nelson net.

Student book answers

Chapter 1 Science inquiry skills

Chapter review questions

Remembering

1 Australian scientist – primary data; WHO scientist – secondary data

2 Independent variable – amount of rainfall; dependent variable – beef production

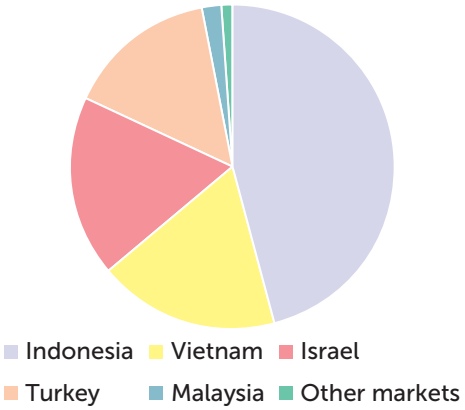
Understanding

3 Repeat the measurement multiple times and calculate an average.

Applying

4 **a** Inference
b Hypothesis
c Prediction
d Conclusion

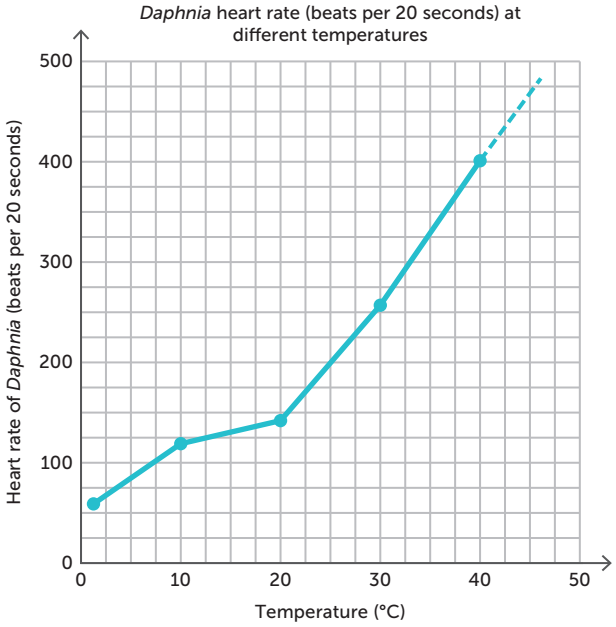
5



Practice exam questions

1 D
2 C
3 B
4 C
5 C
6 B

7 a



Marking criteria	Marks
accurate title that includes both variables	1
choose appropriate graph/line graph	1
correctly allocates independent/dependent variables to X and Y axes respectively	1
scale uses correct intervals and graph size is appropriate for grid size	1
correct labelling of both axes including units	1
data points are accurate and accurately joined	1
Total	**6**

b i 135 beats/20 seconds (accept 130–140, must have units)

ii 470 beats/20 seconds (accept 460–480, must have units)

iii Heart rate at 15°C **or** first estimate **or i** because this is an interpolation/within the range of the data. Heart rate at 45°C is an extrapolation/outside of range of the data.

c i Temperature – it is the variable that the investigator controls/changes

ii Increase the sample size **or** use more *Daphnia* **or** repeating experiment

iii Heart rate in *Daphnia* is affected by temperature **or** heart rate in *Daphnia* is not affected by temperature **or** *Daphnia* heart rate increases with increasing temperature **or** increasing water temperature increases heart rate in *Daphnia*

d Heart rate depends on temperature – when first added to assigned temperature, heart rate will reflect previous temperature **or** heart rate needs time to adjust to assigned temperature. By waiting, the biologist will improve the accuracy/validity of experiment.

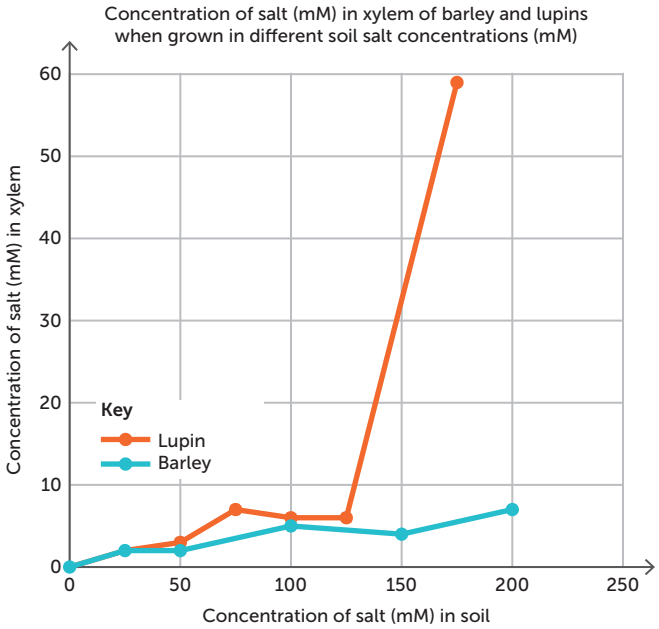
e 1 mark – conclusion is wrong **or** partly wrong **or** only partly right.

3 marks:

- there is a range of hearts beats for each temperature that is broad or overlap those of other temperatures

- 208 beats/20 seconds is also within the range of heart rate for 20°C and 40°C (can also mention 30°C)
- any accurate quote of data that includes range in heart rate for a particular temperature.

8 a



Marking criteria	Marks
accurate title that includes both variables	1
choose appropriate graph/line graph	1
correctly allocates independent/dependent variables to X and Y axes respectively	1
scale uses correct intervals and graph size is appropriate for grid size	1
correct labelling of both axes including units	1
data points are accurate and accurately joined	1
Total	**6**
NOTE 'mean' is required in Y axis label	

b i 5.5 mmol L^{-1} (accept 4 to 7; must have units)

ii 32.5 mmol L^{-1} (accept 31 to 34, must have units)

iii 1 mark – Barley at 175 mmol L^{-1}/estimate 1

1 mark:

barley shows little change between 150 and 200 mmol L^{-1}

or

there are more data points around 175 mmol L^{-1} for barley

or

lupins show huge change between 125 and 175 mmol L^{-1}

or

there are missing data around 150 mmol L^{-1} for lupins.

c Any three of:

- control experiment should only have one (changing) variable
- can properly measure the influence of soil salinity or stops factors that would hide influence of soil salinity
- improve validity of experiment or can draw valid conclusions or valid comparisons
- specific example of uncontrolled influence (e.g. differences in watering could influence salt concentration in soil/xylem).

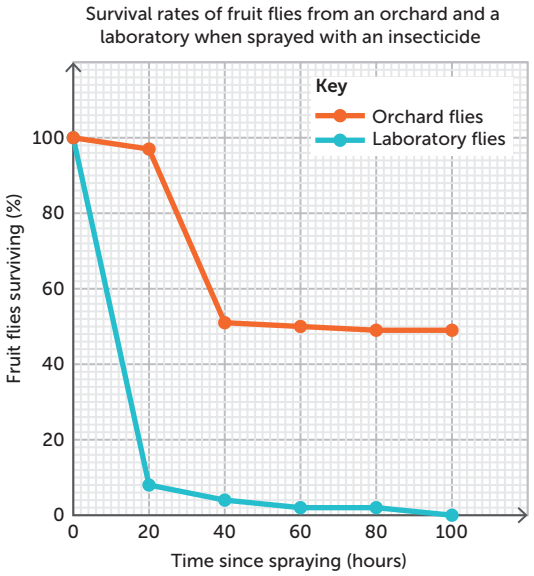
d Any three of:

- improve reliability or can draw more reliable conclusions
- the larger the sample size, the higher the reliability or the smaller the sample size, the lower the reliability
- (large sample size) increases chances of representative sampling/reduces chance effects or (small sample size) decreases chances of representative sampling/increases chance effects
- (large sample size) reduces influence of outliers or (small sample size) increases influence of outliers.

9 Any four of:

- On average, location 2 had more people per household or location 1 had fewer people per household.
- In location 1, most households had 2 people or 1 or 2 people or there were more households with 1 or 2 people than in location 2.
- In location 1, very few households had 6 people or households with 6 people were the least common.
- In location 1, there was a (sharp) decline in numbers after 2 people per household.
- In location 2, most households had 6 people or had 5 or 6 people.
- In location 2, households with 3 people were the least common.
- In location 2, there were more households with 3, 5 or 6 people than in location 1.
- For location 1, any accurate quote of data which gives both the number of dwellings and the number of persons per household.
- For location 2, any accurate quote of data which gives both the number of dwellings and the number of persons per household.
- The range in the number of people per household was the same for both locations.

10 a



b i The survivorship of fruit flies from the orchard will be higher than the survivorship of the fruit flies from the laboratory when sprayed with/exposed to the insecticide

or

The survivorship of fruit flies from the laboratory will be lower than the survivorship of the fruit flies from the orchard when sprayed with/exposed to the insecticide

or

The survivorship of fruit flies from the laboratory and from the orchard will be the same when sprayed with/exposed to the insecticide

or

Fruit flies from the orchard will be more resistant to the insecticide than fruit flies from the laboratory

or

Fruit flies from the laboratory will be more susceptible to the insecticide than fruit flies from the orchard

ii 1 mark – Yes

Any 2 marks:

- the laboratory flies are the control
- they had not previously been exposed to the insecticide
- all (other) conditions were identical

OR

- the laboratory flies are the control
- they had not previously been exposed to the insecticide
- all (other) conditions were identical

OR

Following 3 marks:

1 mark – No

1 mark – Need to measure survivorship in flies that have not been sprayed (with insecticide)

1 mark – Because the orchard and laboratory flies have come from different environments (which could influence the results)

c i 1 mark – 460 (no units required as they are given in question)

1 mark – Any one of:

- number of flies at 20 hours was 970
- number of flies at 40 hours was 510
- 970–510

ii 11 hours (accept 10–12, must have units)

iii 1 mark – Measure survivorship more often

1 mark – (Especially) between 0 and 20 hours or around the time when 50% (of flies) were dead.

Chapter 2 Processes for the continuity of life

Question set 2.1

Remembering

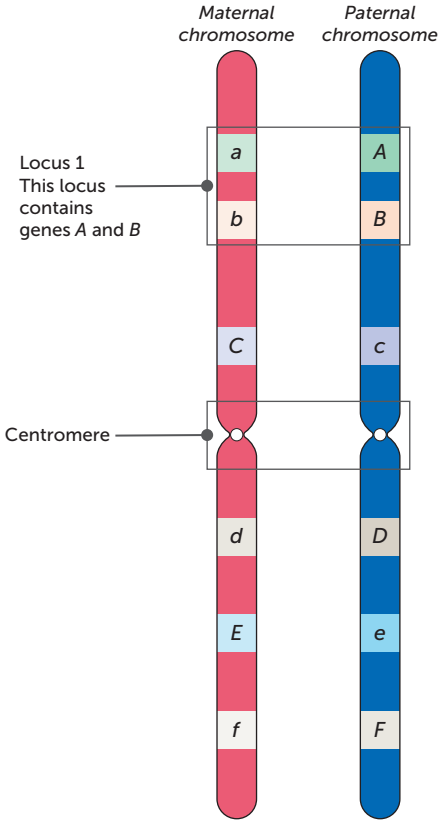
1 **a** Cell division is a process where a cell splits into two functioning cells for an organism to grow and repair. There are several ways a cell can divide depending on the organism. In eukaryotes, cell division either takes place in the process of asexual reproduction (mitosis) or sexual reproduction (meiosis).

b Sexual reproduction is the process when offspring is produced from two parent haploid cells that fuse to form a diploid cell. The offspring, or diploid cell has a mixture of genetic material from both parent haploid cells.

c Asexual reproduction occurs with the division of a cell or organism to produce offspring that inherits genetically identical material to the parents.

2 Constructing a karyotype, or karyotyping, is a process used to observe an organism's chromosomes. Cells are stopped from dividing and chromosomes are released from cells and stained to identify banding patterns. Chromosomes are matched according to banding pattern and size, and arranged from largest to smallest. The sex chromosomes are displayed last, or in the bottom right corner of the chart. patterns.

3



Understanding

4 A haploid cell has only one copy of each chromosome whereas a diploid cell has two copies of each chromosome. Gametes, sperm or egg cells, are examples of haploid cells and a somatic cell is an example of a diploid cell. The haploid number is represented by *n*.

5 Fertilisation is the process of gametes (haploid cells) fusing to produce a zygote (diploid cell). As gametes have half the number of chromosomes of the organism's somatic cells the union of two gametes restores the chromosome number for the organism. This process occurs in sexual reproduction and creates genetic diversity in the offspring.

6 Genes hold information that codes for the expression of specific proteins that determines traits, or particular characteristics that are expressed in an organism.

7 Prokaryotes and eukaryotes differ in that prokaryotic cells lack membrane-bound organelles and that prokaryotes are generally haploid whereas eukaryotes are diploid. The DNA found in prokaryotic cells is in an unbound circular form within the nucleoid region of the cytosol. Plasmids, which are rings of DNA, may also be found in the cytosol and replicate independently from the main chromosome. In eukaryotic cells, which has membrane-bound organelles, DNA occurs in two forms. DNA in an unbound circular form is found in the mitochondria and chloroplasts and in a bound form associated to histones forming tightly coiled chromosomes within the nucleus of the cell.

Analysing

8 Both prokaryotes and eukaryotes have a plasma membrane to contain the cells contents and ribosomes, proteins that assist in building proteins. Prokaryotic and eukaryotic cells contain DNA in unbound circular form. In prokaryotic cells, DNA is located in the nucleoid region of the cytosol and in mitochondria and chloroplasts of eukaryotic cells.

Question set 2.2a

Remembering

1 **a** Interphase is the stage between cell divisions in the cell cycle. Interphase is subdivided into various phases.

b Mitosis is the division of the nucleus of eukaryotic cells and maintains the parental diploid number of chromosomes in daughter cells. Mitosis allows for the replication and transfer of genetically identical material from parent cell to the next generation.

c Meiosis is the division of cells to produce gametes (haploid cells) in sexually reproducing organisms. Two rounds of cell division occur, with the first round duplicating DNA and the second round halving the chromosome number. Meiosis allows for the diversification of genetic material to be passed on to the next generation.

2 The six phases of the cell cycle:

- G_1 (first gap) phase: during the G_1 phase metabolic activity and growth of the cell occurs.
- G_0 phase: cells that are fully differentiated and will not divide any further, remain in the phase of metabolic activity and growth until the cell dies.
- S_1 (synthesis) phase: for cells that will undergo cellular division, cells enter the S phase where DNA is replicated or synthesised.

- G_2 (second gap) phase: cells continue to grow, synthesis of other molecules and reproduction of organelles as cells prepare for cell division.
- M (mitosis) phase: division of the nucleus of the cell.
- C (cytokinesis) phase: the division of the cytoplasm of the cell.

Understanding

3 The terms 'parent' cell and 'daughter' cell are used to differentiate between the original cell from the newly formed (offspring) cells.

4 Mitosis is division of the nucleus. Cytokinesis is division of the cytoplasm.

Analysing

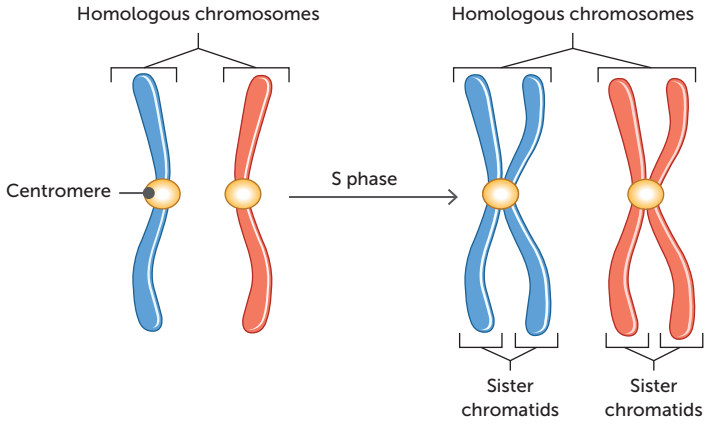
5 Students' own diagrams, based on the information in Figure 2.6, page 32

Question set 2.2b

Remembering

1 The four phases of mitosis are: prophase, metaphase, anaphase and telophase.

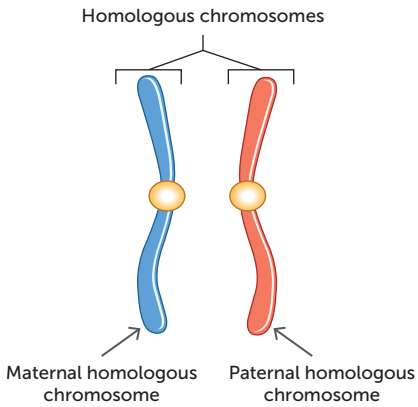
2



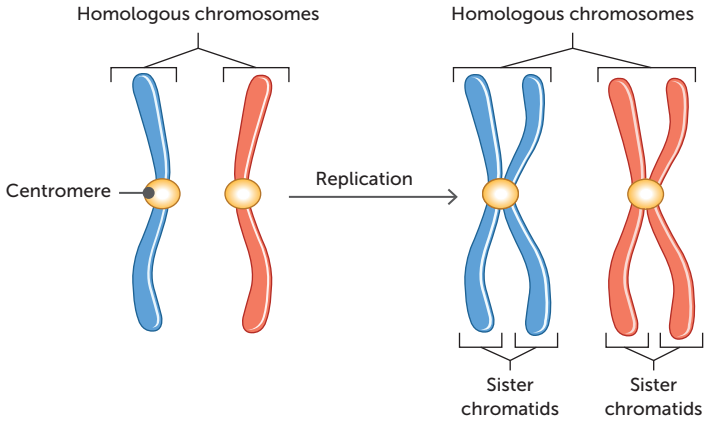
3 Plant cells have a cell wall whereas animal cells do not. During cytokinesis plant cells form a cell plate that will become the cell wall and separate the two daughter cells. In animal cells, the cytoplasm divides by a process known as cleavage, likened to pinching of the cell.

Understanding

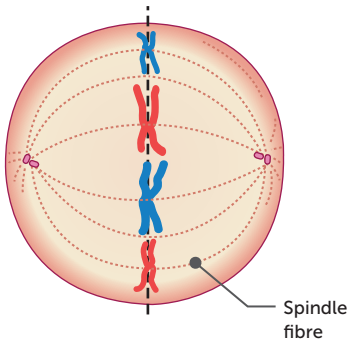
4 a



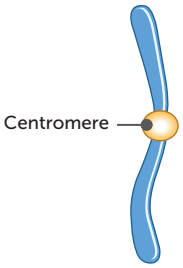
b Diploid describes a cell that has two copies of each chromosome.



c



d

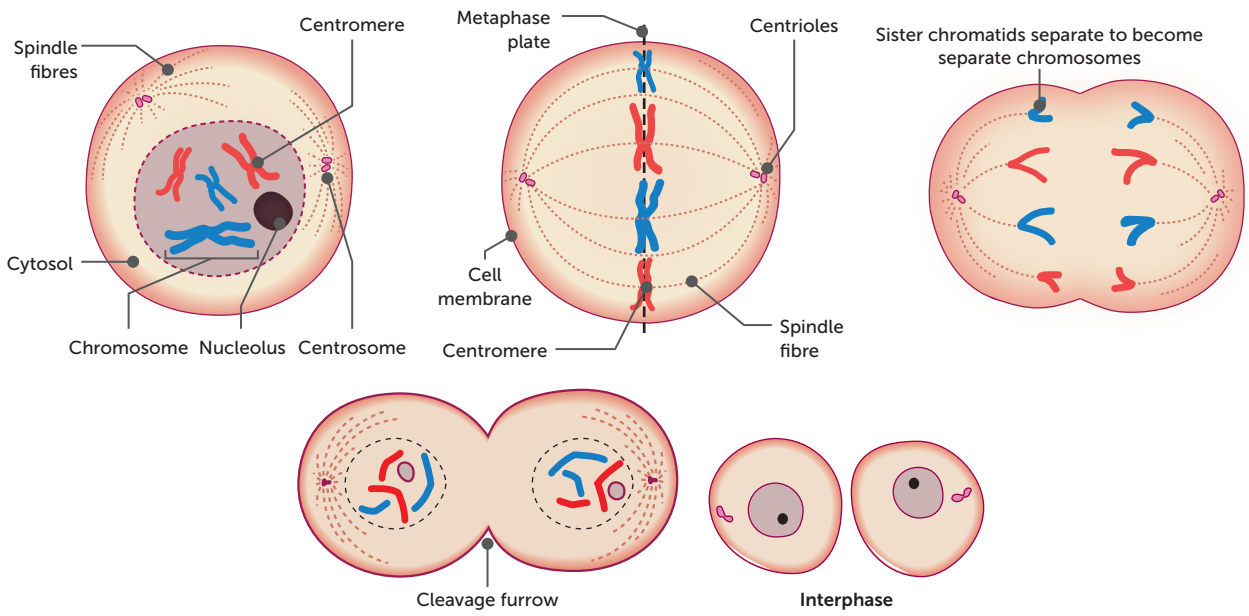


5 Homologous chromosomes have the same number of genes, but they have different alleles for each trait as they come from two different parents. One of the homologous chromosomes is from the mother (maternal) and the other from the father (paternal).

6 Before mitosis begins, the cell goes through S phase and replicates its DNA and chromatids. This doubles the number of chromosomes in a cell. At the beginning of mitosis, the diploid number in the parent cell is 4. During cell division, the cell divides and separates the chromosomes evenly, leaving each daughter cell with the same number of chromosomes as the parent cell originally had. Following mitosis, each daughter cell has a diploid number of $2n$.

Applying

7



Question set 2.2c

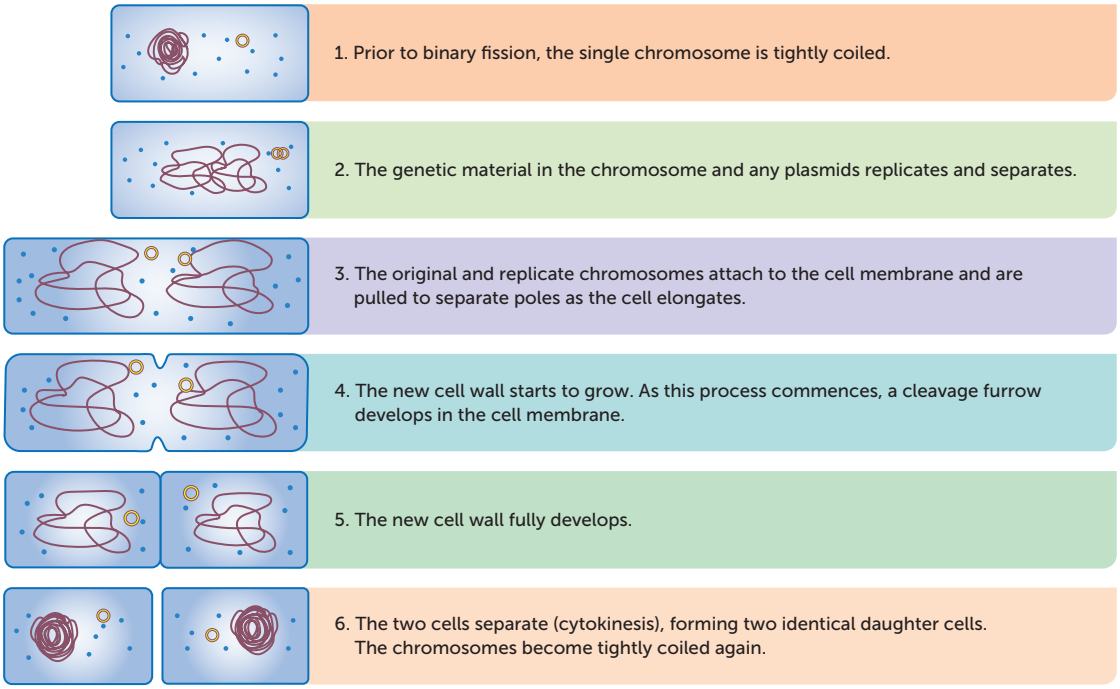
Remembering

1 Chromosome replicates, cell elongates, cleavage furrow develops, new cell wall is completed and cytokinesis.

Understanding

2 Mutation that occur in DNA during cell division is one mechanism by which prokaryotes can increase their genetic diversity. As binary fission occurs relatively quicker than other cell division processes, it is prone to mutations occurring in the DNA, which increases the rate of variation.

3



nelson net.

Question set 2.2d

Remembering

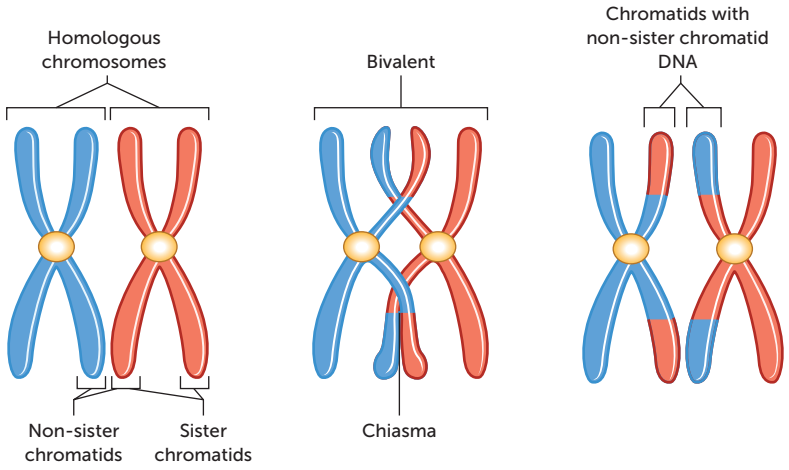
1 Prophase I, Metaphase I, Anaphase I, Telophase I, Prophase II, Metaphase II, Anaphase II, Telophase II.

2 Following the first round of meiosis where each pair of chromosomes is separated, cytokinesis I occurs forming two daughter cells. Following the second round of meiosis, chromatids of each chromosome are separated from each other and cytokinesis II takes place to produce four different daughter cells.

3 Synapsis is the process when homologous chromosomes (maternal and paternal) line up together and connect to allow crossing over to occur.

Understanding

4



5 Independent assortment occurs during metaphase I. Maternal and paternal homologous chromosomes randomly line up at the equator of the cell; that is, it is a random process whether the paternal or maternal chromosome lines up on the left or the right of the other of the metaphase plate. The random arrangement of maternal and paternal homologous chromosomes leads to greater genetic variation in gametes when the final division happens.

6 Daughter cells formed through mitosis are diploid ($2n$), are genetically identical to each other and are somatic cells. Daughter cells formed from meiosis are haploid (n), are genetically diverse from each other and are germ cells (gametes).

Applying

7

Factor	Human	Tasmanian Devil
$2n$ (diploid number)	23	14
Number of chromosomes in parent cell	46	28
Number of chromosomes in a somatic cell, at the end of mitosis	46	28
Number of chromosomes in a sex cell (gamete) at the end of meiosis	23	7
Number of chromosomes at the end of Telophase I	23	7

Question set 2.3

Remembering

1 **a** Fertilisation is the fusion of a female and male (haploid) gamete leading to the formation of a zygote.

b Autosomes are chromosomes that are not sex chromosomes.

c Apoptosis is a programmed and controlled process that leads to cell death.

2 Two different parent cells (diploid - $2n$) are the inputs of meiosis with four genetically diverse gamete cells (haploid - n) being the output of meiosis.

3 Sex chromosomes determine whether a female or a male zygote is formed.

Understanding

4 Asexual reproduction occurs with the division of one parent cell, which usually leads to the offspring having an identical genetic makeup as the parent. This is why offspring produced from asexual reproduction resemble their parents. In sexual reproduction the offspring are usually different from the parents, as there are two genetically diverse parent cells (gametes) that join to form a zygote. Genetic variation is also increased due to the processes of crossing over and independent assortment when gametes are produced.

5 Apoptosis is a necessary process in an organism's development and maintenance so that the organism can grow and function optimally. For example, a developing animal will need to have cells go through apoptosis to form organs and tissues properly.

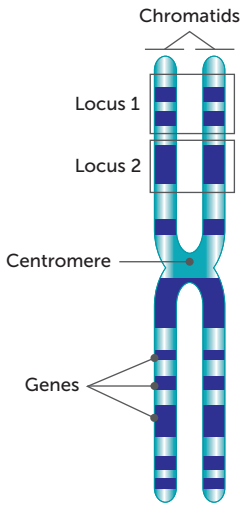
Applying

6 Fertilisation is the process of two gametes joining to form a zygote that will develop into an adult organism. The gametes need to have half the number of chromosomes so that when two gametes join, they produce the correct number of chromosomes for that species.

Chapter review questions

Remembering

1



2 A karyotype is a picture of a person's chromosomes. The 23rd pair of chromosomes are the sex chromosomes. They determine an individual's sex.

3 The cell cycle is composed of stages of division and non-division. During interphase, cells that will undergo division go through preparatory phases where genetic material replicates within the nucleus. In mitosis, chromatin threads condense to form chromosomes. As the nuclear membrane disintegrates, the chromosomes move to the centre of the cell. Chromatids are separated by the shortening of the spindles, which pull each chromatid towards to the opposite pole of the cell. Newly formed nuclear membranes then form around the chromatids, which now decondense to become chromatin. The cell undergoes cytokinesis to form two daughter cells identical to the parent cell, and the cell has been through one cell cycle.

Understanding

4 In any given cell, the amount of DNA doubles during the S phase of interphase as a result of DNA replication. The amount of DNA halves during the C phase in mitosis owing to the formation of two new nuclear cells.

5 Binary fission and mitosis are both examples of asexual reproduction. A parent cell splits approximately equally into two identical daughter cells. Binary fission occurs in prokaryote cells, whereas mitosis occurs in eukaryote cells.

6 Particular regions along the length of a chromosome that code for different proteins that can determine particular characteristics are referred to as genes.

Applying

7 If cytokinesis didn't occur during a cell cycle, one cell with two nuclei would probably result.

Analysing

8 **a** The gametes would be expected to contain 31 chromosomes.

b Somatic cells of the zebra would be expected to contain 44 chromosomes.

c There would be 62 chromosomes in the somatic cell of the donkey.

d The $2n$ number would be 53.

e The zebra karyotype would have 22 pairs of matched chromosomes, whereas the zonkey karyotype would have 53 unmatched chromosomes.

f The zonkey would not be able to pass through the first stage of metaphase in meiosis because there could be no pairing of homologous chromosomes.

g Most hybrid animals are infertile because meiosis cannot proceed and no gametes can form for fertilisation.

