

The answers to the practice questions below are as given to the IB examiners. The following notes may help you to interpret these and make full use of the guidance given.

- There are no half marks awarded. Each mark is shown by the number in the square brackets [1].
- Points worth single marks are separated from each other by a semicolon (;).
- Alternative possible answers are separated from each other by a dash (/).
- Any answer given in **bold** or underlined must be present to score the mark.
- Information in brackets () is not needed to score the mark.
- Notes given in italics are to guide the examiner on what to accept/reject in their marking.
- OWTTE means 'or words to that effect', so alternative wording that conveys the same meaning can be equally rewarded.
- ECF means 'error carried forward', so examiners must award marks for an incorrect answer from an earlier part of a question used correctly in a subsequent step.
- M1, M2 etc. represent method marks to be awarded by an examiner for answers showing the appropriate steps of the working (method) necessary for answering the question.

A1.1 Water

Exercises

- Q1.** In a non-polar covalent bond, electrons making up the bond are shared equally / neither atom sharing the electrons has a greater electron density. In a polar covalent bond, electrons making up the bond are not shared equally / one of two atoms has a greater electron density than the other.
- Q2.** Water molecules are transpired / evaporated from stomata of a leaf.
Hydrogen bonding between water molecules in that area attract each other.
All water molecules in surrounding tissue / xylem are moved up.
Entire column of water in xylem is moved up.
Water is replaced to xylem in roots.
- Q3.** Possible soluble molecules and their functions:
Glucose (or any other monosaccharide or disaccharide) – used for energy / cell respiration.
Amino acids – used for synthesizing proteins / energy.
Proteins – used for a variety of purposes including enzymes.
Ions or salts – maintaining osmotic pressure in blood or other body fluids / more specific purpose if one specific ion is given.
Other answers possible for this question.
- Q4.** Possible insoluble molecules and their functions:
Fats or lipids or triglycerides – energy storage.
Steroids / hormones – chemical messengers.
Cholesterol – component of membrane structure.
Other answers possible for this question.
- Q5.** Webbed feet (for power when paddling) and streamlined body shape.
- Q6.** Presence of liquid water, suitable gravity to hold that water, and an atmosphere to reasonably shield planet surface from ionizing radiation.

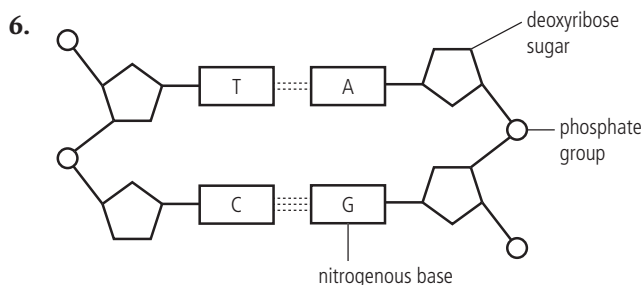
A1.2 Nucleic acids

Exercises

- Q1. eight
- Q2. They are both double-ring structures.
- Q3. (a) The phosphate and sugars are known to be there, but their structure is repetitive and not necessary when giving the sequence of nitrogenous bases.
 (b) When a single strand is given, the other strand is always complementary and thus easily known as well. In both (a) and (b), space and time to give the information desired is saved.
- Q4. That it must be an RNA molecule.
- Q5. C
- Q6. (a) guanine = 22%
 (b) adenine = 28%
 (c) thymine = 28%
- Q7. They do not form hydrogen bonds with each other.
- Q8. Because phosphorus is the central element in each phosphate group and there are many phosphate groups in DNA. Proteins are composed of amino acids and there are no amino acids that contain phosphorus.
- Q9. B

Challenge yourself

- carbons 5 and 3
- carbon 5
- carbon 1
- All eight sketches will look like the bottom sketch of A1.2 Figure 1. Four of the pentagon (sugar) shapes should contain ribose with adenine, cytosine, guanine and uracil. Four of the pentagon shapes should contain deoxyribose with adenine, cytosine, guanine and thymine.
- 11



- Check pattern of the eight added nucleotides. Also check that all adenines pair with thymines and all cytosines pair with guanines.
- The nucleotide circles should be complete nucleotides with a phosphate, a sugar and a nitrogenous base. Check that the phosphate circles are NOT a part of another nucleotide.
- It contains three phosphates.
- ribose (note the hydroxyl group bonded to carbon 2)
- adenine
- $X = 5'$; $Y = 5'$; $Z = 3'$

A1 Practice questions

- water has a high heat of vaporization / heat taken when hydrogen bonds break; water is cohesive so can be pulled up/so can be moved under tension in xylem; water is an excellent/universal solvent/dissolves many different substances; medium for transport in blood/xylem/phloem; medium for metabolic reactions; surface tension due to cohesion allows organisms to live on water surface; water has high heat capacity, therefore a lot of energy is required to change its temperature; ice floats so lakes/oceans do not freeze, allowing life under the ice; high heat capacity so forms a stable habitat/so temperature of water changes slowly; used in chemical reactions/photosynthesis/hydrolysis in organisms; coolant in sweat/in transpiration;

(Total 5 marks)

- O connected to two H forming a V shape; line between O and H of same molecule, labelled as covalent bond; three water molecules bonded together with dashed/dotted lines between O on one molecule and H on another molecule; dotted/dashed line labelled as hydrogen bond; O labelled as partial negative charge/ δ^- and H labelled as partial positive charge/ δ^+ ;

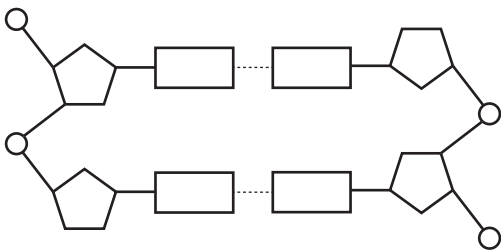
(Total 4 marks)




- (a) increasing/positive trend/correlation
 (b) in the Arctic Ocean, the surface area of sea ice has declined, whereas in Antarctica, the surface area has increased;
 there are greater fluctuations in the surface area of sea ice in Antarctica than in the Arctic;

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

- (c) decrease of sea ice in Arctic is supportive evidence of global warming; increase in sea ice in Antarctic is not supportive evidence of global warming; Antarctic increase / both changes may be associated with climate change (caused by global warming); global warming does not affect all areas in the same way / global warming has complex effects; data is inconsistent/inconclusive / data on its own does not establish cause and effect / not over a very long period of time;

4. Award 1 mark for each item shown correctly connected.



-  phosphate;
-  deoxyribose;
-  nitrogenous base / specific name, for example, adenine/thymine/guanine/cytosine shown connected to carbon-1;
- covalent bond / phosphodiester bond;

hydrogen bond;

nucleotide shown to include phosphate, sugar and base by shape or label;

diagram shows complementary base pairing or A bonded to T, C with G

Award 3 marks max. if the nucleotides are shown in a single strand.

Award 4 marks max. if antiparallel structure is not shown.

(Total 5 marks)

5. found in eukaryotes; consists of DNA wrapped around proteins/histones; histones are in an octamer/group of eight; are held together by another histone/protein; in linker region; help to supercoil chromosomes / to facilitate DNA packing; (function is to) regulate transcription / gene expression;

(Total 4 marks)

A2.1 Origins of cells

Exercises

- Q1. the time needed for its radioactivity to reach half its original level
- Q2. reducing atmosphere; no free oxygen; presence of water vapor; methane, carbon dioxide and ammonia existed in the atmosphere; frequent electrical storms
- Q3. membranes provided a boundary which protected the early cells from their harsh surrounding environment; membranes allowed chemical reactions to occur within the cell without interference from reactions outside the cell; as time proceeded in cell development, membranes allowed specialization of areas within the outermost cell membrane
- Q4. RNA is composed of small sub-units called nucleotides; variation in the sub-unit order could have allowed RNA to carry the cell's genetic code; RNA, such as in modern day ribozymes, could have functioned in the control of chemical reactions within the cell
- Q5. The last universal common ancestor (LUCA) would be at the base of the tree representing all forms of life present today and its ancestors. These forms of life, both past and present, would be represented as branches coming from the LUCA.

A2.2 Cell structure

Exercises

- Q1. C
- Q2. a protein
- Q3. A
- Q4. B
- Q5. D
- Q6. D
- Q7. Mitochondria and chloroplasts have their own circular DNA.
Circular DNA is found in prokaryotes, not in the nuclei of eukaryotes.

Mitochondria and chloroplasts undergo binary fission, as prokaryotes do.

Q8. membrane

Q9. Changes in gene expression make specialization and differentiation of cells possible. This occurs when different signalling molecules in the environment activate or repress different transcription factors, which are necessary to express certain genes in the DNA.

Challenge yourself

- Answer or things to note on drawing: The plasma membrane should be adjacent to but separate from the cell wall. The ribosomes should be dot-like structures within the cytoplasm because of their small size. In the case of ribosomes, there should be many dots reflecting the large numbers of ribosomes which occur in most bacterial cells. The DNA should be shown as long and threadlike with connected ends occupying the central area of the cell.
- The drawings should end with this most logical explanation: 1) the bacterial cell (potential organelle) meets the larger cell; 2) engulfing (phagocytosis) occurs; 3) a section of the larger cell's plasma membrane surrounds the engulfed bacterial cell; 4) two membranes are now present – the one provided by the receiving cell and the one already intact on the bacterium.

A2.3 Viruses

Exercises

Q1. Because all viruses are obligate parasites this means that they are totally dependent on their host cell to carry out the necessary functions of life. Because of this they need no ribosomes to carry out protein synthesis, and they need no mitochondria to produce energy. They only have one type of genetic material (either DNA or RNA) since they can utilize the genetic material they do not have from the host cell for replication. Because they exist inside host cells, they all have similar structures and processes. This is what happens in convergent evolution, similar environments give rise to similar structures and processes.

Q2. D

Q3. D

Q4.

Lytic cycle	Lysogenic cycle
Requires attachment of a virus	Requires attachment of a virus
Requires a host cell	Requires a host cell
New genetic material is synthesized	Viral genetic material integrates into the bacterial DNA
Many new virus particles are produced	No new virus particles are produced
Host cell ruptures releasing many viruses	Host cell continues to reproduce, maintaining the virus genetic material within its genome

Q5. capsid composed of protein; outer boundaries of types of viruses are of a shape which is both specific and consistent from generation to generation; some viruses have an outer layer known as a viral envelope which is derived from the host cell; some viruses have capsids which include an enzyme that aids entry of its genetic material into the host cell

A2 Practice questions

1. (a)

Name of organelle	Structure of organelle	Function of organelle
Nucleus	Region of the cell containing chromosomes, surrounded by a double membrane, in which there are pores.	Storage and protection of chromosomes.
Ribosome	Small spherical structures, consisting of two subunits.	Translates RNA into / synthesizes polypeptides/ proteins;

Lysosomes;	Spherical organelles, surrounded by a single membrane and containing hydrolytic enzymes.	Digestion of structures that are not needed within cells.
Mitochondria;	Organelles surrounded by two membranes, the inner of which is folded inwards.	Aerobic respiration / production of ATP; <i>Do not accept production of energy.</i>

[4]

- (b) eukaryotic; membrane-bound organelles / nucleus (as reason for being a eukaryote) could be plant or animal; probably animal because of the lysosomes;

[2]

(Total 6 marks)

2. (a) resolution: separate points / focus clearly / greater detail / clarity; magnification: size of image / view / picture;

[2]

- (b) I: membrane / (nuclear) envelope; II: mitochondrion / mitochondria;

[2]

- (c) aerobic respiration; correct specific reaction / pathway occurring in mitochondria / ATP production;

[1]

Do not accept production of energy.

- (d) eukaryotic, internal membranes / membrane-bound organelles / presence of mitochondria / double nuclear membrane;

[1]

(Total 6 marks)

3. labelled diagram of generalized prokaryotic (P) and generalized eukaryotic (E) animal cell
(Marks must be awarded if the following comparisons are made as either annotations to the diagram or in narrative / table form.)

P is usually smaller in size, E is larger; both have cytoplasm / protoplasm; P has no nucleus / nucleoid region, E has (membrane-bound) nucleus; P has one chromosome / circular, E has two or more chromosomes; P has DNA only, E has DNA with protein (histones); P has no membrane-bound

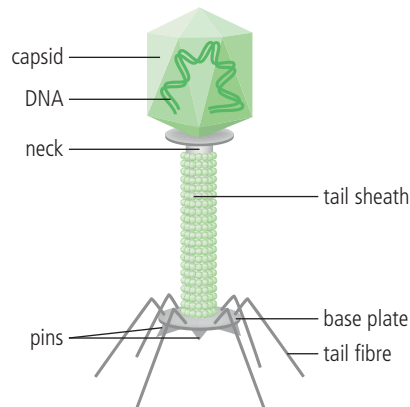
organelles, E has some membrane-bound organelles; E has mitochondria, P does not; E has other example of organelle, P does not; both can have a flagellum / flagella; if flagella then E has 9+2 fibrils, P does not; P can have pili / slime layer / capsule, E does not; P can have plasmids, E does not; both have ribosomes; P has small ribosomes, E has larger ones; both have cell membrane; P has cell wall, E has no cell wall; E has centriole, P has no centriole;

(Total 8 marks)

4. universal genetic code carried by DNA in all cells; over 300 genes or sections of DNA common to all cells; same building blocks for both DNA and RNA in all cells; similar transport mechanisms of cellular materials in and out of cells/within cells; common molecular processes within all cells including replication of DNA molecules and the production of proteins;

(Total 4 marks)

5.



1 mark for each structure properly drawn with label.

