for cell wall and cell membrane to be awarded, but not for internal structures such as the nucleus as their representation was not detailed or accurate enough. In contrast to the membrane diagrams in 6(a), many of these cell diagrams were carelessly drawn with overlapping, multiple or discontinuous lines used for structures that have a single continuous edge.

b. This is a familiar question, though there was a slight twist in that candidates were expected to explain specifically why food chains cannot be long. Nearly all candidates wrote about energy losses between trophic levels and many mentioned the '10% rule' though in some cases got it the wrong way round and stated that 10% of energy is lost. Too few candidates mentioned the most important idea – that release of energy by cell respiration and its use is accompanied by loss of energy from a food chain in the form of heat.

c. This question caused some problems. It was another case where a sentence had been added to set the scene, but it proved a distraction rather than an aid to focus. The wording of the question as a whole was clear, but many candidates seemed not to have read to the end of the second sentence and they did not therefore explain how losses of water by transpiration are replaced. Some answers were concerned exclusively with xerophytic adaptations. An extensive markscheme was devised that allowed these answers to score up to five marks. Those candidates who did actually describe the uptake and transport of water within the plant were able to score full marks. There were few really strong answers and many misunderstandings. One in particular is worth mention: capillary action due to adhesion of water to xylem walls only helps to refill xylem vessels when they are air-filled. If a plant is transpiring the xylem will be filled with water under tension and adhesion cannot cause upward movement.

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

a. Explain the processes by which light energy is converted into chemical energy. [8]

c. Describe how energy flows through and is used by organisms in ecosystems. [4]

Markscheme

a. a. plants/producers/autotrophs convert light to chemical energy by photosynthesis

b. chlorophyll/photosynthetic pigments absorb light

c. electrons are excited/raised to higher energy level

d. excited electrons pass along chain of electron carriers

e. energy from electrons used to pump protons across thylakoid membrane/into thylakoid space

f. chemiosmosis/proton gradient used to make ATP

g. ATP synthase generates ATP

h. pigments arranged in photosystems

i. electrons from Photosystem II flow via the electron chain to Photosystem I

j. electrons from Photosystem I are used to reduce NADP

k. ATP and reduced NADP used in the light independent reactions/Calvin cycle

l. carbohydrate/glucose/carbon compounds produced containing energy

Award marking points for any point made on a clearly annotated diagram.

c. a. producers/plants/autotrophs obtain energy from light/sun/inorganic sources

b. food contains energy / energy passed in the form of food/carbon compounds (along food chains/between trophic levels)

c. consumers obtain energy from other organisms/from previous trophic level

This mark point distinguishes consumers from producers.

d. energy released (in organisms) by (cell) respiration

Reject energy used in respiration.

e. ATP produced

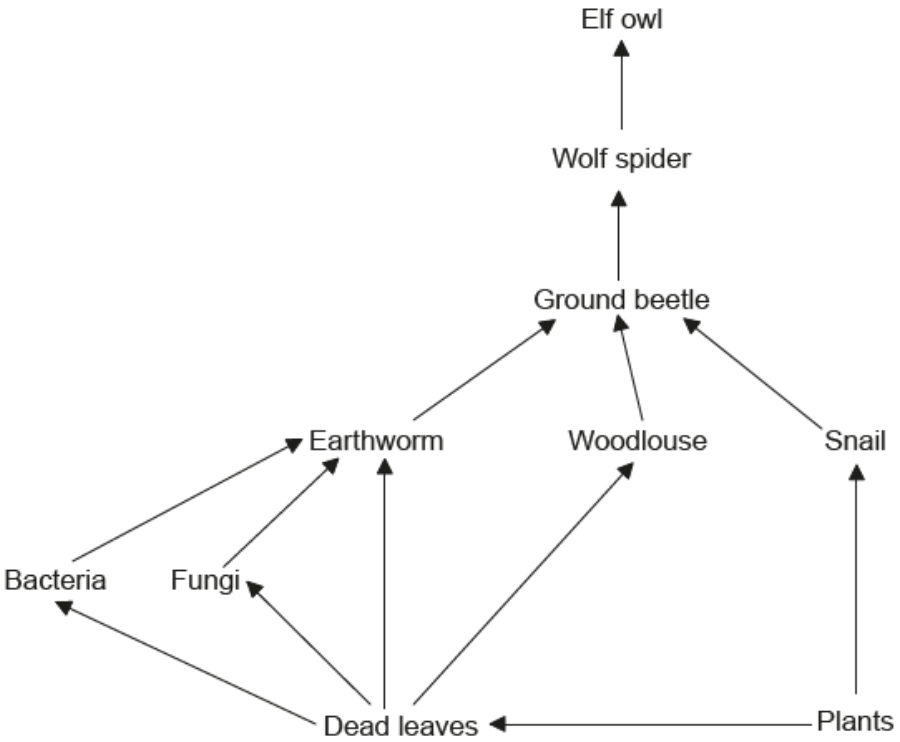
f. energy/ATP used for biosynthesis/movement/active transport/other valid use of ATP

g. less energy available / energy lost at each trophic level

Examiners report

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

The image shows a food web.



[Source: © International Baccalaureate Organization, 2017]

a.i. Using the food web, identify a detritivore. [1]

a.ii. Using the food web, identify a saprotroph. [1]

b. State the name of the domain to which birds, such as the Elf owl, belong. [1]

c. Outline the energy flow through this food web. [3]

Markscheme

a.i. earthworm/woodlouse

a.ii. bacteria/fungi

Do not accept protozoans or nematodes as they are consumers.

b. eukaryote/eukaryota/eukarya

c. a. light energy of Sun is converted by plant/autotroph to chemical energy «in carbon compounds through photosynthesis»

b. detritivores/saprotrophs decay plant material «that accumulates in the soil» to obtain energy *OWTTE*

c. consumers release energy from the carbon compounds by cell respiration energy lost as heat

d. energy is used by organisms for metabolism

e. energy is transferred between organisms/trophic levels through the food chains/web
For mp e, accept specific example such as energy is transferred from primary to secondary consumer etc.

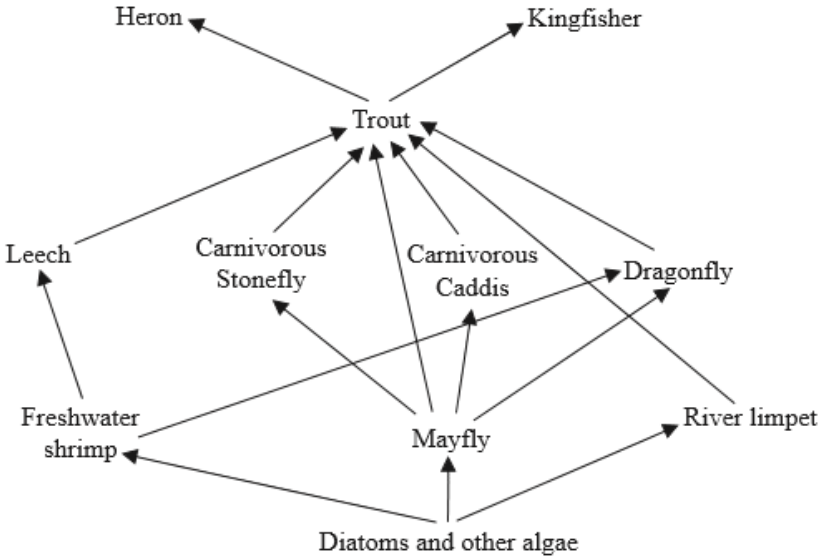
f. energy is lost at each trophic level «so lengths of food chains/web are restricted»
OR
approximately 80/90 % of energy is lost «between trophic levels»
Vice versa

Award mark points that refer to the specific organisms from this food web.

Examiners report

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

The food web below shows some of the feeding relationships found between the organisms living in or near a river in England.



a (i). Identify an organism in the food web that is an autotroph. [1]

a (ii). Identify an organism in the food web that is both a secondary and tertiary consumer. [1]

b. Explain how the flow of energy in the food web differs from the movement of nutrients. [2]

c. Discuss reasons why the levels of a pyramid of energy differ in size. [2]

Markscheme

a (i). diatoms / (other) algae

a (ii). trout

b. nutrients are recycled in a food web and energy enters and leaves/is not recycled;

nutrients are recycled by saprotrophs/returned to environment and reused;

while energy (enters as light and) is dispersed as heat;

c. (the shape of pyramid) shows energy lost from base to top of pyramid/80 to 90 % lost at each trophic level;

(because) energy is used/released through cell respiration/heat/metabolism/ movement (at each trophic level);

not all tissues are eaten *i.e.* bone/hair/cellulose/excretion/undigested/die (so energy is not available for next trophic level);

Examiners report

a (i). Virtually all candidates were able to identify the diatoms/algae as autotrophs in (i)

a (ii). Many identified the trout as both a secondary and tertiary consumer in (ii), although some seemed to think this part of the question asked for two different organisms here, not a single one with two different positions within the food web.

b. Most candidates explained the decrease in energy along a food chain, most referring to the loss of energy due to respiration or heat, but many did not refer to the fact that it cannot be recycled. Many left out reference to nutrients and the fact that they are recycled.

c. In (c) most displayed a general knowledge of the shape of an energy pyramid, but unfortunately, as many had described energy loss in part (b), they did not refer to it again in part (c). However, most mentioned the loss of energy due to respiration, etc. or the fact that some material is not digestion.