9

Mitosis	Meiosis
Nuclear and cell division for growth, repair and replacement of tissues	Nuclear and cell division for producing sex cells (gametes)
Takes place in somatic cells	Takes place in gonads or reproductive organs of living things (e.g. ovaries and testes of mammals, ovaries and anthers of flowering plants, spores of some plants)
One cell division completes the process	Two cell divisions complete the process
Two cells are the outputs	Four cells (gametes) are the outputs
Each daughter cell contains the diploid number of chromosomes ($2n$)	Each daughter cell contains the haploid number of chromosomes (n)
Asexually reproducing organisms (e.g. plant cuttings, runners, bulbs) reproduce by mitotic division of cells; prokaryotes reproduce by binary fission, not mitosis	Sexually reproducing organisms reproduce by fusion of gametes, restoring the diploid number ($2n$) of chromosomes for each cell
New cells or offspring produced by this kind of reproduction do not show variation between them unless there are environmental influences or mutations; they are genetically identical to each other (i.e. clones)	Offspring produced show variation between them
Variation and diversity of offspring are narrowed	Variation and diversity of offspring are increased
Applications include for tissue culture, such as skin grafts and cloning plants	Application include creating new varieties of organisms

Evaluating

10 Eukaryotic chromosomes are generally linear, whereas prokaryote chromosomes are generally circular. Chromosomes are generally single stranded except when they replicate in cell division. From the S phase through to metaphase of mitosis, chromosomes are double stranded.

11 DNA does replicate during meiosis. Instead of two daughter cells produced in mitosis, meiosis results in four daughter cells. If DNA had not replicated, each daughter cell would have one quarter of the DNA of the parent cell.

12 Meiosis produces gametes with half the parental DNA, allowing for joining of two gametes to produce a cell with the parental (somatic cell, diploid) amount of DNA.

13 The cells are not necessarily dead. They could be specialised and in the G_0 phase of mitosis.

14 Students' responses will vary. The answer could include the following:

- Asexual reproduction advantages: advantageous in situations where organisms are unable to move, environments are stable and variation is not important. Less energy is needed for reproduction, compared to sexual reproduction.
- Asexual reproduction disadvantages: where environment changes, lack of variation could kill all organisms.

- Sexual reproduction advantages: allows for variation, creating species that can adapt to new environments and that cannot be wiped out by a single disease.
- Sexual reproduction disadvantages: requires significant energy on the part of the organism to find a mate.

Creating and reflecting

15 Answers will vary

Practice exam questions

1 A

2 A

3 C

4 D

5 63:

- horse sperm/egg/gamete/haploid cell = 32 chromosomes
- donkey sperm/egg/gamete/haploid cell = 31 chromosomes
- egg and sperm/gametes fuse/haploid cells fuse to form zygote/mule/offspring
- 32 + 31 = 63

6 Any four of:

- meiosis is used to produce gametes
- meiosis is disrupted
- mules have an odd number of chromosomes/chromosomes do not match up
- chromosomes do not form pairs (in meiosis) therefore chromosomes do not segregate (to different poles/gametes) correctly
- produce gametes with the wrong number of chromosomes/genes
- mules do not have all of the genes/chromosomes needed (to produce functional gametes)
- mules are hybrids/sterile or mules have the genes/chromosomes of two different species.

7 Binary fission or asexual reproduction:

- Chromosome/genetic material is replicated/duplicated
- Duplicated chromosome/genetic materials moves to opposite end of cell/segregate
- Cell grows/gets large
- Each copy of duplicated chromosome attaches to a different part of the cell membrane
- Cell divides into two daughter cells/cytokinesis
- New cell wall is laid down
- Each daughter cell has a copy of chromosome/genetic material/is identical to the parent.

8 First stage/cell division – Any two of:

- homologous chromosomes pair
- homologous chromosomes line up on equator (of cell)
- homologous chromosomes move to different poles/ends of cell
- Second stage/cell division

- Individual chromosomes line up on equator (of cell)
- Chromatids/split chromosomes/chromosome halves move to different poles/ends of cell

Any one of:

- Results in four cells
- Used to produce gametes
- Halves number of chromosomes/produces haploid cell
- DNA condenses (at the start of the process).

Total 5 marks

Genetic variation:

- Crossing over
- Homologous chromosomes/pairs of chromosomes exchange (homologous) sequence
- Each chromosome is now a blend of maternal and paternal DNA/creates new combinations of alleles (on a chromosome)
- Independent assortment/random assortment of chromosomes
- Maternal and paternal chromosomes (non-homologous) move independently to different poles/nuclei or chromosome pair move to different poles at random
- Produces large range of variation in gametes or mix of paternal and maternal chromosomes in gametes

Total 5 marks

9 **A** chromosome

B sister chromatids

C centromere

D homologous chromosomes

10 Crossing over. It results in new combinations of genes that are different from either parent, contributing to genetic diversity/variation.

nelson net.

Chapter 3 DNA structure and function

Question set 3.1

Remembering

1 Franklin, Wilkins, Watson and Crick.

2 DNA is a twisted helix structure that is double stranded. The steps of a ladder-like centre are made of complementary nucleotides, adenine pairing with thymine and cytosine pairing with guanine; held together by weak hydrogen bonds. The side rungs are made of a sugar–phosphate backbone.

Understanding

3 DNA is not found in the nucleus of a prokaryotic cell because prokaryotic cells do not have membrane-bound organelles and therefore do not have a nucleus. Instead, the single chromosome of DNA is found in the cytosol of the prokaryotic cell.

4

Nitrogenous base	Complementary base pair
A	T
C	G
T	A

Analysing

5

Adenine	Cytosine	Thymine	Guanine
7	3	7	3
21	25	21	25
43	44	43	44

6 Thymine 30%; which leaves 40% in total – 20% cytosine and 20% guanine.

Question set 3.2

Remembering

1 One phosphate group, one deoxyribose sugar, one of four nitrogenous bases.

2 Students' diagrams should show:

- one nucleotide labelled and parts labelled
- a key showing complementary base pairs thymine with adenine and cytosine with guanine.
- 3 weak hydrogen bonds between C and G
- 2 hydrogen bonds between A and T
- antiparallel strands. One strand with either the sugars facing the opposite way or 5′ to 3′ on one strand and 3′ to 5′ on the opposite strand
- Sugar–phosphate backbone labelled and attached by phosphodiester/covalent bonds.

3 DNA contains a deoxyribose sugar, whereas RNA contains a ribose sugar.

Understanding

4 The two strands are oriented in opposite directions. 5′ to 3′ indicates direction from a phosphate group to begin with and ending the strand with a deoxyribose sugar. ON the opposite side, the direction is 3′ to 5′ starting with a sugar and ending with a phosphate group.

Analysing

5
- A nitrogenous base structure enables it to interact and attract the complementary base pair. This helps with holding the form of DNA and with the addition of nucleotides when DNA is copied.
- DNA is a sequence of nucleotides of four different types. The sequence is a unique code for an individual organism. The code can be passed on to generations.
- The unique sequence of nucleotides can also be compared when studying genetics or evolution to show differences between individuals or species.
- The sequence also codes for proteins.

Question set 3.3

Remembering

1 Helicase separates the two strands of DNA by breaking of weak hydrogen bonds; DNA polymerase attaches complementary nucleotides; ligase seals the backbone by creating a phosphodiester bond.

2

Understanding

3 The end-product consists of two identical daughter molecules that are made of one conserved old/parent strand and one new strand. Each molecule is half new and half old.

Analysing

4 DNA replication double the DNA/genetic material readying a cell for cell division. For the daughter cells to have the correct amount of genetic material, the DNA doubles prior to the start during DNA replication in the S phase of the cell cycle.

5 CGGATAACGT

Question set 3.4

Remembering

1 **a** The sequence of consecutive DNA ‘letters’ spanning all the chromosomes of a cell from start to finish is known as the genome sequence.

b Also known as a gene, coding DNA codes for a specific amino acid sequence and forms a polypeptide.

c Non-coding DNA does not code for proteins but can code for other functions.

2 Proteins are the link.

Understanding

3 A DNA triplet is the stored code and consists of three DNA nucleotides, whereas a codon consists of three RNA nucleotides and is a complementary copy of the DNA triplet.

Analysing

4 Nucleotide sequences are read in threes because three nucleotides are required for translation into one amino acid.

Question set 3.5a

Remembering

1 To produce a protein from the DNA genetic code via mRNA

2 Transcription and translation

Understanding

3 Enzymes: help break or form new bonds

Codons code for amino acids

Nucleic acid: DNA stores genetic code, mRNA is a copy and transports it to ribosome, tRNA translates it by transferring amino acids.

Amino acids: the building blocks of polypeptides/proteins.

Analysing

4 Transcription and translation in prokaryotes happens simultaneously. There is only one chromosome containing limited number of genes and no nuclear membrane separating the area of transcription and translation. Ribosomes are readily available as transcription occurs. This is in contrast to transcription and translation in eukaryotes, where there is a nuclear membrane separating the DNA from the ribosomes. Only mRNA can fit through the nuclear pores. Many more genes are found in eukaryotic cells in their multiple linear chromosomes.

Question set 3.5b

Remembering

1 The purpose of transcription is to synthesise a copy of a gene, into a short single strand of mRNA, to carry the genetic information from the nucleus through the nuclear pore to a ribosome for translation.

2 Nucleus

Understanding

3 DNA triplets are composed of three consecutive DNA nucleotides: either adenine, thymine, cytosine and guanine. Codons are made of three consecutive RNA nucleotides but which replace thymine with uracil.

Applying

4 Introns are non-coding RNA. They are removed from pre-mRNA and do not code for a specific protein. This is in contrast to exons, which consist of coding RNA. They join together to form mature mRNA because they do code for a specific protein.

Question set 3.5c

Remembering

1 A chain of amino acids

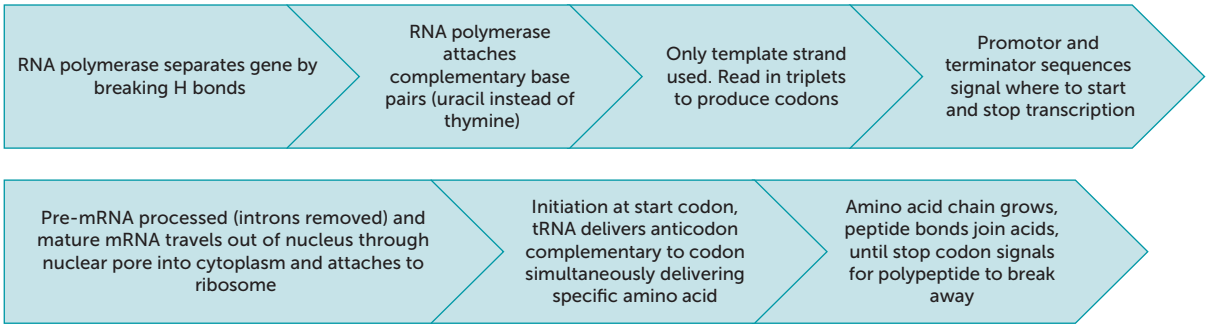
2 RNA polymerase

Understanding

3 tRNA carries anticodons that are attracted to the codons in mRNA. They undergo complementary base pairing so that the correct amino acid, also carried by the tRNA, is delivered to a growing chain of amino acids. Once the amino acid is delivered and a peptide is formed between the new amino acid and the previously delivered amino acid, the tRNA will break away with its anticodon still intact, ready to pick up another of the same amino acids. This interaction occurs at the site of a ribosome.

Creating

4



Question set 3.6

Remembering

1 A large macromolecule made from a chain of amino acids

2 Structural proteins and enzymes

3 Collagen, which performs a structural role in the connective tissue of mammals. Amylase, which is a digestive enzyme helping break down starch into smaller units.

Understanding

4 A codon and anticodon are both made of RNA nucleotides uracil, adenine, cytosine and guanine. Codons are found along a chain of codons on a strand of mRNA. In contrast, a single anticodon (set of three nucleotides) is found on one tRNA molecule. The anticodon (set of three nucleotides) is complementary to the codon (set of three nucleotides).

Analysing

5 Firstly, the mRNA needs to be determined from the DNA, then the codon table used.
A-U-G-U-C-U-C-G-U-G-A-A-U-U-U-U-C-C
methionine-serine-arginine-glutamic acid-phenylalanine-serine

Chapter review questions

Remembering

1 Hydrogen

2
- Twisted double helix
- Four bases adenine pairs with thymine, cytosine with guanine
- Weak hydrogen bonds
- Two H bonds between A and T, three between C and G
- Nucleotide base unit and consists of one phosphate, sugar and base
- Purines (A and G) and pyrimidines (C and T)
- Antiparallel strands running from 5′ to 3′
- Phosphodiester bonds between sugars and phosphates.

3 A genome consists of all the nucleotides, the complete set, in the DNA in a cell.

Understanding

4 Enzymes are biological catalysts that help break or form new bonds.

DNA replication	Protein synthesis
DNA helicase, DNA polymerase, RNA primase, DNA ligase	RNA polymerases

5 Information can act as pieces of a puzzle. Once enough information is gathered from various sources, another step forward in terms of discovery can be facilitated. Rosalind Franklin's diffraction photo and Chargaff's pairing rules of DNA led to Watson and Crick's model of the structure of DNA.

6 One gene can be transcribed to contain introns and exons. The introns do not code for the particular protein required at the time and are removed as non-coding DNA. The exons join together to form the codons required to make the protein.

7 **a** One strand of the DNA helix ladder is maternal and the other strand is paternal.
b Different organisms have different types of DNA because they are very different from each other.

8 A protein's structure directly affects is function. Its three-dimensional structure through its folding enables functional interactions to occur.

Applying

9 Similarities:

- Both produce newly synthesised strands of nucleic acid.
- Both require enzymes to separate the DNA strands and join bases
- Complementary base pairing enable the synthesis.

Differences:

- Only a small part of the DNA strand, a gene, is used in transcribing mRNA whereas DNA replication involves the copying of the whole DNA molecule.
- The main enzymes involved in transcription are RNA polymerases, whereas DNA polymerases are involved in replication.
- Only a single strand is copied in transcription, whereas both strands are copied in replication.
- Replication uses the nitrogenous base thymine, whereas transcription uses uracil.

10 For the chain to form, nucleotides are joined together by a phosphodiester bond for the backbone to be sealed.

11 Pre-mRNA consists of coding and non-coding nucleotides called exons and introns. It is the unprocessed molecule formed immediately after transcription. After processing/RNA splicing, introns are removed and exons join to form mature mRNA ready to exit the nucleus.

12 Weak hydrogen bonds enable the separation required for replication to begin. Enzymes can easily separate the two strands to expose the two template strands because the hydrogen bonds are weak. Then to synthesise a new strand, the attraction between the complementary pairs enables the new strand to easily form and join to an old strand. The result is a semi-conserved molecule.

13 One possibility is

mRNA: GGG-CCC-CCC-GCG

DNA: CCC-GGG-GGG-CGC

Analysing

14

DNA – deoxyribonucleic acid	RNA – ribonucleic acid
Double strand	Single strand
Thymine	Uracil
Contains sugar deoxyribose	Contains sugar ribose
Longer	Shorter

15 **a** Thymine

b Individuals would have tiny variations.

c 8

d Diploid: 16; haploid: 8

Evaluating

16 No DNA requires materials/machinery to replicate. Enzymes such as helicase, RNA primase, DNA polymerases and ligase are needed to separate the strand, attach a primer, attach new nucleotides and create phosphodiester bonds.

17 As the DNA strands are antiparallel and DNA polymerase synthesises DNA in a 5′ to 3′ direction, DNA polymerase will move in the same direction as helicase on the leading strand, that is towards the replication fork. On the lagging strand, DNA polymerase will be synthesising DNA, forming Okazaki fragments in the opposite direction to helicase, away from the replicating fork.

Creating

18 Student answers will vary

19 Protein synthesis steps require transcription and translation of a genetic code.

Transcription:

- In the nucleus, an area of DNA of one gene becomes unzipped by the action of RNA polymerase.
- Weak hydrogen bonds are broken separating the two strands.
- Only one of the two strands of DNA is used, called the template strand, to create an mRNA molecule.
- RNA polymerase binds to a promoter (a start signal) on the DNA/initiates transcription.
- mRNA is produced from the DNA template strand, and is ‘read’ three bases at a time (in triplets)
- mRNA is complementary to the template (non-coding/anti-sense) strand.

The non-template strand/coding strand does not participate in transcription but it is the code for a protein (if you substitute thymine for uracil). This is the sense strand and is the DNA that has the same base sequence as the mRNA

- The new RNA is synthesised in a 5′ to 3′ direction.
- The enzyme RNA polymerase assists in the complementary base pairing (DNA with RNA nucleotides) adenine with uracil, thymine with adenine, guanine with cytosine and cytosine with guanine.
- Uracil is used instead of thymine in RNA.
- Nucleotides are read as triplets and are equivalent to codons on the mRNA.
- The process continues until a terminator signal is reached.
- The mRNA contains codons which are triplets of nucleotides/bases
- At the end of transcription, pre-mRNA contains introns and exons. The introns are removed before the mRNA is ready to exit. Exons join to make the mature mRNA. One gene can code for more than one protein. This is possible because different codons can become introns/exons when a different protein is required by the cell.
- Single stranded mRNA detaches from the DNA and floats through one of the nuclear pores into the cytoplasm.

Translation:

1 mark for any of the following:

- mRNA will locate and attach to a ribosome.
- mRNA will align the first two codon triplets within the boundary of the ribosome.
- The process starts at a start codon.
- The ribosome 'reads' mRNA one codon at a time.
- A specific tRNA floats towards the codon. It contains and delivers the complementary anticodon.
- The tRNA also carries the amino acid specified by its anticodon.
- The amino acid bonds with the first amino acid forming a peptide bond.
- The system of attaching complementary anticodons and their specific amino acids continues until the polypeptide has been formed.
- The type of bond between each amino acid is a covalent bond.
- The order of amino acids was determined by the order of anticodons, which was determined by the order of codons which was determined by the order of DNA triplet bases.
- tRNA breaks away one at a time from its amino acid partner, ready to join to another amino acid of the same type.
- The final codon triplet acts a signal to STOP and the polypeptide breaks away from the final tRNA molecule and floats in the cytoplasm until needed.
- The polypeptide folds to become a protein or joins with other polypeptides to fold and become a protein.

Reflecting

20 Answers will vary

Practice exam questions

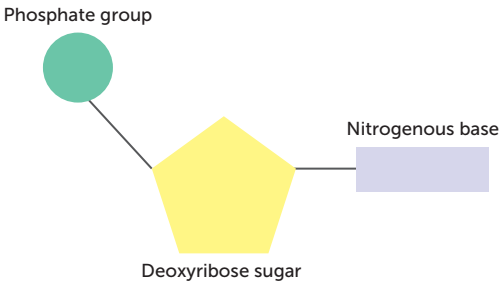
1 B

2 A

3 A

4 B

5



6 **a** Adenine and thymine; cytosine and guanine

b Hydrogen bond

c Adenine

7
- Single-stranded
- String of nucleotides
- Phosphate backbone
- Ribose sugar
- Bases are A, G, C and U.

8
- Used to translate/read genetic code
- Carries a particular amino acid
- Amino acid (that is carried) is determined by anticodon
- Carries amino acid to ribosome
- Recognises (corresponding) codon in mRNA
- Anticodon is complementary to this codon
- Places amino acid in (correct position) growing protein/polypeptide/amino acid chain.

9 Any two of the following:
- DNA contains deoxyribose sugar
- RNA contains ribose sugar 1–2

or
- DNA contains thymine
- RNA contains uracil 1–2

or
- DNA (usually) occurs in the nucleus
- RNA occurs in nucleus and cytoplasm or RNA occurs in cytoplasm 1–2

or
- DNA contains genes
- RNA translates/transfers genetic code 1–2

or
- DNA is (usually) double-stranded
- RNA is single stranded 1–2

or
- DNA is self-replicating/synthesised from DNA
- RNA is synthesised from DNA.

10 Structure (5 marks):
- Consists of two strands/molecule is in the shape of a double-helix/ladder.
- Each strand consists of nucleotides.

Any other 3 marks:
- The (two) strands run in opposite directions or are antiparallel.
- Nucleotides on opposite strands pair.
- The nucleotides on different strands are held together by hydrogen bonds.
- Nucleotides consist of a sugar and phosphate group and nitrogenous base.
- The nucleotides/bases are adenine, cytosine, guanine and thymine.

- Adenine pairs with thymine, cytosine pairs with guanine.
- The nucleotides on the same strands are connected via the sugar and phosphate groups or by phosphodiester bonds.

DNA replication (5 marks) any five of the following:

- The (double-stranded) DNA unwinds/separates or the two strands (of nucleotides) separate.
- Each of the two DNA strands/molecules is copied/acts as a template/becomes half of the new DNA molecule.
- The new strand/molecule is complementary to the original/template strand (the enzyme) DNA polymerase synthesises the new DNA strand/molecule/adds nucleotides to the new strand.
- Helicase unwinds the DNA/double helix/separates the DNA strands.
- The (hydrogen) bonds between adjacent nucleotides/strands are weak and easily broken.
- The process is described as semi-conservative.
- Synthesis is continuous one strand (leading strand, 5′ to 3′).
- Synthesis is discontinuous on the other strand (lagging strand).
- Synthesis occurs in one direction only or in a 5′ to 3′ direction or DNA polymerase can only add nucleotides to the 3′ end or DNA polymerase cannot nucleotides to the 5′ end (therefore) One strand (5′ to 3′) is synthesised continuously (leading strand)/one strand (3′ to 5′) is synthesised in short pieces (lagging strand).
- (On the lagging strand) Short stretches of DNA are joined together to form the new molecule.
- Ligase joins the short stretches of DNA together.
- DNA polymerase corrects mistakes.

nelson net.

Chapter 4 Variation and mutation

Question set 4.1

Remembering

1 **a** Diversity of genetic and phenotypic traits within and between populations

b A phenotype is an observable trait produced by the actions of one or more gene-encoded proteins. The phenotype is influenced by the genotype and the effects of the environment.

c The genotype is the genetic composition of an organism for a particular trait. It is the set of alleles present for a trait.

d An allele is a form of a gene. Different alleles code for the same trait but different versions of the trait.

2 Mutations and sexual reproductive processes

3 Environmental factors such as temperature and pH; epigenetics which affects gene expression and therefore phenotypic variation

Understanding

4 An allele is a form of a gene. A set of alleles is known as a genotype for a specific trait. When a gene is expressed, its protein is synthesised and performs a function that is the observable trait known as a phenotype.

Applying

5 **a** The genotype is the genetic composition of an organism for a particular trait. It will provide instruction for what proteins are to be expressed, how much and when. Protein expression is the observable trait of the genotype and is referred to as the phenotype. Alleles are different versions of the same gene which means that expression of different alleles will create different observable traits.

b In this instance, the mean and the median would be the same: –14°C.

The mean temperature would be the average of the sum of the two temperatures,

$$\frac{-60°C + 32°C}{2} = -14°C.$$

The median temperature would the middle value between the two values. To find this, the range between the two values needs to be determined, then divided in half. This value is then either added to the lower value or subtracted from the higher value to find the midpoint; that is, the range between –60°C and 32°C is 92°C. 92°C divided by 2 equals 46°C.
–60°C + 46°C = –14°C.

Question set 4.2

Remembering

1
- Temperature can determine the sex of sea turtles
- pH can affect the colour of hydrangea flowers

- Food availability can affect the size of an elephant
- Light availability can affect the height of a kangaroo paw plant

2
- Height
- Size
- Skin colour
- Intelligence

3 Epigenetics include chemical tags that can turn genes on or off. This means that epigenetics can control gene expression in for certain traits. If a gene gets turned off, the usual phenotype will be absent or modified. For example, if a mother smokes while she carries her unborn child, the child's epigenetic factors can be altered so that the child becomes obese.

Understanding

4 Environmental temperature interacts with the gene for sex in sea turtles to determine the sex traits, the phenotypic expression of the gene. If sand temperature is greater than 29.1 degrees Celsius, the turtle will hatch as a female and temperatures lower than this, the turtle will hatch as a male.

Question set 4.3

Remembering

1 **a** A mutation is a permanent change in the DNA sequence in a cell of an organism.

b A mutagen is a physical or chemical agent that causes a mutation.

c A somatic cell is a body cell (a non-sex cell).

d A germline cell is a sex-cell or a cell that will differentiate/develop into being a gamete.

2 A mutation occurring on a dominant allele will only require one of the alleles to be altered for the change to be expressed whereas if the mutation is on a recessive allele, both alleles in a set will require the change for it to be expressed. Recessive mutations lead to a loss of function, which is masked if a normal copy of the gene is present. For the mutant phenotype to occur, both alleles must carry the mutation. Dominant mutations lead to a mutant phenotype in the presence of a normal copy of the gene. The phenotypes associated with dominant mutations may represent either a loss or a gain of function.

Understanding

3 Mutations that occur in somatic cells will only be passed on to daughter cells not to offspring. In contrast, mutations that occur in germ-line cells can be inherited by offspring.

Question set 4.4

Remembering

1 To double the genetic material ready for cell division.

2 When a DNA polymerase inserts a wrong nitrogenous base. Adenine, for example, normally base pairs with thymine but may spontaneously undergo a chemical change that makes it resemble a guanine, which pairs with cytosine. During DNA replication, the identity of the

chemically different form of adenine may be mistaken and a guanine is introduced into the DNA sequence instead.

3 The discovery of mutagens made it easier to study the cause and transmission of mutations.

Understanding

4 Homologous chromosomes may not separate and an extra chromosome will end up in one gamete whereas one less chromosome will end up in another gamete.

5 If the cell's repair mechanism does not fix a mutation that occurs during DNA replication then the mutation will be passed on during cellular division. If mutations occur in somatic cells, then the mutation is limited to that cell and the cells of its progeny. If mutations occur during DNA replication in germ cells, then the mutation is carried through all cell divisions which will lead to every cell within the organism carrying the mutation.

Question set 4.5

Remembering

1

Mutagen	Example	Effect
Physical	X-rays	Gene and chromosome aberrations
Chemical	Mustard gas	Substitution mutation
Biological	Bacteria	Galls (Tumours) in plants

2 Complete breaks in the chromosomes across the double strands

3 Physical mutagens are various types of high energy radiation that cause DNA damage whereas a chemical mutagen is caused by a chemical.

Understanding

4 The bacterium achieves this by inserting a plasmid, called a Ti plasmid, into a cell of the host plant. The Ti plasmid contains genes which code for enzymes that cut the host plant's DNA and integrates a segment of the Ti plasmid into it. The cell of the host plant thus becomes modified by horizontal gene transfer. The integrated bacterial DNA contains additional genes that essentially hijack the host plant cell machinery to produce nitrogen- and carbon-rich compounds that the bacterium uses as a nutritional source. The infected cell is also induced to produce hormones that stimulate the plant cells to rapidly divide and grow. The increased cell divisions result in the formation of the distinctive tumour-like gall that is, in effect, a food factory that sustains the expanding population of bacteria

Applying

5 It is likely this unique segment of DNA in the genome of the wild fruit fly is a transposable element or 'jumping gene'. It has replicated and relocated to different parts of the genome.

nelson net.

Question set 4.6a

Remembering

1 Point mutation is a single nucleotide within the original DNA sequence is affected by a substitution, addition or deletion.

2 **a** A substitution mutation is when one nucleotide is replaced by another.

b An insertion mutation is the addition of one or more nucleotides at a site within the original gene sequence.

c A deletion mutation is the loss of nucleotides from a site within the original gene.

3 **a** A synonymous mutation, also referred to as a silent mutation, occurs when the substituted base results in a triplet that codes for the same amino acid as the original triplet. In this case, there is no change to the protein encoded by the mutated gene. It is identical to that encoded by the original gene.

b A missense mutation arises when a single nucleotide substitution changes the amino acid. The protein will be different to the one encoded by the original gene.

c A nonsense mutation occurs when a single point mutation creates a new STOP triplet within the original gene sequence. This leads to early termination of translation of the transcribed gene sequence. As the remaining sequence downstream of the new STOP codon is not translated, the result is the production of an incomplete polypeptide.

d A frameshift mutation causes the reading frame for the corresponding amino acids to be nudged away from the original and all the triplets downstream of the mutation are affected. The consequence for the translated protein is that the amino acids downstream of the mutation bear no resemblance to those of the original polypeptide. Under such circumstances, even a single nucleotide insertion or deletion can have a profound effect on the corresponding protein.

Understanding

4 **a** Deleterious

b Beneficial

c Deleterious

d Neutral

e Neutral

f Beneficial

Question set 4.6b

Remembering

1 A karyotype is formed from photographic images of chromosomes that are re-arranged into matched and ordered pairs. This is the standard form used to display and analyse chromosomes

2 **a** Somatic cells are diploid ($2n$): the cells contain two sets of chromosomes, one set inherited from each parent. The gametes are haploid (n): the cells contain one set of chromosomes.

b Monoploid ($1n$) cells, like haploid cells, contain one set of chromosomes. However, the chromosomes in monoploid cells represent a single complete and operational set. Organisms

function normally with a monoploid number of chromosomes. By contrast, in haploid gametes, the chromosomes represent half the complete set and are packaged in a dormant state awaiting the fertilisation event that will activate them.

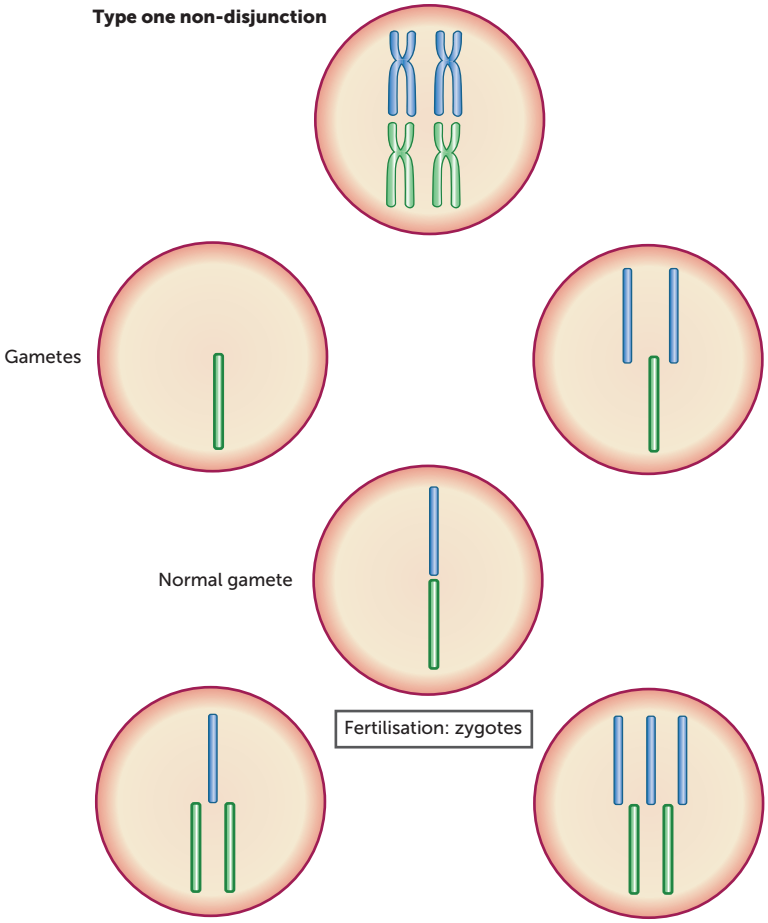
c Monoploid refers to one set of chromosomes, diploid refers to two sets of chromosomes and polyploidy refers to more than two sets of chromosomes.

d Aneuploidy is the condition in which there is an addition or loss of one chromosome from a diploid cell (i.e. $2n + 1$ or $2n - 1$).