(Total 7 marks)

6. (a) lightning as a potential source of energy; large concentration of water vapour in the atmosphere; carbon dioxide and methane were two gases in high concentration within the atmosphere; high surface temperature on the planet due to penetrating ultraviolet light followed by gradual cooling; a number of gases were present in the atmosphere from erupting volcanoes; a reducing atmosphere in which carbon-hydrogen bonds were favoured;

One mark each to a total of four marks.

[4 max.]

(b) Arguments against the model: the early Earth atmosphere was actually a non-reducing environment; in a water environment, individual amino acids do not form more complex structures such as proteins; no proof the gases used in the Miller–Urey model actually existed on early Earth. Arguments for the model: lightning was common on early Earth as an energy source; gases of early Earth allowed a reducing environment resulting in formation of more complex organic compounds; a ‘primordial soup’ type of environment was present, favouring the spontaneous formation of early life.

Answer must have two marks from each argument in order to achieve the four marks possible.

[4 max.]

(c) some of the Earth’s oldest fossilized traces or precipitates have originated at hydrothermal vents; hydrothermal vents present a mineral-rich environment which were essential in the formation of the first life; hydrogen and carbon dioxide both exist near these vents, allowing for the increased development of life; there is a commonality of genetic sequences in the organisms near these vents;

One mark each to a total of three marks.

[3 max.]

(Total 11 marks)

7 RNA can spontaneously form from simpler organic molecules called nucleotides; RNA demonstrates the ability to control chemical reaction thus acting as enzymes; RNA is able to form copies of itself thus allowing possibilities of inheritance properties; RNA is simpler than DNA indicating it was present before DNA;

One mark each to a total of three marks.

(Total 3 marks)

8 The virus attaches to a site on a specific host cell; the virus incorporates its genetic material into the cytoplasm of the host cell; the host cell machinery is used to produce components of the virus; the virus components are assembled into a complete virus; the new virus is released into the host cell’s environment.

One mark each to a total of three marks.

(Total 4 marks)

9. Lytic cycle	Lysogenic cycle
Virus particle attaches to bacterial cell	Virus particle attaches to bacterial cell
Virus injects its genetic material into the bacterial cell	Virus injects its genetic material into the bacterial cell
Virus directs synthesis of viral components by the bacterial cell	Virus does not direct synthesis of viral components by the bacterial cells
Virus genetic material does not recombine with the bacterial cell DNA	Virus genetic material does recombine with the bacterial cell DNA
New viruses are formed for release when the bacterial cell ruptures	No new viruses are formed. Bacterial cell continues to reproduce with the recombined virus genetic material. Bacterial cell does not burst.

Table should show direct comparisons, as above. One mark per comparison.

(Total 4 marks)

A3.1 Diversity of organisms

Exercises

- Q1.** Binomial nomenclature; perfected and popularized by Carl Linnaeus.
- Q2.** The morphological definition of species states that organisms can be placed in the same species if they share similar physical features, whereas the biological species concept states that the organisms must be able to breed and produce fertile offspring.
- Q3.** Size, position of centromere and banding patterns.
- Q4.** Diploid cells have two copies of each chromosome, one paternal and one maternal in each pair ($2n$) whereas haploid cells only have a single copy of each chromosome (n).
- Q5.** A karyogram can be used to determine if an unborn baby will be a girl or a boy. By looking at the 23rd pair of chromosomes, it is possible to determine if

the baby is a girl (two large chromosomes, XX) or a boy (one large chromosome, X and one small, Y).

- Q6.** Two ancestral acrocentric non-human chromosomes, when placed end to end, have a similar length to human chromosome 2. Satellite DNA that is usually associated with the centromere is present in a place on the human chromosome that corresponds to where the ancestral centromere would have been. The banding patterns on the ancestral non-human chromosomes match the human chromosomes.
- Q7.** Advantages: By knowing a person's genome, personalized medicine can help to determine the most effective type of treatment, the optimum dosage and reduce undesired side effects.
- Q8.** For: Environmental DNA barcoding can identify many species from a single sample and is much faster than capturing animals.
Against: Just because DNA is present does not mean the organism is still alive. Barcoding only says that the DNA is present in the sample, it tells us nothing about the numbers of individuals.

Challenge yourself

1. Student's own answer.

A3.2 Classification and cladistics

Exercises

- Q1.** Disadvantages may include the fact that hierarchies can be considered arbitrary and do not necessarily show evolutionary relationships between species. Categories in a hierarchical system do not allow for the accurate representation of gradations in variation.
- Q2.** (a) one difference
(b) four differences
(c) Species B is more likely to be a horse because we would expect more genetic differences between humans and horses than between humans and chimpanzees.
- Q3.** Homologous structures, such as the pentadactyl limb, are those that show a common ancestor but do not necessarily serve the same purpose, whereas analogous structures, such as wings in insects and birds, serve the same purpose but did not evolve from a recent common ancestor.
- Q4.** The hypothesis was refuted by the data he collected, notably differences in the subunit of Archaeal ribosomes, the types of metabolism, using methane or hydrogen, which are not possible in bacteria, transcription and translation in methanogens, which resembled eukaryotes more than bacteria and the presence of certain compounds in their cell membranes or cell walls that are not typical of bacteria.

A3 Practice questions

- A is most similar to B; A is equally similar to C and D; A is least similar to both C and D.
- A
- D
- A
- (a) *Canis aureus*/golden jackal AND *Canis lupus*/grey wolf [1]
(b) *Hapalemur aureus*/golden bamboo lemur AND *Canis aureus*/golden jackal/*Canis lupus*/grey wolf/*Vulpes vulpes*/red fox OR *Vulpes vulpes*/red fox AND *Canis aureus*/golden jackal/*Canis lupus*/grey wolf/*Hapalemur aureus*/golden bamboo lemur [1]
(Total 2 marks)
- methods to prepare cladograms use a different approach from traditional classification/taxonomy; show ancestral relationships; reflect how recently two groups shared a common ancestry; cladograms are (objective/accurate because they are usually) based on molecular differences; they should be considered as a good complement to traditional classification
(Total 2 marks)
- all four organisms have vertebrae; shark is the oldest/furthest from human/other examples of relationships between the four organisms; human only one with all four characteristics; appearance of legs separated others from shark; appearance of mammary glands separated kangaroo and human from bullfrog; appearance of placenta separated human from kangaroo; both kangaroo and human are mammals
(Total 3 marks)

A4.1 Evolution and speciation

Exercises

- Q1.** B
- Q2.** C
- Q3.** D
- Q4.** Farmers and animal breeders noticed that when they selected the members of their breeding population that had the most desirable characteristics, over many generations they ended up with plants and animals that were very different from the original varieties. The plants and animals found on farms today are very different from their ancestors; this is evidence of evolution. The driving force, however, is artificial selection rather than natural selection.
- Q5.** During the Stone Age, farmers planted teosinte. Each generation, they selected the grains that were the largest and softest. Over many generations, maize was developed. Certain traits, such as the husk to protect the kernels, were selected for by artificial selection.
- Q6.** Adaptive radiation occurs when many species evolve from a single species in a relatively short time. Examples include lemurs on Madagascar or finches on the Galapagos Islands where each species evolved to be well adapted to different niches.

Challenge yourself

1. (a)

Characteristic	Bat	Bird	Human	Horse	Dolphin	Turtle
Number of digits (fingers)	5	3	5	1	5	5
Description of phalanges (finger bones) (short/long, wide/narrow)	Very long and thin	Short	Long and thin	Long and wide	Wide	Short
Type of locomotion that the limb is best adapted for	Flight	Flight	Grasping rather than locomotion	Running	Swimming	Swimming and walking

- (b) Birds and horses have lost digits from the original five-fingered common ancestor, presumably for different reasons. It can be hypothesized that wings which had more fingers were heavier and slowed down the birds, whereas natural selection would have favoured mutations of fewer fingers, making the wings lighter. Having no fingers at all would be a disadvantage, however, as wings need some support. Another reason is that the hollow cartilage in the feathers plays some of the role of support and so five fingers are not necessarily needed for support. Fossils of ancient horse skeletons contain more than just one digit on each leg. It can be hypothesized that running through tall grass to escape from a predator might be slowed down by having multiple, heavy digits. Horses born with fewer digits could run faster and escape more easily, increasing their ability of surviving and passing on the genes for fewer digits to the next generation. Also, having one long finger (or in this case, a toe), can generate more torque to run faster than having multiple short toes.

A4.2 Conservation of biodiversity

Exercises

- Q1. B
- Q2. *Many wordings possible.*
Genetic diversity applies to the range of the gene pool within a population of a species. Large, genetically healthy populations tend to have a high genetic diversity. Species diversity is a term used for the number of species (species richness) and abundance of each species (evenness) within an ecosystem.
- Q3. *Many wordings possible.*
The single biggest difference is that most of the factors causing extinctions today are a result of human activities. Humans had not yet evolved when the other five extinction events occurred.
- Q4. *Many wordings possible.*
Increase in ocean temperatures as a result of increased greenhouse gases; acidification of ocean waters as a result of increased CO₂ release; pollution

from coastal communities; overfishing and collection of reef specimens.

- Q5. *Many wordings possible.*
The species must be rated evolutionarily unique (no or few close genetic relatives) and have a rating by the IUCN Red List that indicates protection is warranted.
- Q6. *Many wordings possible.*
Germplasm tissue is the reproductive cells of animals (sperm or ova) and also includes early developing embryo tissue. As many species continue toward extinction these reproductive cells may be used for captive breeding programs. Cryogenic preservation allows long-term storage and future use.
- Q7. *Many wordings possible.*
Germplasm secured from a wild population helps to increase the genetic diversity of organism populations kept in captivity.

Challenge yourself

- Kingdom Animalia, Phylum Chordata, Class Mammalia, Order Carnivora, Family Felidae, Genus *Puma*, Species *Puma concolor*. The Florida Cougar is also a mammal but is not a primate. Therefore the taxa are different starting with Order and moving downwards.
- pest problems; pesticide resistance; declining biodiversity; soil degradation; high use of fertilizers; environmental pollution and climate change; require a lot of water; overproduction of commodity crops; dangerous for bees; high risk of harvest loss; fossil fuel-dependent

A4 Practice questions

- can be sympatric or allopatric; temporal isolation by members of different populations reproducing at different times; behavioural isolation by difference in courtship behaviours; geographic isolation by a population being separated by river/mountain/barrier to contact; an example of a geographic barrier is required; polyploidy;

(Total 3 marks)

2. evidence supports that this is a time in Earth's history with very high species richness; statement does not support environmental health; species richness may simply be a result of adaptive radiation / due to evolution; rate of species extinction is currently very high; scientific evidence suggests many ecosystems are currently threatened; only limited support for changing human reliance on limited resources;

(Total 4 marks)

3. sustainable communities/ecosystems allow continued survival of organisms/OWTTE; natural ecosystems can be sustainable over long periods of time/OWTTE; natural ecosystems/rainforest more sustainable than agricultural areas/plantations; diverse community/high biodiversity/higher biodiversity in natural ecosystems/rainforest OR less/low biodiversity in agricultural areas/agricultural soils; agricultural areas/monocultures more affected by pests/diseases; nutrient recycling (efficient) in natural ecosystems/rainforest; nutrients removed with crops/nutrients removed when crops are harvested OR less formation of humus/less organic matter in agricultural soils; more water recycling/more rainfall/more transpiration in natural ecosystems/rainforest; larger biomass/more carbon stored (in biomass) in natural ecosystems/rainforest; shallower soils/less soil erosion/degraded soils/infertile soils in agricultural areas;

(Total 3 marks)

4. establishment of national parks; establishment of nature reserves; rewilding of damaged areas; reclamation of areas severely degraded areas by strip-mining and clear cutting;

(Total 2 marks)

5. zoo breeding programs; botanical gardens; seed banks; animal tissue banks;

(Total 2 marks)

6. polyploidy is having more than two sets of (homologous) chromosomes; triploid has three sets/is $3n$; tetraploid has four sets/is $4n$; allium/vizcacha rats/other named example; details of chromosome numbers in diploid and polyploid species in the example; non-disjunction/failure of chromosome pairs to separate during meiosis; diploid gamete (can lead to polyploidy);

fusion of diploid and haploid gamete produces triploid cells;

DNA replication but no subsequent mitosis doubles the chromosome number / produces tetraploid (from diploid)

OR

fusion of two diploid gametes produces tetraploid/ $4n$; polyploid/tetraploid (crossed) with diploid/non-polyploid produces infertile offspring;

meiosis fails in triploids because (homologous) chromosomes cannot pair up;

polyploid individuals are reproductively isolated

OR

polyploidy causes instant/immediate speciation

OR

tetraploids can form a new species because they can cross with each other

OR

polyploids cannot cross/produce fertile offspring with diploids;

speciation by polyploidy is common in plants/ commoner in plants than animals; polyploid individuals tend to be larger;

(Total 7 marks)

B1.1 Carbohydrates and lipids

Exercises

- Q1. (a) hydroxyl (or alcohol)
 (b) carboxyl and amine
 (c) phosphate, hydroxyl and amine
- Q2. (a) $C_3H_6O_3$
 (b) $C_5H_{10}O_5$
 (c) $C_6H_{12}O_6$
- Q3. (a) types O and A
 (b) types A and AB
- Q4. (a) condensation reaction
 (b) water would be a product
- Q5. (a) hydrolysis reaction
 (b) water would be a reactant

B1.2 Proteins

Exercises

- Q1. An alpha central carbon, an amine or amino group, a carboxyl group, a hydrogen, and a variable group, of which there are 20 possibilities.
- Q2. 165
- Q3. amino acid + amino acid \rightarrow dipeptide + water
- Q4. (a) At 8°C above the enzyme's optimum temperature, hydrogen bonds would no longer be able to hold the molecule in a suitable shape for catalytic function / the molecule would become denatured.
 (b) 8°C above optimum temperature would likely not be disruptive to the peptide and other covalent bonds within the enzyme. Therefore, the bonds giving shape to the enzyme would become re-established and the catalytic ability would return.
 (c) 50°C above optimum temperature would likely break covalent bonds within the enzyme, disrupting the primary structure. When the molecules return to optimum temperature, the amino acids would no longer

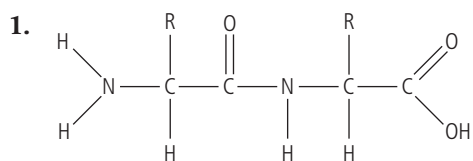
be in proper sequence and could not reform the original shape of the molecule. Therefore, the catalytic ability would return.

