Answers to student book questions

Chapter 1 Questions and answers

1.1 Review

1 Which of the following statements about cells is true?

A Cells are made of organelles, which are the smallest organisational units of life.

B All cells have a plasma membrane, cytoplasm and nucleus.

C All cells are composed mainly of inorganic material such as carbohydrates, proteins, nucleic acids and lipids.

D Cells and their products are the components of all living things.

Answer: D

2 Name three components that all cells possess.

Answer: All cells:

- are surrounded by a plasma membrane (cell membrane)
- contain cytoplasm
- have genetic material in the form of DNA.

3 List the features shared by plants and animals that enable scientists to classify them all as 'living things'.

Answer: All plants and animals:

- are made of cells
- are chemically complex and highly organised
- exchange materials with their environment
- exchange energy with their environment
- are able to sense and respond to their environment
- develop, grow and reproduce
- show adaptive changes over a long time.

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4 Decide whether each of the items listed is living, dead or inorganic. Give reasons for your decision in each case.

grass	timber chair
bee	dry fallen twig
honey	ripening peach on a tree
gravel	sleeping possum
hair	hibernating bat
spider web	growing crystals

Answer:

Living: grass, bee, ripening peach, sleeping possum, hibernating bat. They are cellular, exchange material with the environment (gases, nutrients, wastes) and grow.

Dead: timber chair, dry fallen twig. They are cellular but do not show any of the signs of life listed above.

Non-living: honey, gravel, hair, spider web, growing crystals. They are non-cellular, do not show any of the signs of life listed above. Hair (keratin) is a product of cells and non-cellular, so it is non-living.

5 Define the term 'adaptation'.

Answer: An adaptation is a characteristic of an organism that makes it well suited to its environment and lifestyle.

6 Give two examples of adaptations mentioned in the text.

Answer: Any two of the following:

- 'antifreeze' in the blood of Antarctic icefish
- banksia cones that release seeds after a fire to take advantage of the nutrient-rich ash
- the flying duck orchid that mimics a female wasp.

7 The idea of adaptation is a key component of which biological principles?

Answer: Adaptation is a key component of natural selection and evolution.

1.2 Review

1 **a** Define the terms 'organic compound' and 'inorganic compound'.

b Is carbon dioxide organic or inorganic? Explain.

Answers:

a Organic compounds are complex compounds that contain the elements carbon and hydrogen. All other compounds are inorganic compounds.

b Carbon dioxide is inorganic because it contains carbon but not hydrogen.

2 Which of the following statements is true?

A All organic compounds contain carbon and nitrogen.

B All organic compounds contain carbon and hydrogen.

C All organic compounds contain carbon, hydrogen and oxygen.

D All organic compounds contain carbon and oxygen.

Answer: B

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3 Copy and complete the following table, which should list the four main types of organic compounds that make up organisms, the elements of which each is composed, and the main function of each compound.

Organic compound	Elements	Main function
1		
2		
3		
4	Carbon, hydrogen, oxygen, phosphorus, nitrogen	

Answer:

Organic compound	Elements	Main function
1 carbohydrate	carbon, hydrogen, oxygen	storing energy, structural support
2 lipid	carbon, hydrogen, oxygen (in different proportions to carbohydrates)	storing energy, hormones, vitamins
3 protein	carbon, hydrogen, oxygen, nitrogen and possibly sulfur and phosphorus	cell structure, enzymes, hormones, carrier molecules
4 nucleic acid	carbon, hydrogen, oxygen, phosphorus, nitrogen	genetic material of all organisms, carrying instructions required to assemble proteins from amino acids

4 Match each of the following terms to the correct statement about it.

carbohydrate	byproduct of cellular respiration
carbon dioxide	composed of amino acids
lipid	compound of carbon, hydrogen and oxygen
mineral	examples are phosphorus, calcium and potassium
nucleic acid	fatty substance stored in tissues
oxygen	made of subunits called nucleotides
protein	may be water-soluble or lipid-soluble
vitamin	needed for cellular respiration

Answer:

carbohydrate	compound of carbon, hydrogen and oxygen
carbon dioxide	byproduct of cellular respiration
lipid	fatty substance stored in tissues
mineral	examples are phosphorus, calcium and potassium
nucleic acid	made of subunits called nucleotides
oxygen	needed for cellular respiration
protein	composed of amino acids
vitamin	may be water-soluble or lipid-soluble

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5 Name the units that make up the following compounds.

a nucleic acids

b proteins

c carbohydrates

Answers:

a nucleotides

b amino acids

c simple sugars (monosaccharides)

6 Are minerals and vitamins inorganic or organic? Explain your answer.

Answer: Minerals are inorganic because they are not complex compounds of carbon and hydrogen. Vitamins are complex carbon compounds and are thus organic.