3 Deletions, inversions, translocations and duplications

Understanding

4 The diagram should show two homologous pairs of chromosomes before meiosis. Non-disjunction can occur if both of the homologous chromosomes move to one gamete. See diagram below.



5 This will depend on students' response.

6 Students' own responses

7 Aneuploidy is generally deleterious because having an imbalance of whole chromosomes, and hence many genes, affects cell functioning. However, from an evolutionary point of view there may be benefits of an imbalanced chromosome number when adapting to environmental stressors. Variation is the key to species adaptability and survival.

Applying

8 Karyotypes can show large scale changes to chromosomes. Karyotypes for different individuals in a population can be compared so that beneficial or deleterious mutations can be investigated.

Question set 4.7

Remembering

1 Purpose: to produce gametes for sexual reproduction with half the number of chromosomes ready for fusion with another gamete

Process: two divisions involving prophase, metaphase, anaphase and telophase

Products: four non-identical haploid daughter cells

2 **a** Crossing over is the exchange of genetic material between the maternal and paternal homologous chromosomes (non-sister chromatids).

b Chiasmata is the point of contact between two (non-sister) chromatids belonging to a set of maternal and paternal homologous chromosomes.

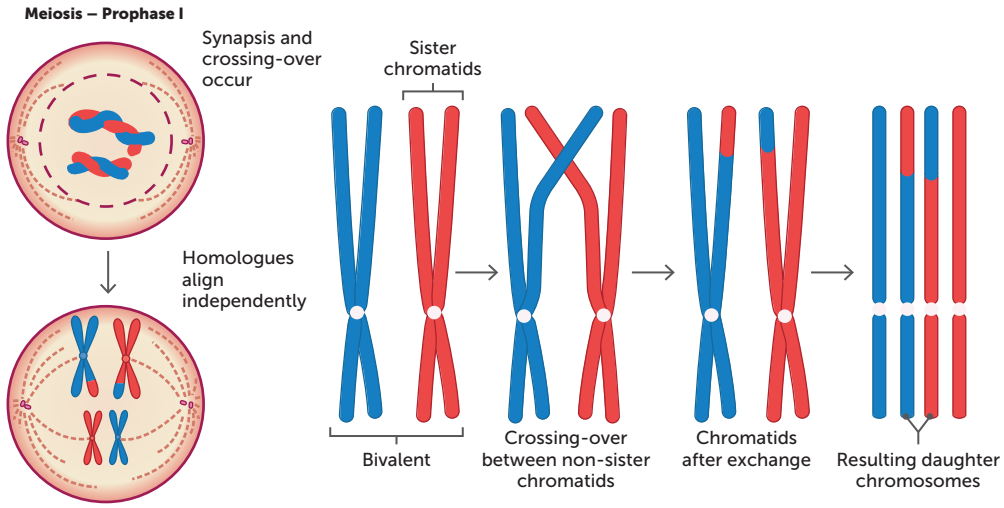
c Independent assortment refers to the random orientation of maternal and paternal homologous chromosomes at the equator during metaphase I. The orientation of each homologous pair is randomly left to right and each pair is not affected by the orientation of any other homologous pair.

d Random segregation is the random separation of a pair of homologous chromosomes into the four different gametes during meiosis

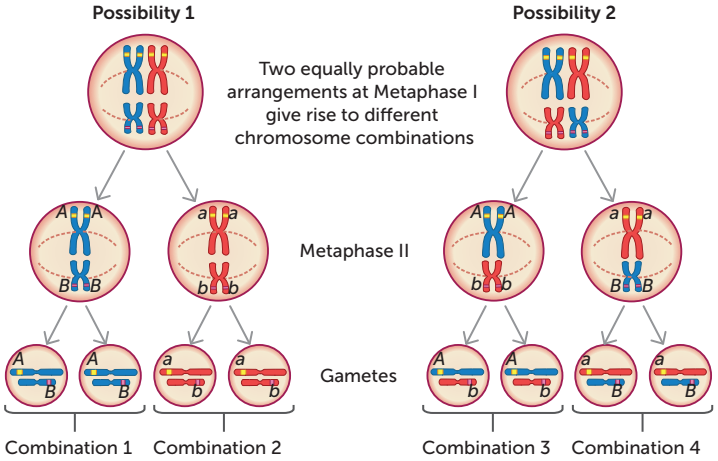
e Fertilisation is the union of haploid male and female gametes during sexual reproduction to produce a diploid zygote.

Understanding

3



4



Applying

5 Sexual reproduction provides genetic diversity because the male and female gametes that are produced contain different combinations of genes than the parent organisms. Asexual reproduction, on the other hand, does not need sperm and eggs since one organism splits into two organisms that have the same combination of genes. Sexual reproduction involves meiosis, which is the process of a cell doubling its DNA, shuffling its genes, and then dividing the shuffled DNA among four cells. Each resulting cell, or gamete, resulting from meiosis has only half the amount of DNA as the parent cell. So in order to form a new organism, two gametes, the sex cells, must fuse, further mixing the genes to produce more genetic diversity.

Asexual reproduction only involves one parent and the offspring a usually identical to the parent after reproduction.

Chapter review questions

Remembering

1 **a** Behavioural

b Biochemical

c Morphological

d Physiological

e Biochemical

2 There are a number of possible answers. One suggestion for each has been given here.

a Duplication of segments 2 & 3 that have then inverted and been inserted back

b Segments 4, 5 & 6 have inverted

c Segments 4, 5 & 6 have been inverted then segments 4 & 5 have been deleted.

d Segments 7 & 8 have been translocated from another chromosome.

3 All of these terms refer to types of single nucleotide mutations (SNPs). In the examples, the SNP is caused by the substitution of one nucleotide for another. The type of nucleotide that is substituted will have varying effects on the translated protein. It may either code for the same amino acid as the original (synonymous), code for a different amino acid (missense), or create a STOP signal (nonsense mutation).

Applying

4 The puppies have the same genotype, the same sets of alleles. However, environmental factors interact with the genes to influence the phenotypes. Even though the same proteins are produced in each puppy, over time, accumulated differences in diet, temperature and exposure to other differing environmental factors would influence the phenotypes.

5 Aneuploid cells have an abnormal number of chromosomes. Because each chromosome contains hundreds of genes, the addition or loss of even a single chromosome disrupts the existing equilibrium in cells and, in most cases, is not compatible with life.

6 **a** This is an insertion mutation.

b As the intron is removed before mRNA leaves the nucleus, there would be no effect on the protein sequence.

c This would likely be a neutral mutation.

7 **a** Karyotype (i) is normal.

b Karyotype (ii) lacks a second sex chromosome. This individual would have Turner syndrome (XO). Karyotype (iii) has an extra chromosome 13. This individual would have Patau syndrome. Karyotype (iv) has an extra chromosome 18. This individual would have Edwards syndrome.

c In all three cases, the errors have been caused by segregation errors in either parent and in either meiotic division. Instead of the two homologous chromosomes separating into different cells, both go into the same cell leaving one half of gametes with two copies of the chromosome and the other half of gametes with no copies. It is interesting that current research is showing that the overwhelming number of trisomies arise from errors during maternal meiosis I.

8

Genetic mutation	Amino acid	Type of genetic mutation	Effect on protein
GTCCCA ↓ GTCCCT	Valine–Proline ↓ Valine–Proline	Substitution	Synonymous – protein same
TCAATA ↓ TAATA	Serine–Lysine ↓ STOP	Deletion	Nonsense – early termination of protein
AGAGGT ↓ AGATGT	Arginine–Glycine ↓ Arginine–Cysteine	Substitution	Missense – change in protein
GCAAGA ↓ GAAAGA	Alanine–Arginine ↓ Glutamic acid–Arginine	Substitution	Missense – change in protein
CAGTAC ↓ CACGTAC	Glutamine–Tyrosine ↓ Histidine–Tyrosine	Insertion	Frameshift mutation – changes to amino acids for the rest of the polypeptide

Analysing

9 GGG could be mutated to GGT, GGC, GGA and still result in a glycine amino acid. It seems the third nucleotide in the codon is most prone to being mutated as this is the only one that has changed.

10 This unusual plant may have been caused by a nucleotide point mutation or a chromosome mutation. Sequencing the genes responsible for growth rate would determine whether there is a point mutation. Karyotyping could determine whether there have been changes to a chromosome.

11 A newborn child's cells are dividing and forming new cells rapidly as the baby grows and tissues develop. The rate of cell division in adults is much lower as growth is complete and cell differentiation is minimal. Dividing cells are more at risk of mutation caused by the X-rays so it is riskier to X-ray young children. Also, with a longer expected lifetime and resultant increased chance of repeated exposure, there is the higher chance of accumulated damage in children compared to adults.

Evaluating

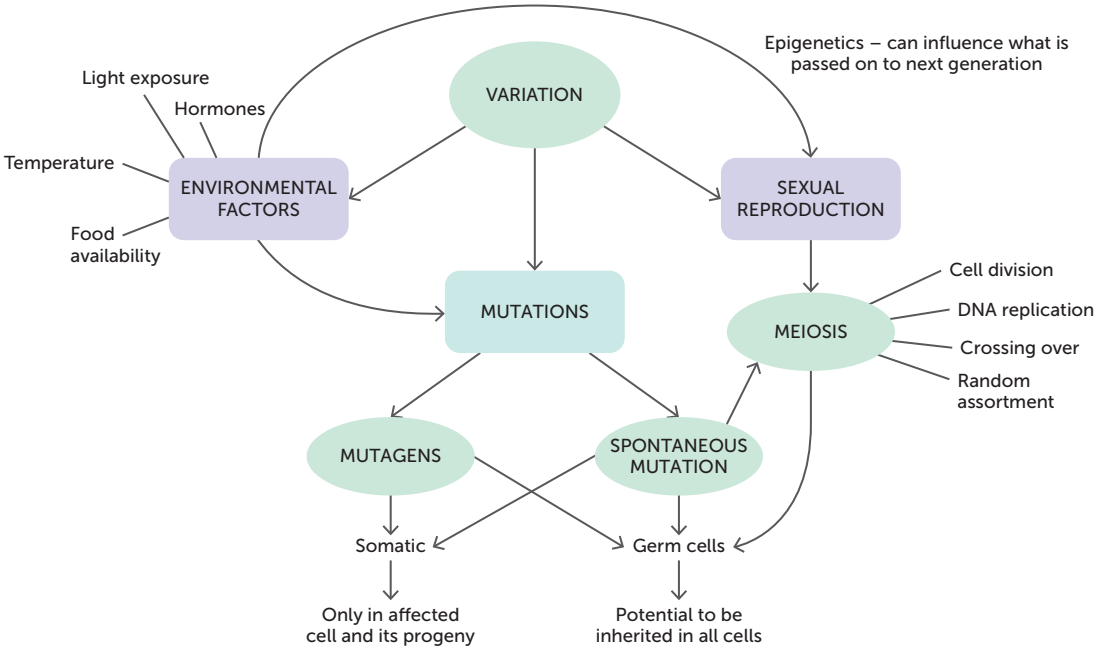
12 This will depend on students' responses after research. Cancers are ultimately caused by genetic mutation.

13 Light skin pigmentation would be beneficial in the Arctic Circle. There are low levels of UV radiation in this environment. Light skin provides better absorption qualities of ultraviolet radiation. This helps the body to synthesise higher amounts of vitamin D for bodily processes such as calcium development. A light skin would be deleterious in equatorial Africa because UV radiation is higher in this environment. Dark skin protects against the damaging effects of UV radiation on DNA. Whether or not a mutation is beneficial is relative to the individual's environment.

Creating

14 Students' own diagrams

15



Reflecting

16 Students' own responses

Practice exam questions

1 D

2 A

3 D

4 B

5 D

6
- Fusion of gametes
- Combines genetic material from two different parents/male and female parents/egg and sperm
- Meiosis produces haploid gametes or gametes with only one copy of each chromosome type
- Restores diploid number of chromosomes or ensures individuals have two copies of each chromosome type
- Create genetic variation/differences.

7
- Crossing over exchanges alleles between homologous chromosomes/pairs of chromosomes
- Chromosomes therefore have a different/new/unique combination of alleles (compared to those in the parent they were inherited from)
- The different/new/unique combination of alleles creates different/new/novel genotypes.

8
- Ultraviolet/UV light is a physical mutagen or the photons in ultraviolet/UV light can damage DNA
- Interferes with base pairing
- Breaks the hydrogen bonds between bases (on complementary/ different DNA strands)
- Free bases pair with neighbouring bases on the same strand or form dimers or the free bases are facing each other (as shown in the diagram)
- Usually thymine/T or cytosine/C or pyrimidines (that form dimers).

9
- Mutation changes DNA sequence/structure or chromosome structure/number or permanent change in DNA
- This creates new genetic/DNA variation/polymorphism or new alleles
- Only process that creates new/unique alleles
- New/different alleles (which come from mutation) are needed to create novel combinations of alleles/genotypes/individuals.

10
- Mutation
- Caused by radiation
- Radiation contains energy
- (Physically) damages DNA or alters structure of DNA
- (As a result) Genes do not function or genes do not function properly (causing the abnormalities)
- Parents may pass changes/mutations to offspring

- Individuals in contaminated areas have high levels of mutation (and hence more abnormalities)
  OR
  Individuals in uncontaminated areas have low/normal levels of mutation (and hence fewer abnormalities).

11 Any two of:

- Homologous chromosomes pair
- Homologous chromosomes line up on equator (of cell)
- Homologous chromosomes move to different poles/ends of cell.

Both of:

- Individual chromosomes line up on equator (of cell)
- Chromatids/split chromosomes/chromosome halves move to different poles/ends of cell.

Any one of:

- Results in four cells
- Used to produce gametes
- Halves number of chromosomes/produces haploid cell
- DNA condenses (at the start of the process).

Any five of:

- Crossing over
- Homologous chromosomes/pairs of chromosomes exchange (homologous) sequence
- Each chromosome is now blend of maternal and paternal DNA/creates new combinations of alleles (on a chromosome)
- Independent assortment/random assortment of chromosomes
- Maternal and paternal chromosomes (non-homologous) move independently to different poles/nuclei or chromosome pair move to different poles at random
- Produces large range of variation in gametes or mix of paternal and maternal chromosomes in gametes.

nelson net.

Student book answers

Chapter 5 Genetics

Question set 5.1

Remembering

1 A line of organisms that always produce offspring with the same phenotype when crossed with one another.

2 Alleles are different forms of a gene. A gene is the stored set of instructions for a protein. One gene may have a set of two or more alleles. A locus is the position a set of alleles (gene) is found on a chromosome.

3 Genotype is the specific combination of alleles belonging to an individual or cell. Phenotype is the actual form taken by a specific feature in a particular individual based on their genotype.

4 The P or parental generation refers to two individual organisms that represent the start of a breeding experiment. Their offspring are the F_1 (first filial) generation and the F_2 (second filial) generation are the offspring of the F_1 generation. The F_2 represent the second generation produced from a cross between two parents (P generation).

5 When an organism contains two dissimilar alleles, it is said to be heterozygous. When an organism contains identical alleles, it is said to be homozygous.

Understanding

6 Tall trait: *TT* or *Tt*; short trait: *tt*. *Tt* is heterozygous and would result in a dominant phenotype, *TT* is homozygous and shows the dominant phenotype, *tt* is homozygous and shows the recessive phenotype.

Analysing

7 Key:

Alleles

T = tall (dominant allele)

t = short (recessive allele)

	T	***T***
T	*TT*	*TT*
t	*Tt*	*Tt*

Genotype ratio: 2 *TT* : 2 *Tt* = 1 *TT* : 1 *Tt*

OR ½ *TT* : ½ *Tt* OR 50% *TT* : 50% *Tt*

Phenotype ratio: 4 tall pea plants : 0 short pea plants

OR 100% tall : 0% short

8 Mendel found when he crossed a purebred tall plant with a purebred short plant that the offspring were all tall. There were no medium-sized plants. Furthermore, when he crossed the F_1 plants, the F_2 generation only consisted of tall or short plants. There was never an intermediary form. Therefore, he concluded that the two factors (now called alleles) do not blend, only the dominant factor, or the recessive factor (if it homozygous) is expressed.

Question set 5.2

Remembering

1 Dominant allele:

- The allele that is always expressed in the phenotype
- An allele that masks the recessive allele if paired with one
- An allele that has the same effect on the phenotype whether it is paired with the same or different one
- A capital letter represents a dominant allele.

Recessive allele:

- The allele that has an effect on the phenotype only when present with the same allele (homozygous), e.g. *ww*
- The allele that is only expressed in the phenotype if in the homozygous state
- The allele that is masked by a dominant allele
- A lowercase letter represents a recessive allele.

2 A monohybrid cross involves fertilisation between two monohybrids, parents with genotypes consisting of one dominant and one recessive allele, that differ in only one characteristic. Only one gene is involved. A monohybrid is an organism that is heterozygous with respect to a single gene.

3 To determine the likelihood of producing a child with a particular trait. Assuming two individuals know their genotype for the trait, using a Punnett square allows them to visualise the potential genotypes of offspring as well as determine the likelihood of trait expression.

Understanding

4 The same genotype in organisms can result in different phenotypical expressions due to different environmental factors the organism is exposed to. An example of this is the 'tall' trait inherited in pea plants. Plants may have the genotype of *TT* for the trait but not all plants with this genotype will grow tall. Environmental factors will have an influence whether the plant will reach a tall, medium or short height. If the plants receive enough water, nutrients and sunlight, the plant would grow tall, but if not all of the factors are present then the plant's height will vary.

5

Pure-breeding parental phenotypes	F_1 phenotypes	F_2 phenotypes	F_2 ratio	F_2 ratio rounded to the nearest whole number
Tall plants × short plants	All tall	787 tall, 277 short	2.84:1	3:1
Purple flowers × white flowers	All purple	705 purple, 224 white	3.15:1	3:1
Green pods × yellow pods	All green	428 green, 152 yellow	2.82:1	3:1
Yellow peas × green peas	All yellow	6022 yellow, 2001 green	3.01:1	3:1
Round peas × wrinkled peas	All round	5474 round, 1850 wrinkled	2.96:1	3:1

6 If the P generation is pure-breeding, the F_1 generation are heterozygous and the proportion of dominant to recessive alleles in the F_2 generation is typically 3:1. The factor that appears the most is dominant over the other factor which can be described as recessive. There is no blending of traits.

Analysing

7 During the process of meiosis, single chromosomes carrying one of a pair of alleles segregate into different gametes. The gametes are male or female and fuse during fertilisation bringing random combinations of alleles together. In a monohybrid cross there are usually only two alleles: dominant or recessive. The phenotype for the recessive condition will only be expressed if both alleles are present. If a dominant allele is inherited it will be expressed and mask the recessive allele. Mendel's 3:1 ratio accounts for the offspring produced from parent hybrids with heterozygous genotypes.

	T	***t***
T	*TT*	*Tt*
t	*Tt*	*tt*

The phenotype ratio 3:1 is the result of random segregation into gametes, during meiosis, of an equal mix of dominant and recessive alleles.

Creating

8 **a** Key

Alleles

F = freckles (dominant allele)

f = no freckles (recessive allele)

Cross

Punnet square cross *Ff* (father) × *ff* (mother – for the mother to have the recessive phenotype of no freckles she must have the homozygous genotype)

	F	***f***
f	*Ff*	*ff*
f	*Ff*	*ff*

Genotype ratio: 2 *Ff* : 2 *ff* = 1 *Ff* : 1 *ff* OR 50% *Ff* : 50% *ff*

Phenotype ratio: 1 freckles : 1 no freckles OR 50% freckles : 50% no freckles

Answer: The probability that the child will have freckles is 50% because half of the offspring were heterozygous, and freckles is dominant.

b This question requires some trial and error.

Reasoning:

The only possible genotype that produces short pea plants is *tt*. Therefore, we can start a Punnet square.

Key

Alleles

T = tall

t = short

Cross between: ? and ?

		t
t		*tt*

The question informs us that one parent is tall and one parent is short. One parent must be homozygous short. The other parent has to be tall and heterozygous in order to produce 50% short pea plants.

	t	***t***
T	*Tt*	*Tt*
t	*tt*	*tt*

Answer: The genotypes of the parents must be *Tt* and *tt*.

Question set 5.3

Remembering

1 To determine the unknown genotype of an organism who is displaying the dominant phenotype

2 It should be crossed with an organism displaying the recessive phenotype because its genotype is known – homozygous recessive.

Understanding

3 If the organism with the unknown genotype has presented with the dominant phenotype, then it could either be heterozygous or homozygous dominant. If the breeder uses a homozygous recessive organism to cross with an organism with an unknown genotype, the homozygous recessive organism can only produce one type of allele. The phenotype ratios then give the breeder evidence for the unknown genotype. If the recessive phenotype appears in the offspring of a test cross, the only way this could happen is if the unknown genotype is heterozygous.

Creating

4 The test cross will involve a female fly who is homozygous recessive for ebony body colour. One of two outcomes will occur and are demonstrated in the Punnett squares below.

Punnett square if the male fruit fly's genotype is *EE*	**Punnett square if the male fruit fly's genotype is *Ee***
E | ***E*** ***e*** | *Ee* | *Ee* ***e*** | *Ee* | *Ee*	***E*** | ***e*** ***e*** | *Ee* | *ee* ***e*** | *Ee* | *ee*
Genotype ratio: 100% *Ee* Phenotype ratio: 100% normal yellow body	Genotype ratio: 50% *Ee* : 50% *ee* Phenotype ratio: 50% normal yellow body : 50% ebony body

The ratio of phenotypes will be used to deduce the genotype of the male fly.

Question set 5.4

Remembering

1 Blood group A genotypes: I^Ai or I^AI^A

Blood group O: *ii*

2 Discontinuous variation is a set of discrete phenotypic categories controlled by a single gene and its set of alleles. There are no intermediary forms.

Understanding

3 A person with blood group AB does not carry the recessive allele for blood group O. They can only pass on the alleles for blood group A or B. Therefore, even if the other parent is homozygous recessive, their children cannot be homozygous recessive – not blood group O.

Key:

Alleles

I^A = Group A

I^B = Group B

i = Group O

Cross $I^A\ I^B \times$?

	IA	*IB*
i	$I^A\ i$	$I^B\ i$
i	I^Ai	I^Bi

Genotype ratios: 50% I^Ai : 50% I^Bi

Phenotypes ratios: 50% blood group A : 50% blood group B

All of the offspring carry the allele for blood group O but do not express it.

4 A bar graph is used to compare distinct categories of data. Discontinuous variation comprises of a set of discrete phenotypic categories with no values in between. Only one gene is involved, resulting in a small number of possible phenotypes. The ABO blood group is an example of discontinuous variation that can be plotted using a bar graph to compare the different categories.

Analysing

5

		MUM	
DAD		I^A	I^A
	i	$I^A\ i$	$I^B\ i$
	i	I^Ai	I^Bi

Baby with blood type A

Question set 5.5

Remembering

1 9:3:3:1

2 Non-homologous chromosomes do not belong to the same pair and do not contain the same genes which means they do not code for the same traits. They consist of alleles of different genes.

Understanding

3 Non-homologous chromosomes are chromosomes that carry genes for different traits instead of the same traits. In contrast, homologous chromosomes are in pairs and carry sets of alleles for the same genes. During meiosis, maternal and paternal homologous chromosomes segregate independent of other homologous chromosomes. This means the individual alleles in a dihybrid cross can separate independently of other all other alleles instead of being separated together with other alleles on the same chromosome. This leads to the 9:3:3:1 ratio of phenotypes.

Analysing

4 **a** Both parents genotype: *RrTt* and phenotype: tall and have red flowers.

b If the genes are on non-homologous chromosomes, the ratio of the phenotypes is 9:3:3:1. This occurs due to independent assortment of maternal and paternal homologous

chromosomes during meiosis. The phenotypic ratio would be 3:1 if the genes *RT* and *rt* were on the same homologous chromosome (as they are linked).

5 Grey fur = *G*; white fur = *g*; black eyes = *B*; red eyes = *b*

P generation: doe = *GGBB*; buck = *ggbb*

F_1 generation: all *GgBb*

Cross: *GgBb* × *GgBb*

	$\frac{1}{4}$***GB***	$\frac{1}{4}$***Gb***	$\frac{1}{4}$***gB***	$\frac{1}{4}$***gb***
$\frac{1}{4}$***GB***	$\frac{1}{16}$*GGBB*	$\frac{1}{16}$*GGBb*	$\frac{1}{16}$*GgBB*	$\frac{1}{16}$*GgBb*
$\frac{1}{4}$***Gb***	$\frac{1}{16}$*GGBb*	$\frac{1}{16}$*GGbb*	$\frac{1}{16}$*GgBb*	$\frac{1}{16}$*Ggbb*
$\frac{1}{4}$***gB***	$\frac{1}{16}$*GgBB*	$\frac{1}{16}$*GgBb*	$\frac{1}{16}$*ggBB*	$\frac{1}{16}$*ggBb*
$\frac{1}{4}$***gb***	$\frac{1}{16}$*GgBb*	$\frac{1}{16}$*Ggbb*	$\frac{1}{16}$*ggBb*	$\frac{1}{16}$*ggbb*

Expected phenotypes: $\frac{9}{16}$ grey fur and black eyes; $\frac{3}{16}$ grey fur and red eyes; $\frac{3}{16}$ white fur and black eyes; $\frac{1}{16}$ white fur and red eyes

Question set 5.6

Remembering

1 Many inherited characteristics are controlled by two or more independent genes, with each gene possibly having two or more sets of alleles that contribute to the phenotype. Polygenic inheritance is the inheritance of a set of genes (polygene) that affects a singular inherited characteristic. An example of polygenic inheritance includes skin colour, with each gene interacting with each other that determines skin colour. No gene is dominant over each other, but each gene contributes to the phenotype.

2 Independent assortment is the principle that different characteristics are inherited independently of one another. Characteristics or traits are not transmitted together but independent of each other. This occurs during meiosis when non-homologous chromosomes line up in the centre of the cell prior to division to form gametes. The distribution of chromosomes in the centre of the cell can occur in various combinations so when segregation happens chromosomes separate independently of each other.

3 For most traits there are more than two forms of alleles for a gene, giving rise to variation within an organism. This is referred to as multiple alleles. An example of a gene having multiple alleles is the gene that determines the ABO blood group. There are three alleles that can combine to potentially generate six different genotypes and four distinct phenotypes. Polygenes on the other hand consists of multiple genes, or a set of genes, that interact with each other to determine a particular phenotype. In addition, each of these genes would most likely

have more than 1 or 2 alleles that are involved. Height is an example of a trait that is controlled by more than one gene. Each gene contributes to the phenotype of the characteristic of the individual.

Understanding

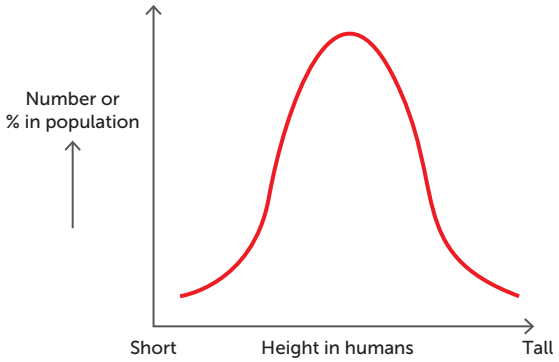
4 Phenotypes that display a range or a spectrum of observable variation of a trait is referred to as continuous variation. The phenotypes in continuous variation are controlled by the inheritance of multiple genes. The genes interact with each other to produce numerous possible variations of the phenotype. Phenotypes that show continuous variation include height and skin colour are examples of characteristics controlled by polygenes. Environmental factors can also have an influence over the phenotype displayed. Discontinuous variation differs as there is only one gene involved and distinct phenotypic categories can be observed, with no intermediate forms. The ABO blood group is an example of discontinuous variation.

Applying

5 Human: ABO blood group in humans have three alleles (I^A, I^B, i).

Drosophila flies have more than 10 alleles for eye colour.

6



Question set 5.7

Remembering

1 In complete dominance, only the dominate allele is phenotypically expressed. If a dominant allele is paired with a recessive allele the dominant allele masks the expression of the recessive allele. An example is the height of a pea plant: if the plant carries the dominant allele, then it will confer height to the plant. Incomplete dominance occurs when two different alleles are present but neither allele is completely dominant. Both alleles partially contribute to the phenotype. Examples of incomplete dominance can include flower colour. In codominance, both alleles are dominant and are fully expressed. Examples of codominance include the ABO blood group and in the colour of flowers.

Understanding

2 A snapdragon plant displaying only pink flowers is an example of incomplete dominance. In this instance there are two different alleles for flower colour, red and white. However, neither allele is completely dominant and both alleles are partially expressed giving the hue pink, a mixture of the allele colours, resulting in an intermediate phenotype.

Applying

3 **a**

Key: alleles

C^W = white coat colour

C^R = red coat colour

Cross $C^WC^W \times C^RC^W$

	CW	***CR***
CW	C^WC^W	C^RC^W
CW	C^WC^W	C^RC^W

Genotype ratios: 50% C^WC^W : 50% C^RC^W

Phenotypes ratios: 50% white : 50% roan

b

Key: alleles

C^W = white coat colour

C^R = red coat colour

Cross ?? $\times$ C^RC^W

	CR	***CW***
CR	C^RC^R	C^RC^W
CR	C^RC^R	C^RC^W

It was a bull with red coat colour.

Question set 5.8

Remembering

1 **a** Autosomal inheritance is the passing on of genes found on autosomes (non-sex) chromosomes.

b Sex linked refers to genes located on a sex chromosome

c X-linked, refers to genes located on the X chromosome

d Y-linked, refers to genes located on the Y chromosome.

2 In the study of genetics, a ‘carrier’ describes a heterozygous individual carrying an allele for a recessive trait.

Understanding

3 **a** Males who have a recessive allele on their X chromosome will always express the trait because they only have one X chromosome. Females will only express the trait when both X chromosomes have the affected allele. A heterozygous female will be a carrier. Males show X-linked recessive traits much more often than females do. This type of inheritance is detected in the pattern of inheritance of a male with the trait and his children. His sons

cannot inherit the trait from their father as they inherit his Y chromosome only. His daughters will get the affected X chromosome, but they will only show the trait if they inherit another affected X chromosome from their mother.

b Heterozygous females will always show the trait and any individuals must have a parent with the trait. Males showing the trait will not pass the affected allele on to their sons (as they must inherit their father's Y chromosome) but they will pass it on to all their daughters, who will also show the trait. A heterozygous female is expected to pass on the allele to 50% of her offspring regardless of their sex.

c The most conspicuous phenotype associated with genes of the Y chromosomes is male gender. Inheritance of the Y chromosome is along the male line from father to sons.