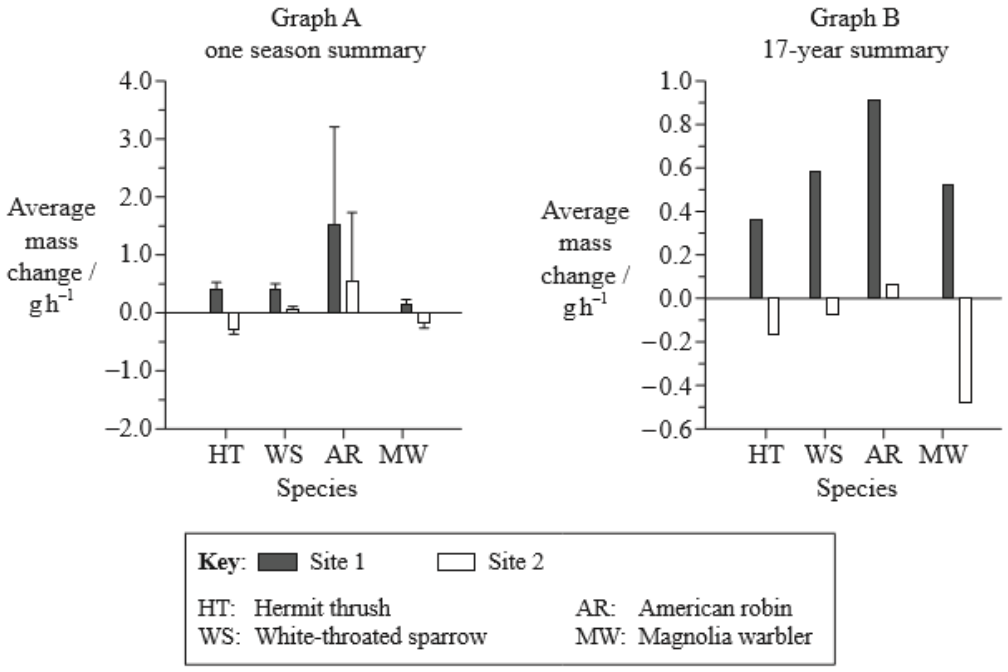
Migrating birds must refuel along the way in order to continue flying. A field study was conducted among four different species of migrating birds known to stop at high quality and low quality food sites. Two techniques were used to assess food quality in the stopover sites. Birds were captured and weighed at the two sites. Blood samples were taken from the birds to determine nutrient levels in their blood. The two techniques were compared for their effectiveness.

The table below shows data collected from the two sites during one season.

Species	Site 1		Site 2	
	N (number captured)	Mean bird mass / g	*N* (number captured)	Mean bird mass / g
Hermit thrush	46	29.8	28	28.3
White-throated sparrow	47	27.9	48	27.2
American robin	8	78.3	10	77.6
Magnolia warbler	30	8.4	10	8.2

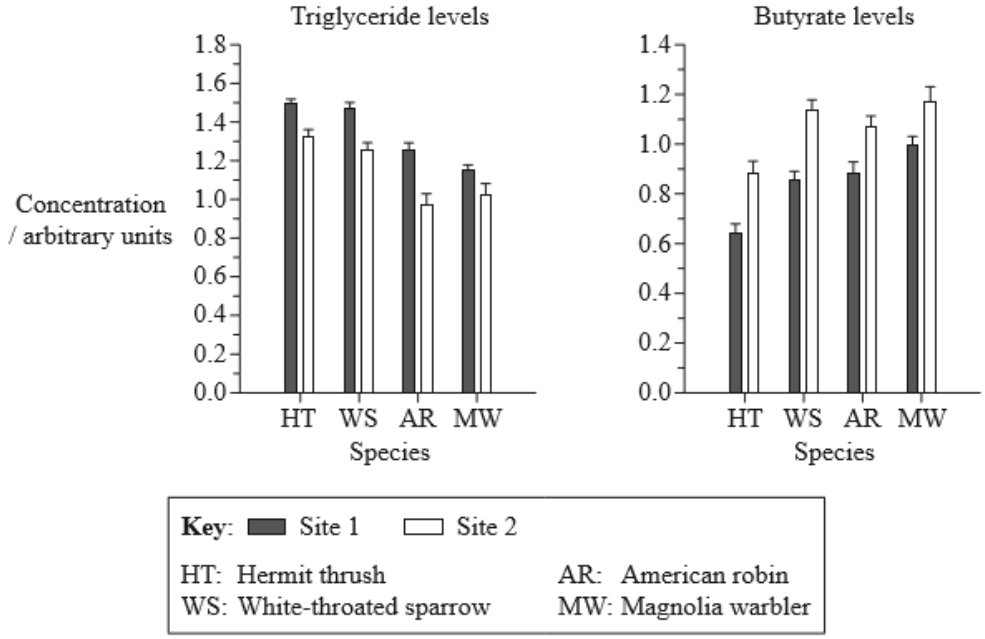
[Source: adapted from C Guglielmo, *et al*., (2005), *Physiological and Biochemical Zoology*, **78**(1), pages 116–125]

A method was used to determine the average mass change in grams per hour (gh^{-1}) during the study. Graph A represents a summary of data collected during one season whereas Graph B represents a summary of data collected over 17 years.



[Source: adapted from C Guglielmo, *et al.*, (2005), *Physiological and Biochemical Zoology*, **78**(1), pages 116–125]

Among birds, high triglyceride concentration in blood plasma indicates fat deposition whereas high butyrate concentration in blood plasma indicates fat utilization and fasting. The following data summarizes triglyceride levels and butyrate levels measured for the same groups of birds.



[Source: adapted from C Guglielmo, *et al.*, (2005), *Physiological and Biochemical Zoology*, **78**(1), pages 116–125]

a. Considering all the birds sampled, identify which species was sampled the most and which was sampled the least. [1]

Most:

Least:

b. Using the data from the table, calculate the percentage difference in mean bird mass for the hermit thrushes refueling at Site 1 compared to those refueling at Site 2. [1]

c. Compare the 17-year summary data for the hermit thrush and the magnolia warbler. [2]

d. Evaluate the one season data for the hermit thrush and the American robin with regard to average mass change per hour at Site 1. [2]

e. Describe, using the triglyceride levels graph, the results at Site 1 and Site 2 for all of the birds. [2]

f. Explain the differences in the triglyceride level and butyrate level for the hermit thrush at Site 1 and Site 2. [2]

g. Scientists have hypothesized that the food quality is better at Site 1 than at Site 2. Evaluate this hypothesis using the data provided. [2]

h. Suggest **one** advantage and **one** disadvantage for blood sampling rather than weighing birds to assess food quality at stopover sites. [1]

Markscheme

a. *most*: white-throated sparrow/WS

least: American robin/AR

(*both needed to award the mark*)

b. 5% / 5.03% / 5.3% (*unit required*) (*Accept answers in the range of 5 % and 5.3 %*)

No indication needed of whether percentage difference is an increase or decrease.

c. both birds show an increase in mass at Site 1 and a decrease at Site 2;

MW has a greater increase than HT at Site 1; (*do not accept larger/greater change*)

MW has a greater decrease than HT at Site 2; (*accept negative change*)

MW has larger mass change at both sites/Site 1 and Site 2;

Do not accept answers quoting only numerical statements.

d. HT data is reliable whereas AR data is unreliable / differences not significant / uncertainty higher with AR;

(because) error bars/variation/range/standard deviation large for AR / larger for AR than for HT;

(because) smaller sample of AR than of HT;

Do not accept comments about whether the data is accurate or not.

e. all have a higher concentration of triglyceride at Site 1 than at Site 2;

HT (and WS) highest at both sites/at Site 1;

MW lowest at Site 1 and AR lowest at Site 2;

Do not allow answers quoting only numerical statements.

f. triglyceride higher at Site 1 because more fat deposition / HT eats more;

butyrate higher at Site 2 because more fat/triglyceride utilized / HT fasts more;

g. (data supports hypothesis) because mean mass at Site 1 is greater than at Site 2 (for all birds);

because mass gained at Site 1 but mass falls (mostly) at Site 2 (over 17 years);

because triglyceride levels higher at Site 1 / butyrate levels higher at Site 2 / more fat deposited at Site 1 / more fat utilized at Site 2 / more fasting

at Site 2;

h. *advantage:*

need to capture bird only once to get data / no need to mark and catch birds again;

more informative data can be gathered; (*do not accept unqualified "more precise"*)

disadvantage:
removal of blood is more stressful/risky for the bird than weighing;
danger of infection / spread of disease / harm to birds;
extra time/money/laboratory equipment is needed to analyse results;
could include fat/triglyceride/butyrate from previous/long-term feeding;
nutrients from food eaten at these sites may not have been absorbed yet;
*Award **[1]** for one advantage and one disadvantage that are not the converse of each other. Do not allow a second advantage or second disadvantage given in the answer.*

Examiners report

a. Part (a) was intended to be an easy start to the question and almost all candidates answered it correctly.

b. The percentage calculation in (b) was only answered by about half of candidates, perhaps because of the wording of the question, which did not make it clear whether the difference should be calculated as a percentage of that at Site 1 or at Site 2. Candidates were expected to calculate the difference between the two masses by subtraction and then divide either by the mass at Site I or at Site 2. Candidates performed many other calculations, but as only one mark was available, no credit was given for these.

c. The best answers in (c) made it clear whether the mass changes were increases or decreases, but many answers were vaguer, referring only to mass changes. There was some confusion between mass and mass change, with some some candidates implying that a negative mass change was a low mass. In some cases answers to this question consisted only of figures quoted from the bar chart, rather than a genuine comparison and so did not score any marks.

d. In (d) candidates were asked to evaluate data. The command term evaluate is defined as assessment of the implications and limitations. In this case it was the limitations of the data that were relevant. Candidates were expected to use the size of error bars and the sample sizes to assess the reliability of the data. Many candidates wrote instead about the differences between the data for the hermit thrush and American robin, without any actual evaluation.

e. Part (e) of question 1 tested a different skill in data analysis. Candidates were expected to pick out the most significant features of the data and as in (c), answers that merely quoted numerical figures from the bar chart mostly scored few marks. The points that the stronger candidates were made were that the triglycerides level at Site 1 was higher than that at Site 2 in all bird species and that the hermit thrush had the highest levels at both sites, whereas the Magnolia warbler was lowest at Site 1 and the American robin was lowest at Site 2.

f. 1(f) was another part of the question where it was important to pay attention to the command term. The term explain indicates that causes, reasons or mechanisms are required. In this case the causes of triglycerides levels being higher at Site 1 and of butyrate levels being higher at Site 2 were expected. The stem of the question had given the explanations that should have been given –fat deposition or fat utilisation.

g. Part (g) involved another evaluation, in this case of a hypothesis. Candidates were expected to conclude that the data supported the hypothesis.

No mark was given this and instead marks were awarded for evidence.