- Q5. (a) The R group for each of the amino acids will differ in structure, electrical charge, and polarity.
 (b) All amino acids in an aqueous solution will have ionized carboxyl and amine groups that will give some solubility in water.
- Q6. C
- Q7. B
- Q8. hydrogen bonds, ionic bonds, disulfide bonds, hydrophobic interactions
- Q9. Secondary structured proteins are composed of non-polar amino acids made up of only a few types of amino acids. The overall structure is very repetitive (alpha helix or beta pleated sheet) and is not suitable for a complex interaction with other molecules.
- Q10. (a) there are four polypeptides joined together to make a single protein
 (b) each polypeptide contains a heme group with iron at its center

Challenge yourself

1. 1 lysine – polar due to ionized 'R' group; 2 aspartic acid – polar due to ionized 'R' group; 3 valine – non-polar; 4 valine – non-polar; 5 cysteine – polar (forming a disulfide bond); 6 serine – polar; 7 asparagine – polar; 8 cysteine – polar (forming a disulfide bond)

B1 Practice questions



two amino acids, one with $\text{NH}_2/\text{NH}_3^+$ end and one with COOH/COO^+ end; peptide bond between $\text{C}=\text{O}$ and $\text{N}-\text{H}$ correctly drawn (labels not required for amino group and carboxyl group); chiral C with H and R group on each amino acid; peptide bond labelled/clearly indicated between C terminal of one amino acid and N terminal of the second amino acid

(Total 3 marks)

2 chains of glucose/1-4 glycosidic linkages/covalent bonding between glucose; beta glucose so alternating orientation of glucose units OR beta glucose forms straight chains; forms microfibrils/long and thin/thin fibres/parallel bundles of cellulose molecules OR hydrogen bonding/cross linkage between cellulose molecules holds them together; high tensile strength/rigid/doesn't stretch so provides support/allows turgidity

(Total 2 marks)

3. (a) I is alpha helix and II is beta pleated sheet [1]
Reject (α) double helix but accept α /A/a and β /B/b instead of alpha and beta.

(b) hydrogen bonds

Reject hydrogen and covalent bonds unqualified and hydrogen bonds between bases.

(hydrogen bonds) between N-H and C=O (on different amino acids);

Reject between amine and carboxyl groups.

(hydrogen bonds) between adjacent turns of the helix/every fourth amino acid (2 max.)

Accept above points in an annotated diagram.

(c)

Globular	Fibrous
water soluble (mostly)	not (water) soluble
rounded shape / tertiary structure	long/narrow shape / no tertiary structure
enzymes/hormones/ catalysis/transport/ defence functions	structural/movement functions

(2 max.)

A table is not required but for each feature the difference between globular and fibrous proteins must be made clear.

(Total 5 marks)

4. Allow mark points shown in a clearly annotated diagram.

In any part of the answer, accept polar instead of hydrophilic and non-polar or apolar instead of hydrophobic.

hydrophilic is attracted to/insoluble in water and hydrophobic not attracted/insoluble; hydrophilic phosphate/head and hydrophobic hydrocarbon/tail in phospholipids; phospholipid bilayer in water/ in membranes; hydrophilic heads (of phospholipids) face outwards/are on surface; hydrophobic tails (of phospholipids) face inwards/are inside/are in core; cholesterol is (mainly) hydrophobic/amphipathic so is located among phospholipids/in hydrophobic region

of membrane; some amino acids are hydrophilic and some are hydrophobic; hydrophobic (amino acids/ regions of) proteins in phospholipid bilayer (core); hydrophilic (amino acids/regions of) proteins are on the membrane surface; integral proteins are embedded in membranes due to hydrophobic properties/region OR transmembrane proteins have a hydrophobic middle region and hydrophilic ends; peripheral proteins are on the membrane surface/among phosphate heads due to being (entirely) hydrophilic OR (carbohydrate) part of glycoproteins is hydrophilic so its outside the membrane; pore of channel proteins is hydrophilic;

(Total 7 marks)

B2.1 Membranes and membrane transport

Exercises

Q1. D

Q2. D

Q3. The phospholipid tails are composed of fatty acids which are hydrophobic (non-polar). The head of the phospholipid includes a phosphate group which is hydrophilic (polar). When placed in water, the hydrophilic head of the phospholipid molecules orient toward the polar water molecules, while the hydrophobic tails of the phospholipid molecules orient inward toward each other resulting in the formation of a bilayer.

Q4. Plant cell membranes have very few cholesterol molecules present in the phospholipid tail region. Animal cell membranes have many cholesterol molecules in this same region. The cholesterol allows fluidity and stability of the animal cell membranes. Plant cells do not need this feature as much due to the presence of a cell wall.

Q5. B

Q6. aquaporins

Q7. Carrier proteins need energy in the form of ATP to transport substances in or out of the cell. Because there is a need for energy, this is an example of active transport.

- Q8.** (Exocytosis is an example of bulk transport.) The enzyme will be made in the rough endoplasmic reticulum and completed in the Golgi body. The enzyme will then be packed into a vesicle and transported to the cell membrane. The vesicle fuses with the cell membrane so that the two membranes combine; and the contents of the vesicle are released outside the cell.
- Q9.** The fluid arrangement of phospholipids and proteins in the cell membrane make exocytosis possible / the molecules in the membrane are not static / the molecules can slide and rearrange themselves. This allows the two membranes to fuse together. The flexibility of the membrane also allows vesicles to form.
- Q10.** Enzymes are large protein molecules. They have charged amino acids. They cannot pass through the phospholipid bilayer.

Challenge yourself

- In haemodialysis, waste in your blood diffuses towards the dialysate because that contains little or no waste. Excess fluid moves, via osmosis, from the blood to the dialysate through a semi-permeable membrane until the concentration of water is the same in the blood and the dialysate. The dialysate must be constantly changed so that waste does not build up and to maintain the correct concentration of water.
- The fatty acids of the endoplasmic reticulum contain mostly unsaturated phospholipids. The double bonds increase branching of the fatty acid tails. The result of this is a thinner membrane which is more fluid, allowing greater curvatures characteristic of endoplasmic reticulum membranes.
- The top drawing is of the endoplasmic reticulum membrane. This membrane is thin compared to the second drawing, which is of a plasma membrane. The thinner membrane is possible due to there being more unsaturated bonds in the fatty acids, resulting in branching of the fatty acid tails. It should also be noted that the heads of the phospholipid molecules of the plasma membrane are closer together than the heads of the endoplasmic reticulum membrane. This allows more protection and stability for the cell.

B2.2 Organelles and compartmentalization

Exercises

- Q1.** The eukaryotic cell possesses a nucleus which allows the separation needed for post-transcriptional modification to occur. The prokaryotic cell does not have a separating nucleus present to allow this modification.
- Q2.** gel electrophoresis; proteins and nucleic acids
- Q3.** Allows division of labour within the cell, with specific tasks performed by organelles or organelle-like areas; enzymes needed for specific tasks are all together in a particular region; chemical reactions are isolated so as not to affect one another; chemical products are isolated so as not to interfere with other reactions going on in the cell.
- Q4.** D
- Q5.** A
- Q6.** B
- Q7.** D
- Q8.** E
- Q9.** C
- Q10.** Extensive membrane surface area of the thylakoids for greater absorption of light; small lumen/space and low volumes of fluid within the thylakoids for faster accumulation of protons to create a concentration gradient; stroma region is like the cytoplasm of the cell: it provides a region where the enzymes necessary for the Calvin cycle can work; double membrane on the outside which isolates the working parts and enzymes of the chloroplast from the surrounding cytoplasm.
- Q11.** Allows a quicker attainment of high proton/hydrogen concentration so that the electron transport chain and chemiosmosis may proceed efficiently.

Challenge yourself

- A
 - C
 - D
 - B
 - D, B. These structures contain the green pigment chlorophyll.
 - The movement allows more chloroplasts to be exposed to a light source. This results in greater production of the products of photosynthesis.

- Any three of the following for full credit:*

requires the expenditure of energy in the form of ATP; involves the movement of substances against a concentration gradient; takes place in highly selective proteins of the membrane which bind with the substance to be transported; allows the cell to maintain different internal concentrations of molecules from the concentrations outside the cell;

(Total 3 marks)

- Selectively permeable means only certain substances may move through the membrane; proteins are highly specific as to which substances may bind to them; the specificity of the protein is due to its particular amino acid sequence; only substances with the correct electrical properties may bind with the protein.

(Total 4 marks)

- allows transcription to occur in the nucleus without interference from processes and molecules present in the cytoplasm; specific enzymes may be grouped together to allow efficient chemical reactions within the cell; allows division of labor within the cell, with specific tasks performed by single organelles or organelle-like structures; allows larger numbers of compartments/organelles providing cells specialized for certain tasks; allows safe and effective storage of materials within the cell;

(Total 4 marks)

- surface area of a cell decreases at a slower rate than the volume of a cell; volume increases by a factor involving cubing the radius, while surface area increases by a factor involving squaring the radius; a large cell, compared to a small cell, has a comparatively smaller surface area with which to bring in needed materials and to rid the cell of waste; cells that become too large are not able to bring in enough materials to meet their needs; cells that become too large do not have enough surface area to adequately rid the cell of waste;

(Total 3 marks)

B2.3 Cell specialization

Exercises

- B
- D
- B
- A
- C
- A

B2 Practice questions

- Any three of the following for full credit:*

the hydrophobic and hydrophilic opposite ends of phospholipid molecules allow the formation of a bilayer with the hydrophobic tails oriented to the middle of the bilayer and the hydrophilic heads oriented to the outside of the bilayer towards water; cholesterol adds fluidity to the membrane in animals; the orientation of the phospholipid molecules allows flexibility along with stability of the membrane; glycoproteins and glycolipids provide adhesive and protective functions to the membrane; proteins fit into the membrane structure based on the hydrophilic and hydrophobic properties of their component amino acids, and allow a degree of stability; the electrical properties of the molecules involved provide the attraction properties to help maintain the overall membrane structure;

(Total 3 marks)

6.

Totipotent stem cells	Pluripotent stem cells	Multipotent stem cells
Only last 4–6 days early in embryo stage	Exist after 4–6 days in embryo stage	Exist after embryo in adult stage
Can produce any tissue in the organism, also a complete organism	Can produce most but not all tissue of the organism, may not produce a complete organism	Can produce only a limited number of cell types and certainly not a complete organism

(Total 3 marks)

7. Extensive membrane surface area of the thylakoids allowing greater absorption of light by photosynthesis; small lumen/space allowing faster accumulation of protons to create a concentration gradient; stroma region similar to the cell cytoplasm providing a region for enzymes necessary for the Calvin cycle to work; double membrane on the outside which isolates the working parts of the chloroplasts from the surrounding cytoplasm.

(Total 4 marks)

8. A nerve impulse / membrane potential takes place due to sodium ions moving into the cell through specialized channels; when sodium moves into the cell, depolarization is said to occur; potassium ions move out of the cell, producing repolarization of the cell; the protein carrier in the sodium–potassium pump binds three sodium ions and pumps them out of the cell, using ATP; after releasing the sodium ions to the cell exterior, the protein pump binds two potassium ions and carries them inside the cell; because more positive charges are going out of the cell than coming in, a negative charge is maintained within the cell.

(Total 3 marks)

9. (a) type 1 pneumocyte – thin and flat in shape, allowing for high surface area
 (b) muscle fibres – membrane capable of impulse propagation; multinucleated, allowing control over the large muscle fibre;
 (c) red blood cells – contain the protein haemoglobin which can combine with and release oxygen; flat disc shape, allowing more surface area for oxygen absorption; flexible and size-limited to allow movement through narrow capillaries;

(Total 3 marks)

B3.1 Gas exchange

Exercises

- Q1. The problem is one of the surface area to volume ratio. When surface area increases, the increase is a squared function. When volume increases, the increase is a cubed function. The surface area to volume ratio of an amoeba is a much higher number compared to the surface area to volume ratio of a rabbit. There is no way an animal like a rabbit could diffuse in and out the respiratory gases necessary for an organism of that size.
- Q2. The concentration gradient of both oxygen and carbon dioxide would quickly equalize and the net diffusion would stop for both gases. Tissues would not be replenished with oxygen, and carbon dioxide would not be taken away.
- Q3. The surfactants produced act to lower the surface tension of the film of water coating the inside of the alveoli. When air rushes out of each alveolus during an expiration, the surfactants prevent the collapse of the thin-walled air sac.
- Q4. C
- Q5. A spirometer measures volumes of air moving into or out of the lungs.
- Q6. The epidermal cells of leaves secrete a waxy coating called the cuticle. The cuticle prevents evaporation of water.
- Q7. High temperature, high wind speed and low humidity.
- Q8. (a) The Bohr shift is a term that describes haemoglobin's lowered affinity for oxygen after binding to carbon dioxide.
 (b) During exercise, there is an increased rate of cell respiration, and muscles will have a greater need for oxygen. The muscle tissue will produce more carbon dioxide, which will bind to haemoglobin, and a higher amount of oxygen will then be released.
- Q9. Cooperative binding refers to the affinity that haemoglobin has for oxygen as a result of oxygen binding. Once a single oxygen binds, the shape of the haemoglobin molecule changes to make it even

more likely to bind a second oxygen molecule. Each additional oxygen molecule increases the affinity even more, up to a maximum of four oxygen molecules.