Applying

4 **a** This type of ichthyosis is likely to be X-linked recessive.

b A male would have inherited the condition from his mother.

c The affected male would pass his Y chromosome on to his sons and therefore there is no chance they would inherit the affected gene, which is on his X chromosome.

5 **a** It is an X-linked dominant phenotype.

b Probability of sons being born with X^g is 50%. Probability of daughters being born with X^g is also 50%.

c Probability of sons being born with X^g is 0%. Probability of daughters being born with X^g is 100%.

Analysing

6 Reasoning

1 Dominant or recessive?

Unaffected individuals II3 and II4 have an affected child making them carriers of a recessive allele. They must carry the allele in order for it to be inherited by their daughter. If the allele was dominant one of the parents would have been affected.

Answer: recessive

2 Autosomal or sex-linked?

Affected daughter III5 must have inherited two alleles for the recessive condition, one from the mother and one from the father. For a recessive condition to be expressed, the individual needs to be homozygous or the trait. If the mode of inheritance was X-linked, and III5 received an allele from the father, the father would have to be affected because he only has one X chromosome. He would have been affected because there would not be a paired dominant allele to mask the recessive allele. X-linked recessive is eliminated.

Answer: Autosomal

7 Since freckles are dominant to no freckles, an affected individual such as I2 must at least have one ***F*** allele. Unaffected individuals must have two recessive alleles (***ff***) in order to not have freckles. Notice, I2 has some children who do *not* have freckles. In order to produce children with a genotype of ***ff***, I2 must be able to donate an ***f*** allele.

Answer: I2 genotype is ***Ff***.

nelson net.

Chapter review questions

Remembering

1 **a** An allele is a different version of the same gene.

b The genotype is a specific combination of alleles.

c The phenotype is the expression of the genotype.

2

Heterozygous	Two different alleles are present for a particular gene locus.
Homozygous	Two copies of the same allele are present for a particular gene locus.
Recessive	Two copies of the allele are required for the phenotype to be observed.
Dominant	Only one copy of the allele is required for the phenotype to be observed.
Codominant	Two different alleles are both fully expressed in the phenotype.
Partially dominant	The phenotype is intermediate between each of those determined by two different alleles.

Understanding

3 When pure-breeding individuals breed among themselves, they always produce offspring like the parents with regard to the gene being studied. Individuals are homozygous for this gene. It was important for Gregor Mendel to use purebred plants in his experiments to ensure that only one type of 'factor' was present in these plants.

4 Even though siblings have one of a pair of homologous chromosomes from each parent, they do not always get the same one. Homologous chromosomes separate at meiosis by random assortment to form gametes and this results in different combinations.

5 A cross between tall and short pea plants involves only one gene. The two alleles are tall (T) and short (t). Each individual plant can only have two alleles. If at least one allele for tall (T) is present, then this will be expressed in the phenotype as tall. An intermediate height cannot be achieved with a dominant–recessive inheritance pattern.

6 In the case of two genes, if alleles are randomly assorted, the alleles of the two genes are transmitted independently of each other from parents to offspring. In other words, each of the alleles of one gene may combine with each of the alleles of another gene in equal probabilities. In this case, we would expect a 9:3:3:1 ratio of phenotypes in the F_2 generation of two pure breeding parents, one of whom has both of the dominant traits and one of whom has both of the recessive traits.

By contrast, two alleles may be inherited together. This is not an independent assortment because these alleles are situated near each other on the same chromosome and are said to be linked. In the F_2 generation of two pure breeding parents, one of whom has both of the dominant traits and one of whom has both of the recessive traits, the expected ratio would be 3:1 – $\frac{3}{4}$ having both dominant traits and $\frac{1}{4}$ having both recessive traits.

Applying

7 **a** Black coat = C^B; white coat = C^W

b Grey parents = C^BC^W; black offspring = C^BC^B; white offspring = C^WC^W; grey offspring = C^BC^W

c Codominance

8 **a** Blood type A = I^AI^A or I^Ai; Blood type B = I^BI^B or I^Bi; Blood type AB = I^AI^B; Blood type O = ii

b

	$\frac{1}{2}\boldsymbol{I^A}$	$\frac{1}{2}\boldsymbol{i}$
$\frac{1}{2}\boldsymbol{I^B}$	$\frac{1}{4}I^AI^B$	$\frac{1}{4}I^Bi$
$\frac{1}{2}\boldsymbol{i}$	$\frac{1}{4}I^Ai$	$\frac{1}{4}ii$

Probability of child with blood type AB = 25%

Probability of child with blood type A = 25%

Probability of child with blood type B = 25%

Probability of child with blood type O = 25%

9

	$\frac{1}{2}\boldsymbol{X^R}$	$\frac{1}{2}\boldsymbol{X^r}$
$\frac{1}{2}\boldsymbol{X^r}$	$\frac{1}{4}X^RX^r$	$\frac{1}{4}X^rX^r$
$\frac{1}{2}\boldsymbol{Y}$	$\frac{1}{4}X^RY$	$\frac{1}{4}X^rY$

Red-eyed female : White-eyed female : Red-eyed male : White-eyed male

1 : 1 : 1 : 1

10 P = pink; p = brown; X^D = normal size; X^d = dwarfism

P generation: ppX^dX^d female and PPX^DY male

F_1 offspring will be PpX^DX^d females and PpX^dY males

Pink normal-sized females and pink dwarf males $PpX^DX^d \times PpX^dY$

	$\frac{1}{4}\boldsymbol{PX^D}$	$\frac{1}{4}\boldsymbol{PX^d}$	$\frac{1}{4}\boldsymbol{pX^D}$	$\frac{1}{4}\boldsymbol{pX^d}$
$\frac{1}{4}\boldsymbol{PX^d}$	$\frac{1}{16}PPX^DX^d$	$\frac{1}{16}PPX^dX^d$	$\frac{1}{16}PpX^DX^d$	$\frac{1}{16}PpX^dX^d$
$\frac{1}{4}\boldsymbol{PY}$	$\frac{1}{16}PPX^DY$	$\frac{1}{16}PPX^dY$	$\frac{1}{16}PpX^DY$	$\frac{1}{16}PpX^dY$
$\frac{1}{4}\boldsymbol{pX^d}$	$\frac{1}{16}PpX^DX^d$	$\frac{1}{16}PpX^dX^d$	$\frac{1}{16}ppX^DX^d$	$\frac{1}{16}ppX^dX^d$
$\frac{1}{4}\boldsymbol{pY}$	$\frac{1}{16}PpX^DY$	$\frac{1}{16}PpX^dY$	$\frac{1}{16}ppX^DY$	$\frac{1}{16}ppX^dY$

F_2 generation:

$\frac{3}{16}$ pink normal-size females; $\frac{1}{16}$ brown normal-size females;

$\frac{3}{16}$ pink dwarf females; $\frac{1}{16}$ brown dwarf females; $\frac{3}{16}$ pink normal-size males;

$\frac{1}{16}$ brown normal-size males; $\frac{3}{16}$ pink dwarf males; $\frac{1}{16}$ brown dwarf males

11 All the F_1 generation are expected to be tall and round-shaped, with yellow fruit.
If tall = T, dwarf = t, round = R, pear-shaped = r, red = Y and yellow = y, their genotype would be $TtRrYy$.

F_1 gametes could be: TRY, TrY, TRy, Try, tRY, trY, tRy, try

Analysing

12 If aurea = A and green = a, the cross would be $Aa \times Aa$.

	$\frac{1}{2}\boldsymbol{A}$	$\frac{1}{2}\boldsymbol{a}$
$\frac{1}{2}\boldsymbol{A}$	$\frac{1}{4}AA$	$\frac{1}{4}Aa$
$\frac{1}{2}\boldsymbol{a}$	$\frac{1}{4}Aa$	$\frac{1}{4}aa$

According to the Punnet square, $\frac{3}{4}$ would show the dominant trait (aurea) and $\frac{1}{4}$ would show the recessive trait (green). However, the offspring were closer to $\frac{2}{3}$ aurea and $\frac{1}{3}$ green. This is probably due to the AA genotype being a lethal combination.

13 C = curly wing; c = straight wing; R = red eyes; r = purple eyes

Test cross = $CcRR \times ccrr$. Offspring would be $\frac{1}{2}$ curly wing, $\frac{1}{2}$ straight wing.
All offspring would have red eyes.

14 a The gene resides on the X chromosome. This is because there are different phenotypes shown in male and female offspring from two pure-breeding parents.

b F_1 flies = X^bY and X^BX^b. Offspring expected: 50% brown bodied, 50% yellow bodied.

Evaluating

15 Students' responses will vary but could include:

Limitations: Mendel's experiments were based on characteristics that were determined by genes found on different chromosomes and all showed one phenotype dominant over another phenotype. He did not consider the effect of the environment on gene expression and he had no idea about epigenetics or the interaction of genes. Considering most characteristics in humans are under the control of more than one gene, Mendelian inheritance patterns can be applied to very few traits.

Benefits: There are some Mendelian inheritance patterns that are found in humans. They have been useful when studying pedigrees of families affected with diseases. Many genetic diseases due to a gene mutation were described after observing inheritance patterns.

Creating

16 Most phenotypes are polygenic. They show continuous variation.

Practice exam questions

1 D

2 C

3 C

4 B

5 D

6 a Any three but must say 'allele' not 'gene':

- albinism is recessive/coloured fur is dominant
- need two recessive alleles/need to be homozygous to be albino
- male and female parents were (both) heterozygotes/carried albino allele
- thus possible to get one albino allele from each parent.

b Any four of:

X-linkage

- not possible for non-albino parents /non-albino father to produce albino daughter/female offspring
- father/male only has one X chromosome
- father does not have albino allele on X chromosome (otherwise it would be albino)
- daughter/female offspring inherit one X chromosome from father
- therefore, not possible for any daughter/female offspring to have two albino alleles

Y-linkage

- male parent is not albino therefore no albino allele on a Y chromosome
- albino sons/male offspring only possible if male is albino OR albino sons/male offspring not possible if male parent is not albino
- albino daughters/female offspring are not possible because they do not have a Y chromosome.

c i 0.25 or $\frac{1}{4}$ or 25%

ii *A* = non-albino allele; *a* = albino/albinism allele

	A	***a***
A	*AA* (non-albino)	*Aa* (non-albino)
a	*Aa* (non-albino)	*aa* (albino)

7 Smooth (3) : Wrinkled (1) or Smooth (75%) : Wrinkled (25%) or $\frac{3}{4} : \frac{1}{4}$

Plus any four of:

- Parents: $S_1S_1 \times S_2S_2$
- F_1 generation: $S_1S_2 \times S_1S_2$
- F_2 generation: S_1S_1 (25%), S_1S_2 (50%), S_2S_2 (25%)
- Smooth is dominant
- Therefore S_1S_1 (25%) and S_1S_2 (50%) will have smooth seeds.

8 **1** *w*(*Y*) or X^wY

2 +(*Y*) or X^+Y

3 *ww* or X^wX^w

4 ++/ X^+X^+ and w^+/X^w (X+ – must have both answers to get mark.)

9 Any two of:

- controlled by (the alleles at) more than one gene/multiple genes
- phenotypes show a continuous distribution/variation
- environment also influences phenotype.

Plus one example:

- height in humans
- weight in humans
- growth rate in animals
- grain yield in plants
- skin colour
- any other suitable example.

10 A dominant allele is expressed in the phenotype even when only one copy of the allele is present/even in a heterozygote/when one or two copies of the allele are present.

A recessive allele is expressed in the phenotype only when two copies of the allele are present/only in a homozygote for the allele.

nelson net.

Chapter 6 Biotechnology – its tools and techniques

Question set 6.2

Remembering

1 **a** Restriction enzymes cut segments of DNA at known sequences

b DNA ligase catalyses a more permanent covalent bond, closing up the sugar-phosphate backbone, forming a phosphodiester bond, and sealing the backbone.

c Primers demarcate on a strand of DNA where polymerases should start elongation/synthesis.

2 A recognition site is a specific sequence of DNA where a restriction enzyme will cut DNA.

3 Phosphodiester bond

Understanding

4

Feature	Restriction enzymes that produce blunt ends	Restriction enzymes that produce sticky ends
Exposed nucleotides	Blunt ends do not have exposed nucleotide bases at each end. The ends of the remaining DNA and the removed fragments all have blunt ends.	Sticky ends contain an overhanging, single strand sequence of exposed nucleotides known as a recognition site that are ready for complimentary base pairing.
Specificity	Non-specific	Specific
Advantage	Can join with any other blunt end fragment	Can join efficiently with a desired fragment that is cut with the same restriction enzyme. Produces specific products at a faster rate.

5 The enzyme that attaches nucleotides does not know where to start synthesis without a primer.

Analysing

6 A plasmid is circular; one cut will cause it to become one fragment. When a linear piece of DNA is cut once, the result will be two fragments.

Question set 6.3a

Remembering

1 **a** To greatly increase the number of copies of a DNA sequence for further laboratory use

b The process of joining two pieces of DNA by complimentary base pairing (joining of over-hanging sticky ends). The two pieces are joined by weak Hydrogen bonds only and therefore temporarily

c A vehicle that transports and introduces foreign DNA/genes into host cells

d All of an organism's genetic information, including all of the DNA that makes up the genes that are carried on all the chromosomes.

2 STRs are sequences of DNA, commonly 4 or 5 nucleotides in length, that repeats a certain number of times. They are highly variable segments of DNA, typically of noncoding and nonregulatory DNA, that occur throughout the genome and contain repeats of the same sequence of several nucleotides lined up, one after the other. They can be used to distinguish between individuals of the same species because they are repeated a unique number of times in different individuals.

3 The machine used in a PCR reaction is a thermal cycler.

4 Denaturation 95°C, Annealing 50–60°C, Extension 72°C

5 Components required for PCR are the DNA to be copied (template), DNA polymerase, a buffer solution that contains salts and other chemicals that help the polymerase to function, a supply of the four nucleotides (i.e. A, T, C, G) from which to build the new DNA molecules, and two primers.

Understanding

6 Denaturation: Two strands of DNA separate.

Annealing: Primers are added to each end of the DNA strand.

Extension: New DNA strands are synthesised.

Applying

7 2^{10} pieces of DNA would be produced if one sample went through 10 cycles of PCR. Five copies of a DNA region would produce 5×2^{10} pieces.

Question set 6.3b

Remembering

1 Negative

2 **a** A sieve and medium for the fragments to travel through.

b A solution the regulates the pH

c Indentations at the negative end of the gel where the sample and standard are pipetted in

d An instrument used to accurately measure the small volume of a sample or standard and transport the mixture into a well in the gel.

3 Gel electrophoresis is a technique that separates large molecules, either fragments of DNA or proteins, according to their size and charge for visualisation and identification purposes. It involves a series of steps:

- Set up the apparatus
- Pipette samples and standard into wells
- Turn current on for fragments to separate in their lanes
- Visualise and compare the banding patterns/profiles from each lane.

Understanding

4 To separate fragments to visualise a unique banding pattern for visualisation and identification purposes. Individual profiles can be compared because they are unique.

5 The ladder runs alongside the samples and is a collection of DNA fragments of known lengths that is used like a marker to help calculate the length of different fragments in base pairs.

Analysing

6 **a** Sample C had the shortest fragment.

b 1000 bp

c Negative

Question set 6.3c

Remembering

1 A microarray is a collection of gene probes attached to a solid surface.

2 Microarrays measure the level of gene expression in a sample of DNA. It can screen a large number of genes at the same time, i.e. efficient and fast. It identifies genes that are being expressed in certain individuals or breeds and shows those genes not being expressed for comparison.

Understanding

3 The process in which the cDNA molecules bind to the DNA probes via complementary base pairing, on the slide is called hybridisation.

4 When a gene is expressed it produces messenger RNA (mRNA). In microarray analysis the mRNA of the cell is transcribed into cDNA and labelled with a fluorescent dye. The cDNA is added to the microarray where any complementary DNA will hybridise. The level of gene expression is determined by the amount of fluorescence of the tagged cDNA that is bound to the probe on the slide and detected by the scanner. The stronger the signal of fluorescence the more cDNA is bound on the slide indicating more mRNA was produced in the sample. The level of fluorescence correlates to the level of gene expression.

Applying

5 Microarrays can be used to determine either gene expression or genetic variation and are applied in medical diagnosis. Microarrays can be used to diagnose cancerous cells, by identifying which genes are operating abnormally, which genes are switched on or off or whether they are over- or under-expressed for that cell type.

Question set 6.4a

Remembering

1 DNA sequencing provides us with very comprehensive information: the sequence of the nucleotides. The genomes of thousands of species have been sequenced, allowing genomes and genes to be compared. Knowing the sequences can help scientists determine the genetic code for particular phenotypes. There may be survival benefits in identifying, for example, genes that increase drought resistance or salt tolerance in plants. In addition, sequencing genes of different species has assisted scientists in determining genetic relatedness and evolutionary links.

2 1 The region of DNA to be sequenced is identified, cut and amplified (using a tool such as PCR) and then heated/denatured to produce single stranded template DNA.

2 Add template DNA, primer, DNA polymerase, all four types of dNTPS (A,T,C,G) and one type of dyed ddNTP into a reaction mixture.

3 The sequencing DNA primer is annealed to the single stranded DNA at the 3′ end of the original strand which provides a starting sequence for synthesis.

4 DNA polymerase extends the new strand by attaching complimentary dNTPs in the 5′ to 3′ direction.

5 When a dideoxynucleotide that has been coloured with fluorescent dye attaches randomly, the newly synthesized strand terminates (the ddNTP disenables the formation of a phosphodiester bond).

6 By performing four separate reactions, four separate sets of chain-terminated fragments can be produced.

7 Following the termination step, heat to denature the partially double stranded molecules, the single stranded chain termination molecules of different lengths can be released from their template and

8 separated using gel electrophoresis. Different coloured nucleotides run in separate lanes.

9 As gel electrophoresis proceeds, a laser scans across the bottom of the gel detecting the different dyes and consequently the base sequence. The terminated strands line up from smallest to largest. The different colours help identify the nucleotide in that position.

10 The sequence of the original region of DNA is then finally deduced by examining the relative positions of the dideoxynucleotide chain termination products in the four lanes of the denaturing gel.

3 The bacterium *Haemophilus influenzae*

Understanding

4 DNA sequencing was originally done manually and relatively slowly using gel electrophoresis and was called Sanger sequencing. It is now done automatically using an automatic DNA sequencer that can sequence a large amount of DNA in a very short time. In this process, the four nucleotides are labelled with four different coloured fluorescent dyes. As electrophoresis proceeds, a laser scans across the bottom of the gel, detecting the different dyes and consequently the base sequence. Instead of a laser, a human scanned the results in Sanger sequencing. A computer can then automatically analyse the information from the gel to read the base sequence in NGS.

While the Sanger method only sequences a single DNA fragment at a time, Next Generation Sequencing is massively parallel, sequencing millions of fragments simultaneously per run.

5 Each time a chemically tagged nucleotide attaches to the template strand, there is a flash of light and this is recorded. A different colour of light flashes for each different type of nucleotide added. The pattern of light flashes reveals the sequence of the template strand in each well. The sequencing software identifies the nucleotides.

Each incorporated nucleotide is identified by its different coloured fluorescent tag.

nelson net.

Question set 6.4b

Remembering

1 Gene mapping involves identifying and recording the positions, or relative positions (the locus), of genes, and the distances between genes, on a chromosome. When a species' genome is mapped, all chromosomes in a somatic cell are mapped.

2 A genetic marker is a gene or sequence on a chromosome with a known location that is associated with a specific trait. Genetic markers may include short DNA sequences such as short tandem repeats, regulatory sites that turn genes on and off or the genes themselves.

3 A genetic marker is used as a distinguishable area on a chromosome that helps a researcher locate genes that cause specific traits such as disease or a desirable phenotype. When a gene exists on a chromosome close to a marker, they are more likely to stay together during crossing over, which enables a researcher to determine the relative location of a gene of interest.

Understanding

4 Sequenced DNA fragments can be aligned to the genome map to aid with the assembly of the genome.

5 Genetic linkage maps, also called genetic maps, identify the relative positions of genetic markers on a chromosome and are based on how frequent the markers are inherited together.

Question set 6.5

Remembering

1 Short tandem repeats

2 Restriction enzymes, PCR and gel electrophoresis

Understanding

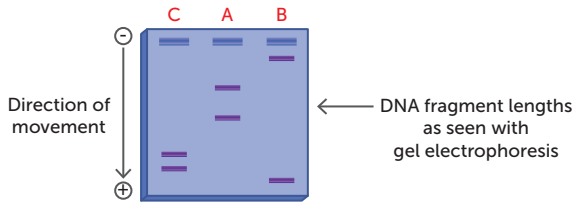
3 PCR amplifies a sample of DNA to gain enough fragments for analysis. Gel electrophoresis is used to separate and visualise the fragments which results in a unique banding pattern for the individual.

4 An individual's DNA profile is unique because of STRs. Within the non-coding regions of an individual's genome there exists satellite DNA – long stretches of DNA made up of repeating elements called short tandem repeats (STRs). As individuals will likely have different numbers of repeats at a given satellite DNA locus, they will generate unique DNA profiles.

Analysing

5 When a current is applied in gel electrophoresis the loaded DNA, which is negatively charged, will move towards the positive electrode. Smaller fragments travel faster through the gel than larger fragments of DNA. Person A has two STR fragments (550 and 900) that can be seen in the middle lane where the fragments are situated closer to the top (900) and midway down (550) the gel. Person B's profile is seen in the third lane (far right). Person B has two STR fragments, one large sized fragment (1200) that would be the slowest to travel through the gel

and is located at the top of the gel and another very small fragment (50) located at the bottom of the gel. Person C has two small STR fragments (100 and 250) and the profile matches the left lane of the gel.



Question set 6.6

Remembering

1 An organism that has been genetically modified/altered by incorporating a foreign gene usually from another species into its genome

2 A vector is a tool that can be used to transport DNA from one organism to a recipient host

3 Many scientists are interested in transforming organisms into transgenic organisms for desirable traits including resistance, faster growth rate, greater product quality and yield, and tolerance to adverse environmental conditions.

Understanding

4 Students' own diagrams. See this weblink for a reference. **http://sphweb.bumc.bu.edu/otlt/MPH-Modules/PH/GMOs/GMOs3.html**

Chapter review questions

Remembering

1

DNA ligase	Joins two single-stranded sections of DNA together
Vector	Vehicle to introduce DNA into a host cell
Primer	Synthetic short, single-stranded DNA molecule
Blunt ends	Result from cleavage by a restriction enzyme at different positions on the two strands of DNA
Plasmid	Small circular self-replicating DNA molecule
Restriction site	Specific site at which restriction enzymes cut DNA
Gel electrophoresis	Sorts DNA molecules based on size and charge
DNA polymerase	An enzyme that catalyses the synthesis of DNA

2 Adenovirus and retrovirus

3 The lowered temperature is necessary to allow base pairing and the formation of hydrogen bonds.

Understanding

4 **a** Blunt ends

b Sticky ends

c Sticky ends

5 DNA itself will not be visible in an agarose gel. To view the separated DNA fragments, fluorescent DNA binding dye is added to the agarose gel before it sets. The DNA-binding dye binds to DNA and fluoresces under ultraviolet light, showing the pattern of bands that can then be photographed.

6 The human immune system is less likely to attack naked DNA compared to viral vectors and there is a lower chance of the inserted DNA disrupting normal gene regulation because there would be no viral DNA.

Applying

7 A baby would share at least 50% of the mother's bands from a DNA profile.

8 **a** Lane 2: 200, 250 and 900 bp

b Lane 3: 150, 400 and 600 bp

c Lane 1: 50, 450 and 650 bp

d Lane 4 : 100, 100 and 450 bp

9 It is likely that *Alu*I has more recognition sites than *Eco*RI because *Alu*I has only four nucleotide bases in its recognition site (AGCT) but *Eco*RI needs 6 nucleotide bases (GAATTC) in its recognition site.

10 **a** *Bam*H1 = 3; *Alu*I = 5

ATATGTGT GGATCCGT CTTAGGTT ATCGAATT CTAGAGCT

ATGGCCTA TTAGCTTC CTGGATCC AACCTGTA TAGAGCTA

CTCGTCAG CTATTGCT ACGGGATCCTAGCTGA TTGGATTC

b *Bam*HI – 4 fragments produced

c *Alu*I – 6 fragments produced

d Cut by both enzymes – 9 fragments produced

e Four cuts would need to be made.

11 The male could be the biological father of all cygnets in Black Swan Family 4 as the cygnets have at least one allele in common with him.

Analysing

12 A small amount of DNA may be available if only one or a few cells are used. Samples from crime scenes, fossilised specimens such as bones and environmental studies may also be found in very small amounts.

Creating

13 Students' own responses

14 Students' own responses

Reflecting

15 a Student answers will vary.

b Student answers will vary.

Practice exam questions

1 C

2 D

3 C

4 C

5 Any four:

- DNA profiling
- extract DNA
- polymerase chain reaction (PCR)/amplify gene or alleles or markers
- screen samples using gel electrophoresis or sequence samples
- specific details of any of the methods (e.g. gel electrophoresis DNA samples separate according to size)
- compare profile of all guinea pigs
- offspring will have alleles/markers from male (and female) parent

6

- Extract/Isolate/Obtain DNA/from organism
- Use PCR/cloning to produce a large amount of DNA/of a particular DNA sequence
- Sequence DNA/use restriction enzymes to produce fragment profile/Amplify DNA region with repeat units/VNTR/STRs
- Use electrophoresis to visualize/separate out different pieces of DNA.

7 Any four:

- Create DNA profile of the virus in these patients.
- Create/obtain DNA profile of hepatitis virus from other sources
- Compare the DNA profiles
- If patients contain same/related strains of virus, then it likely came from the dental practice.
- Use phylogenetic tree to show the relationships among the viruses from the different sources.

8 Restriction enzyme: cuts (target) gene from donor organism or cuts plasmid DNA so gene can be inserted

Ligase: binds (target) gene to plasmid DNA

Plasmid: makes large amounts of (target) gene

Vector: introduces (target) gene to recipient organism.

9 Any four:

- Isolate the gene (that produces chymosin) from cattle
- Use restriction enzymes to remove the gene
- Use same restriction enzyme to cut plasmid/vector
- Insert gene in plasmid/vector
- Place plasmid/vector in bacteria

- Modify culture conditions of bacteria so uptake of plasmid/vector is more likely or transform bacteria
- Bacterial cells can now produce chymosin
- Allow bacterial cells to multiply/clone
- This makes multiple copies chymosin gene or multiple copies of bacteria that can produce chymosin.

Plus any four:

- Ethical, does not require calves to be killed
- Inexpensive/easy to produce (now that the technology has been developed) because does not involve rearing/handling/killing calves or only requires the culture of bacteria
- Easy/fast to produce large amounts
- Regular supply, do not need to wait for calves to be killed
- Less impurities, much easier to purify from microbial cultures than from the stomach of calves
- Increase yield.

10 The following four:

- Gene that causes the desired feature is identified
- Gene is removed from the donor and placed in the recipient
- Recipient/Transgenic/Genetically modified organism should now show feature (if successful).
- Recipient/Transgenic/Genetically modified organism can pass gene/trait to offspring (and hence now have a variety of plant or animal with the feature).

Plus any one of:

- Desired feature/gene can be in a different species/variety/race
- Recombinant DNA techniques are used to modify the organisms or description of recombinant techniques
- Example (must be specific and real), e.g. transgenic cows produce therapeutic proteins (myelin) in their milk or (golden) rice that produces (a precursor to) vitamin A.

Chapter 7 Biotechnology in agriculture and environmental conservation

Question set 7.1

Remembering

1 Agriculture is the science of growing crops and livestock and cultivating soil and microorganisms in which they grow.

2 Restriction enzymes, gel electrophoresis, PCR

Understanding

3 **a** Desired trait: fungal disease (rust) resistance

Reason: Reduce loss of crops and spread of disease, increase/maintain economic benefits

Identification technologies: (PCR) molecular markers for characterizing loci that confer adult plant resistance to leaf rust

b Desired trait: increased litter size, growth rate and carcass quality (such as taste and tenderness)

Reason: Increase productivity, consumption and profits

Identification technologies: PBMARKER includes information on molecular genetic markers

4 **a** Desired trait: fungal disease (rust) resistance

Reason: Reduce loss of crops and spread of disease, increase/maintain economic benefits

b Desired trait: increased litter size, growth rate and carcass quality (such as taste and tenderness)

Reason: Increase productivity, consumption and profits

Question set 7.2

Remembering

1 **a** Roundup Ready® crops are tolerant to the herbicide called Roundup Ready®, which contains the active ingredient glyphosate. Glyphosate inhibits a biochemical pathway in plants disenabling them from producing essential amino acids and causing them to die.

b Herbicides are substances used to manage/control/kill weeds, usually leaving a crop unharmed. They can be classified as selective or non-selective.

c The precursor beta-carotene is a plant pigment that can be converted to vitamin A after consumption.

2 Climate change is an alteration in the pattern of climate over a long period of time, and may be due to a combination of natural and human-induced causes. Climate change is an observed phenomenon thought to be mostly due to human activity, primarily the burning of fossil fuels causing a 40 per cent increase in heat-trapping carbon dioxide in the atmosphere causing a rise in the average global surface temperature.

Understanding

3 Climate change has led to extreme weather conditions which can be the source of adverse environmental conditions. Some abiotic factors, or adverse conditions, crops are grown in include extreme temperatures, drought, flooding, high salinity and deficient soil nutrients. Adverse conditions are factors in the environment that effect the survival of an organism.

Creating

4 Students' own responses

Question set 7.3

Remembering

1 **a** Conservation biology is the integrated study of ecology, physiology, evolution, molecular biology and genetics to sustain biological diversity at all levels. It is a broad approach to preserving what is already there and the due care and attention to protecting it for the future.

b In small populations of animals and plants, there is a risk that closely related, and thus genetically similar, individuals will breed together. The resulting offspring will have an increased risk of deleterious recessive alleles becoming homozygous, causing genetic diseases.

c Quarantine is the isolation of organisms that have arrived from elsewhere or been exposed to infectious or contagious disease. They are monitored until scientists confirm the suspected organism is not or no longer present.

d Biodegradation is the breakdown of an organic substance by micro-organisms such as bacteria and fungi, through decomposition.

2 Biogeography – the size of an ecosystem, its connectedness between habitats and seasonal and geological changes over time have an impact on biodiversity.

Reproductive behaviour – for each species, there is a complex set of behavioural adaptations that coordinate the timing and patterning of reproductive activity. A population relies on reproductive success to maintain a viable gene pool.

Population dynamics – the study of the number, gender, age and relatedness of individuals in a population; factors that require consideration because they determine ecosystem stability which in turn affects reproduction and the passing on of genes for viable gene pools.