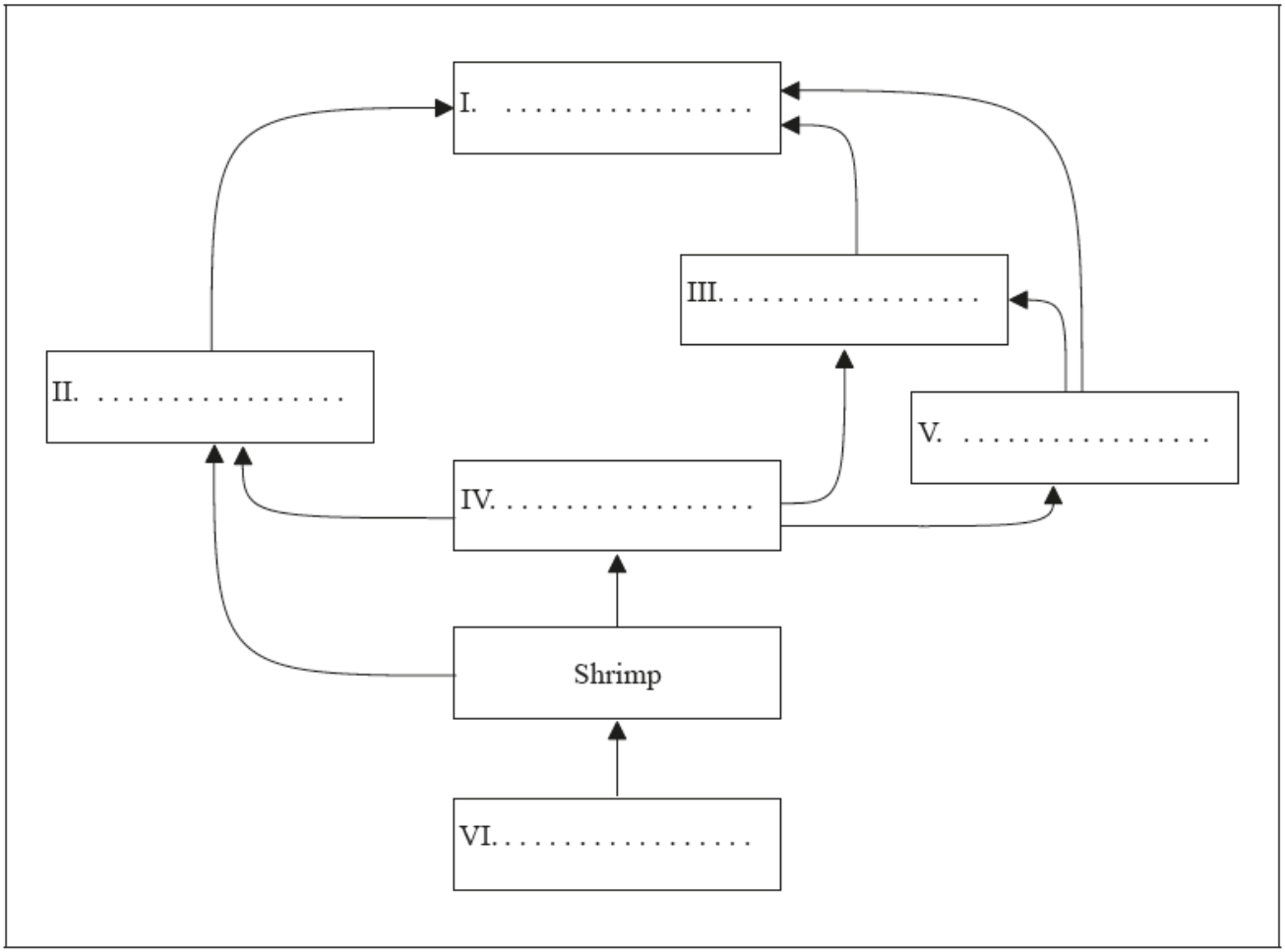
Most candidates only considered the butyrate and triglycerides levels and so scored a maximum of one mark. The second mark was only awarded if candidates gave a broader answer by referring back to differences given earlier in the question for mean mass or mass change between Site 1 and Site 2.

h. The last part of the question involved suggesting and advantage and a disadvantage of blood sampling. A huge variety of answers were given but few candidates gave both an advantage and a disadvantage that the examiners considered acceptable. The disadvantage was the easier of the two and many candidates wrote about the stress of the procedure for wild birds or harm that the loss of blood might cause. The advantage that was most often given was the opportunity to obtain precise measurements for many different nutrients in blood, compared to the rather blunt assessment of food quality that weighing gives. There was some confusion about the meanings of terms such as precision and accuracy. Birds can of course be weighed accurately with great precision, whereas some candidates implied that blood tests were inherently more accurate and precise.

The table provides some information about organisms found in an Arctic environment.

Organism	Prey/food	Predators
Arctic cod	Shrimp	Arctic fox, Narwhal, Seal
Arctic fox	Arctic cod, Seal	Polar bear
Narwhal	Arctic cod, Shrimp	Polar bear
Phytoplankton	None	Shrimp
Polar bear	Arctic fox, Narwhal, Seal	None
Seal	Arctic cod	Arctic fox, Polar bear
Shrimp	Phytoplankton	Arctic cod, Narwhal

a. (i) Label the diagram to complete the food web for the organisms in the table above. [3]

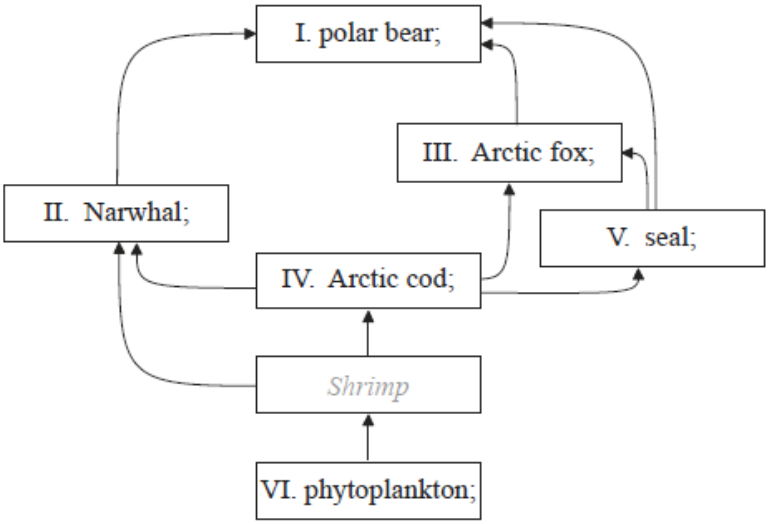


(ii) Deduce the trophic level of Artic cod.

b. Distinguish between the movement of energy and nutrients in an ecosystem. [2]

Markscheme

a. (i) *Award [1] for any three correct answers:*
All 6 = 2 marks
3–5 = 1 mark
0–2 = 0 marks.



[2 max]

(ii) secondary consumer ***[1]***
Do not accept third trophic level.

b. energy moves through/enters and leaves ecosystems / need a constant source of energy;

nutrients cycled between biotic and abiotic environment/in cycles such as C/N;

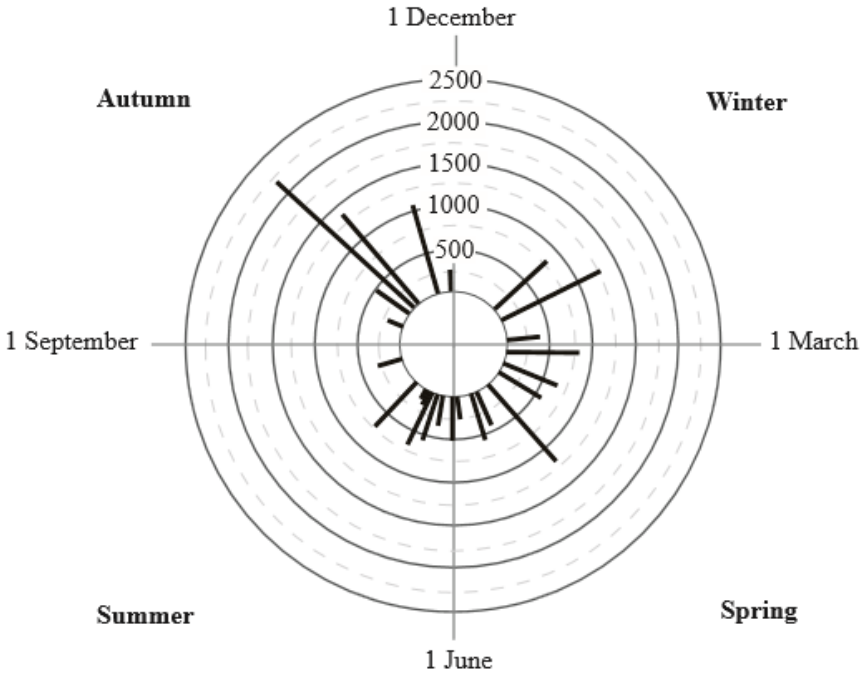
Examiners report

a. In (a) most were able to gain both marks for the food web, but only about half were able to deduce that the arctic cod was a secondary consumer. In part (b) most knew about the 10% passing to the next trophic level in a food chain, but did not apply this to the ecosystem – i.e. that it has to be continually replaced. The concept of 'nutrients' was poorly understood by many.

b. In (a) most were able to gain both marks for the food web, but only about half were able to deduce that the arctic cod was a secondary consumer. In part (b) most knew about the 10% passing to the next trophic level in a food chain, but did not apply this to the ecosystem – i.e. that it has to be continually replaced. The concept of 'nutrients' was poorly understood by many.

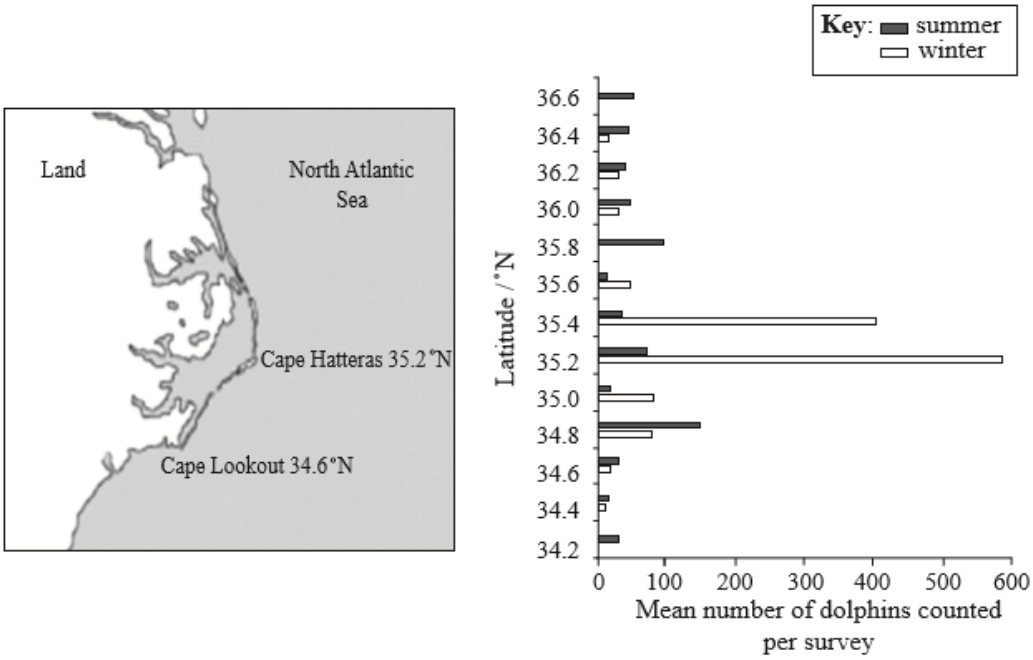
Bottlenose dolphins (*Tursiops truncatus*) inhabit almost all tropical and temperate oceans between 45°N and 45°S. Over a two-year period, aerial surveys were carried out to investigate the seasonal distribution of these animals along the mid-Atlantic and eastern coastal waters of the USA. Sightings were recorded using a global positioning system (GPS) while flying in a regular pattern within approximately 65 km of the shore. A total of 12 760 dolphins were sighted over the two-year period and the data are summarized in the chart below.