1.3 Review

1 What is the scientific method based on?

A observation

B subjective decisions

C manipulation of results

D generalisations

Answer: A

2 Name the key components of the scientific method.

Answer: The key components of the scientific method are: careful observation, making a hypothesis, and conducting a carefully designed experiment to test the hypothesis.

3 Scientists make observations from which a hypothesis is stated and this is then experimentally tested.

a Define 'hypothesis'.

b How are theories and principles different from a hypothesis?

Answers:

a A hypothesis is a statement that can be tested. This involves making a prediction based on previous observations.

b A theory is a hypothesis that is supported by a great deal of evidence from a wide variety of sources. A principle is a theory that is so strongly supported by evidence that it is unlikely to be shown to be untrue in the future.

4 **a** What do 'objective' and 'subjective' mean?

b Why must experiments be carried out objectively?

Answers:

a 'Objective' means that there is no personal bias involved in the observation or experiment. An objective observation can be quantified in some way; for example, by a measurement that can be repeated by other people. 'Subjective' means that personal bias could influence the observation or experiment.

b Experiments must be objective so that the results are not biased by the experimenter. Objective experiments can be repeated exactly by other researchers who want to check the results and conclusions.

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5 Which of the following is an important part of conducting an experiment?

A disregarding results which do not fit the hypothesis

B making sure the experiment can be repeated by others

C producing results that are identical to each other

D changing the results to match the hypothesis

Answer: B

6 **a** Explain what is meant by the term 'controlled experiment'.

b Using an example, distinguish between independent and dependent variables.

Answers:

a In a controlled experiment, two groups of subjects are tested; the groups, or the tests performed on them, are identical except for a single factor (the variable).

b The dependent variable is the variable that is measured to determine the effect of changes in the independent variable. The independent (experimental) variable is the variable that is changed in an experiment. For example, in an experiment testing the effect of soil pH on flower colour, the independent variable would be soil pH and the dependent variable would be flower colour.

7 A scientist carries out a set of experiments, analyses the results and publishes them in a scientific journal. Other scientists in different laboratories repeat the experiment, but do not get the same results as the original scientist. Suggest several reasons that could explain this.

Answer: There could be many reasons why the same experimental results cannot be obtained. The experimental design may be poor because of:

- a lack of objectivity
- a lack of clear and simple instructions
- a lack of appropriate equipment
- a failure to control variables.

Other problems not specifically related to the experiment could be:

- a poor hypothesis that could not be tested objectively
- conclusions that do not agree with the results
- interpretations that are subjective.

8 Design an experiment to test whether temperature is an important factor in the distribution of a mollusc species on a rocky coast. Clearly state the hypothesis that your experiment will test. Explain the methods that you would use. Do not forget to include experimental controls.

Answer: There are many possible answers to this question. The following points should be considered:

- Is the hypothesis simple and testable?
- Is the proposed method simple and clearly documented so that it can be repeated?
- Are all variables controlled except the one being investigated?

You should also have considered whether to design a field experiment (on a rocky coast), where the control of variables would be difficult, or a laboratory experiment, in which case extrapolating the results to the rocky coast may be difficult.