Understanding

3 A viable gene pool is a minimum collection of alleles and genes that have enough diversity for survival in a changing environment and is not subject to inbreeding. This contrasts with a non-viable gene pool where there is not enough genetic diversity for survival in a changing environment and is subject to inbreeding.

4 Biodegradation is the breakdown of an organic substance by a microorganism such as bacteria through decomposition and bioremediation is the deliberately introduced or naturally occurring consumption and breakdown of environmental pollutants by microorganisms.

Reflecting

5 Environmental conservation is a worldwide concern. All ecosystems are connected. Therefore, what happens in one ecosystem can have an effect on me living in another ecosystem. Transfer of pollution for example could be via the ocean, a river of wind. To maintain my own health and the stability of the ecosystem I live in, all ecosystems require conservation.

Question set 7.4

Remembering

1 Gene flow of transgenic crop plants may occur when genes transfer to other species via wind or contaminated tools. This means the introduced gene may be transferred. The introduced gene may have been selected for herbicide resistance, pest resistance or drought resistance. The newly modified species may be transformed to start expressing the gene assisting it to increase its growth rate and become a pest/weed. Farmers may be unable to control the growth of such a weed. This type of weed is known as a 'superweed'.

Understanding

2 A target organism is an organism that the transgenic organism was purposefully engineered to respond to. A non-target organism is a different organism to the one intended to affect.

Reflecting

3 Students should recap the information on page 233.

4 Students' own responses.

5

Benefits of transgenic crops	Risks of transgenic crops
Nutritional value of foods can be improved	New traits could cause adverse health reactions
Crops can be produced that lack known allergens	Removal of traits could have unknown effects
Crops can grow in arid conditions for better yield	Crops may limit biodiversity of local environment
GM crops can produce herbicides to kill pests	Cross pollination could lead to super weeds
Improve food supply in poor countries	Patents restrict farmers from accessing GM seeds
GM crops may have longer shelf lives	Foods with GM components may not be labelled
Reduces economic costs and carbon footprint – less need for land clearing and pesticides	Different governments may have conflicting regulatory standards regarding safe usage.

nelson net.

Question set 7.5

Remembering

1 **a** Cloning is a process of making an identical copy of an original. Whole organisms or individual genes within an organism can be cloned.

b A stem cell is an unspecialised cell that has the potential to develop into many different kinds of cells. Stem cells also have the ability to keep dividing, which specialised cells are unable to do.

2 Genetic

3 Embryo splitting or nuclear transfer

Understanding

4 A clone would have the same genetic material.

5 Embryonic stem cells are from 4–5-day-old embryos and can virtually form any type of cell in the body, whereas an adult stem cell comes from cells after birth and can only develop into a small range of cells.

6 Stem cells have the capacity to keep dividing and renewing themselves. This makes them ideal for cell-based therapies that aim to replace tissues that have degenerated or been damaged, such as Parkinson's disease or diabetes.

Chapter review questions

Remembering

1 Students' own responses. Example could be tungsten wheat. Tungsten wheat has been genetically modified for an increase in yield. The GM wheat has been modified by the introduction of either one or both of two genes that code for glutenin proteins. The modification has increased the protein content of the wheat.

2 Breeding programs are used to increase the numbers of animals that have become endangered in Australia. Breeding programs exist for the mountain pygmy possum in Victoria, the Tasmanian devil and the orange-bellied parrot in Tasmania and the Western swamp tortoise, numbats and dibblers in Western Australia.

Understanding

3 This means the two species need to be reproductively compatible. The male and female gametes need to be able to fuse to form a surviving zygote and new plant. Most GMOs, such as corn, soybeans, and cotton, are not closely related to wild species and therefore will not be compatible and cross pollination is not possible.

4 The main role of PCR is amplification. For identification purposes, PCR would be needed to make many copies for either sequencing or gel electrophoresis, both of which cannot proceed without numerous copies.

For recombinant techniques, PCR would be required to make multiple copies of a fragment of DNA that may contain a gene of interest before further techniques/tools are applied such as restriction enzymes.

Analysing

5 The introduced trait may enable uncontrolled enhanced growth of the GM crop, potentially creating a pest. If they inhabit the same environment of native or other crops, they may outcompete them for resources.

6 **a** 280 mm

b 2.8 times longer

c 1.25 times longer

7 Less than

Evaluating

8 Premature death, unable to survive in the wild if released

9 Benefits include:

- more specific (less random) breeding than with traditional methods such as selective breeding of cattle for larger meat yield
- faster rate of production than traditional methods of waiting for gestation periods
- faster growth rate
- helpful genes from outside of a species can be utilised. Some characteristics from other species are unlikely in the gene pool/selective breeding cannot produce desired phenotype (greater product quality)
- increased productivity of food production/less land required for production (increase yield)
- less use of chemicals that can cause detrimental effects to environment, e.g. pesticides
- genetically modified food production possible in extreme conditions such as cold/drought/ greater tolerance to adverse conditions, e.g. tomato plants having gene for resistance to cold from salmon species inserted
- less expensive drug preparation, e.g. pharmaceuticals in milk
- human insulin engineered so no allergic reactions
- may cure genetic diseases.

10

- Potential environmental impacts, including: unintended transfer of transgenes through cross-pollination (non-GMO crops can be contaminated and unable to sell for farmers), unknown effects on other organisms (e.g. soil microbes), and loss of flora and fauna biodiversity
- Producing monocultures leads to a decline in genetic variation and an increase in risk of being susceptible to changes in the environment
- Resistant crops may pass on genes to closely related weed species making the weed resistant to herbicides
- If there is a high volume of gene transfer to non-target species, there could be more rapid evolution of pesticide-resistant species
- Potential human health impacts, including allergens, transfer of antibiotic resistance markers, unknown effects
- Resistant crops may pass on genes contaminating nearby organic/non-genetically modified crops making the organic crop less valuable. farmers lose organic license

- Domination of world food production by a few companies increasing dependence on industrialised nations by developing countries
- Affects natural food web/ecosystem/biodiversity in area, insects affected may be important food sources for native animals.

11 A captive breeding program, (also known as an insurance population, or conservation breeding program) is a program used to breed distantly related members of an endangered species in a safe environment, to maintain or increase genetic variation in a population, avoid extinction and usually for reintroduction into the wild.

12 DNA profiling can enable scientists in captive breeding programs to identify the most distantly related individuals of an endangered species for strategic breeding purposes.

13 Inbreeding (breeding of genetically closely related individuals) may enable the expression of deleterious recessive alleles by increased chance of offspring receiving two of the same alleles for an unhelpful trait. Over generations, alleles can become extinct quickly, reducing genetic variation and reducing their ability to survive in a changing environment with differing adverse conditions.

14 Disease and herbicide resistance, faster growth rate, greater product quality and yield, and tolerance to adverse environmental conditions

Reflecting

15 The study of living things is paramount prior to applying biotechnology. Biotechnology application involves manipulation DNA for human benefit but not all manipulation is beneficial. Many harmful changes can occur if the biology of the living organisms is not understood. For example, before genes are inserted into crops, scientists should find out if the protein that is expressed is not an allergen.

Practice exam questions

1 D

2 A

3 B

4 D

5 1 mark: States that *Agrobacterium* is used as a vector or to transfer foreign genes/target DNA into the plants

Plus any three of:

- because it naturally/normally transfers DNA/genes to plants (during disease production)
- because it can infect a broad range of host plants
- this natural ability can be exploited **or** bacteria requires little modification to perform this role
- plasmid/DNA contains sequence for integration into plant genome can be used to clone target DNA.

6 Any four of:

- DNA profiling
- extract DNA
- polymerase chain reaction (PCR)/amplify gene or alleles or markers
- screen samples using gel electrophoresis or sequence samples
- specific details of any of the methods (e.g. gel electrophoresis DNA samples separate according to size)
- compare profile of all guinea pigs
- offspring will have alleles/markers from male (and female) parent.

7 1 mark: a loss of genetic diversity in the plant crop

1 mark: explains why genetic diversity may be lost (either one of):

- transgenic crop is a single line or strain/monoculture
- only the transgenic crop may be farmed or unmodified crop may not be farmed (due to favourable characteristics of transgenic)

1 mark: explains the consequences of a loss of diversity (either one of):

- may limit ability of crop to adapt to other aspects of the environment/pests
- could reduce potential to develop desirable crop lines in the future (e.g. by selective breeding).

Any seven of:

Explains how transgenic overshoots environment/becomes a pest:

- water/pests/factors limiting growth of transgenic plant/crop removed
- (therefore, transgenic plant/crop) becomes a weed or difficult to control or shows increased growth/productivity
- (transgenic plant/crop) may monopolise/deplete other resources/soil nutrients/water
- overgrow/outcompete other plants or change food web

Explains how the gene/trait may be transferred to other crops/species:

- transgenic/crop plants may exchange genes/transfer gene/genetic material to other plants/crops/species or introduced gene may be transferred to other plants/crops/species
- resulting in (engineered) trait in another plants/crops/species
- these plants/crops/species may become a weed/superweed/pest because they can no longer be controlled by pests/herbicides/low water/environmental factors

Explains how the use herbicide-resistant transgenics may lead to overuse of herbicides:

- if the plant/crop was engineered for herbicide resistance, farmers may overuse herbicides (to kill weeds)
- (overuse will) pollute the environment or cause evolution of resistant weeds (by natural selection as a result of exposure to a lot of herbicides).

8 Any four of:

- population cannot evolve/adapt/change/respond
- to changing environment or diverse/heterogeneous environment
- because all/most individuals are the same or there are no/few genetic differences among individuals/small gene pool

- natural selection requires/operates on differences among individuals
- disease can spread (quickly) through population
- no/few resistant individuals or all/most individuals are susceptible
- inbreeding/inbreeding depression is increased or favourable alleles/genes may have been lost through genetic drift
- this can decrease fitness or reduce ability of individuals to survive/reproduce or increase abnormalities.

Plus any six of:

- monitor the gene pool of the population/DNA profiling of individuals in populations
- identify at risk populations
- can then protect or intervene
- assess the gene pool for breeding programs
- identify/select genetically suitable/more distantly related breeding individuals (from within the population)
- introduce (genetically different) individuals from other populations
- to increase genetic diversity in the population
- genetically modify individuals/gene therapy/recombinant DNA technology
- can introduce genes from other populations/species or directly edit genes
- create genetically superior types
- (modified) individuals can better cope with a particular threat/disease/adverse condition
- artificially propagate individuals (especially plants)
- specific example, e.g. plants cultured in the laboratory or collect eggs and sperm from endangered animal and implant embryo in common species
- to increase the number of individuals.

9 Any four of:

- ethical, does not require calves to be killed
- inexpensive/easy to produce (now that the technology has been developed) because does not involve rearing/handling/killing calves or only requires the culture of bacteria
- easy/fast to produce large amounts
- regular supply, do not need to wait for calves to be killed
- less impurities, much easier to purify from microbial cultures than from the stomach of calves
- increase yield.

10 Biogeography – any four of:

- nature reserves/conservation areas need to be large enough/ have suitable conditions to maintain viable populations of (target) species
- small populations lose genetic diversity (and may not be viable)
- need connections between reserves or need (wildlife) corridors (or converse, i.e. geographically isolated areas)
- so populations can exchange genes (or converse, will reduce gene flow)

- (exchange) will boost genetic diversity in local populations
- populations (of a species) in different geographical locations will be genetically different
- because they evolved in different environments
- (therefore) individuals should not be deliberately moved (by humans) among locations
- individuals from different locations may be reproductively incompatible
- (mixing genes from different regions) could cause outbreeding depression or reduced fitness.

Reproductive behaviour – any three of:

- behaviour associated with mating or rearing young
- reproductive behaviour may change in captivity or outside of natural environment or if directed by humans (e.g. in zoos) or in small area
- this could mean that only a small number of individuals reproduce, or this could reduce the number of individuals that reproduce
- and produce surviving offspring
- the gene pool would come to reflect only the genetics of these (few) individuals
- there would high levels of inbreeding
- could result in inbreeding depression or a loss of fitness
- could result in loss of (gene/alleles for) natural reproduction.

Behaviours

Population dynamics – any three of:

- about how and why populations change size
- population sizes fluctuate (through space or time)
- smallest sizes pose the most risk to gene pool or population will lose genetic diversity when small
- this happens through genetic drift or random loss of genetic variation
- lost diversity is not quickly recovered (even if population numbers increase)
- (therefore) conservation planning should be based around smallest population size or should allow for times when population numbers will drop or should consider small size in the past
- can identify and potentially correct factors that cause numbers to drop.

Chapter 8 Evidence for the theory of evolution

Question set 8.1

Remembering

1 **a** Evolution is the process of cumulative, gradual, heritable change in a population of organisms that occur over many generations and a relatively long time.

b A common ancestor is a species from which other species have evolved.

2 3.5 billion years

Understanding

3 Lamarck and Darwin both thought that populations changed gradually over time with small changes taking place over generations. Characteristics or traits that were suited to their environment would provide them with an advantage and be more likely to pass these favourable traits to subsequent generations. However, Lamarck's theory believed that traits acquired in an organism's lifetime were able to be inherited by subsequent generations. Darwin's theory of evolution by natural selection was a theory that postulated that within a population there was a range of variation in their characteristics. Characteristics or traits that were suited to their environment would provide them with an advantage and be more likely to pass these favourable traits to subsequent generations. These traits would become more common and the population would gradually change to be better suited to its environment. Individuals that had traits that were not favourable to their environment would decrease in numbers and could potentially die off.

4 Evolution is defined as the process of cumulative, heritable changes within a population over many generations, a very gradual change. Our understanding of how evolution occurs is also evolving over time as more information comes to light. The theory of evolution is based on the changes occurring through natural selection and links all species to a common ancestor. The theory also states that all organisms are fundamentally similar as the basic chemistry was inherited from the common ancestor. To investigate the theory of evolution and to understand how evolution occurs five main sources of evidence are used: earth science, genetics, palaeontology, developmental biology and comparative anatomy.

5 The process of evolution cannot occur in an organism because the process requires the inheritance of a variety of traits over time. Organisms only have one set of traits that they carry throughout their life. The proportion of traits change over generations in evolution whereas an organism's genes will not change, and it will only exist as one generation.

Question set 8.2

Remembering

1 Biogeography is the study of the distributions of organisms and ecosystems and how those distributions have changed over geologic time.

Understanding

2 There are several groups of flora and fauna that share similarities found across the world. Biogeography is the study of current distributions of an organism and compares it with fossils found in different locations to reconstruct its evolutionary history. This contributes evidence to the understanding of continental drift when land masses separated and in turn how species separated developing independently of each other, adapting to their new environment over the years.

3 Climate changes can affect populations of organisms in many ways. If the climate changed to a hot and humid environment large land herbivore would need to adapt to regulate their body temperature to the new climate. Those members that could survive the changed climate may have adapted by changes to their hair or fur composition, greater vasodilation ability and decreasing their size to adapt to the hotter weather. Changes would also occur in their food source, some plants would flourish, others would die out and this could also impact the population. If the entire population were not able to adapt to the new conditions, then it is possible they would become extinct.

4 **a** Prokaryotes, the first life, appeared in the Precambrian era.

b Dinosaurs existed in the Triassic, Jurassic and Cretaceous periods of time.

c *Eucalyptus* species would not be found naturally in Africa, as Africa had broken away from the land mass Australia was a part of before the first Eucalyptus plants appeared in Australia. Africa separated from Gondwana in the Jurassic period (160 mya) when gymnosperms were dominant. Angiosperms began to flourish in the Cretaceous period as Gondwana continued to break apart. Eucalyptus plants appearing later in the Palaeogene period (66–23 mya) as Australia was breaking away from Antarctica.

Question set 8.3

Remembering

1 To diagrammatically display the evolutionary relationships between different species. The branches link species to common ancestors. The further away a common ancestor is to a pair of species, the more distantly related they are.

2 Bioinformatics is the digital storage, retrieval, organisation and analysis of a large volume of biological data. Bioinformatics has dramatically increased the size, accuracy and scope of data sets, such as those needed for comparative genomics.

Understanding

3 **a** Comparative genomics is a field of biological research in which researchers use a variety of tools to compare the complete genome sequences of different species. The more similar in sequence the genes and genomes of two species are, the more closely related those species are in their evolutionary history.

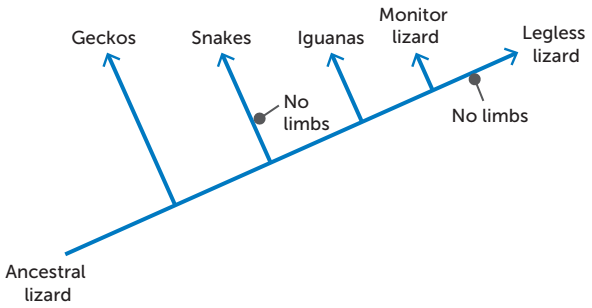
b Comparative biochemistry is the study of different species proteins, their fundamental units – amino acids, enzymes and cell machinery. It involves the analysis of the similarities and differences and the results enable evolutionary biologists to determine the degree of relatedness between species.

4 Bioinformatics has dramatically increased the size, accuracy and scope of data sets. The similarities in sequence, function and abundance of genes across organisms can be used to identify molecular homologies and reveal the shared common ancestry of diverse species.

5 **a** Monitor lizard

b Snakes, iguanas, monitor lizards and legless lizards

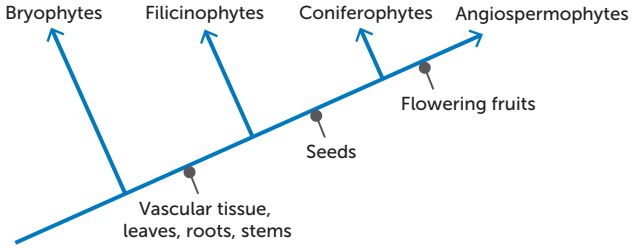
c



Creating

6

	Vascular tissue (xylem and phloem)	Seeds	Cones	Spores	True roots	Flowers and fruits
Bryophyta (e.g. mosses)	–	–	–	Yes	–	–
Filicinophyta (e.g. ferns)	Yes	–	–	Yes	Yes	–
Coniferophyta (e.g. pine trees)	Yes	Yes	Yes	–	Yes	–
Angiospermophyta (e.g. roses)	Yes	Yes	–	–	Yes	Yes



Question set 8.4

Remembering

1 Organic matter needs to be deposited and covered in sediments in an environment that lacks oxygen. In these conditions, over many millions of years, fossilisation may occur.

2 Superposition is fundamental to the interpretation of Earth history, because at any one location it indicates the relative ages of rock layers and the fossils in them. The basic principle is that the oldest rock layer is found at the bottom of a rock with each consecutive layer above, relatively younger.

Understanding

3 Most fossils are formed from the hard remains of animals, such as bones or teeth. Sharks do not have hard bones; their skeleton is made up of cartilage. This means that sharks' teeth are the only hard part that has a chance to be preserved.

4 Transitional forms may be studied.

5 Jellyfish do not contain any hard parts, so fossilisation would be rare.

Applying

6 **a** The rocks were formed by sedimentation.

b Fossil Y is probably older than fossil X and younger than fossil Z unless the strata have been folded.

7 Charcoal can be dated using the technique of carbon dating. The amount of carbon-14 compared to carbon-12 in the charcoal is measured. This amount is then compared to the ratio of carbon-14 to carbon-12 in the atmosphere at present. The age of the charcoal is calculated knowing the two amounts and knowing the half-life of carbon-14. It is reasonable to assume that the stone tools are the same age as the charcoal.

Question set 8.5

Remembering

1 Morphological features are structural features.

2 Analogous structures are found in vertebrate and octopus eyes. In the vertebrate eye, the nerve fibres lie in front of the sensory cells of the retina, whereas in the octopus eye they lie behind them. Because of this, the vertebrate eye has a blind spot where the optic nerve emerges from it, whereas the octopus eye lacks one. Homologous structures are found in a cat's foreleg and bats wing. They possess the same fundamental structural feature known as the pentadactyl limb.

3 Dorsal notochord (a solid tissue running along the back); pharyngeal slits (which turn into gill slits in fish), a dorsal nerve chord and a tail that extends past the anus.

Understanding

4 Both structures can assist scientists in determining evolutionary relatedness- whether they share a recent or distantly related ancestor. Homologous structures in two different species have the same fundamental structural plan but different functionality, usually due to living in different environmental conditions. Analogous structures have a different fundamental structural plan but have developed to perform the same function.

5 The study of embryos of vertebrate groups show that they may have a common aquatic ancestor because they all possess certain structural features as embryos that disappear as they take on their adult form, e.g. post-anal tails.

Evaluating

6 Vestigial structures are described as ‘useless’ or ‘aborted’ organs. The presence of the organ may indicate it was once used in an ancestral organism. They are not always useless though and they are unable to prove ancestry. Reliability is low compared to other types of evidence.

7 Genes that suit an organism to its environment will be preserved, or conserved, while other genes around it may evolve. Two distantly related species may share very similar gene sequences for proteins whose functions are much the same in those species.

Question set 8.6

Understanding

1 Divergent evolution occurs when a parent species diverges into two or more habitats and speciation occurs. For example, the big cats have diverged into grasslands (e.g. lions, which are largely unable to climb), African forests (e.g. leopards, which are expert tree climbers) and Asian forests (e.g. tigers that are expert tree climbers).

2 Convergent evolution is when unrelated organisms evolve similar adaptations in response to their environment. Australian mammals of many families have evolved similar behaviours (e.g. feeding at dawn and dusk, resting in the shade during the height of daytime temperatures) and structures (e.g. long back feet for hopping, grey colour to make detection by prey difficult at dawn and dusk).

Analysing

3 A homologous structure is a feature that has the same general structure but different functions in different organisms. Pentadactyl limbs have evolved in different animal groups in different ways to suit a variety of different functions. Therefore they are homologous structures.

4 In constructing phylogenies, evidence is collected and analysed to form hypotheses about how organisms are related. Characteristics of living organisms are compared to fossil forms to determine which ones are shared. For example, if you look at a modern snake you might not see obvious limbs, but fossils show that ancient snakes did have limbs. Limbs are a shared character inherited from a common ancestor.

Chapter review questions

Remembering

1 Palaeontology, biogeography, developmental biology, morphology and genetics

2 Lamarck suggested that organisms pass on characteristics that they acquired during their lifetimes to their offspring; suggesting individual efforts during the lifetimes of organisms were the mechanism that drives adaptation.

3 **a** The concept of gradualism assumes that evolution occurs as a steady, slow divergence of lineages at an even pace.

b The theory of punctuated equilibrium states that species remain fairly stable for long periods of time but may swiftly change to a new species.

c Biogeography is the study of the distribution of organisms and ecosystems across the world and through geologic time.

d Vestigial structures are homologous structures stemming from a common descent. They eventually cease to provide a functional use for an organism.

e Homologous structures are common physiological structures shared by different organisms that stem from their descent from a common evolutionary ancestor.

f Comparison of genome sequences of different species or individuals.

4 Fossils are formed under very specific conditions. To become a fossil, an organism needs to have hard parts. It must die and, before being eaten, be buried in an anaerobic environment very quickly. It must then be preserved through geologic time, without being destroyed by geological processes or removed by erosion. After all this, its categorisation as a fossil is still dependent upon its discovery by people, who may use it as part of the fossil record.

Understanding

5 Convergent evolution

6 It is most likely that birds and bats share the same environment and through convergent evolution have developed similar characteristics. More evidence is needed to discover the relatedness of these animals.

7 **a** The Hawaiian archipelago contains many different habitats and many niches suitable for fruit flies.

b Adaptive radiation may have been involved when some members of a parental species were blown onto an island where they bred and evolved under the environmental pressures of a different niche.

8 **a** Adaptation

b Convergent evolution has resulted in the similar appearance of the sugar glider and the flying squirrel. These organisms have evolved similar adaptations. As different parental species (on different continents) moved into forests, they were both able to make a living efficiently in trees if they could move from tree to tree without descending to the ground. Gliding is an efficient method of transport even if it only allows movement from higher to lower levels.

c These animals are different in other ways because they are restricted by the available genes of the gene pool of the parental (placental or marsupial) species.

Applying

9 **a** Ancestors of birds probably had four fingers and five toes.

b The fossil record is not complete. Many species did not fossilise and even if fossilisation did occur, the chance of a complete skeleton fossilising and then being preserved long enough for people to find it is very low.

Analysing

10 Students are required to research their own responses.

Evaluating

11 a Palaeontology via the fossil record: 'It has only one known fossil ancestor, a 10 million-year-old skull fragment found in Colombia' and 'a pair of claws on their wings, a characteristic similar to those seen on the bird-like dinosaur *Archaeopteryx*, which had three wing claws'.

b Biogeography: 'the fossil pre-dates the land bridge between North and South America by 8 million years' and 'perhaps because of its extensive history of geographic isolation'.

c Developmental biology: no evidence.

d Morphology: 'Chicks of the Hoatzin show a characteristic shown in no other living bird; a pair of claws on their wings'.

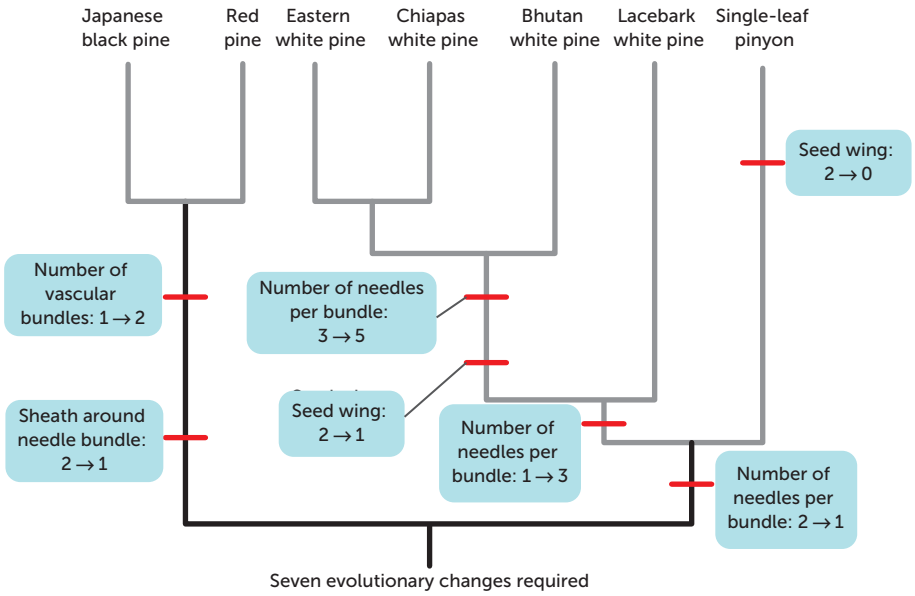
e Genetics: 'Genetic analysis of the living Hoatzin has shown it is so unique that it has its own suborder'.

12 a Transitional form refers to an organism that is believed to be an intermediate state between an organism and its ancestral organism. The intermediate organism shares characteristics of both distinct groups. Transitional form fossils found provides evidence for the evolution of major groups over time.

b Lack of available DNA from the *Archaeopteryx* would limit the use of molecular homology and comparative genomics.

Creating

13



14 Chiapas pine and Eastern white pine

15 Comparing sequences of genomes or genes is a more accurate way of determining how closely related species are. Percentage differences can be calculated by computer software programs. Morphological comparisons are based on observation and can be subjective and reliant on finding adults of the same age and sex and living in the same environment. The fossil record is incomplete and fossils themselves may simply consist of a tooth or part of a bone. To build and assess the rest of the organism some assumptions are made.

Practice exam questions

1 A

2 C

3 D

4 B

5 D

6 Any four of:

- (progressively) reduced the number of digits
- started with four digits
- digit five was lost early on
- digits two and four have also been reduced
- forefeet of modern horse comprises only one (main) digit/digit three
- accurate quote from the figure that gives time, taxon name and details of forefeet
- forefoot elongates/widens/more robust over time (as horse height increases)

  Note: can use fingers or phalanges instead of digits but maximum of 3 marks if candidate refers to toes in answer.

7 Any four of**:**

- fossils/fossil record
- preserved bones (from forefeet)
- bones are likely to be preserved/common in the fossil record
- compare fossil evidence with forefoot in modern horse/comparative anatomy
- can age fossils using index fossils/date bones/date rock (in which the fossil was found).

8 Any four of:

- branching of the tree represents the relationships
- recent/descendent species are at the tips of branches
- shared/common ancestors are at base/trunk of the tree
- nodes/branching point represent a common ancestor
- branch length represents divergence time/similarities/differences
- closely related species will be grouped in same part of tree or unrelated species will be grouped in different parts of tree
- tree constructed from DNA/morphological/biochemical data (which reflect relationships).

9 First (Oldest): Prokaryotic cells

Second: Eukaryotic cells

Third: Marine animals

Fourth: Land plants

10 Fossils – Any three of:

- Show past life/extinct species or show traces of past life/extinct species
- Can be dated or assigned to a time period
- Can follow changes in a trait/organisms/species over time

- Show transitional/intermediate/ancestral forms (which show how one group evolved from another)
- Specific example, Archaeopteryx/forms that show features of both birds and dinosaurs

Comparative anatomy – Any three of:

- Homologous structures
- Structures developed from the same plan
- Different functions
- Shows the relationships among organisms (despite modification or different functions)
- Specific example, e.g. pentadactyl limb of vertebrates

or

- Convergent evolution or analogous structures
- Different structures
- Same function
- Evolved independently
- Specific example, e.g. wing of bat and insects

or

- Vestigial structures
- Structure that is no longer functional/reduced in size
- Can be traced to functional structure in other organisms
- Shows evidence of relationships among organisms
- Specific example, e.g. appendix in humans.

Comparative embryology – Any two of:

- (Embryos)show features that are not present/obvious in adults
- These features can show relationships among organisms or ancestry of organisms
- Specific example, e.g. embryos of whales have limb buds

Comparative genomics – Any two of:

- Large amounts of genetic/sequence data are compared
- The closer the sequence (DNA/RNA/Amino acid) the more closely related the organisms.
- Build phylogenetic trees
- Determine evolutionary relationships (from phylogenetic trees)

or

- Genetic code is (almost) universal
- Implies that all organisms have descended from a common ancestor.

nelson net.

Chapter 9 Mechanisms of evolution and speciation

Question set 9.2

Remembering

1 **a** Mutation is a source of new alleles in a population's gene pool. Mutation is a permanent change in the DNA sequence of a gene.

b Variation therefore is the difference in DNA sequences that give rise to different forms of genes (alleles) that results in different phenotypes.

c A group of individuals of the same species that live in the same area interbreed, producing fertile offspring

Understanding

2 The type of variation that results from mutation is new variation – a new allele; a permanent change to the DNA sequence. Whereas the type of variation that results from crossing over is a recombination of the existing alleles – no change to the DNA sequences; no new alleles. However, two recessive alleles may combine. In both cases, new phenotypes can emerge in a population.