Each bar corresponds to a single survey and the length of the bar corresponds to the total number of bottlenose dolphins counted in that survey. The circles with numbers indicate numbers of dolphins.



[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.]

As part of the same study, coastal aerial surveys were carried out over the same time period by 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.



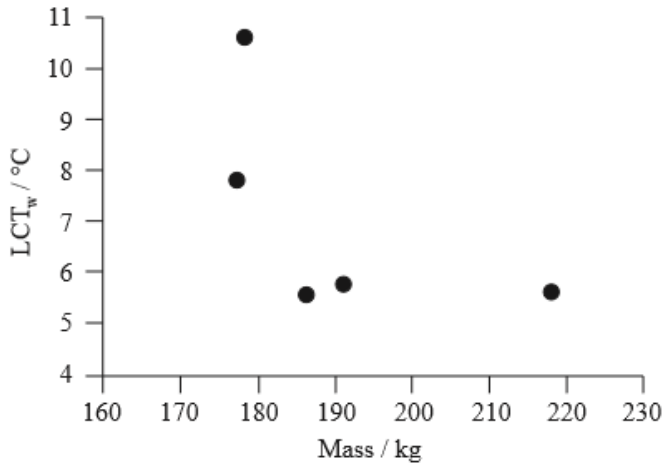
[Source: adapted from Leigh G. Torres, William A. McLellan, Erin Meagher and D. Ann Pabst (2005) 'Seasonal distribution and relative abundance of bottlenosedolphins, *Tursiops truncatus*, along the US mid-Atlantic Coast.' *Journal of Cetacean Research and Management*, 7 (2), pp. 153–161.]

In a different study, researchers investigated the role of water temperature as a possible factor in the distribution of bottlenose dolphins. The rate of metabolism (measured as the rate of oxygen uptake per unit mass) of five captive adults was measured under a range of water temperatures. The rate of metabolism was found to increase significantly when the water temperature fell below a certain value known as the lowest critical water temperature (LCT_w). Below this temperature the body uses more energy to combat the cooling effect of the surrounding water. The data for these animals are summarized below.

Animal	Sex	Age / years	Mass / kg	LCT_w / °C
1	male	27	177.3	7.8
2	male	24	191.4	5.7
3	male	26	219.7	5.6
4	male	14	187.0	5.5
5	female	33	178.2	10.6

Adapted with permission from L.C. Yeates and D.S. Houser (2008) 'Thermal tolerance in bottlenose dolphins (*Tursiops truncatus*).' *Journal of Experimental Biology*, 211, pp. 3249–3257, Table 1. doi:10.1242/jeb.020610: The Journal of Experimental Biology: jeb.biologists.org

The graph below summarizes the relationship between LCT_w and body mass.



[Adapted with permission from L.C. Yeates and D.S. Houser (2008) 'Thermal tolerance in bottlenose dolphins (*Tursiops truncatus*).' *Journal of Experimental Biology*, 211, pp. 3249–3257, Figure 4. doi:10.1242/jeb.020610: The Journal of Experimental Biology: jeb.biologists.org.]

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

b. Calculate the mean number of dolphins counted per survey for the winter season. [1]

c. Compare the data for the dolphin populations in winter and summer. [2]

d (i) Compare the distribution of dolphins in summer and winter. [2]

d (ii) Suggest **one** reason for the differences in distribution. [1]

e. Outline the relationship between body mass and LCT_w for male dolphins. [2]

f. Suggest **one** reason for the high LCT_w measured for the female dolphin. [2]

g. Evaluate the hypothesis that water temperature determines the range and distribution of bottlenose dolphins in the wild. [2]

h. Explain how an increase in water temperature due to global warming could affect the distribution of bottlenose dolphins along the eastern coast of the USA. [2]

Markscheme

a. 2200 (*allow answers in the range 2175–2225*)

b. 800 (*allow answers in the range 750–850*)

c. more surveys in summer / fewer in winter;

larger average/biggest number sighted (per survey) in winter / converse;

larger total number of dolphins (from adding up all surveys) in summer;

variation in both seasons / overlap in numbers between summer and winter;

Do not accept answers relating to distribution.

Do not accept answers stating that the dolphin population is higher in winter.

d (i) 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*;

d (ii) 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;

e. male dolphin with the lowest body mass has the highest LCT_w;

with larger dolphins/above 180/185/187 kg no change in LCT_w with body mass;

weak negative correlation / as mass increases LCT_w drops / *vice versa*;

uncertainty due to small amount of data;

f. *Accept any of the following points about the female:*

older so (possibly) has a lower metabolic rate / other result of age;

higher surface area to volume ratio (than male);

less active than males so releasing less metabolic heat;

less insulation due to subcutaneous fat/adipose tissue;

suckling / pregnant / part of mass was fetus;

g. supported as water temperature affects metabolic rate;

supported as dolphins will avoid areas with water below their LCT_w;

water temperature is unlikely to be a factor for bigger males;

wide (latitude) range in summer suggests temperature does not determine range;

few animals / only one female / only narrow range of latitudes investigated;

data may not be reliable since the study was conducted in captivity;

h. may migrate/move range further north;

migrate to area with cooler/suitable water temperature;

ocean currents may change;

most productive waters/food supply may be further north;

distribution more spread out (due to warmer waters in more areas);

Examiners report

a. The unusual circular form of the graph made it more difficult to read off the value for the largest number of dolphins in a single survey and only about two thirds of candidates did this carefully enough to earn the mark.

b. There was quite a lot to do here; three values had to be read from the graph and then a mean value calculated. Again about two thirds of candidates scored the mark.

c. There were plenty of valid comparisons for candidates to make and most scored two marks. Some candidates failed to understand that the results are merely sightings of dolphins and not total population counts; they therefore incorrectly implied that the population size varied considerably during each season.

d (i) Candidates found this question more challenging and in some cases it was clear that they had not studied the data carefully enough. As in all compare questions, the answer should make genuine comparisons and not describe the two things separately, in this case the winter and summer distributions. Some candidates did not understand that a population is a number of organisms and a distribution is where those organisms live.

d (ii) A huge variety of suggestions for the difference between the summer and winter differences was given by candidates and many of these answers were considered valid. The answer could have been based either on possible differences in dolphin behaviour between summer and winter for example breeding, or possible differences in the environment such as water temperature.

e. Answers were in many cases weaker than expected. Most candidates stated that as mass increased, the LCT_w of make dolphins decreased, which earned one mark. The difficulty came in earning the second mark. The mark scheme gives a variety of other points that can be made, for example that the individual dolphin with the lowest mass had the highest LCT_w or that above 187kg there does not seem to be much if any further decrease in LCT_w. Many candidates seemed to realize that to get the second mark they needed to give more than the negative correlation but then merely restated the correlation in different phraseology.

f. Any possible reason for the high LCT_w in females was accepted, though not simply that she was older –some reason for higher LCT_w in an older female was required.

g. Candidates found this question hard and the examining team had some sympathy with them as there isn"t very much basis in the data for evaluation of the hypothesis. The most effective answers concentrated on the graph of mass against LCT_w as this shows that the metabolic rate of dolphins will have to increase if dolphins are in cold water. Some candidates realized this, but few then went on to comment on the small sample size or the fact that this data was obtained with dolphins in captivity and that in the wild there could be a different trend.

h. This was expected to be an easy and high scoring question, but many candidates struggled with it and revealed gaps in their understanding of the data given earlier in the question. It is important to read all of the text in a data-based question, as it places the data in context and often gives information without which the data cannot be understood properly. In many cases candidates based their answer on faulty understanding. For example, a surprisingly large number decided that Cape Hatteras was on the equator and that to find cooler water dolphins could move north or south. No detailed geographical knowledge was needed to score two marks, but geographical misunderstandings did not help. The answer expected in advance by the examining team was that the dolphins population would move north in response to global warming to find cooler water. It was given be a minority, but other valid answers were accepted.

The Chinese soft-shelled turtle, *Pelodiscus sinensis*, lives in salt water marshes. The turtle can live under water and out of water.

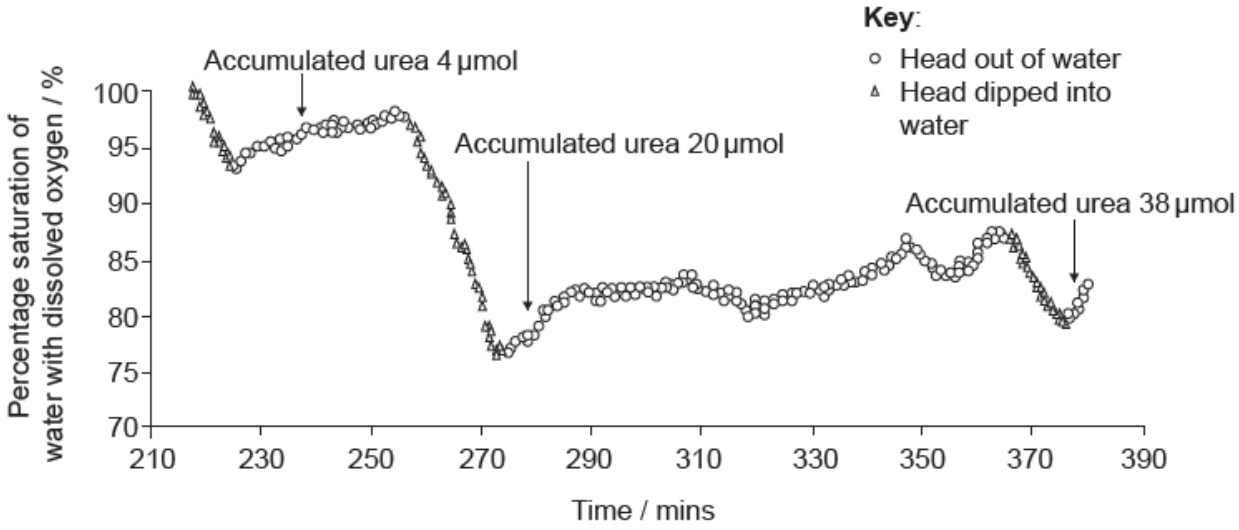
These turtles have fully developed lungs and kidneys, however, many microvilli have been discovered in the mouth of *P. sinensis*. A study was undertaken to test the hypothesis that oxygen uptake and urea excretion can simultaneously occur in the mouth.