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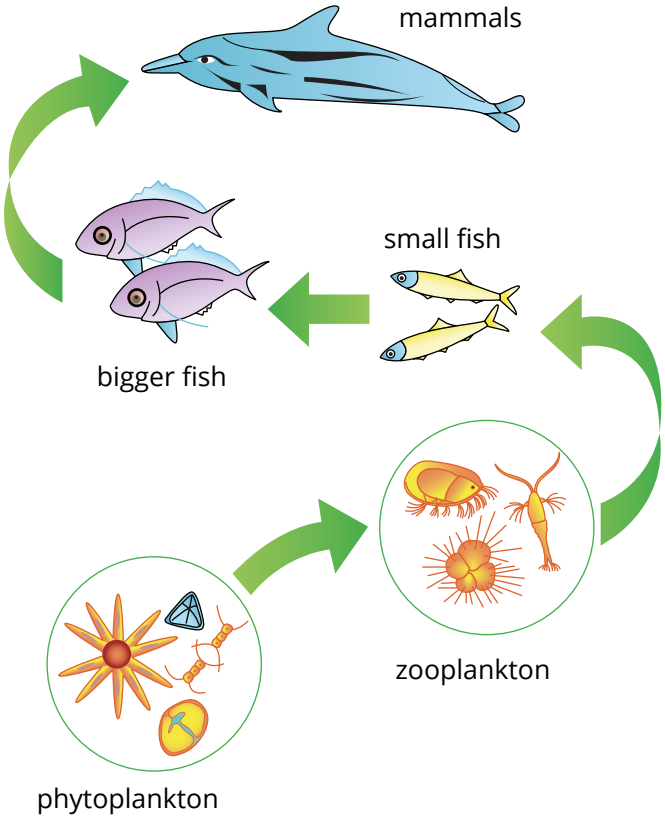
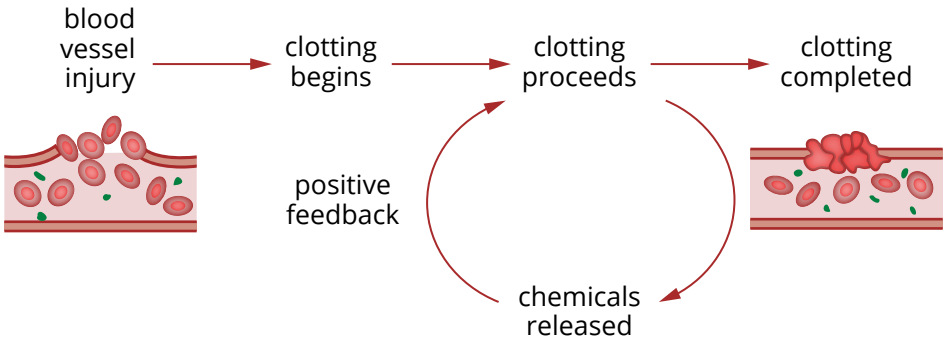
9 Explain what is represented by the visual model below.



Answer: The model represents a food chain in which phytoplankton are producers and the other organisms are consumers.

10 Discuss the benefits and limitations of using the feedback loop model shown below.



Answer: This model clearly represents the process that the body goes through to clot a wound. However, a feedback loop is a complicated process within the body and this model only represents it in the most simplistic form. It does not take into account the severity of the wound, the age or health of the individual or any underlying conditions.

11 Explain the benefits of using a torso model to learn about the parts and relative positions of the organs in the human body.

Answer: Advantages of using the torso model include the following:

- The torso contains all of the major organs of the human body in their relative positions.
- The organs can be easily seen without harm or invasive procedures.
- Organs are the correct size and colour.
- Organs can be removed, examined and put back to help with learning.

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12 Explain two limitations of using models. Include an example.

Answer: Any two of the following points would be a suitable answer:

- Models are never exactly like the real object, they are a representation of reality.
- Models often simplify a concept and this can lead to confusion.
- Models rely on our current understanding of concepts, which may be wrong.

13 Discuss how computer modeling could assist in representing and learning scientific concepts.

Answer: Computer modelling can create more detailed and realistic representations of biological processes.

1.4 Review

1 Write each of the five numbered inferences below as an, 'if ... then ...' hypothesis that could be tested in an experiment.

a This grass receives the rain runoff from the path when it rains.

b The concrete path insulates the grass roots from the heat and cold.

c People do not walk on this part of the grass.

d The soil under the path remains moist while the other soil dries out.

e More earthworms live under the path than under the open grass.

Answers:

a If grass receives water runoff from a path, then the grass will grow taller.

b If the grass roots are cooler, then the grass will grow taller.

c If people do not walk on the grass at the edge of a path, then the grass will grow taller.

d If the soil is moist, then the grass will grow taller.

e If there are many earthworms in the soil, then the nutrients in the soil will increase, resulting in taller grass.

2 Write a hypothesis for each of the following purposes:

a to test whether carrot seeds or tomato seeds germinate quicker

b to test whether sourdough, multigrain or white bread goes mouldy the quickest

c to test whether Trigg the dog likes dry food or fresh food better

Answers:

a If carrot seeds and tomato seeds are planted at the same time, then carrot seeds will germinate quicker (this could also be the other way around).

b If sourdough bread, multigrain bread and white bread are all placed in a moist plastic bag, then multigrain bread will go mouldy the quickest.

c If Trigg is given a choice of dry food or fresh food, then he will eat the fresh food first (this could also be the other way around).