- Q10.** To the left means that fetal haemoglobin will bind oxygen at lower partial pressures as compared to the mother's haemoglobin. This is important in the placenta when fetal and maternal haemoglobin will compete for oxygen supplied by the mother's blood. More often than not it will be the fetal haemoglobin that will bind a free oxygen molecule.

Challenge yourself

- Step 1: The diaphragm relaxes decreasing the volume of the thoracic cavity. (Given in question.)
Step 2: The internal intercostal muscles and another set of abdominal muscles help to lower the rib cage. These actions also help to decrease the volume of the thoracic cavity.
Step 3: Because the thoracic cavity has decreased its volume, the pressure inside the thoracic cavity increases. This leads to increased pressure 'pushing' on the passive lung tissue.
Step 4: The lung tissue responds to the increased pressure by decreasing its volume.
Step 5: This leads to a positive pressure inside of the lungs. Air is forced out through your open mouth or nasal passages.
- 173 stomata mm^{-2} (± 10 stomata mm^{-2})

- Q4.** The arteriole end of a capillary bed is under higher blood pressure compared to the venule end. Often, molecules are forced out between capillary cells or through fenestrations.
- Q5.** Blood is in a continuous circuit pathway or, in other words, it circulates in a closed system. Lymph vessels pick up lymph fluid in capillary beds and release it back into a vein.
- Q6.** Thin walls, large surface area in contact with tissues, narrow diameters, fenestrations (in some areas).
- Q7.** The companion cells and the phloem sieve tubes must be able to actively transport sugars and other molecules in. This creates a low water potential area, which attracts water by osmosis from nearby xylem vessels.
- Q8.** An increase in blood pressure for blood that has been reoxygenated. Each time blood enters a capillary there is a dramatic decrease in blood pressure. Fish first send blood through capillaries in gills and then immediately to capillaries in the body tissues. The blood of mammals only travels through one capillary bed before being repumped for higher pressure.
- Q9.** The right and left sides of the heart are beating in synchrony. Both atrioventricular valves close at the same time (lub sound) and then both semilunar valves close at the same time (dub sound).

Challenge yourself

- Gender has a greater correlation coefficient as non-smoking males show a higher incidence of future heart disease than females who smoke at many ages.
- Age 55. At this age there is an obvious positive change in slope for all data sets.
- (a) age 55
(b) age 45
- Questionnaires rely on people's memory and truthfulness. Some people may not want to divulge information on smoking habits. Family history of heart disease as a control factor may not be known.
- No. Any data based on correlations does not show causation.
- Right atrium - Right atrioventricular valve - Right ventricle - Right semilunar valve - Pulmonary artery - One of many branches of pulmonary artery - Capillary within lungs - Vein leading to pulmonary vein -

B3.2 Transport

Exercises

- Q1.** (a) vein
(b) artery
(c) artery
(d) vein
(e) artery
- Q2.** Correlation studies show only correlations. They do not show cause and effect.
- Q3.** Without a continuous water column, the cohesion forces between molecules would not be possible.

Pulmonary vein - Left atrium - Left atrioventricular valve - Left ventricle - Left semilunar valve - Aorta
- One of many branches from aorta - Capillary within body tissue - Veins leading back to right atrium

B3.3 Muscle and motility

Exercises

- Q1.** (a) actin, myosin and titin
(b) myosin
(c) actin and titin
(d) titin
(e) titin
- Q2.** the myosin head is released from the actin filament
- Q3.** (a) biceps
(b) internal intercostal muscles
- Q4.** the inside of its exoskeleton
- Q5.** (a) pelvis
(b) lubrication of the joint
- Q6.** (a) holds bone to bone at a joint
(b) holds muscle to bone

B3 Practice questions

- 1.** diaphragm and external intercostal muscles contract; diaphragm moves down/becomes flatter OR external intercostals raise the ribcage/move the ribcage up/out; muscles/diaphragm/intercostals increase volume of thorax/expand the thorax OR muscles/diaphragm/intercostals decrease pressure in the thorax; as volume (of thorax/lungs) increases the pressure decreases; air enters (lungs) due to decreased pressure/higher pressure outside body; air flows to lungs through trachea and bronchi/bronchioles
(Total 4 marks)
- 2.** prevents backflow/ensures one-way flow/controls direction of flow; open valves allow blood to flow through OR opening and closing of valves controls timing of blood flow (during cardiac cycle); closed (semilunar) valves allow ventricles/chambers to fill with blood OR closed (semilunar) valves allow pressure in ventricles to rise (rapidly); valves open when pressure is

higher upstream/OWTTE/converse for closed valves; AV/bicuspid/tricuspid/mitral valves prevent backflow from ventricle to atrium OR AV/bicuspid/tricuspid/mitral valves open when pressure in atrium is higher (than in the ventricle)/when atrium is pumping/contracting; semilunar/aortic/pulmonary valves prevent backflow from artery to ventricle OR semilunar/aortic/pulmonary valves open when pressure in ventricle is higher (than in the artery)/when ventricle is pumping/contracting;

(Total 4 marks)

- 3.** (a) 35% [1]
(b) 15% [1]
(c) both show an increase in the risk of CHD as age increases; men/women with (either) siblings with AHD show an increased risk (relative to their control); men have greater risk than women of developing a CHD (at all ages); both men and women/women only are more likely to develop CHD if their sister has the disease; men with a brother with CHD have a greater risk than women with a brother with CHD; [3]
Accept any other valid comparison using the graph.
(d) hereditary/genetic predisposition; similar (unhealthy) lifestyles/diets; [2]
(Total 7 marks)

- 4.** (a) plasma membrane in phloem/sieve tubes but not in xylem/vessels OR xylem/vessels dead/acellular and phloem/sieve tubes alive; xylem vessels have thicker walls (than phloem); xylem (vessel) walls are lignified (but phloem walls are not); phloem vessels have sieve plates (whereas xylem vessels have no cross walls); xylem/vessels are wider/larger than phloem/sieve tubes; companion cells in phloem (but not in xylem); [2]
(b) water is polar/a dipole/oxygen slightly negative and hydrogen slightly positive; polarity results in hydrogen bonds/attraction between water molecules; hydrogen bonding/polarity causes cohesion of water (molecules); cohesion/hydrogen bonding allows water to withstand tension/withstand low pressure/be pulled (upwards)/moved against gravity; cohesion/hydrogen bonding prevents column of water (in xylem) from breaking/column of water is maintained; adhesion of water to xylem/vessel walls (due to hydrogen bonds); [2]
(Total 4 marks)

5. action potential/depolarization/nerve impulse arrives at end of motor neuron; neurotransmitter/acetylcholine released, causing action potential (in muscle sliding filament model) / filaments/actin and myosin slide past each other; myosin heads bind to sites on actin / form cross-bridges; myosin (head) moves actin filament using energy from ATP; actin moved towards the centre of sarcomere/M line/M band; sarcomeres shortened; (binding of) ATP causes release of myosin head from actin; conversion of ATP to ADP and P causes myosin heads to change angle; cycle (of events) repeated (during muscle contraction);

Accept the above points in annotated diagrams.

(Total 6 marks)

6. arteries have thick/muscular walls; veins have thin/flexible walls; capillary walls are single cell thickness; arteries carry blood away from heart; veins carry blood towards the heart; capillaries/capillary beds connect arteries and veins; arteries change lumen diameter (to help regulate blood pressure); arteries have elastic fibres to maintain blood pressure between contractions; veins have internal/passive valves; capillaries permit molecular exchanges with tissues;

(Total 9 marks)

7. A

8. ventilation refreshes air in lungs; allows diffusion of oxygen and carbon dioxide between air and blood; oxygen needed for aerobic cell respiration; carbon dioxide by-product of aerobic cell respiration; inhalation a result of increased volume of thorax/lungs; inhalation a result of diaphragm contracting; inhalation a result of contraction of external intercostal muscles; exhalation a result of decreased volume of thorax/lungs; exhalation a result of contraction of internal intercostal muscles;

(Total 8 marks)

9. Sketch should include the following: upper epidermis; palisade mesophyll; spongy mesophyll; vascular bundle; xylem; phloem.

(Total 6 marks)

B4.1 Adaptation to environment

Exercises

- Q1. Narrow leaves, dense and shallow root system, resistant to salt spray and short-term immersion in salt water, nodes and rhizomes will produce asexual growth if sand accumulates at base of the plant.
- Q2. The optimum tolerance range is the range between the upper and lower levels of an abiotic factor where the organism is expected to be in greatest abundance.
- Q3. B (note: not all deserts are 'hot' deserts)
- Q4. Data collected in the Hawaiian Islands shows a negative correlation. In other words, increased carbon dioxide in the atmosphere correlates with a lower pH in the ocean.
- Q5. Living coral reefs contain a photosynthetic algae called zooxanthellae. When water becomes turbid (not clear) it impairs the amount of sunlight penetrating the water that is available for photosynthesis.
- Q6. An instinct has evolved in many predators to avoid brightly marked and colored prey animals. The predator cannot distinguish between prey that has poison and prey that does not.

Challenge yourself

- positive correlation
- The Hawaiian Islands are far from major land masses where local sources (of carbon dioxide) are likely to be significant.
- The cycles represent the growth seasons for local plant life. Longer day periods of summer will have more carbon dioxide removed from the air for use by photosynthesis (as compared to shorter days).
- No, only a negative correlation.
- The data suggests that absorption of carbon dioxide by the oceans is correlated with a lowered pH. Studies have shown that a lowered pH leads to less availability of calcium compounds for reef-building by corals.

B4.2 Ecological niches

Exercises

- Q1.** A
- Q2.** C
- Q3.** A
- Q4.** Answers may vary but can include pack hunting, ambush or pursuit. The answer should include some of the features of the behaviour that help the predator find or catch the prey.
- Q5.** The oriental hornet can still obtain energy from sunlight absorbed by its cuticle even if there is no food available.
- Q6.** Both fundamental and realized niches refer to the environmental position that a species occupies in an ecosystem. Fundamental niches represent all the environmental conditions where a species is able to live and reproduce, whereas the realized niche is where the species actually lives, and takes into account interactions with other organisms, such as competition and predation.

B4 Practice questions

- 1. (a)** medium to low [1]
(b) lower crown, far from trunk [1]
(c) A table format is not required. [2]

Aspect	Varied tit	Marsh tit
relative use of upper crown to other habitats	less	more
use of close distance to trunk OR use of mid distance to trunk	same	same
highest use OR use of far distance to trunk	closer to trunk; less	far from trunk; more
selectivity of areas within upper crown	more concentrated in one section	all across three sections

- (d)** smaller birds make more use of the habitat further from the trunk / larger birds make more use of the habitat closer to the trunk [1]

- (e)** their food is close to the trunk / fewer predators close to trunk / too big for small outside branches [1]

Accept any valid suggestion.

(Total 6 marks)

- 2. (a)** 0–10 metres [1]
(b) *Bythotrephes* found at all depths down to 20–30 m/ none below 30 m; greatest number/density (of organisms) at 10–20 m; least number/density (of organisms) at 0–10 m [2]
(c) avoids/driven away by light (to colder water); in absence of light attracted to warmer water; can tolerate a wide range of temperature (accept numbers in the range 4/5–20/25°C) [2]
(d) zooplankton found in (warmer) surface water where small plants/algae/phytoplankton are found due to light; as predator, *Bythotrephes* moves up to the surface to feed on zooplankton at night; as prey, *Bythotrephes* moves to lower/darker depths during the day to avoid being (easily) seen by predators/fish [2]

(Total 7 marks)

- 3. (a)** From day 0 to day 10, both rotifer populations increase, but in flask Z when in competition with water fleas, the rotifer population hits a maximum of about 1600 and then decreases until they completely die out on day 18. In contrast, the rotifer population in flask X when they are living alone continues to increase until they reach a maximum of about 4250. [2]
(b) Rotifers and water fleas occupy the same niche in plankton and are in direct competition for the food supply given to them. This type of interspecific competition leads to the elimination of one of the two populations. The rotifers appear to have been out-competed by the water fleas. This demonstrates the competitive exclusion principle. [3]

(Total 5 marks)

- 4. (a)** *D. tigrina* live at the top of the tree, while *D. coronata* live at the bottom of the tree. [1]
(b) No two species in a community can occupy the same niche. [2]

- (c) different food/prey;
different predators;
active at different times of the day;
present at different times of the year;
different nest sites;
different temperatures;
Do not accept 'different habitats'. [2]
- (d) The fundamental niche is the potential niche an organism can occupy while the realized niche is the actual niche it inhabits once limiting factors or competition have acted upon it. [2]
(Total 7 marks)

5. Saprotrophs, such as fungi and bacteria, play an important role in the decay of dead organic materials. They decompose organic material, making the nutrients available to other organisms.
(Total 3 marks)
6. Stinging nettles produce chemicals that are irritants and give a herbivore a burning sensation that dissuades them from eating the plant. Phytotoxins, such as alkaloids and tannins, can make animals sick when ingested.
(Total 3 marks)

C1.1 Enzymes and metabolism

Skills box page 369

1. activation energy
2. endergonic reaction
3. because the result is products which have energy available for work, i.e. ATP
4. Reactant bonds involved in the reaction would be stressed, allowing the reaction to proceed with less activation energy required.
5. A
6. chemical bonds

Skills box page 373

1. A
2. D
3. Denaturation. The large change in pH would cause the enzyme's three-dimensional shape to change. The active site and substrate would no longer be close fits.
4. Yes. Lower temperatures usually do not break hydrogen bonds. The rate will be slow mostly due to lack of collisions due to the lower temperature. However, the three-dimensional shape of the enzyme remains intact. Therefore, when this enzyme is placed back in a higher optimum temperature, its activity increases. Important to note is if an enzyme which works optimally at a lower temperature is placed in a much hotter environment, its three-dimensional shape is permanently changed.