Initial experiments involved collecting nitrogen excretion data from *P. sinensis*. The turtle urinates both in water and out of water. When in water it allows waste products to be washed out of its mouth. When out of water it regularly dips its head into shallow water to wash its mouth. The table shows the mean rates of ammonia and urea excretion from the mouth and kidney over six days.

	Excretion of nitrogen by the mouth / $\mu mol\ day^{-1}\ g^{-1}$ turtle		Excretion of nitrogen by the kidney / $\mu mol\ day^{-1}\ g^{-1}$ turtle	
	Turtle submerged in water	Turtle out of water	Turtle submerged in water	Turtle out of water
Ammonia	0.29	0.30	0.63	0.54
Urea	0.90	1.56	0.07	0.73

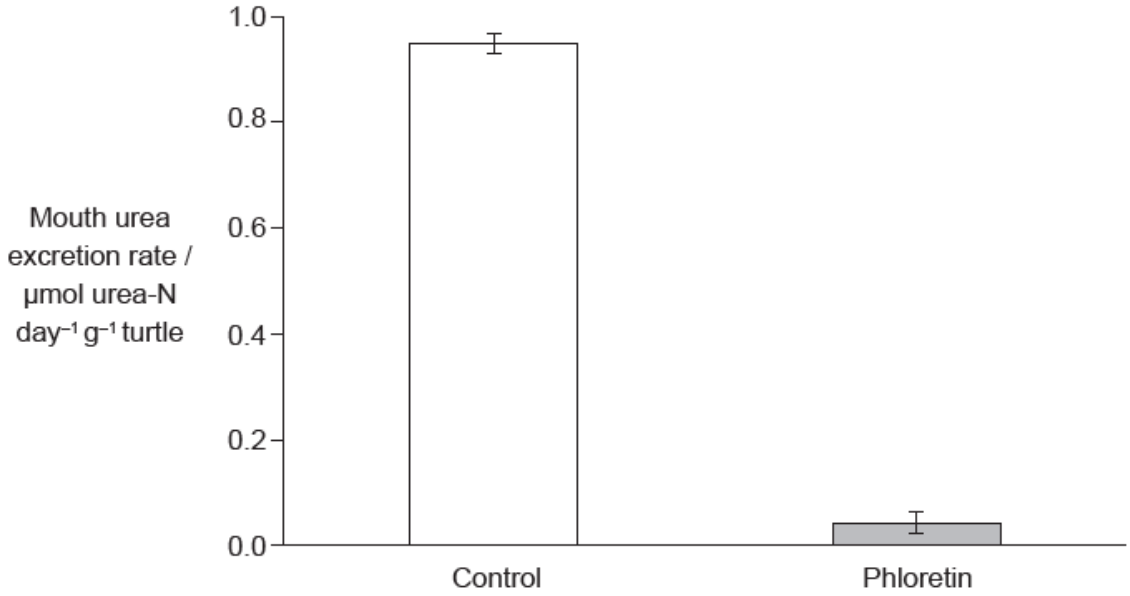
[Source: Reproduced with permission, Y. Ip *et al*. (2012) *The Journal of Experimental Biology*, 215, pages 3723—3733. jeb.biologists.org. doi: 10.1242/jeb.068916]

It was noted that during long periods out of water, turtles rhythmically moved their mouths to take in water from a shallow source and then discharge it. Changes in the dissolved oxygen and the quantity of accumulated urea in the rinse water discharged by the turtles were monitored over time as shown in this graph.



[Source: adapted with permission from Y. Ip *et al*. (2012) *The Journal of Experimental Biology*, 215, pages 3723–3733.]

In order to test whether a urea transporter was present in the mouth tissues of the turtles, phloretin (a known inhibitor of membrane proteins that transport urea) was added to the water in which a further set of turtles submerged their heads. The results of that treatment are shown.

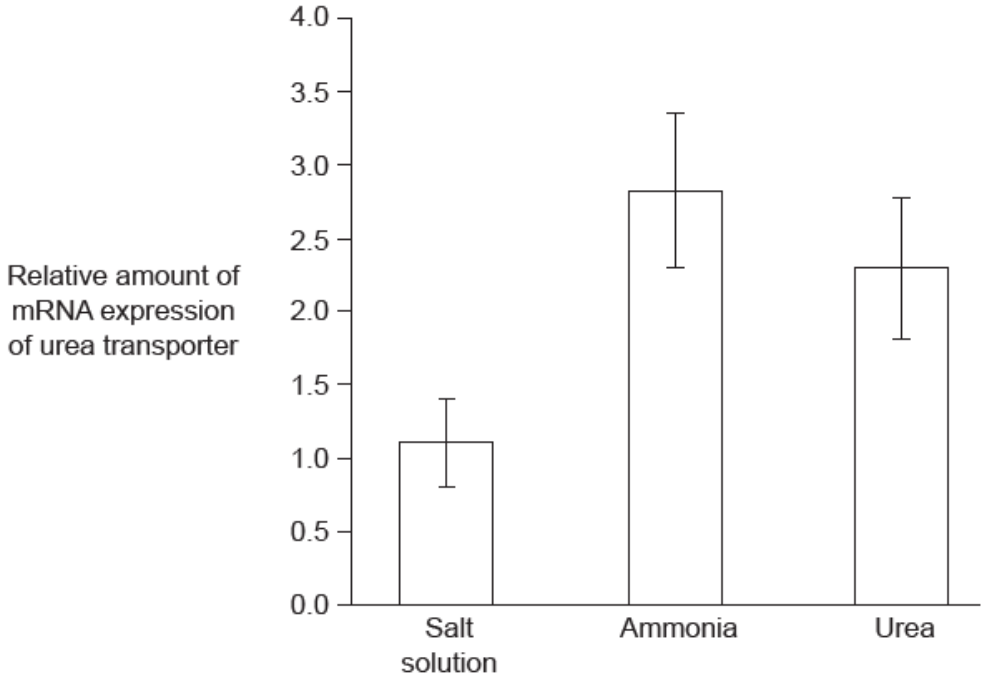


[Source: Reproduced with permission from Y. Ip *et al*. (2012) *The Journal of Experimental Biology*, 215, pages 3723–3733. jeb.biologists.org.]

Further research was conducted to determine where mRNA expression of a urea transporter gene might be occurring in *P. sinensis*. Gel electrophoresis was used to analyse different tissue samples for mRNA activity.

[Source: Reproduced with permission from Y. Ip *et al.* (2012) *The Journal of Experimental Biology*, 215, pages 3723–3733. jeb.biologists.org.]

Expression of the urea transporter gene by cells in the turtle's mouth was assessed by measuring mRNA activity. Turtles were kept out of water for 24 hours and then injected with either a salt solution that matched the salt concentration of the turtle, dissolved ammonia or urea, followed by another 24 hours out of water.



[Source: © International Baccalaureate Organization 2017]

a. Deduce whether the excretion of ammonia or urea changes more when a turtle emerges from water. [2]

b. Compare and contrast the changes in urea excretion in the mouth with the changes in urea excretion in the kidney when a turtle emerges from the water. [3]

c.i. Describe the trends shown by the graph for dissolved oxygen in water discharged from the mouth. [1]

c.ii. Suggest reasons for these trends in dissolved oxygen. [2]

d. Deduce with a reason whether a urea transporter is present in the mouth of *P. sinensis*. [2]

e. Outline the additional evidence provided by the gel electrophoresis results shown above. [2]

f.i. Identify which of these turtle groups represent the control, giving a reason for your answer. [1]

f.ii. Suggest a reason for the greater expression of the gene for the urea transporter after an injection with dissolved ammonia than an injection of urea. [2]

g. The salt marshes where these turtles live periodically dry up to small pools. Discuss the problems that this will cause for nitrogen excretion in the turtles and how their behaviour might overcome the problems. [3]

Markscheme

a. a. urea

b. for both mouth and kidney

c. percentage change/change in μmol day^{-1} g^{-1} greater with urea/other acceptable numerical comparison

b. a. both higher/increased on emergence from/with turtle out of water

b. both increased by 0.66 «μmol^{-1} g^{-1} when turtle emerges from water»

c. % increase is higher in kidney / kidney 940% versus mouth 73/75% / increase is higher proportionately higher in kidney / kidney x10 versus mouth nearly double/x1.73

d. urea excretion by mouth greater than kidney out of water «despite larger % increase in kidney excretion»

c.i. decrease «when head is submerged» and increase when head is out of water

c.ii. a. oxygen absorbed from water/exchanged for urea when head dipped in water«so oxygen concentration decreases»

b. lungs cannot be used with head in water / can «only» be used with head out of water

c. oxygen from water «in mouth» used in «aerobic cell» respiration

d. oxygen from air dissolves in water when head out of water «so oxygen concentration increases»

d. a. urea transporter is present

b. less urea «excreted»/ lower rate «of urea excretion» / excretion almost zero when phloretin/inhibitor was present

e. a. mRNA only in mouth and tongue/in mouth and tongue but not esophagus intestine kidney or bladder

b. bands / lines indicate mRNA for/expression of urea transporter gene

c. urea transporter gene expressed / urea transporters in mouth/tongue / not expressed/made in esophagus/intestine/kidneys/bladder

d. mRNA/transcription/gene expression/urea transporters higher in tongue/more in tongue «than mouth»

f.i. salt solution is control because it does not contain a nitrogenous/excretory waste product / it matches the salt concentration of the turtle / the turtle's body already contains salt / because the turtle lives in salt water/salt marshes / because nothing has been altered

f.ii. a. ammonia is «highly» toxic/harmful

b. ammonia is more toxic than urea/converse

c. ammonia converted to urea

d. urea concentration raised «by injecting ammonia»

e. difference between ammonia and urea «possibly» not «statistically» significant

g. *Problems:*

a. urea becomes more concentrated «in small pools» / lower concentration gradient «between tongue/mouth and water»

b. less water available for urine production/excretion by kidney

OR

less water in ponds for mouth rinsing/more competition for pools (to use for mouth rinsing)