3 Select the best hypothesis, and explain why the other options are not good hypotheses.

A if light and temperature increase, the rate of photosynthesis increases

B transpiration is affected by temperature

C light is related to the rate of photosynthesis

D multigrain bread gets mouldy faster than white bread

Answer: D

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A hypothesis should test only one independent variable and predict the relationship between the independent and dependent variable. Option 'A' has two independent variables, and options 'B' and 'C' do not predict the type of relationship between the independent and dependent variable.

4 **a** State the meaning of the term 'variable'.

b Copy and complete the table below with definitions of the types of variables.

Independent variable	Controlled variables	Dependent variable

Answers:

a Variables are the factors that change during an experiment and which can influence results.

b

Independent variable	Controlled variables	Dependent variable
The experimental variable—the factor that is being changed.	Factors that you want to keep the same for every trial to ensure a fair test.	The factor that you are measuring to get results; it is dependent on your independent variable.

5 Identify the independent, dependent and controlled variables that would be needed to investigate each of the following hypotheses:

a Hypothesis: An increase in temperature will lead to an increase in the rate of transpiration in plants.

b Hypothesis: If there is no light, there will be no photosynthesis in the leaves of a plant.

c Hypothesis: If a cup of hot chocolate has a lid on it, then it will stay hot for a longer period of time.

d Hypothesis: Because thin candles have less wax to burn, they will burn faster than thick candles.

Answers:

a independent variable: temperature

dependent variable: rate of transpiration

controlled variables: include humidity, type of plant used, type of soil or nutrients, air composition

b independent variable: the presence/absence of light

dependent variable: the presence/absence of photosynthesis

controlled variables: include temperature, humidity, type of plant used, type of soil or nutrients, air composition

c independent variable: lid or no lid on the hot chocolate

dependent variable: temperature of the hot chocolate

controlled variables: amount of chocolate in the drink, volume of the drink, starting temperature of the drink, cup size and material

d independent variable: diameter (thickness) of the candle

dependent variable: time taken for the candle to burn

controlled variables: type of wax in candle, type/material of wick, room temperature candles burnt in, length of wick

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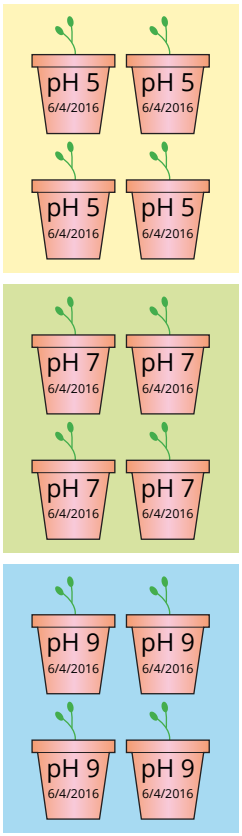
6 Consider the seedling growth investigation below.

Purpose
To investigate the effect of pH on seedling growth.

Hypothesis
If the soil pH is increased, then seedling growth will increase.

Procedure

1 Germinate twenty pea seeds on damp cotton wool and choose twelve with a height of about 12 mm.
2 Plant a seedling in each of twelve pots of the same size. For each pot, use 80 g of quality potting mix, and water with 10 mL of tap water. Safety note: ensure that gloves and a mask are worn when handling potting mix, as it may contain harmful microbes.
3 Label each pot with the pH treatment the soil will receive: four pots at pH 5, four pots at pH 7 and four pots at pH 9.
4 Weigh each pot to the nearest 0.1 g. Draw up a data table and record the results for each pot in the column for day 0.
5 Reweigh the seedlings in their pots 2 days later. Record the results for each pot in the column for day 2.
6 Immediately after weighing, give each plant 10 mL of water at the appropriate pH according to the label on the pot.
7 Repeat steps 5 and 6 every 2 days for the next 10 days.
8 Keep plants in the same position where light is available to maintain lighting conditions.
9 Repeat steps 1–8 twice to reduce the chance of variability between trials.



a State the independent variable for the experiment.

b State the dependent variable for the experiment.

c List the controlled variables stated in the procedure.

d Explain the importance of controlling all variables except the dependent variable.

Answers:

a The independent variable is the pH of the soil.

b The dependent variable is the mass of the germinating seedlings.

c The controlled variables are the type of seeds, initial height of seedlings, size of pots, type and amount of potting mix, amount of water, and position of pots.

d This ensures that the results gathered are due to the effect of the independent variable on the dependent variable and not some other factor. This is also called fair testing.