3 Sexual reproduction was 'designed' to generate variation within a species or population. Variation within a population ensures that if changes to their environment occurs there would be an increase in chances that there would be individuals that have characteristics that would allow adaptation to the changes. This guarantees the survival of the population. The cycles of division of different parent cells to form gamete cells, haploid in nature to fuse with another genetically diverse gamete, or haploid cell creates variation in the next generation of organism. The processes of crossing over and random assortment during meiosis further increase variation within a species. Mutations that occur during the DNA replication stage of meiosis and that are not corrected are carried through to the next generation. Mutations provide extra possibilities for variation for the next generation.

4 When an allele is beneficial and selected by the environment it gives the advantage of the organism to survive to sexual maturity and reproduce. The number of organisms carrying the beneficial allele increases within a population over time. Organisms that don't carry the beneficial allele will have lower numbers in a population. If environmental pressures remain constant, then eventually those organisms that carry the non-beneficial allele may remain in low numbers or may not die out depending on various factors. In the case of the *B. betularia* moths, the ratio of white to dark forms have adjusted as the environmental pressures have changed over time. Changes to an entire population is a gradual process, and even though environmental factors may currently favour the white moth so that the 'white' colour allele becomes the beneficial allele for survival, one would still expect there to be dark coloured moths to exist as there was variation in colour form prior to the industrial revolution.

nelson net.

Question set 9.3

Remembering

1 **a** Natural selection occurs when selection pressures in the environment confer a selective advantage on a specific phenotype to enhance its survival and reproduction; this results in changes in allele frequency in the gene pool of a population. It is a process in which individuals that have certain inherited traits are more likely to survive and reproduce at higher rates than other individuals because of those traits. This can cause changes in a population's allele frequencies and therefore it is a mechanism for evolution.

b Sexual selection is a selection process between male and female individuals of a population of an inherited trait that assists in copulation or the winning of a mate.

c Artificial selection (selective breeding) is the intentional breeding/reproduction of individuals with desirable traits resulting in changes in allele frequencies in gene pools over time. The traits are beneficial to humans.

Understanding

2 Natural selection pressures act on traits in the population, resulting in some traits becoming more common as others became less so. This results in changes to the gene pool. Natural selection is the mechanism of evolution.

3 The advantageous variations in traits are naturally selected for their suitability to the environment. Over time, natural selection of the advantageous variations changes populations, resulting in evolution.

4 Variation has increased in terms of the numerous types of breeds there are now. But most of the traits selected for in this process of artificial selection has been for human interest. Many alleles that may have assisted the breeds to survive in the wild have been lost.

5 A random mutation occurs in the DNA of individual bacterial cells. The mutation protects the bacterial cell from the effects of the antibiotic – it becomes antibiotic resistant. Bacteria without the mutation die when the antibiotic is present. Antibiotic resistant bacteria survive and can reproduce with less competition from non-resistant bacterial strains. The genes for antibiotic resistance are passed to the offspring. Over time the whole population of bacteria becomes antibiotic resistant because the antibiotic resistant bacteria are best suited to their environment.

6 Long tail feathers evolved by sexual selection. The process is not simply natural selection because other than winning a mate, the tail provides no benefit for surviving their environment. Females prefer males with long tail feathers (tails) therefore the males with long tails are more likely to mate, reproduce, passing the gene for long tails to offspring. The frequency for the allele would have increased over generations. They would have had a higher reproductive rate than males with short tail feathers.

Question set 9.4

Remembering

1 **a** The founder effect is when a small group of individuals migrates and establishes a population in a new location.

b Genetic drift is a term that applies generally to random changes in genetic frequency in small populations. Each of us inherited half our alleles from our mother and half from our father, and which of these alleles were passed on was a matter of chance. In a small population there is a chance that some alleles present in a parental group will not be passed on at all, and these alleles may be permanently lost from the gene pool.

2 (Example) Northern elephant seals have reduced genetic variation most likely due to being hunted. Hunting reduced their population size to as few as 20 individuals at the end of the 19th century. Since then their population has rebounded to over 30 000 but the genes still carry the marks of their bottleneck. They have much less variation than a population of southern elephant seals that have not been hunted.

Understanding

3 An allele is one of different versions of the same gene (at the same locus).

4 Variations that can be passed to the next generation may give an individual an advantage in survival and reproduction compared to the rest of the population. Evolution theory is based on individuals with the alleles best suited to their environment surviving, reproducing and passing their alleles on to future generations.

Question set 9.5

Remembering

1 Gene flow the transfer of alleles that results from emigration and immigration of individuals between populations.

2 Immigration refers to individuals that join a population whereas emigration refers to individuals leaving a population.

Understanding

3 The gene pool of a population may be changed by chance in recombination and mating, migration, the bottleneck and founder effects, and differential selection of phenotypes of individuals in a population.

4 Gene flow is the exchange of alleles of genes between individuals. Gene flow can take place between populations. Immigrants may add new alleles to the gene pool and emigrants may completely remove some alleles or significantly change the frequency of others.

Question set 9.6

Remembering

1 **a** Micro-evolution is change below species level. Micro-evolution refers to any small-scale change in the gene pool of a population

b Speciation and macro-evolutionary changes result from an accumulation of micro-evolutionary changes over many generations and a very long time. Small-scale changes occur over one generation but because of the very long timescale (3.5 billion years), the micro-evolutionary changes accumulate into large changes. The large changes in a gene pool can be significant enough to lead to the production of a new species. This is known as speciation. For example, speciation of Galapagos' finches over many generations and time.

Macro-evolution encompasses the grandest transformations in evolution, such as the origin of mammals and the radiation of flowering plants. Macro-evolutionary patterns are generally what we see when we look at the large-scale history of life. It occurs over a very long time! Speciation is the link between micro-evolution and the broad pattern of evolution known as macro-evolution. Macro-evolution is the result of a series of speciation events.

2 Speciation – when one species splits into new species after many accumulated micro-evolutionary changes. Macro-evolution is the result of a series of speciation events.

Applying

3

Process	Contribution to micro-evolution
Mutation	A gene or chromosome has undergone a change relative to the original gene or chromosome.
Selection	Individuals with certain inheritable traits survive and reproduce more successfully than other individuals.
Gene flow	This is the transfer of alleles that results from emigration and immigration of individuals between populations.
Genetic drift	This is a change in the gene pool of a population as a result of chance; usually occurs in small populations.
Non-random mating	Preferential mating increases the frequency of some alleles more than others.

Question set 9.7

Remembering

1 Speciation occurs when a single population becomes two separate populations that are unable to interbreed due to changes that produce physical, biological or behavioural barriers. Selection pressures act on the separated populations to cause micro-evolution, which can begin to change them in different ways. Over time their allele frequencies may become so different that the individuals are no longer able to interbreed.

2 Mechanisms leading to isolation of populations include reproductive, geographic, temporal, behavioural and morphological mechanisms.

3 When a single population becomes isolated, so the two separate populations are unable to interbreed and the selection pressures on each population are different, the gene pool of the each population changes. Over time their allele frequencies may become so different that the individuals are no longer able to interbreed even if they are reunited. Micro-evolution has occurred.

4 Allopatric speciation takes place when organisms that could interbreed do not do so because their ranges do not overlap owing to geographic isolation.

5 Geographic barriers physically prevent individuals of a species from associating to breed. Geographic isolating mechanisms include large bodies of water such as seas, mountain ranges and changes to habitat owing to land clearing and desertification.

Understanding

6 Isolating mechanisms prevent individuals within a population from breeding. They reduce the alleles in the gene pool involved so that the range of available phenotypes is restricted.

Question set 9.8

Remembering

1 When a species becomes extinct, it ceases to exist.

2 Mass extinction is the extinction of many species over a relatively short (geological) period of time. The largest mass extinction event on Earth was the 'Great Dying', 250 mya.

Understanding

3 Scientists believe that the Australian bushfires were caused by climate change which brought about extended drought and high temperatures.

4 Limiting the increase in global warming to less than 1.5 degrees would reduce the worst effects of climate change.

Chapter review questions

Remembering

1 **a** The gene pool is the range of genes and all their alleles present in a population.

b Allele frequency is the proportion of a particular allele among all allele copies at a given locus being considered in a population.

c Genetic drift is a change in the gene pool of a population as a result of chance; it usually occurs in small populations.

2 Refer to Figure 9.18 in the student book.

Understanding

3 The bottleneck effect refers to a change in the gene pool of a species when a reduction in population numbers leads to a small genetic diversity. The human gene pool would have been reduced resulting in some alleles being lost in the population. The smaller population has less genetic diversity than the original population and deleterious recessive alleles may have a higher chance of coming together than they did in the original population. An example can be observed in Amish communities.

4 Students' responses will vary.

5 Members of a population with favoured alleles become more common than those individuals who are not as suited to the environment. This changes the frequency of alleles in the gene pool. The basis of evolutionary theory is that favourable traits become more common. Hence changing gene pools lead to evolutionary change. For example, some members of a locust population may be resistant to local pesticides. When crops are sprayed with pesticide, the locusts with resistance survive and pass on their alleles for resistance more than non-resistant locusts. This change in the gene pool eventually leads to an evolutionary change in the locust population.

Applying

6 Micro-evolution describes a change in the gene pool of a single population over a short time. Historically there were many isolated small human communities with distinct gene pools. Now, increased gene flow is leading to greater heterozygosity, causing changes in the gene pool.

7 As a mechanism for evolution, natural selection is the better term. 'Fittest' is commonly thought of as being the strongest or having the highest stamina or intelligence. In terms of natural selection, 'fittest' refers to those individuals who are best suited to a particular environment and who reproduce the most offspring. Many organisms are the 'fittest' because they cooperate with other organisms, rather than competing with them.

8 **a**
- The sub-populations are isolated from the parent population.
- Isolated due to lack of trees after bushfire – in which they used to live.
- This is a physical barrier causing them to live in different environments separated and preventing gene flow.
- With different selective pressures, over generations, micro-evolutionary changes will accumulate due to natural selection.
- Genetic drift will also cause different changes in each gene pool over generations.
- Mutation in the different gene pools will also expand their differences.
- After a very long time and many generations, the two sub-populations may not be able to interbreed to produce fertile and viable offspring resulting in two new species.
- This is known as speciation.

b Yes, because there was a physical barrier causing a separation between the two sub-populations, isolating them and preventing gene flow.

Analysing

9 Students' diagrams will vary.

10 The modern synthesis of the theory of evolution is a theory that combines Darwin and Wallace's theories with new knowledge about the inheritance of variable traits.

11 Adaptive evolution refers to changes in populations of organisms that make the population better adapted to its environment over time. Sexual selection describes a form of selection where individuals with certain inherited characteristics or behaviours are more likely than others to obtain mates and pass on their genes. Genetic drift is a change in the gene pool of a population as a result of chance, which usually occurs in small populations. The founder effect is a type of gene flow that occurs when a few individuals that have become isolated from a larger population do not carry all the alleles that were present in the original population.

12 Mutations are the ultimate source of variation within a population. They result in new alleles. Evolutionary change depends on variation.

13 Individuals of the same species live in the same geographic area and readily interbreed to produce fertile offspring. Pre-human fossils would not show whether the members of these groups could interbreed, nor would they show the fertility of their offspring. The fossils would show similarities and differences in structure only.

14 **a** Chimpanzee

b Chimpanzee and gorilla

c Human and chimpanzee

d Students' responses will vary.

Evaluating

15 a An adaptation is a change in a feature (behavioural, physiological, structural) of an organism that aids its survival in a particular habitat.

b A subspecies is a group of organisms within a species that interbreeds more freely than with other members of the species and has features that are more similar compared to individuals of the rest of the species.

c Step 1: There needs to be variation within a species.

Step 2: Two or more groups of the species are isolated from each other in some way (e.g. reproductive isolation, geographic isolation, behavioural isolation).

Step 3: Individuals in each group no longer interbreed with individuals in the other groups owing to this isolation.

Step 4: The groups are exposed to different selection pressures so different genotypes are selected.

Step 5: After a period of time, if the groups are brought back together, they cannot interbreed with each other to produce fertile offspring.

Creating

16 Students' diagrams will vary.

Practice exam questions

1 C

2 A

3 B

4 B

5 C

6 D

7 a

Defines the biological species concept:

- a group of organisms that interbreed
- to produce fertile offspring
- cannot breed with the individuals of another species.

or

Defines the phenetic species concept:

- a group of organisms that are similar to each other
- and are distinct from those in other sets
- based on overall similarity (genetic morphological, ecological).

or

Defines the evolutionary species concept:

- a lineage of organisms that maintains its identity from other lineages
- and has its own evolutionary tendencies and fate.

b
- a physical barrier divides population/geographical isolation.
- prevents gene flow (between the different populations) or individuals (from the different populations) from interbreeding
- environment/conditions/selection pressures on either side of barrier are different
- population on either side of barrier become different due to natural selection
- may also become different due to mutation or genetic drift
- differences will increase/accumulate over time
- if individuals are no longer able to interbreed, new species or speciation.

c
- changes allele frequencies
- changes are random or occur by chance
- (causes) loss of diversity/alleles from a population
- (causes) differences between populations

d 1 mark: states that larger horns have evolved by sexual selection or due to their disadvantageous effects

Plus any 4 marks:

- larger horns are not favoured by natural selection
- females preferred the males with larger horns/males out-compete other males to mate with females
- males with larger horns were more likely to mate or breed
- therefore, males with larger horns left more offspring than males with smaller horns or passed on allele/s for larger horns to offspring
- therefore, the frequency of allele/s for large horns increased over time

8 1 mark: Macroevolution

Any 3 of the following:

- evolution above the level of the species
- major or large-scale changes
- over a long period of time/millions of years
- trend within a large group/taxon
- accumulation of many small/micro-evolutionary changes.

9 1 mark: Micro-evolutionary change is change within a population/species **or** small-scale change

Plus any 2 marks:

Micro-evolution

- involves changes in the frequency of alleles/genotypes/phenotypes
- via natural selection/genetic drift/mutation/gene flow
- change from one generation to the next is small
- operates over small timescales

Plus 1 mark: macro-evolution is change at/above the level of species or large-scale evolution

Plus 3 marks:

- occurs over many generations or very long periods of time
- (over this time scale) micro-evolutionary changes accumulate into large changes
- changes may become so great that they lead to the production of a new species or speciation or individuals that cannot interbreed.

Plus any 1 mark:

- macro-evolution focusses on trends/patterns within whole taxa/lineages (rather than changes within a species) or the evolution of new lineages (rather than species)
- these patterns arise (in part) because different populations/species evolve in new/different directions by micro-evolution
- life has been evolving for approximately 3.5 billion years ago (which is sufficient for very large changes to accumulate)
- specific example that shows relationship between micro-evolution and macro-evolution.

10 3 marks

- (Micro-evolution is) change within a population/species or small scale change
- Description includes that salt tolerance would evolve by natural selection (must state natural selection)
- Description includes that plants must vary in their ability to tolerate salt or that a mutation produces a genetic variant/allele that confers salt tolerance

Plus any 7 marks of the following:

- Plants are exposed to salt (in the environment)
- Plants that tolerate the salt/saline environment survive for longer/are healthier/more productive/have a selective advantage **or** the converse
- (Therefore the salt tolerant plants) produce more offspring compared to those that are not tolerant **or** the converse
- Offspring (of salt tolerant plants) inherit the alleles/genes for salt tolerance
- (Therefore) the frequency of the alleles/genes for salt tolerance is higher in the next generation
- (So long as the salt is present) salt tolerant plants will leave more offspring compared to other plants **or** the process will continue over many generations
- The frequency of the alleles/genes for tolerance will get higher and higher
- Eventually/after many generations all plants/the whole population will be salt tolerant **or** will have the salt tolerant alleles/genes

11 Any five of the following:

- Happens when only a small number of individuals reproduce or the number of breeding individuals is smaller than the total number of individuals (due to chance)
- Only a (random) subset of the alleles passes to the next generation
- Hence the allele frequencies change (from one generation to the next)
- Changes in allele/gene frequencies are random/due to chance
- Results in (random) loss of alleles/genes from populations or fixation of one allele

- Offspring are formed from very small, non-representative sample of the parents' gametes
- (Happens because of) small population size/small number of breeding individuals/captive populations/endangered species
- (And because of) bottlenecks/temporary reductions in population size
- (And because of) founder effects/when population is started by a small number of individuals.

Plus any five of the following:

- Happens when individuals move/migrate from one population to another
- And then breed in the new population/contribute to gene pool
- Allele frequencies in the (original and destination) populations may be different
- Migrants may have different alleles/allele frequencies to individuals in the destination population
- (The inclusion of migrants) will change the allele frequencies in the destination population
- The new population will be more like the source population or the allele frequencies in the original and destination population become more similar
- Immigrants can introduce new alleles (into the destination population) or emigrants can remove alleles (from the source population).

12 Any 10 of the following:

- (Large ancestral) population is subdivided (into subpopulations)
- (Subdivided by) a physical barrier or a mountain range or desert or river
- Physical barrier prevents individuals moving (between subpopulations)
- (Therefore) there is no gene flow between (sub)populations
- (Sub)populations evolve independently or gene flow can no longer smooth out differences or (sub)populations are isolated
- (Sub)populations are in different environments or face different selection pressure
- Therefore (natural) selection will favour different traits in the different (sub)population/environments
- Will result in differences in the genetic composition or in allele frequencies (of two (sub) populations)
- (Sub)populations will be adapted to different environments
- Genetic drift may cause (random) differences (in genetic) composition or allele frequencies
- Mutation may cause (random) differences (in genetic) composition or allele frequencies
- Genetic differences (between (sub)populations) increase through time/over many generations
- Eventually (sub)populations are unable to interbreeding/exchange genes or are reproductively isolated
- Because individuals are no longer genetically compatible
- (Once unable to interbreeding/exchange genes or reproductively isolated) (sub)populations are regarded as separate species
- (Daughter) species evolved in different locations.

Chapter 10 Homeostasis and thermoregulation

Question set 10.1

Remembering

1 A stimulus is a signal or a change that deviates away from normal and creates an action towards the change. The source of a stimuli can be either an internal or external and can be detected by different types of receptors. A response is an action made towards the effects of the stimuli. The response action can either amplify or counteract the effect of the stimuli depending on the requirements of the system.

2

Type of neuron	Simple labelled diagram	Function
Sensory neuron	See Figure 10.4 in the student book	Transmits impulses from the source of stimulation, via the PNS to the CNS
Interconnecting neuron	See Figure 10.4 in the student book	Relays the electrical impulses from sensory neurons to the appropriate motor neurons
Motor neuron	See Figure 10.4 in the student book	Transmits nerve impulses via the PNS to the effectors

3 The endocrine and nervous systems

Understanding

4 Homeostasis is the maintenance of a constant internal environment. A relatively constant internal environment (in particular, pH and temperature) is important for enzyme activity. Enzymes control cell metabolism and are active only within particular sets of conditions. If enzyme activity fails, cell functioning is affected and the organism suffers. The concentration of substances such as glucose, carbon dioxide, various ions and nutrients also impacts on cell function.

5 Avoiding injury or death is clearly essential for the survival of the organism. As such, the cells of an organism coordinate a response to immediate threats in the external environment, such as a luring predator or falling rocks. A coordinated response requires signals from the external environment to be detected and conveyed to cells which then must respond appropriately.

6 Internal receptors receive signals from within the body about the internal environment. Examples: chemoreceptor, osmoreceptor. The external receptors of organisms detect changes in their external environment. Examples: photoreceptor, thermoreceptor.

Applying

7 The hypothalamus contains both thermoreceptors and osmoreceptors which detect changes in internal temperature and water content in the blood.

Question set 10.2

Remembering

1 A stimulus–response model describes a stimulus being detected by a receptor. The information is then processed and a message is conveyed to an effector, which carries out the response to the stimulus.

2 **a** Stimulus: a signal that causes a response

b Receptor: structure that detects or receives a stimulus

c Effector: something that carries out a response to a stimulus

d Response: the result of a stimulus

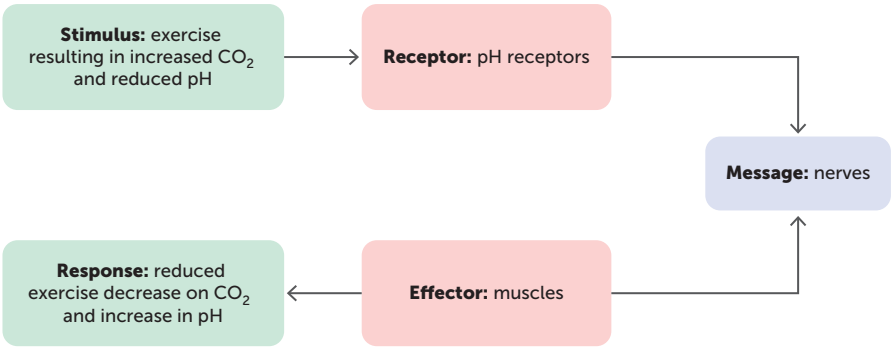
Understanding

3 Students' own examples

4 Negative feedback is a process that responds by changing the direction of a stimulus. Positive feedback is a response that reinforces the original stimulus. Positive feedback is not associated with homeostasis, as it usually takes a factor away from rather than back to normal.

Applying

5



Question set 10.3

Remembering

1 **a** Cell membranes can become too fluid allowing unwanted substances to be transported in and out.

b Cells may lose water to dilute the waste to maintain water homeostasis.

c Cells may become damaged or die because too much oxygen can be toxic.

d Animals' cells can burst and plant cells become turgid

e The cell can become hypertonic compared to its surroundings. This will lead to water moving in by osmosis and eventually the cell may burst if it is an animal cell.

2 Carbon dioxide and heat are by-products, as well as water.

Understanding

3 The optimum range is the set of values for an internal factor that enable an organism to function best. The optimum range falls within the tolerance range and enables organisms to function at their healthiest state. Outside of the tolerance range for any factor may lead to death for an organism.

4 Metabolism is the sum of chemical reactions that occur within an organism to maintain life. Cellular respiration is one type of chemical reaction.

Applying

5 When temperatures rise above tolerance range, enzymes can denature and become useless in catalysing reactions. Consequently, metabolic reactions will proceed too slowly for an organism to remain alive.

Question set 10.4

Remembering

1 Endotherms: Red kangaroo, Human, Tasmanian devil; Ectotherms: Goanna, Snake, Green tree frog

2 Structural features, behavioural strategies and physiological adaptations

Understanding

3 An endotherm can generate heat using metabolic processes to maintain a stable internal body temperature. This contrasts with an ectotherm who cannot use metabolic processes to gain heat. Instead, heat is gained from the external environment. An endotherm's body temperature can remain within a set range whereas an ectotherm's body temperature is dependent on the external temperature of its surroundings.

Creating

4 Endotherms have a set of benefits unique to them. Firstly, body temperature can remain independent of external temperature. This enables endotherms to live in more extreme environments. They can be active at night (when some ectotherms are not) or more often during the day/season. Being more active may reduce the chance of predation.

Ectotherms have a set of benefits unique to them. Firstly, their heat source mainly comes from the environment therefore less energy requirements for these animals. Therefore, they need to consume less food. They can spend less time hunting for food. They can tolerate larger fluctuations in their internal body compared to endotherms.

nelson net.

Question set 10.5

Remembering

1 Students' own diagrams

2

Stimulus	Physiological response	Effect
Increase in temperature	Dilation of blood vessels on the skin	More heat lost through radiation
	Hairs flatten on skin, trapping less air	Increase in heat lost through conduction then convection
Decrease in temperature	Constriction of blood vessels on the skin	Less heat lost through radiation
	Hairs rise and trap air	Less heat loss through conduction
	Shivering	Heat gained from increase in metabolic activity

3 Heat balance is achieved when heat loss and heat gain are the same. There are many physical and metabolic methods of maintaining heat balance.

Understanding

4 Vasodilation occurs when blood vessels dilate or widen. This increases blood flowing through the skin, thereby increasing the amount of heat radiated and lost by the skin via the blood.

5 In very cold conditions, the increase in metabolic rate may be insufficient to maintain body temperature within tolerance limits. A major adaptation that enables animals to save energy, when food is scarce and temperatures are very cold (or very hot), is torpor. Torpor is a physiological state of decreased metabolic rate and physical activity. Torpor reduces energy and water cost for the animal. Other animals in these conditions may hibernate which is a longer torpor.

6 The shape of an organism affects the surface area to volume ratio. The greater the ratio, the more heat is lost or gained from the environment. Larger, more rounded animals have a lower surface area to volume ratio and so lose less heat to the environment. They are often found in cold places.

7 Arteries carry warm blood away from the core of the body (where the heart is found) to the extremities. Veins carry cooler blood back to the core from the extremities. Arteries and veins are located adjacent to each other, close enough for heat to be transferred by conduction and/or radiation. Additionally, arteries and veins carry blood that flows in opposite directions which means there is always a high temperature gradient between them. The 'counter' flow of the blood leads to heat being exchanged all the way along the length of the exchanger (adjacent artery and vein) increasing the efficiency of the system to a higher rate than if the blood was flowing in the same direction. The result is maximum heat transfer and minimum heat loss to the environment. This phenomenon can be found in the foot of a penguin and the flipper of a dolphin.

Creating

8 Students' own responses

Chapter review questions

Remembering

1 Homeostasis can be defined as the processes involved in maintaining a constant, internal environment, within tolerance limits, despite changes in the internal and external environment.

2 If adjustments are made that reinforce the original stimulus, the mechanism is referred to as positive feedback. For example, just before a tadpole changes (metamorphoses) into an adult frog, negative feedback is changed into positive feedback. The concentration of thyroxine rises and triggers metamorphosis.

Understanding

3 Ectotherms cannot generate their own heat for thermoregulation. They gain heat from external sources. Basking in the sun enables them to receive heat gained via radiation from the sun. This helps them warm up, become active.

4 To warm up the reptile requires heat from an external source because it is an ectotherm and cannot generate heat from metabolic activity. The spreading out increases the surface area contacting the warm rock. This maximises the rate of heat transfer via conduction.

5

Structural	Behavioural	Physiological
Insulation Hair Shape and size	Sheltering Muscle movement	Vasodilation and constriction of blood vessels Sweating Metabolism

6 The surface area of the ears varies between the examples given in Figure 10.29. It can be explained by the different conditions in which the foxes live. In hot conditions a relatively large total surface area increases the surface from which radiation can take place. Heat loss is increased in hot conditions. The Arctic fox, in cooler conditions, reduces heat loss by the fact that the ears have a smaller surface area.

7 When the kangaroo exhales, evaporative cooling occurs. The increased rate of breathing increases the water vapour escaping because heat is drawn from body to the water and travels out in the vapour to the external environment. The heat is drawn out of the body for the change of state of liquid to water vapour, a gas. This results in cooling the kangaroo body temperature.

Applying

8 Sodium/Potassium are required at specific levels for the healthy functioning of neurons and muscles. Too much or too little can cause the malfunctioning of the nerves, messages will not be sent appropriately, muscles may contract uncontrollably.

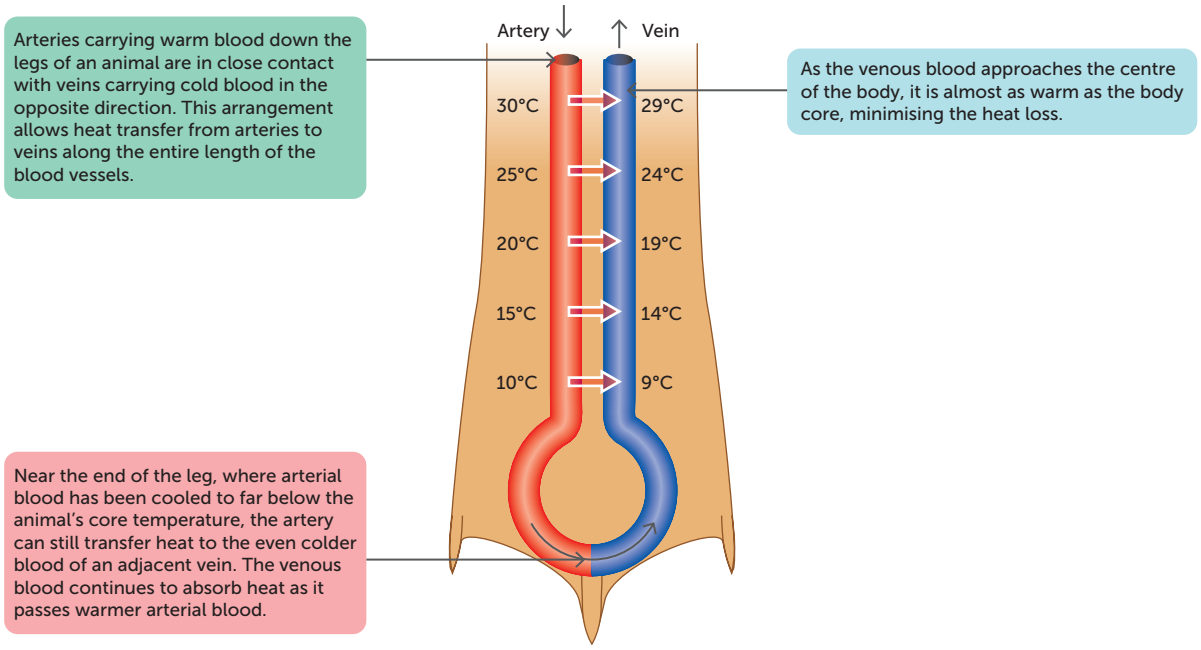
9 Torpor and hibernation

10 Students' responses will vary.

11 If receptors fail, stimuli will not be detected. This would affect the regulation and maintenance of the internal environment. If this is not maintained within narrow limits, cell functioning and efficiency will be reduced.

Analysing

12



13 **a** Eskimo pup: –24°C

b Sloth: +28°C

c Ground squirrel

d Species living in Arctic conditions have a lower critical temperature than species living in tropical conditions. When lower critical temperatures are reached, metabolism increases at a higher rate in tropical than in Arctic creatures.

Evaluating

14 The main wastes that require removal are carbon dioxide and nitrogenous compounds. If these are not removed, the pH of the interstitial fluid will change, affecting enzyme function. When enzymes are not working at their optimum, metabolic functioning is affected.

Creating

15 Students' own responses

Practice exam questions

1 B

2 A

3 B

4 A

5 C

6 D

7 **a** The effector receives signals from the coordinating centre/modulator (1); brings about change (needed to maintain homeostasis) (1)

b Receptor detects stimulus (1); sends signal to the processor/coordinating centre/modulator

c Response/feedback reduces stimulus

8 (i) stimulus; (ii) receptor; (iii) coordinating centre/modulator; (iv) effector

9
- Blood flowing from body to ears is relatively warm
- Ear is in close contact with air
- Therefore, heat in blood can be lost via the ear
- If air temperature is warm, rabbits increase blood flow to ears
- This will increase heat loss (providing blood is cooler than air)
- Heat is lost by radiation (and by convection if rabbit is moving)
- If air temperature is cold, rabbits decrease blood flow to ears
- Heat is retained in body of rabbit (rather than lost to the environment).