Behaviour to overcome problems:

c. «still able to» dip mouth into/mouth rinse in water/pools

d. «still able to» excrete urea «though the mouth» in the small pools

e. more conversion of ammonia to urea/urea excretion rather than ammonia

f. more urea transporters/expression of urea transporter gene

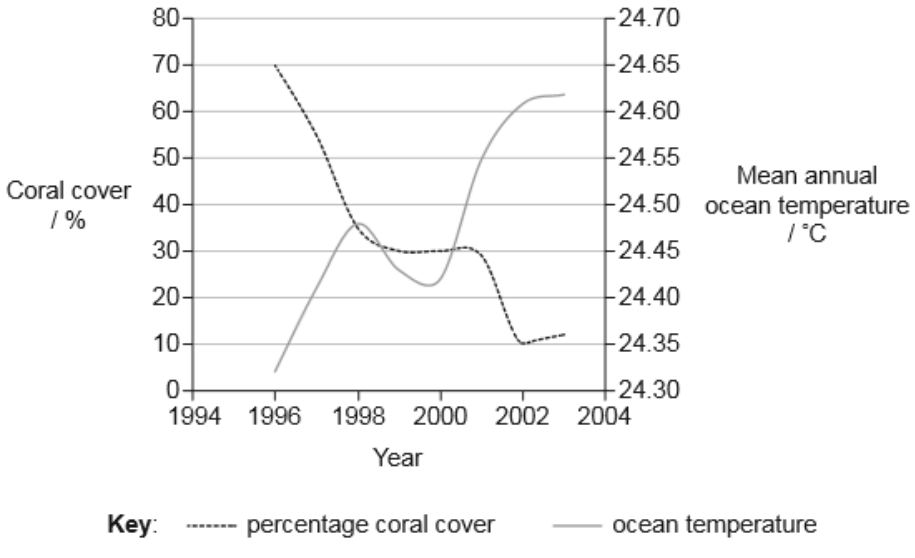
g. urea excreted «in mouth/via microvilli» by active transport/using ATP

h. excretion with little/no loss of water

Examiners report

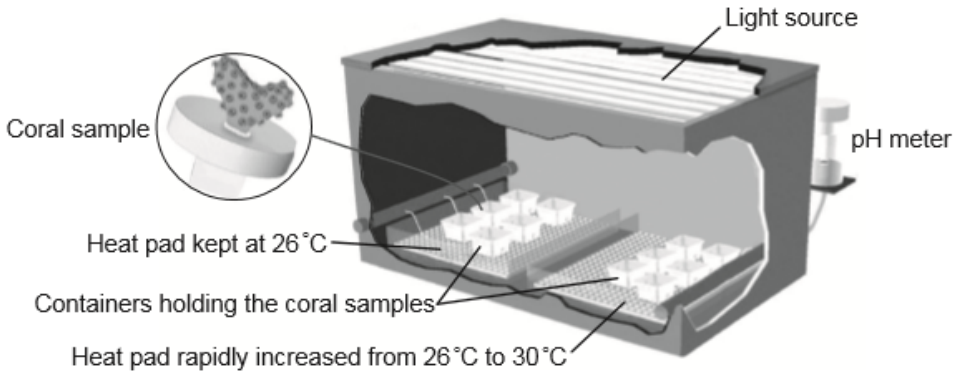
a. [N/A]
b. [N/A]
c.i. [N/A]
c.ii. [N/A]
d. [N/A]
e. [N/A]
f.i. [N/A]
f.ii. [N/A]
g. [N/A]

Coral reefs are among the most spectacular ecosystems on Earth. They support a rich diversity of life and provide economic benefits to the people who use them. In Papua New Guinea in the Pacific Ocean north of Australia the following data were collected. Coral cover is the percentage of the reef surface covered by live hard coral.

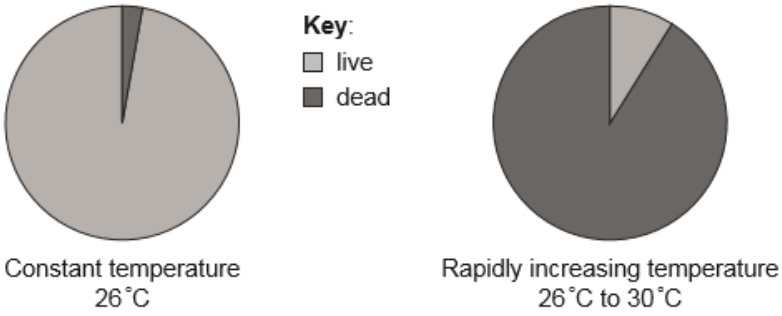


[Source: adapted from Jones et al. (2004), The Encyclopedia of Earth, Patterns of Coral Loss]

In order to test the effect of temperature, live samples of a species of coral, *Pocillopora damicornis*, were placed in an experimental chamber at a constant pH, water depth and low light. All the coral samples were started at 26°C and half of them were rapidly increased to 30°C.

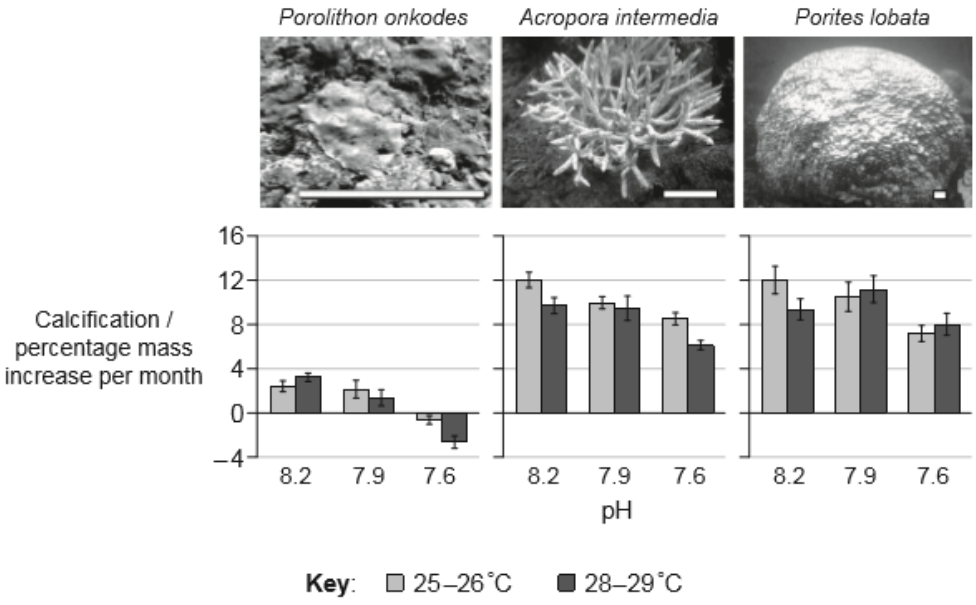


The pie charts show the percentage of live and dead tissues at the end of the experiment.



[Source: Adapted from Mace G. Barron, Cheryl J. McGill, Lee A. Courtney, and Dragoslav T. Marcovich, "Experimental Bleaching of a Reef-Building Coral Using a Simplified Recirculating Laboratory Exposure System," *Journal of Marine Biology*, vol. 2010, Article ID 415167, 8 pages, 2010. doi:10.1155/2010/415167]

Acidification of the world's oceans is an increasing threat to the health of oceanic life including coral reefs. Corals perform calcification to create their calcium carbonate exteriors. An experiment was conducted on Heron Island, Southern Great Barrier Reef, Australia. For the experiment the pH was altered by dissolving carbon dioxide in the water. Three different coral species were used, with each test group at two different temperature ranges and three different pH values. The white line in each photograph represents 5 cm.



[Source: Adapted from K. R. N. Anthony, D. I. Kline, G. Diaz-Pulido, S. Dove, and O. Hoegh-Guldberg, "Ocean acidification causes bleaching and productivity loss in coral reef builders," *PNAS*, vol. 105 no. 45, 17442–17446, Copyright 2008 National Academy of Sciences, U.S.A.]

a. Calculate the difference in coral cover in 1996 and 2002. No working required. [1]

. . . . . %

b. Describe the evidence that the ocean temperature has an effect on coral cover. [2]

c. Suggest causes for the changes in ocean temperature. [2]

d. Identify **one** advantage of conducting this experiment in the laboratory rather than in the ocean. [1]

e. Comment on whether the experimental data supports the observed data from the ocean. [1]

f. (i) Describe the trend in calcification when the pH is decreased at 25 –26°C. [3]

(ii) In environmental studies, a critical value is the level at which a population declines or shows signs of poor health. Suggest a critical pH for *P. onkodes*.

(iii) Using all of the data, comment on the hypothesis that ocean acidification in warming seas will have the same effect on all species of coral.

g. Suggest another marine animal that has parts made of calcium carbonate and may therefore be damaged due to ocean acidification. [1]

h. Outline causes of ocean acidification. [2]

i. Discuss the need for international cooperation to solve the problems of declining coral populations. [3]

Markscheme

a. 60 (%)

b. a. coral cover decreases as temperature rises (between 1996 and 1998/2000 and 2002) / negative correlation between temperature and coral cover / coral cover highest when temperature is lowest/vice versa

b. coral cover remains constant when temperature drops (between 1998/1999 and 2000)/remains (nearly) constant when temperature stops rising (between 2002 and 2003)

c. no proof of causation / only a correlation / other factors could be affecting the coral

Do not award this mark for "inversely proportional", but the mark can still be awarded if other parts of the answer give one of the alternative parts of the mark point.

c. a. increased carbon dioxide/methane in the atmosphere / carbon dioxide emissions from burning of fossil fuels / other specific source of a named greenhouse gas

b. increased greenhouse effect / more heat/long wave radiation trapped in the atmosphere

c. heat transfer from atmosphere to ocean / ocean absorbs heat from atmosphere

No marks for increased CO_2 in the oceans, global warming or climate change.
The idea of an increase must be included, not just greenhouse effect or heat trapping.

d. control of variables/pH/light/temperature / no predators of coral

e. a. supports because there is more dead coral/less % cover at the higher temperature

b. (experimental data) does not support (observed data) because experimental temperatures were (all) higher/rose much faster

The answer must make it clear whether or not the data provides support.

f. (i) less calcification in all three/each species (as pH decreased)

(ii) 7.6 / 7.7 / 7.8

Accept any pH that is 7.6 or higher, but lower than 7.9.