Exercises

- Q1. The bonds and general shapes are specific for both the enzyme and the substrate. If the substrate does not have a compatible shape and appropriately positioned electrical forces, the substrate will not fit the active site of the enzyme.
- Q2. D
- Q3. B
- Q4. In competitive inhibition, the competitor molecule combines with the active site directly. This prevents the substrate from combining with the enzyme. In

non-competitive inhibition, the active site is not bound by the outside molecules. In this case, the molecule combines with an alternative site on the enzyme causing a conformational change resulting in decreased enzyme function.

- Q5.** Inhibition occurs at the very first step in the pathway so that a build-up of intermediate substrates in the cell does not occur. By inhibiting the pathway at the first step, energy is also conserved since the following reactions in the pathway would not occur.
- Q6.** When a molecule combines with an enzyme at the allosteric site, the bonds of the active site are 'stressed' which alters its shape and stops the catalytic activity. However, the bonds are not broken. If the molecule is released from the allosteric site, the stressed bonds will return to their original positions.

C1.2 Cell respiration

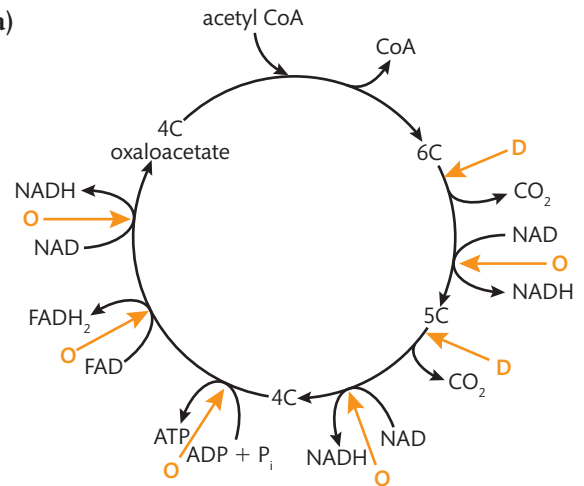
Exercises

- Q1.** lactic acid and ATP
- Q2.** carbon dioxide, water and ATP
- Q3.** because ATP distributes energy within cells
- Q4.** Pyruvate and lactic acid are produced during anaerobic respiration, within the cytoplasm of the cell.
- Q5.** Occurs in the inner membranes of the mitochondria and the membranes of the cristae. These membranes contain numerous electron acceptors which are easily oxidized and reduced, allowing the flow of electrons down an energy releasing pathway.
- Q6.** NAD accepts high energy electrons and transports them to the electron transport chain.
- Q7.** (a) glycolysis – cytoplasm
 (b) link reaction – matrix
 (c) Krebs cycle – matrix
 (d) oxidative phosphorylation – inner membranes of the mitochondria

- Q8.** C
Q9. C
Q10. C

Challenge yourself

1. (a)



- (b) Decarboxylation is evident because the cyclic intermediate compound lost a carbon. Also, it is evident because a carbon dioxide is released at each of the two sites.
- (c) Oxidation is evident because reduction occurred to form NADH from NAD, FADH₂ from FAD, and ATP from ADP + P_i. Whenever oxidation occurs, reduction must also occur.

C1.3 Photosynthesis

Exercises

- Q1.** The amount of light absorbed plotted against the wavelength of light produces the absorption spectrum for that pigment, whereas the action spectrum indicates the rate of photosynthesis at different wavelengths of light.
- Q2.** Reactants: carbon dioxide and water. Products: glucose and oxygen.
- Q3.** The oxygen produced is vital for the respiration of many organisms. The glucose produced is a food source for many organisms.
- Q4.** C
Q5. a, c, b, d

- Q6. photosystem I
 Q7. chemiosmosis
 Q8. Provides electrons to the light-dependent reaction; provides hydrogen ions for chemiosmosis.

Challenge yourself

- Both the rate of photosynthesis and the light intensity are increasing. This indicates a positive correlation between these two factors.
- When a protein or enzyme is denatured, its structure is altered. When the structure of a protein or enzyme is changed, it can no longer perform its original function. Because enzymes and other proteins are essential to the process of photosynthesis, altering their shape drastically decreases the rate of photosynthesis.
- Factors which could increase the photosynthetic rate include increasing the temperature (but not so much that there is denaturation of the proteins involved) and increasing the light intensity.
- Procedures are quite variable here. Using carbon dioxide levels as a limiting factor, the following procedure is a possibility.*
 - Place a single, equal sized sprig of a water plant such as Elodea in each of five different test tubes.
 - Add cool, unboiled spring water to test tube one.
 - Add cool spring water that has been boiled for 30 seconds to test tube two.
 - Add cool spring water that has been boiled for 1 minute to test tube three.
 - Add cool spring water that has been boiled for 2 minutes to test tube four.
 - Add cool spring water that has been boiled for 5 minutes to test tube five.
 - Place all five test tubes at an equal distance from the same light source.
 - Count the number of bubbles produced by the Elodea sprig in each test tube.
- A possible procedure would be: if boiling spring water for an increasing length of time decreases the amount of carbon dioxide present, then the rate of photosynthesis by *Elodea* when exposed to a light source will decrease when it is placed in spring water that has been boiled for a longer period of time.

C1 Practice questions

- C
- increasing fructose 6-phosphate concentration (initially) causes an increase in activity; the activity levels out / remains constant as (substrate) concentration continues to rise [2]
 - more collisions with active site as concentration rises; at high substrate levels, all active sites are occupied so no further increase in rate / enzyme working at maximum rate [2]
 - decreases activity; at all fructose 6-phosphate concentrations; most effect at intermediate fructose 6-phosphate concentrations / little difference at high fructose 6-phosphate concentrations; ATP acts as an inhibitor [2]
 - end-product inhibition; respiration rate decreased if ATP already available [1]

(Total 7 marks)
- 07:30 / 7.30 am / 7.5 hours (accept answers in range up to 07.45) [1]
 - 17:00 / 5.00 pm ($\pm \frac{1}{2}$ hour) [1]
 - 250 ppm (± 30 ppm) (*unit required*) [1]
 - at night / darkness / no light, only respiration occurs so CO₂ increases; in day / with light, both respiration and photosynthesis occur / photosynthesis exceeds respiration in day; CO₂ is used by photosynthesis and level decreases; when sun sets, CO₂ again increases as only respiration occurs [2]

(Total 5 marks)
- at low dipyrene concentrations, there is no effect on enzyme function; as concentration of dipyrene increases, increased inhibition of enzyme activity [2]
 - over a range of concentrations in the experiment, dipyrene appears to have no effect on the enzyme function (of COX-2); may be inhibited at concentrations higher than those used in the experiment [2]
 - it would limit inflammation due to COX-1 and COX-3; but not COX-2; effective only at high doses [2]

(Total 6 marks)

5. A
6. C
7. A
8. C
9. A
10. C
11. D
12. A
13. B

C2.1 Chemical signalling

Exercises

- Q1.** Hydrophobic ligands bind with intracellular receptors since they can easily pass through the cell membrane. Hydrophilic ligands bind with hydrophilic ligands because they cannot pass through the cell membrane.
- Q2.** neurotransmitters
- Q3.** Hormones travel through the bloodstream in very small quantities. They may bind with a receptor in a target cell far away from where they are produced.
- Q4.** The kinase domain must be phosphorylated.
- Q5.** Intracellular receptors affect gene expression. Hormones are a common ligand which binds with these receptors.
- Q6.** A protein kinase selectively modifies proteins by covalently adding phosphates to them (phosphorylation).
- Q7.** C

Challenge yourself

1. Quorum sensing is at work and the concentration of autoinducer is not at the threshold level for luciferase production when the bacterium is free-living. There is no benefit for the lone free-living bacterium to produce light. However, when in the light organ of the squid, glowing provides an advantage. It allows the bacteria to fulfil their end of the symbiotic relationship, keeping the squid safe from predators.

C2.2 Neural signalling

Exercises

- Q1.** Potassium from inside the cell moves to the outside via potassium channels, generating a negative charge in the inside of the membrane versus the outside.
- Q2.** Internode distance, axon diameter and presence of a myelin sheath all affect the speed of action potentials in neurons.
- Q3.** The presence of Schwann cells means the action potentials 'jump' from one node to the next.
- Q4.** A: dendrites; B: cell body; C: axon; D: Schwann cell
- Q5.** Calcium activates a pathway that moves vesicles containing the neurotransmitter toward the presynaptic membrane.
- Q6.** A
- Q7.** B
- Q8.** (a) Either an action potential is produced, or it is not. There is no variation in electrical impulse intensity.
- (b) Each action potential must reach a minimum threshold potential in order to be self-propagated.
- (c) The period of recovery after depolarization during which the neuron is unable to respond to additional stimulation.

Challenge yourself

1. More sodium ions are outside the neuron fibre than inside, due to the action of the sodium–potassium pump. There are more potassium ions inside the neuron fibre than outside. However, because the Na–K pump transports three Na ions outside for each two K ions inside, there exists more positive ions outside the fibre than inside. This creates the negative charge of the fibre at resting potential.
2. only at the nodes of Ranvier
3. Depolarization only occurs at the nodes of Ranvier. The impulses jump from node to node forgoing the need for depolarization all along the neuron fibre.

- 9, 29 and 39 milliseconds are the points on the x-axis where the sodium–potassium pump would be beginning to work to re-establish a resting potential after each depolarization.
- If discrete sensory information (stimuli) from a receptor was received repeatedly faster than 5 milliseconds apart, there would be no chance for the neuron axon to repolarize. This would result in the stimuli not being able to cause depolarization and an action potential/nerve impulse would not be generated.

- Represents a faster means of impulse transmission along a neuron; Schwann cells produce myelin sheaths with nodes of Ranvier between them; depolarization and repolarization only occur at the nodes of Ranvier; impulses/action potentials jump from node of Ranvier to another node of Ranvier.

(Total 3 marks)

C2 Practice questions

- Cell body possesses organelles that allow the cell to carry out life functions; the dendrites receive stimuli; the axons conduct impulse away from the cell body.
(Total 3 marks)
- A neurotransmitter increases the permeability of the postsynaptic neuron to sodium ions; sodium ions diffuse into the cell; neuron becomes depolarized; impulse is propagated.
(Total 4 marks)
- A
- D
- In many cases, signal transduction pathways intersect, resulting in the same pathway being stimulated by different receptors.
(Total 3 marks)
- All signalling events begin with a ligand; a ligand binds with a receptor; the binding of a ligand with a receptor initiates a chain of events that leads to a change in cellular activity.
(Total 3 marks)
- Mechanism by which bacteria can alter group behavior related to population density; allows individual bacteria within colonies to carry out coordinated functions; coordination is due to the production of autoinducers; as concentration of autoinducers increases to a threshold level, gene expression by the entire bacterial population is altered; example: bioluminescence production in the bacterium *Vibrio fischeri* as a symbiont in the Hawaiian bobtail squid.
(Total 3 marks)

C3.1 Integration of body systems

Exercises

- frontal lobe of the cerebrum
 - cerebellum
 - medulla oblongata
 - occipital lobe of the cerebrum
 - frontal lobe of the cerebrum
- The advantage is speed of response. The part of the body damaged will be moved before the sensation of pain is experienced. This will decrease the tissue damage.
- C
- Increased exercise produces more carbon dioxide. Within a red blood cell, carbon dioxide and water will form carbonic acid catalyzed by an enzyme called carbonic anhydrase. Carbonic acid will dissociate into a bicarbonate ion and a hydrogen ion. The increase in hydrogen ions lowers the pH.
- A neuron is a single cell of the nervous system and is either sensory or motor. A nerve is a collection of neurons bound together by a protective sheath. The nerve may contain only sensory neurons, only motor neurons, or a mix of both.
- light
 - pressure
 - a specific chemical
 - damage to tissue, sensed as pain
- Auxin enters phloem tissue to travel to the roots.
 - Auxin travels into nearby cells by diffusion and is transported out of that cell by auxin efflux carriers. Auxin efflux carriers are positioned so that there is a one-way direction of movement of the auxin.