10 1 mark: Endotherms generate their own body heat

1 mark: Ectotherms rely on external environment for temperature control

Any 2 marks:

Endotherms
- (body heat is generated) from metabolism **or** biochemical/chemical reactions in cells
- maintain (relatively) constant internal/body temperature
- have adaptations/features/behaviour to control heat loss/gain to ensure internal body temperature remains constant

Any 2 marks:

Ectotherms
- (ultimately) obtain heat from sun/object warmed by sun **or** rely on external sources of heat
- body temperature fluctuates with external environment
- use adaptations/features/behaviour to control heat loss/gain

Costs – any 2 marks:
- endotherms have a higher metabolic rate (compared to ectotherms of same size)
- need to expend more energy (to fuel metabolism) or have higher energy requirements
- have greater food demands or need to spend more time obtaining food.

Benefits – any 2 marks:
- less dependent on environmental temperatures (compared to ectotherms) or body temperature is independent of external temperature
- can live in very cold environments or in a broader range of environments
- active at night or at more times during a day (in places where night-time temperatures are low)
- being active at night may help to reduce predation
- (higher internal temperatures) may provide protection against some pathogens.

11 Structural: Any one structural feature and essential 5 associated marks

- thick fur coat
- traps layer of air close to body/provides insulation
- air is a good insulator
- this reduces heat loss by conduction/heat transfer
- stops air flow close to body
- this reduces heat loss by convection
- hairs may be hollow (more insulation from hollow core)
- furry tail can be folded over nose/extremities to improve insulation

or

- body shape
- rounded, stocky body
- small ears/short limbs
- lowers surface area:volume ratio
- reduced surface area in contact with environment
- reduce area for heat transfer

or

- body fat
- builds up fat reserves in summer
- fat is a good insulator/poor conductor
- does not contain much water/blood vessels
- separates core from outside environment/traps heat inside
- only cooler surface is in contact with cold air
- reduces heat loss by conduction
- fat food reserve
- used to boost metabolism, which generates heat

or

- counter-current heat exchange
- in paws/extremities
- potentially high rate of heat loss from extremities (lack fur/in contact with ground)
- warm arterial blood (moving from heart to paws)
- passes close to cold venous blood (moving from paws to heart)
- heat is transferred from warm blood to cold blood
- heat transfer is by conduction or conduction and radiation
- blood is already cooled by the time it moves into extremities
- (therefore) less heat loss through extremities.

Physiological: Any one physiological feature and essential 5 associated marks

- counter-current heat exchange
- in paws/extremities

- potentially high rate of heat loss from extremities (lack fur/in contact with ground)
- warm arterial blood (moving from heart to paws)
- passes close to cold venous blood (moving from paws to heart)
- heat is transferred from warm blood to cold blood
- heat transfer is by conduction or conduction and radiation
- blood is already cooled by the time it moves into extremities
- (therefore) less heat loss through extremities

or

- vasoconstriction
- blood vessels in skin constrict
- restrict blood flow (to skin)
- reduce temperature of skin
- reduce heat loss through radiation
- most blood remains below (insulating) fat layer

or

- shivering or increased muscular activity
- muscles contract and relax
- happens rapidly and repeatedly
- this requires energy
- energy comes from metabolism
- which generates heat as a by-product/some energy is released as heat

or

- increase metabolic rate
- hormones increase metabolic rate
- adrenalin/adrenal gland
- thyroxine/thyroid gland
- metabolic reactions are not 100% efficient
- heat is a by-product/some energy is released as heat

or

- piloerection
- hairs raised to trap (more than the usual amount of) air
- (this response is) controlled by sympathetic nervous system
- trapped air) provides insulation
- this reduces heat loss by convection/heat transfer.

12 Any ten of the following:

- Homeostasis
- Internal environment remains (relatively) stable/constant
- Despite changes in environment
- Achieved via negative feedback

- The response reverses the stimulus/the change in the environment
- (Negative feedback is a type of) stimulus-response model
- Change in the (internal or external) environment
- (Change is called) a stimulus
- Receptor detects stimulus/change
- Receptor produces a signal (may be chemical or electrical)
- The signal is sent to a processing centre or brain or central nervous system or modulator
- Processing centre or brain or central nervous system or modulator coordinates a response
- A message is sent to effector (usually a muscle or gland in animals)
- Effector brings about a response
- Specific example (e.g. glucose levels in animals, water balance in a plant).

Chapter 11 Regulation of water, salts and gases

Question set 11.1

Remembering

1 Water is the universal solvent. Metabolic reactions occur in a solution mainly comprised of water.

2 The three types of solution that can be within a cell are isotonic, hypertonic and hypotonic conditions and affect the cell in different ways. Osmosis is the process where water passively moves from a low to high concentration of solute (salts). When a cell is under isotonic conditions the internal and external environment of a cell have an equal concentration of solutes and there is no movement of water in or out of the cell. The cell is in an optimal state and maintains a constant shape. Under hypertonic conditions the solute concentration outside of the cell is greater than within the cell. The unequal concentration leads to water moving out of the cell into its surroundings. This causes the cell to lose its shape or turbidity and shrivels up. Under hypotonic conditions the cell has a greater concentration of solutes than its surrounding. This causes water to move into the cell via osmosis causing the cell to swell up and possible burst.

3 Removal of nitrogenous wastes; regulation of water concentration in blood; maintaining ion levels in the blood.

Understanding

4 The glomerulus is the site in the nephron where fluid and solutes are filtered out of the blood to form a glomerular filtrate. This is known as filtration. The proximal and distal tubules, the loop of Henle, and the collecting ducts are sites for the reabsorption of water and ions. Reabsorption is the process of substances in the filtrate being absorbed again back into the blood. This second reabsorption enables regulation of water and ions.

5 **a** A solute is a substance that is dissolved in a solvent.

b Water is known as a universal solvent because more substances dissolve in water than any other substance.

Applying

6 See Figure 11.1 in the student book

Question set 11.2

Remembering

1 Proteins and nucleic acids

2 Three types of nitrogenous waste are ammonia, urea and uric acid. It is essential to remove these wastes as they are toxic.

Understanding

3
- Ammonia – none (it is a direct product)
- Urea – moderate (it requires some energy and happens in the liver)
- Uric acid – extremely high (to convert it to a form that is non-toxic)

Applying

4 The availability of water can affect the type of nitrogenous wastes produced. This is because ammonia is highly toxic and requires high volumes of water to dilute it when excreted directly. It easily dissolves in water so if water is available there is no need for an animal to convert it into another form. However, many terrestrial animals have moderate amounts of water. Not enough to dilute ammonia into a solution that is not toxic. These animals convert to urea. For other animals, water may be very scarce, so they convert to a semi-solid paste known as uric acid. The form is insoluble to water and suits an environment that is arid.

Question set 11.3

Remembering

1 Antidiuretic hormone

2 As loop of Henle increases in length, urine concentration increases.

Understanding

3 Reabsorption can be controlled through the use of ADH. When blood water content decreases below optimal range, more ADH is secreted and sent to the kidney nephrons. The extra amount of hormone increases the permeability of the collecting duct wall, increasing reabsorption, decreasing volume of urine and increasing concentration of urine. If blood water content increases above optimal range, less ADH is secreted, decreasing the permeability of the nephron collecting duct walls, decreasing reabsorption.

Applying

4 See Figure 11.5 in the student book.

Question set 11.4

Remembering

1 Osmoregulators regulate their osmotic concentration to be either higher or lower than their external environment. Osmoconformers allow their osmotic concentration to be equal to the concentration of the external environment.

2

Structural	Behavioural	Physiological
Sweat pores Waterproof outer layer	Panting Reducing surface area Burrowing	Thirst Water reabsorption Concentrated wastes High tolerance of waste products

Understanding

3

Marine fish	Freshwater fish
Loses too much water via osmosis across the skin. Gains too many salts via drinking seawater and eating food.	Gains too much water via osmosis across the skin and when eating food containing water. Loses too many salts via diffusion and in urine.

4 Osmoconformers can tolerate the fluctuation in salinity in their surroundings better than osmoregulators. Osmoconformers reduce the need to move water into and out of their bodies and need to spend less energy regulating their internal osmotic concentration.

5 Excretion allows an organism to rid itself of waste molecules that could be toxic if allowed to accumulate. It also allows the organism to keep the amount of water and dissolved solutes in balance.

Question set 11.5

Remembering

1 **a** As light intensity increases, transpiration rate increases.

b As temperature decreases, transpiration rate decreases.

c As wind increases, transpiration rate increases.

d As humidity decreases, transpiration rate increases.

2 The opening and closing of the stomata is controlled by the guard cells. Light stimulates opening of stomata. By the use of active transport, Potassium ions K^+ are purposely moved into guard cells. This creates a concentration gradient. Guard cells take up water by osmosis and become turgid. Because their inner walls are rigid they are pulled apart, opening the pore. In darkness water is lost, guard cells become flaccid and the inner walls move together closing the pore, decreasing water loss.

Understanding

3 Water is pulled from roots to leaves via the transpiration pull. The transpiration pull is the set of forces needed to pull water from the roots to the leaves such as cohesion and adhesion. Cohesion is the attractive force between water molecules. As water evaporates from the leaves, columns of water are drawn up through the xylem vessels. Adhesion is the attractive force between water molecules and the inner walls of the xylem vessels. The combining forces are collectively known as the capillary action. Capillary action is defined as the movement of water within the spaces of a porous material due to the forces of adhesion and cohesion.

Transpiration is the evaporative loss of water, in the form of water vapour, from plants usually through small pores called stomata (singular, *stoma*) found on the surface of a plant, mostly on the underside of leaves. The evaporation and diffusion out of the stoma occurs because of the concentration gradient of water vapour between the inside and outside of the leaf. Water vapour moves down the concentration gradient, from an area of high water content to an area of low water content. The transport of water through the plant also results in water loss. As water is lost at the top of the steam of water, a pull force is exerted on the water molecules below.

4 Evaporation is change of state for liquid gas. Transpiration occurs when water vapour evaporates and diffuses out of the plant. The water cannot leave the plant in liquid form therefore transpiration cannot happen without evaporation.

Creating

5 Students' own responses

Question set 11.6

Remembering

1 **a** Xerophytes are plants adapted to live in arid environments. They have developed specialised features that minimise water loss whilst still allowing for gas exchange.

b Halophytes are plants that live in environments of high salinity in the soil, that is, a high salt concentration. Places such as salt marshes and the mud flats of estuaries.

2 Arid environments cause water to be lost from plant cells via osmosis. Environments with high salinity can cause water to move out of roots down a concentration gradient in halophytes.

3 The labels should read:

1 Cuticle
2 Upper epidermis
3 Palisade cells
4 Mesophyll cells
5 Lower epidermis
6 Stoma
7 Guard cells
8 and 9 Xylem phloem
10 Vascular tissue

Understanding

4

Type of adaptation	Adaptation	How it works	Example
Xerophytes			
Structural	Thick waxy cuticle	Impermeable to water, preventing evaporation and water loss. Stops uncontrolled evaporation through leaf cells.	*Gunniopsis quadrifida* (Australia's Sturts pigface), a succulent
	Small leaf surface area	Smaller number of stomata leading to less water loss. Less surface area for evaporation. Smaller surface area of leaf is exposed to the drying effects of the wind, reducing evaporation and reducing water loss.	Conifer needles, cactus spines
	Sunken stomata and hairy stomata	Stomata in sunken pits or with hairs prevent water loss by increasing the relative humidity in the vicinity of each stoma, decreasing concentration gradient and reducing evaporation and diffusion. Creates a microclimate.	Marram grass, cacti
Halophytes			
	Filtration structures in roots	Prevent salt from entering their roots. Mangroves have an ultrafiltration system that can filter approximately 90% of sodium ions from the surrounding salt water. The three layers of the filtration system surrounding the root traps sodium ions but allows water to pass through as it is pulled into the xylem.	Mangroves
	Salt glands	Salt is directed to plant surfaces where salt glands secrete salt to reduce the salt content in the plant	

Creating

5 See Figure 11.20 in the student book.

nelson net.

Chapter review questions

Remembering

1 When there is an increase in the water content in the bloodstream, the effector responds to the change using negative feedback so that balance is maintained within the system. The effector in this case is the pituitary gland, which responds by decreasing the release of antidiuretic hormone (ADH) that is responsible for water reabsorption in the kidneys. With negative feedback levels of water within the bloodstream are returned to optimal levels.

2 Carbon dioxide and oxygen are gases that exchanged through the stomata of a leaf. Under hot conditions water vapour is released out of the plant via the stomata to reduce the temperature of the plant.

3 Antidiuretic hormone (ADH) is the hormone that can change the permeability of the walls of the collecting ducts in the nephrons of the kidney. When water levels drop below optimal ADH is released into the blood stream where it has a direct effect on the cells of the collecting ducts by increases the reabsorption of water. When water levels reach an optimal level, the pituitary gland reduces or ceases the release of ADH.

4
- Fish: osmoregulatory mechanism
- Worm and small crustaceans: isotonic with external watery medium
- Phytoplankton: able to tolerate a wide variety of body fluid concentrations; become isotonic

5 The thirst mechanism

6 Students' own diagrams. The sunken stomata form a pit in which water vapour can fill, creating a microclimate that is more humid than the external environment. The concentration gradient between the water vapour inside the leaf and the area just outside the leaf is reduced. A lower concentration gradient slows the evaporation and diffusion processes which slows transpiration which slows water loss.

Understanding

7 Water balance would be affected because water would enter the marine fish. The mechanisms to cope with excess water would not be present.

8 Bilbies produce very concentrated urine due to their very long loop of Henle and high amount of reabsorption of water.

9 The longer the loop of Henle, the more water reabsorption can occur.

a Terrestrial mammals convert ammonia to the less toxic substance, urea. It is then released as concentrated urine containing less water. Diagram B represents their nephrons.

b Freshwater fish are surrounded by water. They produce abundant amounts of dilute urine containing ammonia so would need the least amount of water reabsorption. Hence diagram A represents their nephrons.

c Reptiles produce uric acid which is the least toxic form of nitrogenous waste and contains very little water. They would need the most amount of water reabsorption. Hence diagram C represents their nephrons.

10 1 Glomerulus

2 Proximal tubule

3 The descending loop of Henle
4 The ascending loop of Henle
5 Distal tubule
6 Collecting duct

Applying

11 Metabolic activity: Chemical reactions that occur in an organism to maintain life/homeostasis. These can involve the breakdown or build-up of molecules. Many of these reactions occur in a water medium or water solvent. Water dissociated compounds into their ions so that they can react with other ions. Many reactions require water as a reactant. Without water a reaction such as photosynthesis cannot proceed.

Analysing

12 $1.5 \div 180 \times 100 = 0.83\%$

13 As filtrate flowed through the nephron, water, ions and other substances were reabsorbed back into the blood stream via passive or active transport. Although many substances get filtered out of the blood, they are actually needed still to maintain homeostasis. Other substances that are reabsorbed are glucose, amino acids. Ions that are reabsorbed include sodium, potassium, calcium, magnesium and chlorine.

Evaluating

14 Halophyte adaptations include excluding, compartmentalising and accumulating salt to then eliminate salt. These adaptations are crucial for survival I a highly salt ridden environment. Some halophytes have very long roots that extend down to the water table and others have shallow roots to take advantage of any rainfall.

Some areas on earth are becoming more arid with high levels of salinity. Some of these areas of land used to be agricultural land.

If any of the halophyte survival adaptations could be incorporated into crops, they may be able to grow in soil with high salinity, where our current crops cannot grow. This may prevent starvation for many people.

Funding in this area is definitely worthwhile.

Creating

15 Students' own diagrams

Reflecting

16 Plants have several complex adaptations that are very helpful. Adaptations to increase water gain (wide spreading shallow roots or long taproots that reach the water table), adaptations that limit water loss (leaf, stomatal, metabolic adaptation) and water storage adaptations. Additionally, adaptations of halophytes allow them to live in extreme saline conditions where no other plants or many animals could tolerate. The ability to filter and accumulate and eliminate salt whilst maintaining transpiration and other metabolic processes and gas exchange is phenomenal.

However, plants are limited to structural and physiological adaptations for homeostasis. Animals can use behavioural responses to maintain water balance too. ADH, long loops of Henle and the thirst mechanism are critical but without being able to move to water sources, they would be much less effective.

Practice exam questions

1 A

2 B

3 B

4 D

5 Yes, 1 mark. Plus two of the following:

- Homeostasis is maintenance of a relatively constant internal environment
- (Marine) fish maintains (relatively) constant salt-water balance despite external environment
- (Marine) fish maintain internal salt concentration at a lower concentration than seawater
- (Marine) fish is osmoregulating to maintain internal salt-water balance.

6 Any of the following four:

- Stomata on lower surface
- Stomata in pits or sunken stomata
- Hairs/trichomes
- Cuticle (on upper surface)
- Multicellular/thick epidermis
- Guard cells.

7 Any two of the following:

Advantage 1 (large surface area of roots):

- (roots) cover a large surface area
- increases chances of finding water or provide anchorage

Advantage 2 (roots close to surface):

- can access surface water or small amounts of water on the surface
- can absorb water before it evaporates or can quickly absorb water

Advantage 3 (large volume of roots):

- large volume (of roots)
- more room to store water.

8 **a**

Animal	Type of nitrogenous waste
Desert rat	Urea
Bony fish	Ammonia or urea and ammonia
Insect-eating bird	Uric acid
River dolphin	Urea

b Ammonia

c 1 Ammonia, 2 Urea, 3 Uric acid

d Any four of the following:

- dry/low water conditions
- (uric acid) is not very soluble
- requires very little water to excrete
- compensates for high cost of production (in dry environment)
- in eggs where it is not possible to remove waste
- (uric acid) has low toxicity
- minimises weight for flight

e Any four of:

- salt concentration is higher in surroundings than in body or salt concentration in body is lower than in surroundings or fish is hypotonic to surroundings or surroundings are hypertonic to fish
- (therefore) fish loses water to environment
- water is lost by osmosis
- (loss) happens mainly at gills/in mouth
- (when) water comes into close contact with blood vessels
- fish also gain ions from environment
- minimise water loss/maximise water retention by producing small amounts of urine
- also produce concentrated urine

9 Any four describing how gas exchange and water loss occurs (4 marks):

- gas exchange occurs through stomata
- stomata need to be open (for gas exchange to occur)
- (a lot of) water is lost through open stomata
- water is lost through transpiration/evaporation

Plus 2 marks per feature – 6 marks total: Minimising water loss while still allowing gas exchange- Any three of the following (6 marks)

Stomatal activity

- stomata only open at night/close during the day
- temperature is usually cooler at night/no solar radiation
- open when water loss is least/closed when water loss is greater

Stomatal adaptations

- stomata are sunken
- surrounded by moist/humid air or
- hair in stomatal pits/hair on leaves
- helps to trap moist air which reduces evaporation or
- stomata are on underside of leaf
- reduced light/energy absorption reduces evaporation or
- reduced number of stomata
- decrease points of water loss when open

Leaf adaptations/changes

- roll leaves to trap moisture
- reduce number/size of leaves/dropping of leaves (deciduous)
- reduce number of stomata/reduced size of stomata
- (these) reduce unnecessary water loss/the number of open stomata or
- adjust position of leaves (vertical leaves)
- reduce light intensity/absorption (which would increase transpiration)
- reduces transpiration (and therefore water loss)
- keeps leaf cooler (reduces evaporation) or
- thick leaf cuticle
- ensures that water is only lost through open stomata

Other features/characteristics

- store water (in roots, stems and leaves)
- water is available during dry periods (so stomata can be opened)

Chapter 12 Pathogens and their diseases

Question set 12.1a

Remembering

1 **a** An infectious disease is a disease caused by a pathogen that can be transmitted from host to host.

b A pathogen is an organism that causes an infectious disease.

c Contagious refers to an infectious disease able to be transmitted directly from infected host to susceptible host.

2 Virus, bacteria, fungi, protist

Understanding

3 Infectious diseases are caused by specific pathogens. To find out the specific cause, apply Koch's principles:

1 The potential pathogen must always be present when the disease occurs.

2 The organism should be isolated from the host and grown in pure culture.

3 Organisms from the pure culture are inoculated into a healthy, susceptible host. If the disease develops, this is further evidence for a specific cause.

4 The organism can then be re-isolated, grown in pure culture and compared to the organism first injected for confirmation.

However, they can only be fully applied to organisms that can be cultured such as bacteria. Viruses require a host to replicate and can't be cultured in a Petri dish. Therefore, DNA/RNA (nucleic acid) testing is used to confirm the presence of a specific pathogen.

4 Influenza is classified as a zoonotic disease in the form of bird flu or swine flu because it can exit one vertebrate group, such as birds, and enter a different vertebrate group, such as humans.

Question set 12.1b

Remembering

1 **a** Susceptibility of a host depends on genetic or constitutional factors, specific immunity, and nonspecific factors that affect an individual's ability to resist infection or to limit pathogenicity.

b Incubation period is the time between infection and the onset of symptoms.

2 Surface coats that inhibit phagocytosis, surface proteins that help bind to host cells, type of toxin produced.

Understanding

3 Symptoms are a set of signs that can be evidence for an infectious disease. A cough, for example, can indicate an infection in the lungs. However further testing is required to confirm the suspected disease. However, a cough can be due to asthma or a virus or bacteria.

4 Pathogenicity is the capacity for a pathogen to cause disease in a host. The measure of severity of the disease is known as virulence.

Question set 12.2

Remembering

1 Examples could include:

Influenza – fever, muscle aches and pains, chills

Ross River virus – rash, swollen and painful joints, headache

Honey bee virus such as deformed wing virus – deformed wings, flightless, premature death

ABL – paralysis, delirium, convulsions/muscle spasms, death

2 An obligate parasite is a parasite that depends on a host organism for its life cycle and reproduction to be completed.

3 1 Attachment

2 Endocyctosis (entry) of virus nucleic acid, DNA/RNA, into host cell

3 DNA/RNA enters nucleus of eukaryotic host cell

4 Viral DNA/RNA directs host cell to replicate nucleic acid and make copies of viral proteins via translation.

5 New viral DNA/RNA and proteins assemble at the host's cell membrane.

6 Newly formed viruses exit the cell and cell may lyse (break down) causing cell death.

Understanding

4 All viruses cause some type of disease, as they rely totally on host cells for their reproduction

5 A virus is relatively tiny 30–300 nm (most other are minimum or a micrometre in length)

6 Deoxyribonucleic acid (DNA) is a double-stranded molecule and ribonucleic acid (RNA) is a single-stranded molecule

7 A virus needs to attach to specific receptor molecules on the surface of host cells. Not all cells in a host organism contain the correct viral receptor

Applying

8 The ABL virus attacks the central nervous system: paralysis, delirium, convulsions/muscle spasms, death (if treatment is too late). The virus travels to the brain and cause inflammation of the brain which leads to death.

nelson net.

Question set 12.3a

Remembering

1 1 After asexually reproducing inside host cells, cells may lyse and cause tissue damage.
2 Toxins may interfere with the normal functioning of cells.
3 The pathogens can lower the strength of a hosts immune system making the host more susceptible to other infectious diseases.

2 Binary fission is the division of a cell into two without mitosis; a prokaryotic cell splitting to form two, identical daughter cells. Students' own diagrams.

Understanding

3 **a** having a capsule – may be used to help the bacteria stick to surfaces, such as teeth or mucous membranes. The capsule is a large, well-organised layer sitting outside the cell wall. It usually increases the virulence of a species, as it makes it harder for the body's immune system or antibiotics to attack the inner bacterium.
b forming endospores/spores – spores are a dormant form of the bacteria that can withstand adverse conditions and can remain in this form until conditions become favourable.

4 Shape – rod, spherical, spiral, vibrio; grow in aerobic/anaerobic conditions

Question set 12.3b

Remembering

1 Membrane organelles, including a membrane bound nucleus enclosing the DNA stored in chromosomes.

2 Example: phytophthora, causes plants to wilt, rot and die as hyphae grow inside the roots of the plant. The hyphae develop into mycelium which acts as a barrier for the host's transport of nutrients and water. Once symptoms start, the plant can die soon after.

3 Symptoms initially are fever, headache, shivering/chills. If left untreated and the host is susceptible, the effect on the host can be more severe such as the development of anaemia, organ failure (liver) and death.

4 Fungi are usually multicellular whereas protists are usually unicellular. Fungal cell walls are made of chitin. Protist cells may or may not have cell walls. If they do, they are usually cellulose based.

Understanding

5 Pathogens structural features can vary greatly and these differences in structure can affect the impact they have on a host which results in a unique set of symptoms for each pathogen.

6 Bacterial pathogens structure is prokaryotic (membrane bound organelles/nucleus are absent) and they may perform asexual reproduction (binary fission) inside their hosts causing tissue damage. They are small and simple but have an array of surface proteins that help them attach to host cells. Fungal pathogens structure includes membrane bound organelles (eukaryotic) and a different life cycle of reproduction which can be sexual or asexual. When fungal cells

grow inside host organisms, they efficiently absorb nutrients from their host through long thin filaments that have a high surface area to volume ratio. The pathogen depletes the host's nutrients causing the host to become sick.

7 Malaria is the disease that the pathogen *Plasmodium* causes. *Plasmodium* is a group of protists that cause the disease malaria.

Chapter review questions

Remembering

1 **a** Sudden onset of fever, cough, muscle and joint pain, sore throat, runny nose (attacks respiratory system)

b Rash, swollen joints, painful joints, headache, fever

c Paralysis, delirium, convulsions, death (attacks nervous system)

2 Deformed wing virus: wing deformity, flightlessness, death

3 Fungi produce spores that are very long lived. This is an adaptation that improves transmission rates as they can remain alive for years germinating when conditions are suitable. The hyphae of fungi can penetrate the external surface of a plant, for example, gaining entry to the host.

4 Differences:

- Bacteria are cellular with organelles such as ribosomes whereas viruses are non-cellular
- Bacteria reproduce asexually via binary fission whereas viruses can not reproduce asexually or sexually, instead they use host cells to replicate their nucleic acid and protein coats.
- Bacteria causes crown gall of plants and tuberculosis. Viruses cause influenza and Ross river fever.

5 **a** Coughing up sputum, fever, night sweats, weight loss

b Sudden involuntary muscle spasms, lock jaw, painful muscle stiffness, headache

c Galls form on crown of plant, wilting, stunted growth, death

6 Fungi: chytridiomycosis, athlete's foot

Protists: *Phytophthora*, malaria

7 *Phytphthora* have cellulose-based cell walls instead of chitin.

Understanding

8 Protists are a diverse group of species. Some are partially plant-like, some animal-like and some fungi-like.

9 Tuberculosis affects the respiratory system; malaria affects the circulatory system

10 The symptoms of tuberculosis are mostly related to the respiratory tract because the pathogen damages tissue at the base of the lungs causing mucus to build up which causes coughing which help clear the mucus from the lungs. The symptoms of malaria are different because different system is being affected. Instead of macrophages being damaged, red blood cells are damaged which impacts the host in different ways. Damaged red blood cells cause the host to develop headache, fever and even anaemia.

11 Students' own diagrams. Annotated steps below:

Replication begins at the 'origin of replication', the chromosome, attaches to the plasma membrane, both the chromosome and plasmid replicates, the cell elongates, a septum/cleavage furrow forms, cytokinesis/cell pinches in two, two new identical daughter cells each possessing plasma membranes and cell walls.

Applying

12 Pathogenicity is the capacity for a pathogen to cause disease in a host. The measure of severity of the disease is known as virulence. Influenza virus changes strain each year which can involve a change in virulence factors. The pathogenicity is very high each season, but the severity of the disease may vary. Some viruses have protein on their protein coat that make attachment to host cells easier. This is a virulence factor because it enables replication to happen more easily and therefore more cell/tissue damage.

13 Endocytosis is the process by which material can pass through and into a cell membrane. The cell membrane folds inwards to form a small sac around the incoming material, which is the case for viruses when they inject their nucleic acid into the host cell or may extend outwards for larger particles like the action of macrophages (which is termed phagocytosis).

Analysing and creating

14 **a** Non-cellular, consists only of nucleic acid and protein coat

b Prokaryotic, no membrane bound nucleus/organelles, single circular chromosome, plasmid

c Cell wall made of chitin, usually multicellular but can be unicellular, grows hyphae, mycelium and sporangia to produce spores, reproduces using spores

d Highly diverse group, mostly unicellular

Students' own Venn diagrams.

15 **a** The incidence of BSE in cattle in 1985 was very low. In about 1988 it started to increase rapidly, reaching a peak in 1992. It then fell to low levels by 1995.

b Increase in biosecurity (answers may vary)

c Yes, it is zoonotic if it has transferred from vertebrate group to human.

16 The point of attachment and the point of assembly at the cell membrane

Practice exam questions

1 D

2 B

3 D

4 A

5 B

6 Any four of:

- Eukaryote/eukaryotic cell
- Nucleus
- (May have) multiple nuclei
- Mitochondria/membrane bound organelles

- (Usually) single cell
- (Usually) small/microscopic
- Cilia/flagella/pseudopodia
- May have cell wall **or** protective outer layer

7 Virus:

- Nucleic acid or with DNA or RNA
- Protein coat
- Non-cellular
- Very small/microscopic

Bacteria:

- Circular chromosome
- Contain plasmids, or small loops of DNA
- Ribosomes present
- Plasma membrane encloses cytoplasm
- Cell wall present (in most groups)
- Small/Microscopic
- Different shapes (spherical, rod-shaped, spiral, vibrio)
- Unicellular (usually)

Fungi:

- Cell wall present
- Unicellular or multicellular (must have both to get mark)
- Microscopic or Macroscopic (must have both to get mark)
- Made up of filaments/hyphae/mycelium

8 Infectious disease is caused by a pathogen and the pathogen can be transmitted from one host to another host. Non-infectious diseases are not.

9 **a** Crown gall: caused by bacterium and affects plants

b Chytridiomycosis: caused by fungus and affects amphibians/frogs

c *Phytophthora* dieback: caused by protist and affects plants/jarrah trees

10 Binary fission (1 mark)

Any three of the following steps:

- Chromosome/Genetic material is replicated/duplicated
- Duplicated chromosome/genetic material moves to opposite end of cell/segregates
- Cell grows/gets large
- Each copy of duplicated chromosome attaches to a different part of the cell membrane
- Cell divides into two daughter cells/cytokinesis
- New cell wall is laid down
- Each daughter cell has a copy of chromosome/genetic material/is identical to the parent.

Chapter 13 Spread of pathogens

Question set 13.1

Remembering

1
- Portal of entry
- Exploit a nutrient rich area of host
- Evade defense mechanisms
- Replicate
- Portal of exit
- Reservoir (other than human reservoir)
- Mode of transmission

2 Eyes, ears, wound, mouth, nose, vagina

3 Mucus membranes are surface membranes that are moistened with slimy, sticky and viscous mucus. The respiratory tract is covered in mucus membranes (and the digestive and excretory tracts).

Understanding

4 Signs are objective measurements (such as blood pressure and heart rate) that indicate disease whereas symptoms are subjective observations (such as pain and headache) that indicate disease.