(iii)

a. greater reduction in calcification as pH drops at the higher temperature in ***P. onkodes*** than on the other two species (so hypothesis not supported)

This answer is based on the larger drop in calcification between 8.2 and 7.6 at both temperatures in onkodes than the other two species.

b. net loss in calcification at lowest pH and highest temperature in ***P. onkodes*** whereas there is still calcification in the other two species (so hypothesis not supported)

This answer is based only on whether there are positive values for calcification or negative.

c. warming reduces calcification at all pH levels in ***A. intermedia*** but not in the other two species (so hypothesis not supported)

This answer is based on the drop in calcification at each pH when the temperature rises in intermedia, whereas in the other species there is a rise at one or more of the pHs.

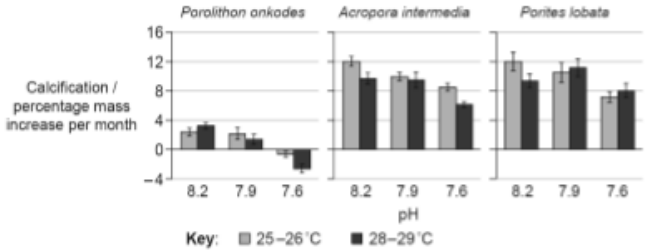
d. combined effect of acidification and warming is a larger reduction inncalcification in ***A. intermedia*** than in the other two species (so hypothesis not supported)

This answer is based on the larger overall drop in calcification between pH 8.2 at 25/26°C and 7.6 at 28/29°C.

e. more calcification as temperature rises at lower pH/pH 7.9 and 7.6 in ***P. lobata*** whereas there is less in the other two species (so hypothesis not supported)

The answer must either state pHs 7.9 and 7.6 or specify lower pH or greater acidification.

f. more calcification as pH drops from 8.2 to 7.9 at higher temperature in ***P. lobata*** whereas there is a drop/no rise in the other two species (so hypothesis not supported)



The answer must state the two pH values and state higher temperature or 28-29°C.

g. Mollusca/named marine mollusc with a shell/crustacean/named marine crustacean/Porifera/sponges/named calcareous marine sponge

Reject terrestrial examples. Reject sea shells, shellfish. Specific named examples must be verified if it is uncertain whether they have calcified parts.

h. a. carbon dioxide makes an acid/carbonic acid in water

b. (carbon dioxide from) burning fossil fuels/forest fires

c. carbon dioxide forms solution with/dissolves into water/oceans/rain

Do not award a mark for stating only that carbon dioxide causes ocean acidification.

Do not award marks for methane sources or sources of unspecified greenhouse gases or statements about increased carbon dioxide in the atmosphere.

i. a. international cooperation needed to reduce carbon dioxide emission/concentrations

b. carbon dioxide produced anywhere increases the greenhouse effect/global warming/ocean acidification/health of coral everywhere

c. ocean currents/tides/wind move carbon dioxide/acid/heat around the world / oceans of the world are interconnected/part of one overall system

d. (some) coral reefs are in international waters (or words to that effect) / coral reefs cannot be protected by single national governments alone

e. the more groups of people/nations/corporations that reduce their carbon emissions, the lower the impact on coral will become / not enough for one country/group/corporation to reduce carbon dioxide emissions

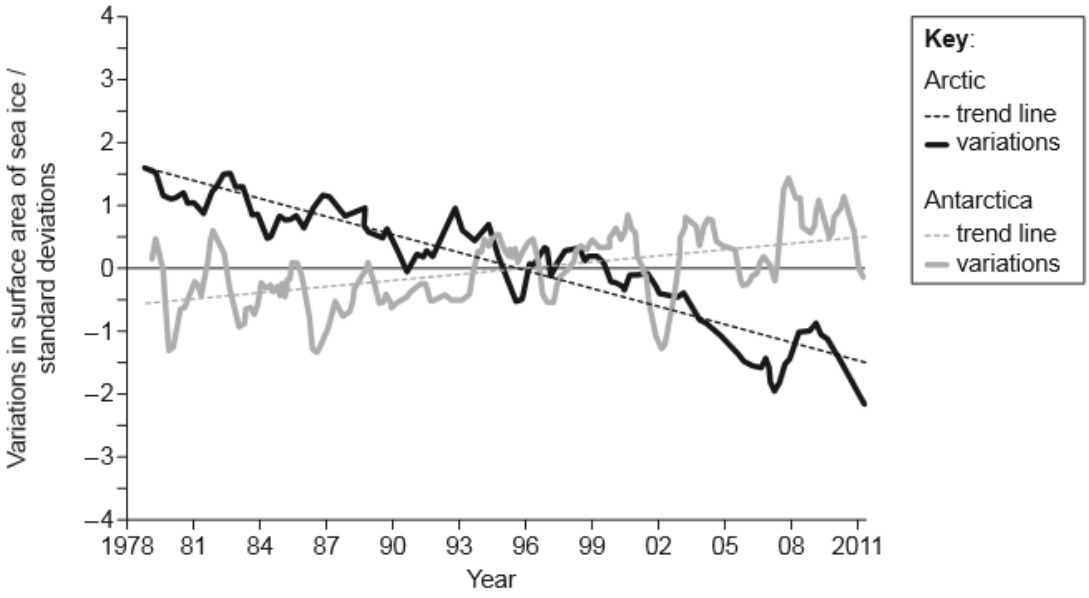
f. sharing of technology/research/information/resources

g. aid to poorer/developing countries (to help with coral conservation)

h. reference to an economic/ecological benefit of conserving coral reefs

Examiners report

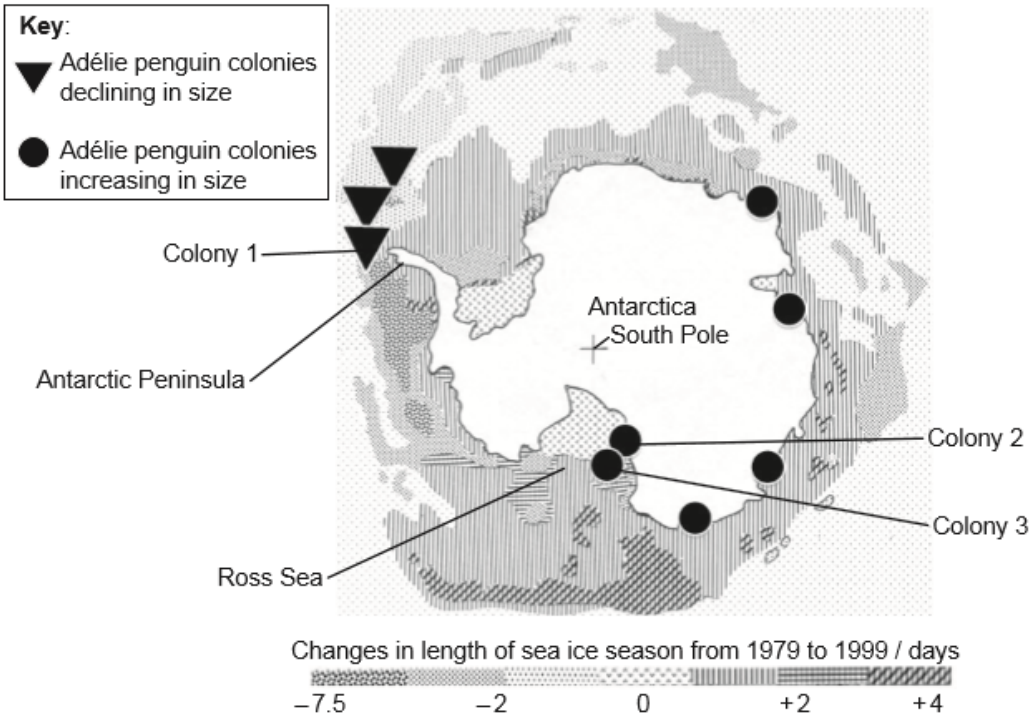
a. [N/A]
b. [N/A]
c. [N/A]
d. [N/A]
e. [N/A]
f. [N/A]
g. [N/A]
h. [N/A]
i. [N/A]



[Source: © International Baccalaureate Organization 2015]

Global warming has changed both the thickness and surface area of sea ice of the Arctic Ocean as well as the Southern Ocean that surrounds Antarctica. Sea ice is highly sensitive to changes in temperature.

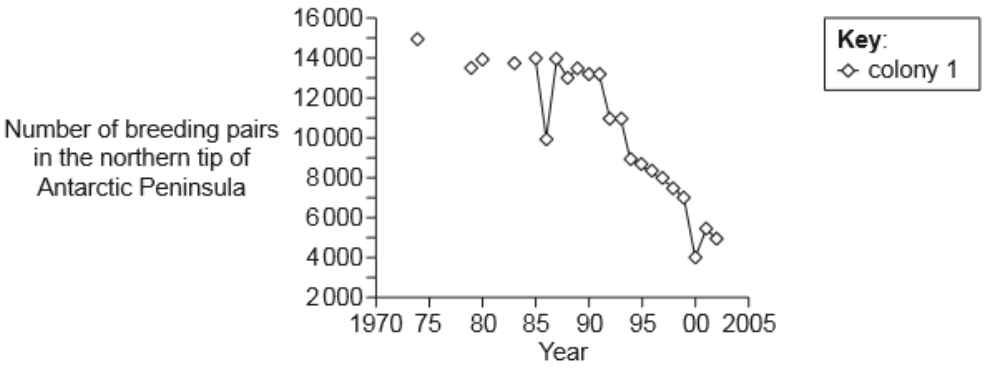
Scientists have calculated a long-term mean for the surface area of sea ice in the Arctic and in the Southern Ocean around Antarctica. This mean value is used as a reference to examine changes in ice extent. The graph shows the variations from this mean (zero line) over a period of time.