- Q8. A 'rotten apple' is one that is over ripening. The ripening process produces the gas acetylene. This acetylene is absorbed by nearby apples and they also begin to quickly ripen. This can spread to all apples kept in the same location (like a barrel).
- Q9. D

C3.2 Defence against disease

Exercises

- Q1. (a) platelets release clotting factors (molecules) that initiate clotting process
 (b) fibrinogen is a soluble protein that becomes insoluble fibres helping to form the clot
 (c) thrombin is the enzyme that converts soluble fibrinogen to insoluble fibrin
- Q2. C
- Q3. the antigen they are specific for and an activated helper T-lymphocyte that they are also specific for
- Q4. mitosis
- Q5. Antibiotics target bacterial cell processes that are different to eukaryotic cell processes. Viruses have no cell processes on their own. If a virus was using a eukaryotic cell as a host, the only way to damage the virus would be to damage the host cell. Healthy (non-infected) host cells would also be damaged.
- Q6. A primary immune response does not involve memory cells. It takes time for the first immune response to occur and that is enough time for the pathogen to damage body tissues, creating symptoms.
- Q7. B

Challenge yourself

- (a) A^+ , A^- , O^+ , O^-
 (b) O^+ , O^-
 (c) AB^- , A^- , B^- , O^-
- The higher the R_0 value, the higher the percentage of individuals necessary to achieve herd immunity.
- Herd immunity has been achieved for smallpox. In fact, the vaccination program for smallpox was so successful that it is believed that smallpox no longer exists in the population.
- Failures in science and the science industry need to be known so that people can weigh the pros and cons of scientific advancements. As horrible as that vaccine failure was, it represented only a tiny fraction of the total vaccines administered. In addition, the failure led to much better oversight of the vaccine industry. The position of those in science is that the risks inherent with vaccines are not zero, but that the advantages greatly outweigh the risks.
- $5.7 - 1.6 = 4.1$ difference between values
 $(5.7 + 1.6) / 2 = 3.7$ (average of two values)
 $4.1 / 3.7 \times 100 = 111\%$ difference between values
- $5.7 - 2.8 = 2.9$ (difference between new and old R_0 value)
 $2.9 / 2.8 \times 100 = 104\%$ change in R_0 value

C3 Practice questions

- Both name and function required for mark.
 I. relay or interneuron and initiates a reflex arc (when stimulated)
 II. motor neuron / motor neuron axon and carries a reflex arc motor impulse to muscle
 (Total 2 marks)
- nerve impulse from medulla/brain acts on heart/right atrium; pacemaker/sinoatrial node/SAN increase/controls contraction of heart; epinephrine/adrenaline (rapidly) increases heart rate
 (Total 2 marks)
- D
- skin/mucus membranes act as barrier (to pathogens); (skin/stomach) acid prevents growth of many pathogens; lysozyme in mucus can kill bacteria; pathogens caught in sticky mucus and removed from body; inflammatory response/inflammation can cause swelling/redness/fever (to inhibit the pathogens); phagocytes/macrophages/leucocytes/white blood cells (non-specifically) identify (pathogens/bacteria/fungi/viruses) as foreign; (phagocytes/macrophages/leucocytes/white blood cells) ingest pathogens; specific helper T-lymphocytes

recognize one specific antigen; (antigen-specific) lymphocytes clone themselves; specific B-lymphocytes/leucocytes produce antibodies; antigen–antibody complex formed and stimulates destruction of pathogens / antibody–antigen complex forms clumping; (Total 7 marks)

5. antibiotics (are chemicals) used to treat bacterial diseases; bacteria vary in their (genetic) resistance to antibiotics; resistance arises by (random) gene mutation; when antibiotics are used, antibiotic-sensitive bacteria are killed; (natural) selection favours those with resistance; resistant bacteria survive, reproduce and spread the gene for resistance / increase allele frequency of resistant bacteria; the more an antibiotic is used, the more bacterial resistance / the larger the population of antibiotic-resistant bacteria; genes can be transferred to other bacteria by plasmids; doctors/vets use different antibiotics but resistance develops to these as well; multiple-antibiotic resistant bacteria evolve/it becomes difficult to treat some infections;

(Total 6 marks)

6. (a) week 34 and 2014 [1]
 (b) start of epidemic/first cases in rural areas OR epidemic spreads to suburbs later; higher maximum number of cases/greater increase in rural areas OR converse for suburbs; increase came earlier in rural areas (than suburbs) OR number of cases peaked earlier in rural areas OR more cases in rural areas (than suburbs) in 2014; decrease came earlier in rural areas (than suburbs) OR decreasing in rural areas but not in suburbs in 2015/by end of study period OR more cases in suburbs than rural areas in 2015; (large) fluctuations in both; [3]
 (c) (overall decline due to) lower cases in rural areas; answers relating to people who died from the disease or develop immunity to it: fewer cases due to death of people who had the disease/people recovering OR more people vaccinated/became immune/made antibodies/were not vulnerable to infection; answers relating to health care workers or availability of resources: more doctors/nurses/medical equipment/treatment centres/hospital/spending/aid/NGOs; answers relating to medical techniques used to tackle the epidemic: better treatments/infection control/hygiene/quarantine/new vaccine/new antiviral drugs; answers

relating to the public and patients: education/better awareness/avoidance of infection/taking precautions/vaccination accepted; answers relating to reservoirs of infection: fewer infected people (who could spread infection)/fewer bats/less contact with bats; [2]

(Total 6 marks)

C4.1 Populations and communities

Exercises

- Q1. D
 Q2. A
 Q3. B
 Q4. B
 Q5. A
 Q6. Top-down controls are those by which a species' population can be reduced by other species feeding on it. Predation and herbivory are top-down controls. Bottom-up controls are those by which a species' population can be reduced due to a lack of resources. Examples of bottom-up controls are a lack of food, sunlight (for photosynthetic organisms) or minerals.

Challenge yourself

- Answers will vary but may include possibilities such as: herbivores such as the tropical birds will rely on fruits from the trees, many species of birds and monkeys will rely on the trees for habitat, carnivores such as wild cats will rely on smaller animals for food, the plants and trees will rely on decaying waste from the animals to obtain nutrients in the soil. In addition to depending on insects to pollinate their flowers, some plants use the help of birds or bats.
- Crustose corallines decreased with elevated nutrients, which was harmful to the coral. Frondose macroalgae increased dramatically from 20% to approximately 64% cover. This was also harmful to the coral.

Algal turfs decreased. This was beneficial to the coral but overall the corals were harmed by elevated nutrients and low herbivory.

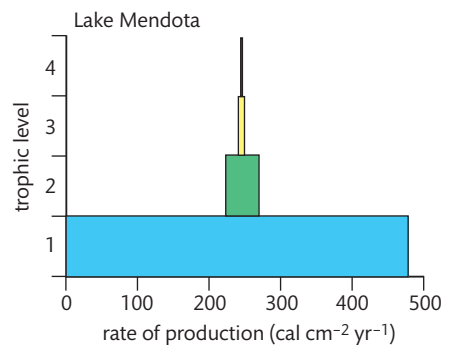
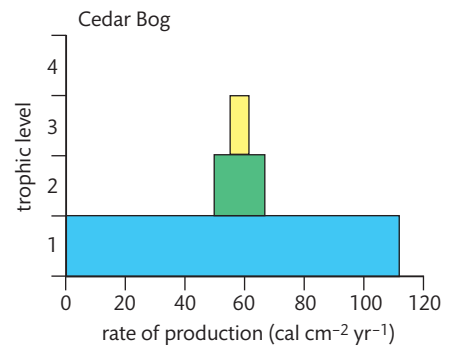
3. Yes, the prediction was confirmed. With elevated nutrients, the crustose corallines achieved only 1.7% of cover and the algal turfs 14.5% of cover, while the macroalgae covered 73.7% of the space.
4. At site B, with elevated nutrients and high herbivory, the crustose corallines achieved almost 72% cover. This was beneficial to the reef because this alga helps build the reef. High herbivory along with elevated nutrients allowed the crustose corallines to outcompete the other two types of algae.
5. Eutrophication-induced macroalgal blooms are caused by elevated nutrients. When this is combined with low herbivory, the macroalgae dominate, as is evidenced by the 63.7% cover that was measured at site A. The macroalgae outcompete the reef-building crustose corallines algae.

C4.2 Transfers of energy and matter

Exercises

- Q1. A
- Q2. B
- Q3. It is a closed system because it is sealed. No air, water, food or waste can go in or out. Only light energy from the Sun can enter the greenhouse and heat energy can diffuse into the environment around Biosphere 2.
- Q4. (a) peat
(b) coal
(c) crude oil
(d) natural gas

- Q5. (a) *Pyramids should have correct scales and units, and trophic levels should be shown: two for Cedar Bog and three for Lake Mendota.*



- (b) Both lose approximately 90% of the energy at each trophic level. Cedar Bog has almost four times less biomass overall and one fewer trophic level than Lake Mendota.
 - (c) The efficiency increases significantly as we go up the trophic levels in the pyramids.
 - (d) Lake Mendota can sustain another trophic level because it has a significantly larger biomass than Cedar Bog.
- Q6. (a) The drawing should reflect the relationships between all seven organisms, with grass at the bottom and the hawk at the top: arrows from grass to rabbits, grasshoppers, and mice; arrow from rabbits to hawks; arrows from grasshoppers to toads, mice, and garter snakes; arrows from mice to hawks; arrow from toads to hognose snakes; arrow from hognose snake to hawk; arrow from garter snake to hawk.
 - (b) The toad is on trophic level 3.

Challenge yourself

1. 315 ppm; 420 ppm
2. 133%
3. seasonal fluctuations in activities such as photosynthesis

C4 Practice questions

1. identify a single species of grasshopper to work with; capture as many as possible (using nets, for example); mark the grasshoppers captured in the first sample; release them back into the habitat; allow time for them to mix; capture as many as possible, and count unmarked and marked; use the proportion of marked and unmarked to apply the Lincoln index; assumptions: the mark does not make the organism more visible to predators; the mark does not injure or kill the grasshoppers; the population is a closed one with no individuals arriving or leaving;

(Total 6 marks)

2. In parasitism, the host is often harmed, whereas in mutualism both organisms benefit from the relationship. Example of parasitism (e.g. *Plasmodium* or intestinal worms). Example of mutualism (e.g. lichens or root nodules).

(Total 2 marks)

3. (a) $19,580 \text{ kJ m}^{-2} \text{ yr}^{-1}$ (units required) [1]
 (b) (i) autotrophs lose 55% of their gross products to heat compared with the heterotrophs which lose 96.3% (96) of their food energy / 41% more than autotrophs; numerical comparison required [1]
 (ii) animals use a lot of energy to move / maintenance of body temperature / other valid reasons [1]
 (c) decomposers are responsible for the recycling of (inorganic) nutrients / breakdown of organic molecules to inorganic compounds [1]
 (d) autotrophs need nutrients (from the soil); decomposers release these nutrients; fewer decomposers will lead to slower / less recycling of nutrients; limits growth of autotrophs; limits (net/gross) productivity of autotrophs; [2]

(Total 6 marks)

4. (a) primary consumer [1]
 (b) June to August 1994 (1 month); May to June 1993 (1 month) [1]
 (c) there is a rise in the population starting every (Antarctic) summer; every year numbers remain low from March until November / from fall / autumn until the beginning of summer; no data available for spring 1994; increase in numbers coincides with increase in light; decrease in numbers during fall / autumn; [2]
 (d) (i) lowest sea water temperature is associated with highest numbers of larvae; larvae numbers increase when temperature drops below -1.5°C ; no larvae at temperatures above -1.5°C ; bigger increase in numbers during July / September 1993 than in July / September 1994 although temperatures the same; [2]
 (ii) global warming causes rise in sea water temperature; lower numbers of larvae; because larvae only present at sea water temperature below -1.5°C ; [2]

(Total 8 marks)

D1.1 DNA replication

Exercises

- Q1. TAC TGG CGA
- Q2. hydrogen
- Q3. III, IV, II, I
- Q4. The two strands have different carbons of deoxyribose exposed at their ends.
 3' _____ 5'
 5' _____ 3'
- Q5. Only one primer is needed on the leading strand, it is continuous. However, the lagging strand requires a primer for the beginning of each Okazaki fragment that forms at the replication fork.
- Q6. DNA replication can only occur in the 5' to 3' direction. Since the two strands of a DNA molecule are antiparallel, one strand forms continuously as the replication fork progresses. The other strand forms discontinuously in fragments as the replication fork progresses. This discontinuous formation takes a bit longer.

Challenge yourself

1. suspect 3

D1.2 Protein synthesis

Exercises

- Q1. mRNA carries the genetic code from the DNA of the nucleus to the ribosomes of the cytoplasm. tRNA carries amino acids to the mRNA-ribosomal complex for assemblage into a protein. rRNA structurally makes up most of the ribosome.
- Q2. methionine (start), alanine, arginine, isoleucine, phenylalanine, stop codon
- Q3. (a) mRNA
(b) tRNA
- Q4. Universality – all life shows the same genetic code, codons represent the same amino acids in all organisms. Degeneracy – more than one codon codes for the same amino acid.

- Q5. Eukaryotic mRNA requires processing because it contains introns (non-coding sections). The introns are removed from primary mRNA to produce a mature mRNA transcript which moves out of the nucleus on its way to the ribosome. Prokaryotic mRNA has no introns.

- Q6. C

Challenge yourself

1. isoleucine, arginine, glycine, aspartic acid, stop codon

D1.3 Mutation and gene editing

Exercises

- Q1. D
- Q2. C
- Q3. (a) Somatic cells are made using mitosis and are found all over the body, whereas germ cells use meiosis to produce gametes and are found in the ovaries or testes.
 (b) A mutation in somatic cells will only affect the individual and is not heritable in any offspring, whereas a mutation in germ cells will affect the individual and can also be passed on to offspring.
- Q4. Benzene is an example of a chemical mutagen, and UV light from the Sun is an example of mutagenic radiation.
- Q5. Gene knockout techniques involve the rendering of a gene unusable, in order to see the effects it has on the organism. Mice can be used as models in place of human subjects, in order to do laboratory tests on them. Maintaining a library of model organisms with various known knockouts for specific genes allows researchers to carry out tests on animals with a variety of genetic traits similar to those in humans. Examples include mice that have a genetic propensity for obesity, anxiety or cardiovascular disease.