5 A wound found in the epidermal layer of a plant or animal is a portal of entry because the physical barrier has been opened. The wound then allows entry of pathogens.

Question set 13.2

Remembering

1
- Direct contact: the transmitting of a pathogen through physical touch between infected host and susceptible host via skin or body fluids. Body fluids are any liquids that come from inside the body, including sweat, tears, vomit, nasal secretions, blood, saliva and urine.
- Close contact: the transmitting of a pathogen via airborne droplets, by close proximity (usually within one meter and immediately) between infected and susceptible host such as sneezing/coughing. When an individual coughs or sneezes, small droplets of mucus that may contain pathogens are ejected and then inhaled by someone close by.
- (other) Reservoir: transmission from reservoir directly to susceptible host. A reservoir is a living or non-living site where a pathogen normally resides and possibly replicates.

2
- Vectors: a living thing (usually an arthropod such as a mosquito) that transmits a pathogen from an infected host to susceptible host.
- Airborne droplets/fomites: pathogens can be transmitted inside airborne droplets (aerosols) that are sneezed or coughed into air and are suspended in air currents for a period of time before being inhaled or land on a surface such as a table or tissue.
- Soilborne/waterborne/foodborne/vehicle: A non-living object that carries a disease-causing agent from one host to another in the life cycle of a pathogen. Inanimate objects that can carry disease are car tyres, gardening tools, clothing, soil, water.

3 An organism or habitat in which a pathogen can reside. Three types are human hosts, soil, bats (who can be infected or not infected- simply a vector).

Understanding

4 Direct transmission is the transfer of a pathogen from an infected host, or other reservoir, to a susceptible host by direct contact or droplet spread. Whereas indirect transmission is the transfer of a pathogen from a reservoir to a host through vehicles (inanimate objects), vectors (living intermediaries) or suspended air particles. Indirect transmission may require one or more steps whereas direct transfer usually involves one step.

5 Direct transmission via airborne droplets through close proximity is classified as direct because transmission is by direct spray over a few feet (before the droplets fall to the ground) from infected host respiratory system into susceptible host's respiratory system. This is in contrast to indirect transmission via airborne droplets because this mode involves the droplets being carried further distances by air currents before being inhaled or dropping to a fomite before being transmitted.

Question set 13.3

Remembering

1

Disease	Pathogen type	Pathogen name	Mode/s of transmission (most common to least common)	Life cycle specifications [portal of entry, site of replication (sexual/ asexual reproduction), reservoir, portal of exit]
Influenza	(RNA) Virus	Influenza A, B, or C	Direct, close contact via airborne droplets Indirect via fomites	Entry and exit via respiratory system Replicate inside epithelial cells in the respiratory tract Human host reservoir
Ross River virus	(RNA) virus	Ross River virus	Indirect via mosquito vector	Entry via skin – blood feed Replicate in mosquito vector epithelial cells and muscle cells of the infected human host Reservoir – marsupials such as wallabies. Entry and exit via two different blood feeds Exit not applicable from human host

Disease	Pathogen type	Pathogen name	Mode/s of transmission (most common to least common)	Life cycle specifications [portal of entry, site of replication (sexual/ asexual reproduction), reservoir, portal of exit]
Viral diseases of honeybees such as deformed wing virus disease	Virus	Deformed wing virus	Indirect via vector varroa mite Direct via vertical transmission from bee to offspring	Entry and exit via skin – blood feeds from varroa mite vectors Replicate in bee
Australian bat lyssavirus	(RNA) virus	Australian bat lyssavirus	Direct contact with bat reservoir/vector bodily fluids, through a bite or scratch	Entry via site of bite or other break in skin. Replication in bat reservoir and infected human host before travelling along nerves to CNS Exit not applicable from human host.

Understanding

2 Lower than influenza and Ross River Virus because although there are high human densities and high pathogen populations, the mode of transmission is inefficient. All three interrelated factors are required for efficient spread through human populations.

3, 4, 5 Students' own diagrams.

Question set 13.4

Remembering

1 Host population density, population of pathogen, mode of transmission

2 Globalisation is the process by which the world is becoming increasingly interconnected as a result of massively increased trade, economic, travel and cultural exchange.

3 Climate change refer to; changes in global average air and ocean temperatures, rising global sea levels, long-term sustained widespread reduction of snow and ice cover, and changes in atmospheric and ocean circulation and regional weather patterns, which influence seasonal rainfall conditions. This has led to an increase in more severe weather events

Understanding

4 ABL is spread to humans by the saliva of infected bats when the saliva comes in contact with mucous membranes or broken skin, or through bat bites or scratches. Infection is fatal but infection in humans is low. One reason is, unlike mosquito vectors, bats do not use humans as a

primary source of food, they consume insects or fruits. Mode of transmission is direct contact. However, humans usually only come into contact with a bat/flying fox when one is injured, which is a rare occurrence. The mode of transmission is a limiting factor for this pathogen. Regardless of the growth of the pathogen population, or the human host population density, without a more effective mode of transmission, the spread of ABL is limited.

5 Bird flu is a type of zoonotic disease that spread quickly throughout different countries because of animal trade, a form of globalisation. Infected birds were imported and acted as international carriers of the pathogen.

6 Climate change is causing a rise in average air temp and extreme floods/rains. Mosquitos are more active in warmer temperatures. As previously cold areas become warmer, mosquitos will spread further along with the pathogen they carry. With the extra water bodies left after floods and rains, mosquitos exploit these as breeding grounds, increasing the area in which mosquitos can breed and the number of offspring they produce.

7 When antibiotics were first synthesised, they killed most bacteria and used to treat many affected people and pets. All bacteria in a population died including any resistant strains of the bacterium. Either through mutation or gene transfer, a bacterium gained a resistant gene to the antibiotic. When the antibiotic was taken again for an infection, all but the resistant bacteria died. The resistant bacterium survived and reproduced and passed its resistant gene on to offspring. This problem was exasperated by patients not taking a complete course of antibiotics. When they only took them for the first few days, the weaker bacteria were killed leaving behind more resistant bacteria. After many generations, a new population of resistant bacteria evolved. This was a form of natural selection. The selective pressure of an antibiotic selected for the antibiotic resistant strain of bacteria to survive, reproduce and pass on the advantageous trait.

Creating

8 Students' own infographics

Chapter review questions

Remembering

1 The purpose of a host is to provide the pathogen with a moist, nutrient rich environment to assist in its survival and reproduction.

2 Enter, exploit nutrients, replicate, exit and transmit to new host

3 Growth of pathogen population, density of host population and mode of transmission

Understanding

4 Swimming zoospores attach and penetrate the skin of amphibians, zoospores germinate and replicate asexually, sporangium grows, zoospores grow by mitosis inside the (zoo)sporangium (also known as a thallus), zoospores are released via a discharge tube, into water. It can re-infect another host indirectly by swimming though water or directly by skin to skin contact between infected host and susceptible host.

5 **a** Site: mosquito gut, form: male gametes and female gametes fuse to form zygotes

b Site 1: liver cells, form: sporozoites

Site 2: red blood cells, form: merozoites

6 1: Influenza – direct by close contact via coughing/sneezing of airborne droplets out of respiratory system and into a susceptible host's respiratory system by inhalation. Or indirect by pathogens residing on fomites. They were coughed/sneezed by an infected person and airborne droplets landed on the fomite such as a table. A susceptible may touch the table then touch food and consume it.

2: Tuberculosis – direct by close contact via coughing/sneezing of airborne droplets out of respiratory system and into a susceptible host's respiratory system by inhalation. Or indirect by pathogens residing on dusty fomites. They were coughed/sneezed by an infected person and airborne droplets landed on the fomite. The dust particles containing the bacteria may become airborne after a disturbance such as wind and then inhaled by a susceptible person. The bacteria then enter the respiratory tract of the human host.

Applying

7 Climate change involves changes in global air/ocean temperatures and rainfall patterns. Mosquitos act as vectors for some diseases, such as malaria. If previously cool regions became warmer, mosquitos may move into the area, and may increase in activity because they are temperature sensitive. The vectors would be carrying the pathogen into new areas increasing the spread of the disease. Extra water bodies would increase breeding grounds and vector populations further increasing spread.

8 The first difference is the pathogen types. Malaria is caused by a protist and RRV is caused by a virus. The second difference is malaria does not have an extra reservoir whereas RRV has a marsupial reservoir which makes its life cycle more complex.

9 The vorroa mite is thought to be a vector for a honeybee disease DWVD. IF it enters the country and begins to spread the disease, many of our crops and native plants will not get pollinated. Money spent on biosecurity may save us indirectly from starving/losing crops.

10 An epidemic is a sudden increase in the prevalence of a particular disease that spreads rapidly through a region or nation after an outbreak. Whereas a pandemic is the rapid spread throughout the world.

11 Tuberculosis spreads easily because all three interrelated factors are above threshold. Pathogen population, host density and mode of transmission. Urban areas result in crowded living. Mode of transmission is by close contact and the population of the pathogen can grow rapidly in these conditions.

Analysing

12 **a** Same pathogen type – bacteria

b Pathogen forms – both have spores and both spores reproduce via binary fission/asexually and germinate

c Tetanus bacterium is anaerobic, crown gall bacterium is aerobic

d Spores of crown gall are zoospores and are motile in water. Spores of tetanus are not. They reside in soil reservoir.

Evaluating

13 Argument for: Antibiotics have been overused to the extent that bacteria have become rapidly resistant to antibiotics. The trend seems to point at the future with no effective antibiotics. Without effective antibiotics, many people, especially vulnerable people will die.

Argument against: All people should have the right to accessing healthcare when it is needed. The spread of many diseases can be reduced by taking antibiotics. Helping sick people get better fast will help them return to work and alleviate business's economic stress.

14 Pros: Urbanisation can stimulate job growth and for many people earning an income will enable them to afford health care (such as vaccinations) and better living conditions (access to clean water) which in turn helps reduce the spread of disease. It can provide services such as hospitals that are not found in rural areas.

Cons: Many urban areas have poor sanitation causing many people to be susceptible to infectious disease. Urbanisation can cause over-crowding which means many people live in contact/close contact with each other. Any disease spread via direct contact by physical contact or close contact modes will spread much faster compared to a rural area.

Creating

15 Use a control and test group. Use several Petri dishes as the control group and several as the test group for repetition/reliability. In one Petri dish have only the bacteria and in the other Petri dish have the same bacteria and the antibiotic. Incubate for the same length of time. Compare the amount of bacteria growth in both groups. Repeat the whole experiment several times (replication).

A different experiment could be set up using an additional group of a currently used antibiotic to show a comparative effectiveness.

Practice exam questions

1 A

2 B

3 B

4 A

5 Any four of:

- Affected people were treated with the antibiotics.
- Antibiotics killed bacteria in most individuals/cured most individuals. This halted the spread/killed off antibiotic sensitive strains of the bacterium
- A bacterium acquired resistance to the antibiotic through mutation or through the acquisition of a plasmid with a resistance gene. These resistant bacteria were unaffected by the antibiotic
- The antibiotic resistant bacteria continued to be transmitted/continued to reproduce. Therefore, the antibiotic resistance bacteria are becoming more common
- Natural selection favoured the antibiotic resistance strains or the antibiotic sensitive strains were selected against. Pathogens evolve rapidly in changing environment (antibiotic represents a change environment).

6
- Female mosquito/*Anopheles* mosquito – vector
- Bites/takes blood from infected person– blood contains protist
- Protist reproduces in mosquito
- Transmitted when mosquito bites – transmitted in (mosquito) saliva.

7
- Different types of transmission
- Tuberculosis is caused by bacteria transmitted from person to person/no vector involved
- (Tuberculosis) transmitted by close contact/droplets/sneezing therefore (potentially) spreads (readily) to wherever there are people
- Modern transport/movements of people help spread/tuberculosis asymptomatic
- Malaria is transmitted through vector/mosquitos/transmitted indirectly
- Distribution of vector influences distribution of disease or distribution of malaria reflects distribution of (*Anopheles*) mosquito that transmits it/vector.

8
- An epidemic is where many individuals in a region/area are infected
- High population density increases susceptibility (to epidemic) influenza is spread through close contact
- Higher population density/more people in an area more often infected people will come into contact with uninfected/susceptible people (therefore) influenza will spread faster in high density areas.

9
- Poor healthcare increases susceptibility more risk/chances of the disease spreading
- Fewer individuals will be immunised/able to access vaccine hence will be a high proportion of susceptible individuals/low herd immunity
- More people will be infected few people will have access to antiviral drugs
- Antiviral drugs limit ability of virus to reproduce/can shorten duration of illness/the time during which an individual can infect someone else
- Few people will have access to quarantine/can be isolated from
- Others/poor hygienic practices infected individuals are more likely to come into contact with susceptible ones/transmit the disease
- An epidemic is where many individuals in a region/area are infected (but only if this has not been paid in under population density).

10 Spread through spores or spores in soil – any three of:
- (spores are spread by) human activities or movement of (contaminated) soil/plants/ equipment
- (spores are) carried by water/run off
- (some) spores can swim
- (some) spores can survive for a long period of time
- (spores can be) spread by animals (on surface/in the digestive system/by activities e.g. digging)
- (spores can be) spread by root to root contact

- disease caused by protist
- infects plants.

Maximum of 6 marks:

Quarantine – maximum 3 marks

- quarantine
- restrict/ban access to certain places/bush tracks/heavily infected areas (this will) limit opportunity to transport spores out of this area
- restrict/ban access when raining/wet/soil is wet because (swimming) spores are active during the wet or because more likely to pick up contaminated mud.

Hygiene/physical preventative measure – maximum 3 marks

- hygiene/physical preventative measure
- wash/disinfect equipment/shoes/clothes before/after entry to areas (this will) reduce the chances of carrying spores away from or into unaffected areas
- do not transport soil/plants (from affected areas) this could contain spores (that will spread disease to elsewhere).

Miscellaneous – maximum 3 marks

- apply phosphite
- (phosphite) increases resistance to infection
- educate/inform the public
- (education is important because) human activities are the main source of spread local eradication
- kill all trees/sterilise soil in heavily infected areas.

Chapter 14 Pathogen management strategies

Question set 14.1

Remembering

1 The three categories that an emerging disease are classified into:
- diseases that have recently appeared in the population, such as COVID-19
- diseases that have occurred previously but until recently have affected smaller numbers in isolated places, such as Ebola
- diseases that have occurred previously but only recently associated with a newly identified pathogen.

2 **a** Epidemiology
b Management of an infectious disease
c Emerging disease

3 Absence of pathogen, signs and symptoms of the disease.

4 Once the life cycle of a pathogen is known then the disease can be targeted appropriately to control or prevent the spread of the disease. Factors that can be targeted include the mode of transmission, environmental factors that aid and suppress the life cycle and the characteristics of infected people.

Understanding

5 Due to globalisation, outbreaks can spread quickly transitioning to epidemics and pandemics within hours. If authorities are aware of outbreaks, they more effectively can coordinate management strategies to contain and prevent spread. The source of the disease, identity of the pathogen, treatment plans, predictive mathematical modelling, funding allocations and biosecurity can be delivered more efficiently. This can lead to the reduction in spread of disease and reduction in treatment and infrastructure repair costs.

Question set 14.2a

Remembering

1 **a** Biosecurity
b Quarantine

2
- A plant or plant product, including flowers, cuttings, bulbs, fruit and vegetables (excludes canned or cooked plant products)
- Seed
- Absorbent pet litter derived from plant material
- Soil

- Plant growing media and landscaping material such as potting mix, wood chips and mulch
- Cargo containers.

Understanding

3 Southeast Asian countries are in close proximity to the northern states and territories of Australia. Ships often carry illegal goods and pets into our borders. Refugees may also be carrying disease and may need to be quarantined.

Question set 14.2b

Remembering

1 **a** Immunisation is the act of protecting someone from disease by the use of a vaccine

b Vaccination is the administration of a vaccine to the bloodstream to cause immunity, usually by injection. Immunisation is what happens in your body after you have the vaccination.

c Antibodies are special proteins produced by white blood cells that react with and help make pathogens harmless. Antibodies are also known as immunoglobulins and are produced by specialist white blood cells called B-cells.

2 1 A critical (high enough) proportion of the host population becomes immune to a specific disease.

2 Immunity is usually by an artificial vaccine (or can be gained naturally by recovery from disease) causing the formation of specific antibodies and memory cells against a specific pathogen.

3 This limits the spread of the disease as there are too few susceptible people to sustain the spread. The pathogen cannot reproduce at a high enough rate to sustain its population.

4 Infected hosts carrying the pathogen are more likely to come into contact with immune individuals, reducing the possibility of transmission; reducing the risk for susceptible people.

5 The higher the proportion of immune individuals, the greater the protection.

6 Protects people who cannot be vaccinated such as old or pregnant.

7 The proportion of a herd who are immune depends on the virulence of pathogen.

Understanding

3 1 A critical number of Australians should be vaccinated/immunised against a current strain of Influenza.

2 The vaccine will stimulate specific antibodies and memory cells for the specific strain of influenza.

3 This limits the spread of the virus because there are too few susceptible individuals.

4 Because infected hosts carrying the disease are less likely to come into close contact, the mode of transmission, with others preventing transmission and spread.

5 The higher the number of immune Australians the more protection susceptible people have.

6 and 7 The critical proportion depends on the virulence of the strain of influenza.

4 Students' own diagrams.

nelson net.

Question set 14.2c

Remembering

1 It generally consists of a reservoir, portal of exit from an infected host, mode of transmission, portal of entry, replication and a susceptible host.

2 Students' own diagrams

Understanding

3 Malaria causes the highest number of deaths in children and other susceptible groups such as the sick. Children are more susceptible to the disease compared to adults. Malaria can have a higher impact on people with weak immune systems and generally children have weaker immune systems, especially if they have just finished being breastfed and not receiving the mother's antibodies anymore.

a The vaccine targets sporozoites by blocking their entry into liver cells. Normally plasmodia in this form will reproduce asexually and develop into merozoites which precedes the red blood cell cycle. If the sporozoites can be blocked, merozoites will not develop. This prevents the red cell cycle, anaemia and further transmission into the mosquito for sexual reproduction. This can stop the spread.

b Students' own diagrams

Question set 14.2d

Remembering

1

	Antibiotics	**Antivirals**
Difference 1	Only work on bacteria	Only work on viruses
Difference 2	Can inhibit reproduction or destroy the pathogen	Can only inhibit replication

2 Bacteria are prokaryotic and therefore drugs target structural features and metabolic characteristics of prokaryotes that are significantly different from those in eukaryotic cells. Viruses are not cellular and most antivirals that destroy viruses also harm eukaryotic cells. Drugs that effectively inhibit viral infections are highly toxic to host cells because viruses use the host's metabolic enzymes in their reproduction.

Understanding

3 Structures such as peptidoglycan and structures that inhibit processes such as protein synthesis and replication are targeted because the cell cannot finish forming or cannot reproduce. This stops the pathogen from persisting and stops the spread.

4 Influenza changes strain rapidly. The most virulent strain/s are used to form the yearly vaccines. Previous vaccines for previous strains become ineffective.

nelson net.

Question set 14.2e

Remembering

1 Coughing into elbow. The elbow acts as a barrier preventing the pathogen from transmitting to a susceptible host via the airborne droplets.

Specialist masks. One type acts as a barrier for pathogens during exhalation out of an infected host's respiratory tract and other types prevent the inhalation of the airborne droplets of the pathogen into a susceptible host's tract.

2 Hand washing: removes pathogens or eliminates the pathogens on the hand. This stops the pathogen from spreading via contact or fomites.

Sanitation: treating excreta with chemicals to kill microbes preventing the transmission via waterborne means.

Understanding

3 (Example) Australian bat lyssavirus

Professionals handling bats wear thick specialist gloves that are resistant to a puncture. This acts as a barrier if a bat scratches or bites a susceptible host.

If a bat does scratch or bite a potential host, disinfecting the wound may kill the pathogen before it enters the bloodstream.

4 Some bat populations are under threat due to habitat loss and therefore some injured bats need attention. If they are injured gloves can make handling them a lot safer by reducing the risk of transmission. However, gloves only resist punctures, they are not entirely puncture proof.

Disinfecting the wound can be effective in killing ABL before it can cause harm. However, this treatment only works if it is done immediately after the bite. Once the pathogen enters the nervous system there is no cure.

Applying

5 Students' own mind maps

Question set 14.3

Remembering

1 There are several steps undertaken when investigating an outbreak with the aim of controlling further spread of the disease in question. The investigation begins with confirming the outbreak, the number and diagnosis of known cases. The investigators formulate a case definition which includes information of the type of illness and the place and time. The following steps include finding cases, gathering information and developing and testing the hypotheses. The final steps involve communicating findings and implementing control measures, although these two aspects can happen throughout the investigation as relevant information comes to hand.

2 A notifiable disease is a disease that has been nominated by a state health authority that when a person is diagnosed with this particular disease, the state health authority must be notified. This is done so the state health authority can monitor disease activity within the community. Diseases on the list include: AIDS, all hepatitis diseases, influenza, whopping cough, tetanus, measles and tuberculosis.

Understanding

3 Mathematical modelling is a tool used by epidemiologists to predict the spread of disease in a population and to simulate the effects of possible interventions. There are many factors that can have an impact on the spread of disease and models need to have good predictive ability taking into considerations the complexity of the pathogen and how it is transmitted through a population. Supercomputers are invaluable with the amount of information or data they hold and processing power they can compute. This allows for increasing the complexity of the model by analysing relationships between possible variables. However, mathematical models have a trade-off between complexity and accuracy and each scenario needs to be assessed to determine the most appropriate approach to take. Also, as models rely on data to make accurate predictions, they have less reliability with emerging diseases due to limited known information, or data, about the disease.

Chapter review questions

Remembering

1 Quarantine, immunisation, breaking the life cycle of a pathogen, medications – antibiotics and antivirals, physical preventative measures.

2 An epidemiologist's role is to work to prevent or minimise the impact of diseases in the population. Their work may include such activities as identifying outbreaks, determining the effectiveness of a vaccine, and calculating the cost effectiveness of various means of controlling disease transmission. Occasionally, epidemiologists act as 'detectives' who track down the cause of an emerging disease, determine its reservoir and mode of transmission, and help organise health care workers to bring the disease under control. Epidemiologists aim to describe patterns of disease, identify causes of disease and provide data for management of a disease. They analyse data gathered about notifiable diseases.

3 **a** Imported goods and contaminated clothing may be brought to an island. The wildlife on the island may not have previously been exposed to this disease. There would be little resistance. The spread of the disease can be rapid.

b Increasing mobility, particularly by air travel, means that emerging infectious diseases now have the potential to spread worldwide at alarming rates.

4 Herd immunity occurs if a large enough proportion of the population is immune to a disease and there are too few susceptible individuals to sustain disease spread. An example is smallpox.

5 Regular hand washing can prevent individuals from contracting infections, particularly those that are spread by direct contact routes. Good hand-washing practices are also important in hospitals, particularly for reducing the spread of antibiotic-resistant bacteria between patients.

Understanding

6 Tetanus is transmitted directly from soil to humans. Immunity can protect an individual but it cannot protect a unimmunised person because it is not contagious (not spread from person to person).

7 If enough healthy individuals are vaccinated, the chance of the people unable to receive vaccinations coming into contact with an infected person is so low that they are unlikely to contract the disease.

8 Data collection about disease rates (even when they are stable) is used for surveillance. Any changes to the rate can be quickly detected and appropriate action can be taken.9. Research a recent outbreak of an emerging/remerging disease (such as SARS or Swine Fever) and describe the management strategies used to control the spread. Include what they did and who (WHO, UN, Government or community) did it.

9 Answers will vary. Example given for swine fever.

Swine fever, which spread via contact with infected pigs, ingesting pig products or contact with fomites – contaminated clothing, vehicles, tools.

Community/farmers eliminated contaminated pigs. Biosecurity, checking products entering and exiting facility. Disinfecting tools and vehicles.

Centre for Food Safety, World Organisation for Animal Health, Chinese and other governments, conduct careful monitoring and inspection of pigs pre and post-mortem.

It was confirmed that it was not zoonotic.

Individuals should thoroughly cook pork before consumption.

Applying

10 a TB is caused by *Mycobacterium tuberculosis* and is spread by droplet infection. Infected individuals inhale the bacteria, which settle in their lungs. To avoid spread of the disease, people are kept away from patients. If people must be close to the patients, masks are worn to avoid breathing in the bacteria.

b Yes, this is a type of quarantine because there is enforced isolation of individuals carrying the disease in order to prevent the spread of that disease into healthy populations.

c Contact tracing

11 a Zygotes of the malarial parasite Plasmodium develop into sporozoites in the gut of the female Anopheles mosquito and then migrate into her salivary gland → Mosquito bites a human; sporozoites enter bloodstream and move to the liver → Merozoites can return to the liver and cause further bouts of malaria → Sporozoites reproduce asexually in liver cells → Merozoites (resulting from asexual reproduction of sporozoites) move into the bloodstream and from there enter red blood cells, where they reproduce asexually → Some merozoites can form male and female gametocytes; these are released into the bloodstream → Blood is sucked from an infected human by a female mosquito; gametocytes travel to the mosquito's gut where they mature into gametes and fuse to form zygotes.

b Malaria can be spread quickly and can be distributed over a large area due to the mobility of the mosquito.

c Hh provides the biggest selective advantage as individuals with hh have abnormal red blood cell shapes that cause anaemia and HH individuals have no resistance to malaria. Hh individuals have normal shaped red blood cells and some resistance to malaria.

d As explained in part c, individuals heterozygous for sickle cell anaemia have a survival advantage over other genotypes in areas near the equator where malaria is common. They produce more offspring than HH individuals, in turn passing on the h allele to offspring. Some offspring will be homozygous for the sickle cell allele. This results in more of the population with sickle cell disease.

12 a In winter, it may be that cooler air and lower humidity promotes the transmission of the influenza virus from one person to another. It could be that people are indoors more often during the winter. This means they are in close contact more often, and this promotes transmission from person to person.

b When virus particles are spread by coughing and sneezing, surfaces can become contaminated. If a person touches these surfaces their hands also become contaminated. Hand washing removes the virus particles before they are spread to the person's respiratory system.

c Herd immunity would not provide protection as the virus mutates so rapidly. A high proportion of the population would not be immune to all the different strains.

Analysing

13

	Disease surveillance	Predictive modelling
Type of information	When and where particular infections are occurring	Mathematical models that can predict the spread of disease
Ways of gathering information	Notification of public authorities when individuals are diagnosed Use of the internet and social media	Mathematicians and biologists collaborate to develop mathematical models to predict disease spread
When technique is useful	When public health authorities need to know when and where particular infections are occurring	Use to explore the likely effects of newly emerging pathogens and changes in environemental conditions. They can also be used to design and predict the effects of potential public health interventions

Evaluating

14 Mosquito control – mildly effective because mosquitos are active and numerous. Populations change as climate changes and water bodies increase.

Barriers such as clothes and bed nets – excellent but the clothing only effective is it covers all areas of skin. Bed nets sprayed with insecticide have proven highly effective. However, the use of them is not consistent and they need respraying every few months.

Insect repellent is effective against most mosquitos, either killing or repelling them. Avoiding bites. However, some mosquitos are resistant, and repellent is a high cost for many poor people.

Avoid being outdoors at dusk or dawn or during periods of high mosquito activity.

Surveillance of endemic spread so that epidemic spread can be identified through comparison.

Identifying infection among reservoir marsupials and using mosquito control among them.

Creating

15 Students' own Venn diagrams

Practice exam questions

1 A

2 B

3 A

4 D

5 Use of insecticides:

- to kill mosquitos or
- eliminate standing water/oil on water
- remove/disrupt mosquito breeding or
- modify human behaviour/avoid being outdoors at times when mosquitos are active/use netting/use repellent/wearing protective clothes
- avoid being bitten (stops transmission) or

Biological control of mosquitos:

- specific details of biological control (e.g. mosquito fish) or
- anti-malaria drugs
- fewer infected people/fewer pathogens in the people.

6 Quarantine – maximum 3 marks:

- restrict/ban access to certain places/bush tracks/heavily infected areas
- (this will) limit opportunity to transport spores out of this area
- restrict/ban access when raining/wet/soil is wet
- because (swimming) spores are active during the wet or because more likely to pick up contaminated mud (hygiene/physical preventative measure – maximum 3 marks)
- hygiene/physical preventative measure
- wash/disinfect equipment/shoes/clothes before/after entry to areas
- (this will) reduce the chances of carrying spores away from or into unaffected areas
- do not transport soil/plants (from affected areas)
- this could contain spores (that will spread disease to elsewhere)

Miscellaneous – maximum 3 marks:

- apply phosphite
- (phosphite) increases resistance to infection
- educate/inform the public
- (education is important because) human activities are the main source of spread
- local eradication
- kill all trees/sterilise soil in heavily infected areas
- will reduce risk of disease spreading from this area
- (need to) stop the spread because there is no cure

7 The phenomenon of herd immunity protects individuals who are unable to be vaccinated for a particular disease. If a large proportion of individuals in a population are vaccinated and protected against a disease, the pathogen cannot spread and infect other individuals. The spread

of disease is limited and the risk of an unvaccinated and unprotected individual catching the disease is very low.

8
- Influenza is spread through close contact.
- If one member of the household has the disease, there is a (high) risk that it will be transmitted to other people in the household.
- In location 2/locations with large households, more people are likely to be infected or in location 1/locations with small households, fewer people are likely to be infected.
- Infected individuals can spread the disease to individuals from other households.
- The more infected people there are, the greater the chances that an uninfected person from another household will come into contact with them

  or

  the fewer infected people there are, the lower the chances an uninfected person from another household will come into contact with (if all else is equal).
- The rate of transmission/spread (outside of the household) will also depend on the population size/density/vaccination or other factors.

9
- Influenza is caused by a virus.
- Antibiotic sonly work on bacteria.
- Antibiotics work by targeting structures that are present in bacterial cells or antibiotics work by targeting structures that are not present in a virus.
- Specific details, e.g. antibiotics target cell wall of bacteria or ribosomes of bacteria (protein synthesis).
- Antiviral drugs are used to treat viral diseases.
- Antiviral drugs disrupt the life cycle of the virus.

10

• Kill the prawns at the affected farms • Virus cannot survive without prawns/disrupt the life cycle of the virus	1–2
• Delay putting (new) prawns back in affected farms • Give time for any viral particles in the environment to die/disrupt the life cycle of the virus	1–2
• Chlorinate water/clean environment in the (affected) prawn farms • Kill all viral particles in the environment	1–2
• Kill (unaffected) prawns at nearby farms • Even if viral particles escape (from affected farms) there will be no hosts for them to infect/disrupt the life cycle of the virus	1–2
• Quarantine all equipment/prawns on affected farms • Prevent spread of virus through contaminated equipment or affected prawns	1–2
• Physical barriers to prevent water from affected farms going into river • Prevent spread of virus by river water	1–2
• Vaccinate prawns • Create large numbers of immune prawns or to create herd immunity	