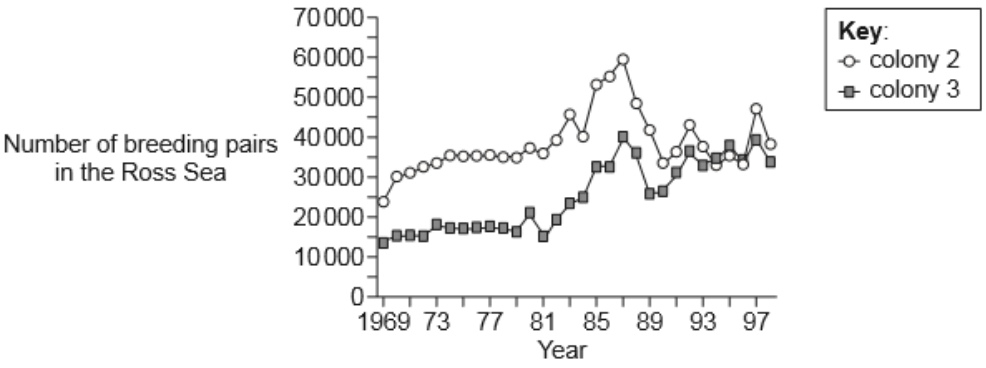


[Source: Data sourced from the penguinscience.com website]

Adélie penguins (Pygoscelis adeliae) are only found in Antarctica and need sea ice for feeding and nesting. Biologists are able to deduce how these penguins have responded to changes in their environment for the last 35 000 years, as the Antarctic conditions have preserved their bones and their nests. The image is a map of Antarctica and the surrounding Southern Ocean. It shows the trends in the length of the sea ice season (days of the year when sea ice is increasing) and the sites of nine Adélie penguin colonies.

The graphs show the changes in penguin population in three of the colonies shown on the map.





[Source: Data sourced from: www.penguinscience.com/clim_change.php]

a. State the trend in the surface area of sea ice in the Southern Ocean around Antarctica. [1]

b. Distinguish between changes in the surface area of sea ice in the Arctic and Antarctica. [2]

c. Discuss the data as evidence of global warming. [3]

d. Describe the trends in the length of the sea ice season around the Antarctic Peninsula and in the Ross Sea. [2]

e. Analyse the trends in colony size of the Adélie penguins in relation to the changes in the sea ice. [3]

f. Discuss the use of Adélie penguins in studying the effects of global warming. [3]

Markscheme

a. increasing/positive trend/correlation;

b. a. in the Arctic ocean the surface area of sea ice has declined whereas in Antarctica the surface area has increased;

b. the rate of change is greater for the Arctic than for Antarctica;

c. there are greater fluctuations in the surface area of sea ice in Antarctica than in the Arctic;

For mp a, it is acceptable if there is no comparative term such as "whereas" or "but";

c. a. change / decrease / melting of sea ice is expected with global warming;

b. decrease of sea ice in Arctic is supportive evidence of global warming;

c. increase in sea ice in Antarctic is not supportive evidence of global warming;

d. Antarctic increase / both changes may be associated with climate change (caused by global warming);

e. global warming does not affect all areas in the same way / global warming has complex effects;

f. data is inconsistent/inconclusive / data on its own does not establish cause and effect / not over a very long period of time;

d. *One mark for correct description of the trend off the Antarctic Peninsula and one mark for correct description for the Ross Sea; accept correct statements other than those listed in the scheme but do not award a mark for contradictions; marks can be awarded for correct statements about the sea ice season for Antarctica overall; Some students are referring to moving South in the Ross Sea when it is clear that they are moving North. If you can discern their intention, then give the BOD on this;*

Antarctic Peninsula:
a. decrease/stable at the base of the peninsula / decrease in the area of the penguin colonies/West of the tip / increase/+1 above and below the peninsula / variable pattern;

Ross Sea:
b. sea ice is increasing / +1 in the Ross Sea / area below / North of the Ross Sea / lower Ross Sea / Southern part of Ross Sea/closest to the South pole is stable/no change to the length of the sea ice season / variable pattern;

e. a. (off AP) sea ice season has declined as has penguin population;

b. colony 2 and 3 sea ice season has <u>not</u> declined <u>and</u> population increased;

c. colony 3 increase in population <u>and</u> growing length of sea ice season;

d. colony 2 has stable / increasing numbers and sea ice season is not changing;

e. colony size and sea ice season length/area are correlated;

f. Population numbers for colony 1 and 3 the same at start of study but both experience a big (opposite change);

Accept answers that refer to "sea ice" or "sea ice area".

f. a. global warming leads to climate / environmental change; *eg* temperature change / ice melting

b. stable ice associated with stable population / no climate change;

c. ice changes associated with population changes;

d. changes in penguin population size can indicate climate change / global warming;

e. example of how climate change can alter population; *eg* prey availability / habitat loss;

f. not all species will be affected in the same way (so care needed in applying conclusions more widely)

g. there is information on changes of population over the past 35 000 years;

Examiners report

a. Nearly all students noted the positive trend.

b. Most students noted that while the Arctic showed a decline, Antarctica showed an increase. Weaker answers involved a descriptive account or failed to notice a second difference between the Arctic and Antarctic data. Noting that the rate of change for the Arctic was greater was more commonly included in answers than detecting that the data was more variable for Antarctica.

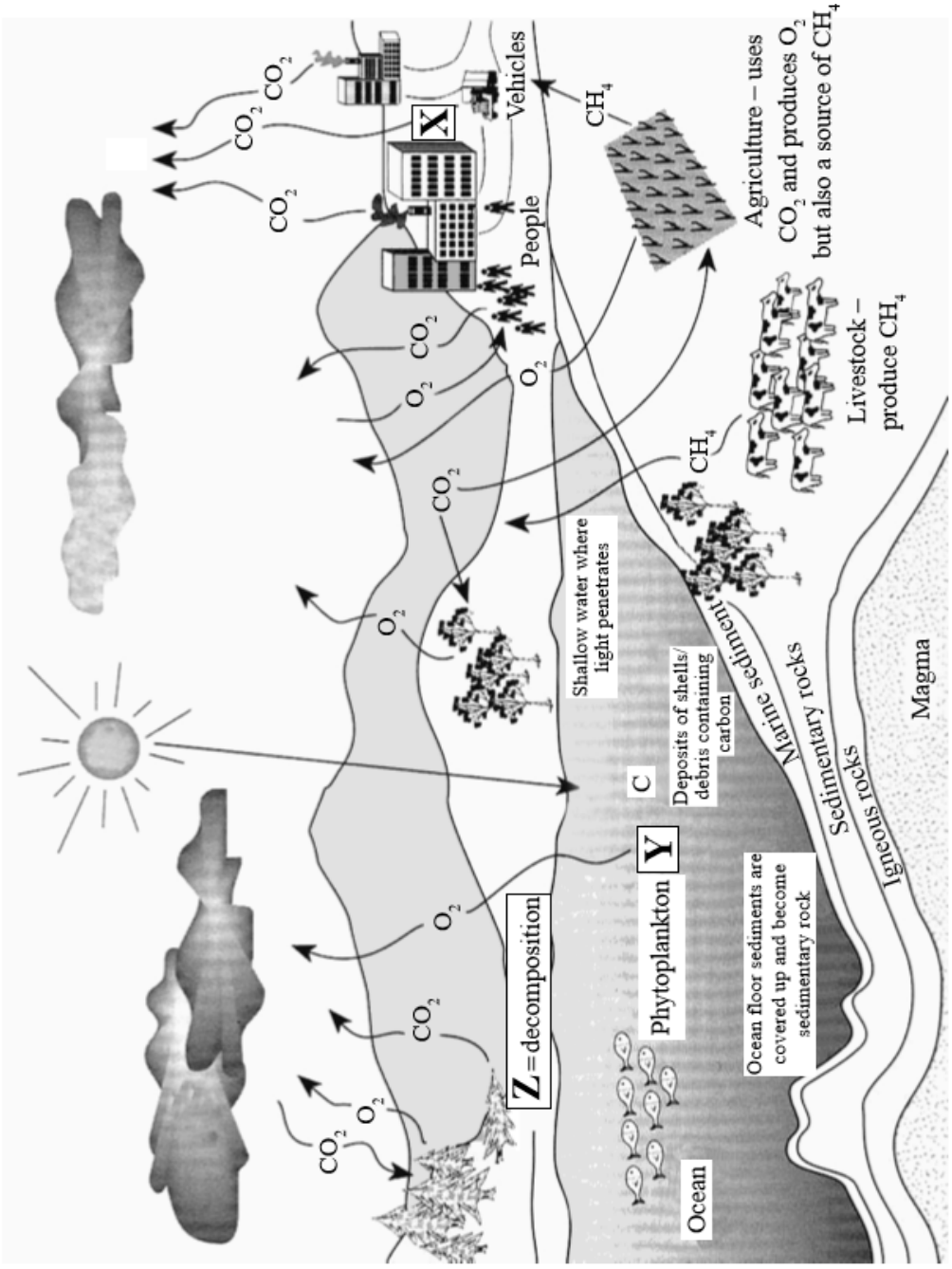
c. Most candidates noted that the data for Antarctica was supportive evidence of global warming. Weaker answers failed to state that the data was equivocal; strong candidates suggested global warming could lead to climate change with different outcomes in different locations.

d. Some respondents on the G2 forms raised concerns about the presentation of the data but most students earned these marks. A broad range of answers were accepted.

e. A number of candidates failed to link sea ice changes to population size changes. Better answers differentiated between colony 2 being stable and colony 3 having a growing ice season.

f. Many answered that penguin population changes could be used as indicators of the effects of global warming. Few extended the discussion to refer to historical data or limits to generalizing effects on penguins to other species.

The diagram below shows the carbon cycle.



[Source: adapted from www-das.uwyo.edu/~geerts/cwx/notes/chap01/carbon_cycle.jpeg]

a. State the process occurring at X and Y. [2]

X: .....

Y: .....

b. Suggest **one** type of organism that can be involved in process Z. [1]

c. Explain the relationship between the rise in concentration of atmospheric carbon dioxide and the enhanced greenhouse effect. [3]

Markscheme

a. X: combustion / burning;

Y: photosynthesis;

b. (saprotrophic) bacteria/fungi / saprotrophs

*Award **[0]** for decomposers*

c. carbon dioxide is a greenhouse gas (naturally produced by organisms);

human activity has increased the normal level of CO_2/caused enhanced greenhouse effect;

short-wave radiation from the Sun is re-radiated as longer wave radiation/ infrared/heat;

infrared/heat captured by greenhouse gases/CO_2;

Accept any of the above points shown in a clearly annotated diagram.

Examiners report

a. Many students were confused by the large schematic diagram, and did not understand the word „process" in part a. They were not able to state that X is combustion/burning and that Y was photosynthesis.

b. Due to the fact that "decomposition" was in the stem, "decomposers" was not allowed in part b. Saprotrophs/bacteria or fungi were accepted.

c. The hole in the ozone layer seemed to be well known in the South American centres. Unfortunately this has nothing to do with the answer expected in part c about the enhanced greenhouse effect! Few seemed to distinguish between the short wavelength/high frequency UV rays from the Sun and the long wavelength/low frequency IR rays reflecting back through the thickening atmosphere.