D1 Practice questions

1. B
2. B

3. A
4. mRNA is used as a template / guide; mRNA is “read” in base triplets / codon; each codon specifying addition of a particular amino acid to the growing polypeptide; ribosomes bind to mRNA / initiation; ribosomes move along mRNA, facilitating addition of amino acids / elongation; tRNA bring amino acids (to mRNA-ribosome complex); tRNA has a complementary anti-codon; that binds to a specific codon; stop codon causes release of polypeptide / termination;

Remember, up to TWO quality of construction marks per essay.
(Total 5 marks)

5. C
6. both in 5' to 3' direction; both require ATP; DNA is transcribed and mRNA is translated; transcription produces RNA and translation produces polypeptides / protein; RNA polymerase for transcription and ribosomes for translation / ribosomes in translation only; transcription in the nucleus (of eukaryotes) and translation in the cytoplasm / at ER; tRNA needed for translation but not transcription;

(Total 4 marks)

7. composed of mRNA base triplets; called codons; 64 different codons; each codes for the addition of an amino acid to a growing polypeptide chain; the genetic code is degenerate; meaning more than one codon can code for a particular amino acid; the genetic code is universal; meaning it is the same in almost all organisms; (AUG is the) start codon; some (nonsense) codons code for the end of translation;

(Total 6 marks)

8. Single-nucleotide polymorphisms are caused when a base substitution, insertion or deletion happens. The point mutation can be neutral and not have an effect on the resulting protein. The mutation can generate a codon that generates a new amino acid to the polypeptide chain; for example, GAG > GTC.

(Total 3 marks)

9. The genetic code is read using codons which are made of three nucleotides; an insertion or deletion of three nucleotides or any multiple of three will shift the code but will not affect the other codons that were originally in the sequence; in such a case, a polypeptide can still be formed; however, if the insertion or deletion involves a number of nucleotides that is not a multiple of three, a frameshift can happen; this can result in

nonsense codons which will not produce a functional protein; or this can result in the unexpected production of a STOP codon which would put an end to the translation and not produce a functional protein.

(Total 4 marks)

10. C

11. The DNA strand to be silenced is used as a template to make guide RNA; the gRNA is attached to the Cas9 protein; the mix is injected into cells; the gRNA finds the place on the mutated DNA where it needs to attach; a protospacer adjacent motif helps the Cas9 protein attach to the DNA; Cas9 cleaves the DNA double strands at the place where the gRNA has been programmed to indicate the cleavage point; when the cell attempts to repair the cut, errors such as frameshifts silence the gene.

(Total 5 marks)

D2.1 Cell and nuclear division

Exercises

- Q1. growth and repair
- Q2. Since the chromosomes are pushed and pulled by microtubules during mitosis, the disruption of their formation would prevent the chromosomes from getting to where they need to be. This could lead to one or more non-disjunctions.
- Q3. 48
- Q4. Cytokinesis needs to happen once mitosis is complete because we need to be sure that the chromosomes have been replicated. Only after cytokinesis can the growth of the daughter cells begin.
- Q5. In animal cells there is an inward pinching of the fluid plasma membrane to form cleavage furrows. Plant cells form a cell plate instead, which is built up by vesicles midway between the two poles of the cell and expands outwards towards the sides of the cell.
- Q6. Knowing the percentage of cells undergoing mitosis indicates how rapidly tissue is growing. Tissue that is growing too quickly is an indication of cancer.

D2.2 Gene expression

Exercises

- Q1.** D
- Q2.** B
- Q3.** C
- Q4.** The predominant mechanism involves the methylation of DNA and the subsequent recruitment of binding proteins that preferentially recognize methylated DNA.
- Q5.** Both species are mammals and have many of the same genetic characteristics as humans. Mice are easy to breed and keep in a laboratory but they are not as genetically close to humans as primates are, so if researchers want to see more human-like genetic traits affected by epigenetics, they use primates such as rhesus monkeys. Although many ethical questions are raised by the use of animal models in research, it is easier for researchers to get approval from ethics committees to do research on animals than for human subjects.

D2.3 Water potential

Exercises

- Q1.** Plants will wilt when in a hypertonic environment. This is because water will move out of the plant cells to equalize the solute concentration inside and outside the cell. The result of water moving out of the plant cells is decreased turgor pressure, pressure potential, and resulting wilting.
- Q2.** Aquaporins are hydrophilic tunnels that traverse the cell membrane. They allow polar water molecules to move across the cell membranes in much greater amounts. They allow dynamic equilibrium to be achieved much faster between intracellular and extracellular water concentrations.
- Q3.** Fertilizing a plant too often would result in a hypertonic environment surrounding the plant roots. The result of this would be water moving out of the cells to equalize solute concentrations. The plant would wilt and possibly die.

Q4. The plant cell wall prevents the plant cell from bursting. The animal cell does not have a cell wall and so can burst.

Q5. D

Q6. The equation for determining water potential is:

$$\Psi_w = \Psi_s + \Psi_p$$

The solute potential, Ψ_s , and the pressure potential, Ψ_p , have the greatest effects on water potential in plants. The solute potential is due to the concentration of solutes present in the water. The pressure potential is due to the pressure produced by the cell contents against the cell wall.

Challenge yourself

Example	(a) Term to describe external cell environment	(b) Direction of water movement	(c) Result of osmosis
1. Raisins placed in pure water	Hypotonic	Water moves into the raisin	Raisin swells
2. Human red blood cells placed in high solute concentration solution	Hypertonic	Water leaves red blood cells	Red blood cells shrink
3. Gargling with salt water to relieve a sore throat	Hypertonic	Water leaves cells of the throat	Throat cells shrink, decreasing swelling, and providing relief from symptoms

- 4.** Drinking seawater would increase the salinity of blood. This would serve to draw water out of the cells, which may ultimately crenate and die. The body would be full of water, but the person would be thirstier than ever. The results of dehydration would appear faster by drinking seawater.

D2 Practice questions

1. A
2. C
3. D
4. new combinations of genes produced by crossing over; during prophase I; homologous non-sister chromatids exchange sections of DNA; random orientation of homologous chromosomes/bivalents; during metaphase I; generates a different genetic combination for each egg or sperm produced; (Total 4 marks)
5. D
6. At least one characteristic is controlled for: they have the same genes. If they grow up in the same environment, it is more likely that they will have had similar experiences. If one of them has a genetic disease and the other does not, researchers know that it must be epigenetic regulation of gene expression and not just the genome that is affecting the twin. (Total 3 marks)
7. Air pollution includes ground-level ozone (O_3), nitrogen oxides (NO_x), particulate matter (PM) and polycyclic aromatic hydrocarbons (PAHs). DNA methylation affects white blood cells and brain cells. Genes such as CCL17 that control the immune system have different levels of methylation depending on whether the mother of the child was exposed to high or low levels of PAHs. Babies of women exposed to higher air pollution levels have a lower body mass on average compared to those of women exposed to lower air pollution levels. Embryonic cells and the cells of a developing foetus are more susceptible to modifications of their epigenetics due to chemicals in the environment than cells later in life. (Total 4 marks)
8. (a) Water would enter from the hypotonic external environment resulting in swelling of the red blood cell possibly to the point of bursting the cell membrane. [2]
(b) Water would enter the plant cells from the hypotonic external environment resulting in an increase in cell turgor pressure due to the cell wall present. [2]

(c) Water would enter the freshwater-dwelling organism possibly resulting in bursting of the cell membrane unless a contractile vacuole is present. The contractile vacuole is capable of removing excess water from the organism so that optimal water pressures internally are maintained. [2]
(Total 6 marks)

9. (a) The solution would most probably have a low solute concentration, a hypotonic solution. [1]
(b) A hypotonic solution would result in more water molecules moving from the solution and into the cells of the individual. This movement is due to the lower solute concentration outside the cells than inside, resulting in the net movement of water into the cells of the individual. [2]
(Total 3 marks)
10. an arrow going from side A to side B
(a) side A = -200 kPa [1]
(b) side B = -300 kPa [1]
(Total 2 marks)

D3.1 Reproduction

Exercises

- Q1. testis, epididymis, vas deferens, urethra, vagina, cervix, uterus, Fallopian tube
- Q2. The inner wall of the uterus is called the endometrium. During the first portion of the cycle, the endometrium is thin (not highly vascular). Under the influence of oestradiol secreted by ovary cells, the endometrium becomes thicker and more vascular in preparation for a possible embryo. Late in the second half of the cycle, the endometrium breaks down and creates the blood flow of menstruation.
- Q3. inside of one of the two fallopian tubes
- Q4. C
- Q5. moisture, oxygen, and proper temperature
- Q6. Sexual: provides genetic variation for a population to survive environmental change. Asexual: quicker, less energy needed, can colonize an area with only one parent plant present.
- Q7. A

- Q8.** Late in pregnancy there is a natural drop in the progesterone produced by the placenta. This drop signals the pituitary gland to secrete the hormone oxytocin. Oxytocin stimulates the first uterine contraction to begin labor. This first contraction stimulates more oxytocin secretion, and contractions become more frequent and forceful. This is positive feedback because the cycle of contraction and oxytocin release build on each other and will only stop when birth occurs.
- Q9.** The hormone hCG, which can be tested for to determine a pregnancy.
- Q10.** Three blood vessels. Two carrying deoxygenated blood from the fetus to the placenta and one carrying oxygenated blood from the placenta to the fetus.

Challenge yourself

1. (a) diploid
(b) haploid
(c) haploid
(d) diploid

D3.2 Inheritance

Skills box

	Gene	Description	Location	Polypeptide product
1.	ABO	blood type	9q34.2	histo-blood group ABO system transferase
2.	HBA1	human haemoglobin subunit	16p13.3	alpha subunit of haemoglobin
3.	HBB	human haemoglobin subunit	11p15.4	beta subunit of haemoglobin
4.	HBD	human haemoglobin subunit	11p15.4	delta subunit of haemoglobin
5.	F9	blood clotting (coagulation), a faulty allele causes haemophilia	Xq27.1	coagulation factor IX

It is not at all likely because they are on separate chromosomes. HBB and HBD are part of a linkage group because they are very close together on the same chromosome (both at 11p15.4).

Exercises

Q1. Because the allele for colour blindness is recessive and sex linked, in order for a woman to be colour blind, she must have two recessive alleles, one on each of her X chromosomes: X^bX^b . In any other case, she would be carrying at least one dominant allele to cancel out the effects of the colour blindness allele. In most populations, it is rare to receive one of these recessive alleles and even more rare to get both alleles for colour blindness. On the other hand, it is much easier for a man to get the condition because there is no locus on the Y chromosome to carry a dominant allele to mask the recessive allele on his X chromosome. As a result, the presence of just one b allele is enough to give him colour blindness.

Q2.

	C^R	C^W
C^R	$C^R C^R$	$C^R C^W$
C^W	$C^R C^W$	$C^W C^W$

- Q3.** In the top row, one circle and one square should be joined by a horizontal line. They should both be labelled pink. In the next row, showing the F_1 generation, the four offspring plants should show one red, two pink and one white.
- Q4.**
- (a) $X^H X^h$ for the mother and $X^H Y$ for the father.
 - (b) Girls can be either $X^H X^H$ or $X^H X^h$ and the boys can be either $X^H Y$ or $X^h Y$.
 - (c) Both possible genotypes for the girls give them normal blood clotting. The genotype $X^H Y$ gives a boy with normal blood clotting. $X^h Y$ would be a boy with haemophilia.
 - (d) The only carriers are the mother and any daughters with $X^H X^h$. (Males cannot be carriers.)
 - (e) 1 in 4, or 25%.
- Q5.**
- (a) 1, 3 and 8
 - (b) FF, Ff, ff
 - (c) A cross showing $Ff \times Ff$ gives a 50% chance.
 - (d) 100%

- (e) Rare alleles are rare in the general population but much more common between people who are closely related. Inter-marriage between close relatives increases the frequency of genetic diseases.

Challenge yourself

1. The reason for this deviation from the expected results is that there is another phenomenon acting on the assortment of the genes: they are linked (on the same chromosome) and as a result, do not show the 9:3:3:1 expected ratio.
The offspring that are recombinants are purple + round and red + long.

- Q9. ADH will position aquaporins in the collecting ducts of each kidney so that water can leave the collecting duct and be returned to the bloodstream. Any circumstances that lead to a lowered volume of water in the bloodstream will initiate this. This includes not drinking enough fluids containing water, losing a great deal of water from perspiration and frequent ventilation (during exercise), being in a warm/hot environment that stimulates perspiration.

Q10. C

D3.3 Homeostasis

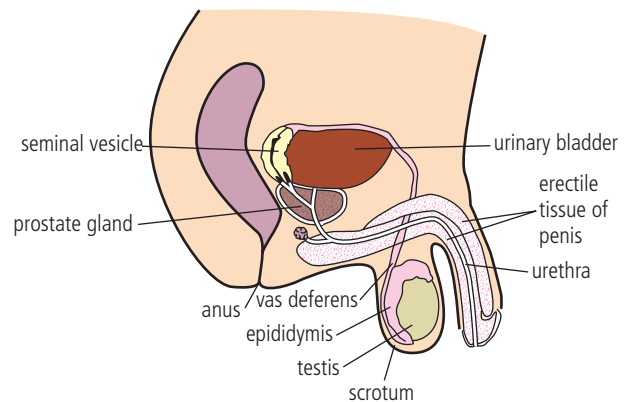
Exercises

- Q1. C
- Q2. (a) insulin
(b) glucagon
- Q3. (a) cells in the pancreas that produce insulin
(b) Any two of: retina, nerves, kidney, heart, blood vessels.
- Q4. (a) cooling
(b) warming
(c) warming
(d) cooling
- Q5. Generation of heat without ATP production, especially useful in infants.
- Q6. The arteriole that takes blood to the glomerulus is larger in diameter than that of the arteriole that drains blood away from the glomerulus. This creates an increase in blood pressure that is only alleviated by opening fenestrations in the glomerulus capillary bed.
- Q7. A
- Q8. After exiting the tubule of the nephron, molecules will be taken back into the bloodstream through the peritubular capillary bed that surrounds the nephron tubule.

D3 Practice questions

1. FSH/follicle stimulating hormone stimulates the development of follicles/follicle cell division in the ovary (to produce eggs) (*Two different hormones must be identified.*); LH/luteinizing hormone triggers ovulation/development of the corpus luteum; oestrogen stimulates development of the uterine lining/endometrium (*Description of role required as well as name of hormone.*); progesterone maintains the uterine lining/endometrium OR inhibits other hormones by negative feedback, e.g. FSH; HCG stimulates ovary to produce progesterone (in early pregnancy); other verifiable hormone and roles relevant to the menstrual cycle
(Total 2 marks)

2.



scrotum shown around testes; testis/testes/testicle shown inside scrotum; epididymis shown adjacent to testis and connected to sperm duct; sperm duct/vas deferens shown as double line connecting testis/epididymis to urethra; seminal vesicles – sac shown branched off sperm duct, not off the urethra; prostate gland shown positioned where sperm duct connects with urethra; urethra shown as double line linking bladder to end of penis; penis shown with urethra passing through it.

Award 1 mark for each structure clearly drawn and labelled that conforms to the description given above.
(Total 5 marks)

3. (a) A, B, AB and O [1]

All four phenotypes must be shown to award the mark. [1]

(b) allele I^A and allele I^B are (co)dominant as they are both expressed in the heterozygote/AB type blood/OWTTE [1]

(Total 2 marks)

4. (a) tall and yellow [1]

(b) both indicate the same phenotypes / both represent tall green plants (AaBb indicated

unlinked genes and $\frac{A\ B}{a\ b}$ linked genes; AaBb

indicates genes on different chromosomes and

$\frac{A\ B}{a\ b}$ on the same chromosome; independent

assortment/AB, Ab, aB and ab (gametes) with AaBb independent assortment/only AB and ab

gametes with $\frac{A\ B}{a\ b}$ (unless there is crossing over); [2]

(Total 3 marks)

5. (high blood glucose levels) detected by pancreas islet cells/beta cells; insulin secreted in response (to high blood glucose/glucose above threshold level); insulin stimulates cells to absorb glucose; glucose used in cell respiration (rather than lipids); glucose converted to glycogen (in liver/muscle cells); glucose converted to fatty acids/triglycerides/fat; negative feedback process; (Total 5 marks)

6. early embryo produces hormone HCG (human chorionic gonadotropin); test includes use of monoclonal antibodies specific to HCG; HCG filtered by mother's kidneys; mother's urine tests positive for HCG if pregnant; (Total 2 marks)

7. (a) heterozygous offspring (grey body, normal wings)

$$\begin{array}{c} b^+ \quad | \quad b \\ vg^+ \quad | \quad vg \end{array} \quad \text{OR} \quad \begin{array}{c} b^+ \quad | \quad b \\ vg^+ \quad | \quad vg \end{array}$$

homozygous recessive parent (black body, vestigial wings)

$$\begin{array}{c} b \quad | \quad b \\ vg \quad | \quad vg \end{array} \quad \text{OR} \quad \begin{array}{c} b \quad | \quad b \\ vg \quad | \quad vg \end{array} \quad \text{OR} \quad \begin{array}{c} b \quad | \quad b \\ vg \quad | \quad vg \end{array} \quad [2]$$

(b) not a 1:1:1:1 ratio (because of linkage) OR not independent assortment OR grey normal and black vestigial types/parental combinations/double dominant and double recessive were commoner than 25%/commoner than expected; (linked genes) so were on the same chromosome; grey body vestigial wing and black body normal wing are recombinants OR 2% plus 3% of the offspring are recombinants; recombinants due to crossing over/exchange of genes between (non-sister) chromatids OR 2% and 3% of offspring were due to crossing over OR genes inherited together unless separated by crossing over; crossing over between the two loci/between the two genes on the chromosomes; few recombinants/not much crossing over because genes/gene loci close together;

Accept any of these points from an annotated diagram. [2]
(Total 4 marks)

8. X: cortex; Y: ureter (Total 2 marks)

9. higher nitrogen/urea as blood enters nephron/Bowman's capsule than when it leaves the nephron (in the renal vein); most small soluble molecules/glucose/nutrients/ions are removed from blood in Bowman's capsule; through ultrafiltration; proteins/blood cells/large molecules remain in the blood; as filtrate moves through the nephron (tubule), water is returned to the blood (by osmosis); glucose/nutrients returned to the blood by active transport (and diffusion) / selective reabsorption; in the proximal convoluted tubule; urea / uric acid remain in the filtrate / removed from blood; sodium is pumped into the medulla in the loop of Henle; water reabsorption is enhanced by a high sodium gradient (in the medulla); permeability of the collecting duct membrane is regulated by hormones/ADH; water concentration in urine is variable to maintain homeostasis in the blood; more oxygen/less carbon dioxide in blood entering (kidney) than in blood leaving (kidney)

(Total 7 marks)

D4.1 Natural selection

Skills box

1. Group K, ponds with no other fish.
2. It is not possible to control whether or not other fish were present in the ponds in the field.

3. Ponds with *R. hartii* had more spots per fish both in the greenhouse and in the field compared to the fish in ponds with *C. alta*.
4. Answers will vary. Possibilities include: Temperature is easier to control in a greenhouse than outdoors. Predators such as birds could remove fish from the ponds if they were outdoors. If leaves or other debris from outdoors fell in the ponds, it could alter the pH of the water.

Exercises

- Q1. meiosis and sexual reproduction
- Q2. The dark speckles on the eggs are good camouflage in the nest on the ground. If brightly coloured eggs were produced, they would be more visible to predators from a distance. As a result, they would be more likely to be eaten. This means that the chicks inside would never have the chance to grow up and reproduce. So the genes for the bright egg colour would not be passed on to the next generation.
- Q3. The first spraying will kill most insects in the population, but a few will be naturally resistant. Those few survive and reproduce. The offspring will contain a large percentage of resistant insects.
- Q4. Cryptic colours that blend in with the background allow the males to hide better and mean that they are more likely to survive. Brightly-coloured males tend to be noticed more easily by predators and be selected against. However, the males need to stand out if they are to be attractive to females so ornate colours that make them stand out against the background make them more easily noticed by females and this trait is also selected for.
- Q5. $q = 0.10 = 0.32$
 $p = 1 - 0.32 = 0.68$
 $q^2 = 28/278 = 0.10$
 $2pq = 0.44$
 $p^2 = 0.46$
- Q6. (a) In Lagos, Nigeria, the frequency of **D** is 0.83 and the frequency of **d** is 0.17. In Abha, Saudi Arabia, the frequency of **D** is 0.73 and the frequency of **d** is 0.27.
 (b) For the French Basques the frequency for **d** (0.51) is three times greater than the frequency

in Lagos and nearly twice the frequency in Abha.

- Q7. In artificial selection, humans decide which traits will show up in the next generation by breeding only those with the desired traits. In natural selection, the abiotic and biotic environment selects for some traits and against others.

D4.2 Stability and change

Exercises

- Q1. C
- Q2. The oxygen needed by decomposing bacteria in a body of water is a measurement called Biochemical Oxygen Demand (BOD). Eutrophication increases the BOD.
- Q3. Some species are larger and/or live longer and have more time to accumulate mercury through biomagnification.
- Q4. A cover crop keeps vegetation over the soil. This reduces the effect of rainwater drainage. The cover crop can also be tilled under to increase organic material in the soil.
- Q5. D
- Q6. The tipping point refers to an extent of rainforest removal that will lead to the forest no longer being able to sustain its own regenerative characteristics. For example, the cooling and weather-generating effects of transpiration will no longer occur on the scale necessary to sustain the current rainforest climate.
- Q7. lichens or moss
- Q8. Primary succession requires the formation of soil by many generations of lichens and moss. This is a very time-consuming process. Secondary succession typically starts with soil.

Challenge yourself

1. 1980: 6.2% reduction; 1990: 10.0% reduction; 2000: 14.0% reduction; 2010: 18.1% reduction; 2020: 19.8% reduction

D4.3 Climate change

Exercises

- Q1. B
- Q2. D
- Q3. A
- Q4. increases in temperature > permafrost melts > methanogenic archaeans become active and decompose organic matter > methane released into atmosphere > increased methane concentrations in the atmosphere lead to increases in temperature > even more permafrost melts
- Q5. In a garden greenhouse, it is the glass that lets in light but traps heat. On Earth, greenhouse gases in the atmosphere play that role.
- Q6. Coral bleaching is caused when slight changes in the water occur, often because of human activity: temperature increases or acidification of the water because of increased CO₂ levels, for example, contribute to the problem.
- Q7. A

Challenge yourself

- There is a strong correlation.
- No. Correlation does not mean there is causality. It could be just a coincidence. To conclude that one is causing the other, a mechanism needs to be able to explain how the phenomenon works.
- Scientists cannot draw a conclusion of causality from a correlation unless they can provide a logical mechanism explaining the causality. As CO₂ is known to be a greenhouse gas that can radiate heat energy back to Earth, there is a mechanism for causality in this case.

D4 Practice questions

- C (Total 1 mark)
- B (Total 1 mark)
- C (Total 1 mark)

- “scientists would accept” hypothesis A as the better one as mutations are random; scientists would reject hypothesis B because characteristics acquired during the lifetime of the individual being inherited is Lamarckian/not part of the evolution by natural selection theory/not all mutations are heritable; “the resistance” mutation would be present in the population initially and not caused by the shampoo “as hypothesis B states”; both hypotheses include variation in the population of lice “resistant and non-resistant”; variation is necessary for natural selection to occur; frequency of the best adapted increases and these individuals reproduce/pass on resistance to their offspring, so the resistant population increases “so hypothesis A is better”

(Total 3 marks)

- mutations cause variation among organisms of same species/population; some variations/mutations make an individual more suited to its environment/way of life; individuals that are better adapted are more likely to survive and produce offspring; individuals pass on genetic characteristics/mutation/variation to offspring; natural selection increases frequency of characteristics/alleles that make individuals better adapted;

(Total 4 marks)

- sustainable communities/ecosystems allow continued survival of organisms/OWTTE; natural ecosystems can be sustainable over long periods of time/OWTTE; natural ecosystems/rainforest more sustainable than agricultural areas/plantations; diverse community/high biodiversity/higher biodiversity in natural ecosystems/rainforest OR less/low biodiversity in agricultural areas/agricultural soils; agricultural areas/monocultures more affected by pests/diseases; nutrient recycling (efficient) in natural ecosystems/rainforest; nutrients removed with crops/nutrients removed when crops are harvested OR less formation of humus/less organic matter in agricultural soils; more water recycling/more rainfall/more transpiration in natural ecosystems/rainforest; larger biomass/more carbon stored (in biomass) in natural ecosystems/rainforest; shallower soils/less soil erosion/degraded soils/infertile soils in agricultural areas

(Total 3 marks)

- (a) One mark for correct description of the trend off the Antarctic Peninsula, one mark for correct description for the Ross Sea; accept correct statements other than those

given here 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 move South in the Ross Sea when it is clear that they are moving North; if you can discern their intention, then give them the benefit of the doubt on this.

Antarctic Peninsula: decrease/stable at the base of the peninsula / decrease in the area of the Penguin colonies/West of the tip / increase/ above and below the peninsula / variable pattern;

Ross Sea: sea is increasing / 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; [2]

- (b) (off AP) sea ice season has declined as has penguin population; colonies 2 and 3 sea ice season has not declined and population increased; colony 3 increase in population and growing length of sea ice season; colony 2 has stable / increasing numbers and sea ice season is not changing; colony size and sea ice season length/area are correlated; population numbers for colonies 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'.

[2]

(Total 5 marks)

8. A (Total 1 mark)

9. C (Total 1 mark)

10. carbon dioxide is a greenhouse gas; increases in carbon dioxide increase/enhance the greenhouse effect; greenhouse effect is a natural phenomenon but not its increase; Earth receives short-wave radiation from the Sun; re-radiated from Earth as longer wave radiation/infrared/heat; carbon dioxide/greenhouse gases trap/absorb longer wave radiation/infrared/heat; global warming happened during same time/period as carbon dioxide rise; carbon dioxide concentration correlated (positively) with global temperature/global temperature (causal) link accepted by most scientists; no proof that human-made increases in carbon dioxide have caused global warming; increases as carbon dioxide concentration increases;

(Total 5 marks)

11. (a) Capricorn and Bunkers group [1]

(b) there is no clear trend [1]

(c) effects (generally) increase with temperature anomalies/WSSTA; effects increase for all different coral covers;

OR

in the 25–49% cover there is an anomaly/is not an increasing trend; harmful effect is higher in coral covers between 50–75%/vice versa; [2]

(d) 50%/25%/49%;

OR

25–49% (coral cover); [1]

(e) the closer the corals are (to each other) the easier the transmission; other organisms in the community may act as vectors/carriers / OWTTE; [1]

(f) Similarities: similar range of cover in both periods; weak correlation/no correlation in either;

Differences: higher WSSTA range/more WSSTA in 1998–99 than in 2002–03; positive (2002–03) versus negative correlation (1998–99); more coral reefs with very low % of coral cover (0–20%) in 2002–03;

Must respond with one similarity and one difference for full marks. [2]

(g) coral cover lower on reefs with higher temperature; corals would not be able to maintain their skeletons; [1]

(h) (if coral reefs are lost) habitat will be lost; some organisms/coral can decline if the water becomes too acidified; coral bleaching could occur/become worse;

OR

coral could expel their mutualistic alga/zooxanthellae; enzymes could be denatured; real environmental conditions/larger scale investigations/more variables studied; [3]

(Total 12 marks)