7 Decide whether each of the following is a primary or a secondary source.

a a newspaper article about global warming

b an experiment to investigate chemical changes when mixing combinations of chemicals

c an interview with a forensic scientist about using science in tracking of criminals

d a website with information about genetic engineering

Answers:

a secondary source

b primary source

c primary source

d secondary source (but could be a primary source if the site includes original research articles or images)

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8 You are learning about genetically inherited diseases and are searching for facts about cystic fibrosis. From the list below, which would be the best resource to use? Explain your answer.

A the book *Cystic Fibrosis*, published in 1997

B the article 'Living with cystic fibrosis' published in the *Daily Mail* on 23 February 2008

C the website www.cysticfibrosis.org.au, accessed on 30 October 2015

Answer: C

The best resource is the website www.cysticfibrosis.org.au because it is recent information and the site is run by the Australian Cystic Fibrosis Organisation, so is reliable. The book *Cystic Fibrosis* is too old, as it was written in 1997. Since that date there have been medical advances in the treatment of this disease. The article 'Living with cystic fibrosis' might be useful, but its target audience appears to be the general public. The information might therefore be simplified and not detailed enough for your requirements.

9 **a** Complete the following table.

Ocular lens	Objective lens	Total magnification	Field of view (µm)
10×	4×		
	10×		
	40×		
	100× (oil)		

b Which magnification and field of view would be best for viewing:

i protists about 20 µm long?

ii yeast cells about 7µm in size?

Answers:

a

Ocular lens	Objective lens	Total magnification	Field of view (µm)
10×	4×	40×	4.5 mm
10×	10×	100×	1.5 mm
10×	40×	400×	450 µm
10×	100× (oil)	1000×	150 µm

b **i** Magnification: 1000× Field of view: 150 µm

ii Magnification: 1000× Field of view: 150 µm

10 Convert 2.5 mm (millimetres) into µm (micrometres).

Answer: 2500 µm

11 What is the difference between a quadrat and a transect?

Answer: A quadrat is an area of a particular shape and size that is used to sample an ecosystem. A transect is a straight line along which an ecosystem is sampled.

12 Why is it important for quadrats to be located randomly across the area being studied?

Answer: To ensure the population estimate is a true reflection of the whole area.

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13 Describe a sampling technique that would be suitable for each of the following investigations:

a the changes in a coastal community over sand dunes

b the number of turtles in a pond population

c the number of clover plants in a lawn

Answers:

a transect sampling

b mark and recapture

c quadrat sampling or point sampling

14 What three things (the 3Rs rule) should be considered in the care and use of animals in schools?

Answer:

The three things that should be considered are:

- replacement of the use of animals with other methods
- reduction in the number of animals used
- refinement of techniques to reduce the impact on animals.

15 Explain the difference between ingestion, inhalation and absorption.

Answer: Ingestion is eating something, or taking it into your body through your mouth. Inhalation is breathing something in, or taking it into your body though your nose or lungs. Absorption is where chemicals soak through the skin and enter the bloodstream.

16 Explain the reasons for having MSDS for the chemicals used in the laboratory.

Answer: An MSDS contains important safety and first aid information for teachers and students about chemicals. It provides the information that employers, workers and emergency crews need to safely manage the risk of hazardous substance exposure.

17 If you spilled a chemical substance with the following label on yourself, what would be the appropriate thing to do?

Answer: Immediately inform your teacher, remove your lab coat and any clothing, and thoroughly wash any skin the substance has come into contact with. If it is a large spill covering lots of your body, you will need to use the safety shower.

1.5 Review

1 What is the difference between raw and processed data?

Answer: Raw data is the data you collect in your logbook when you conduct your research; it is direct measurements that have not been changed in any way. Processed data is raw data that has been mathematically manipulated. For example, if you measured the amount of a substance then that is raw data, but if you wanted to determine the rate by dividing that the amount of a substance by a certain time interval, your results would be processed data.

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2 What is the difference between quantitative and qualitative data?

Answer: Quantitative data relates to numeric variables that can be counted or measured (quantified) and recorded with units (e.g. centimetres, grams, kilometres, seconds). Qualitative data relates to categorical variables and can be counted or described but not measured (e.g. dog breed, plant genus or taste of fruit). Observations of categorical variables can be recorded as descriptions or images.

3 Identify which of the following pieces of information about a cup of coffee are qualitative, and which are quantitative. Place a tick in the appropriate column.

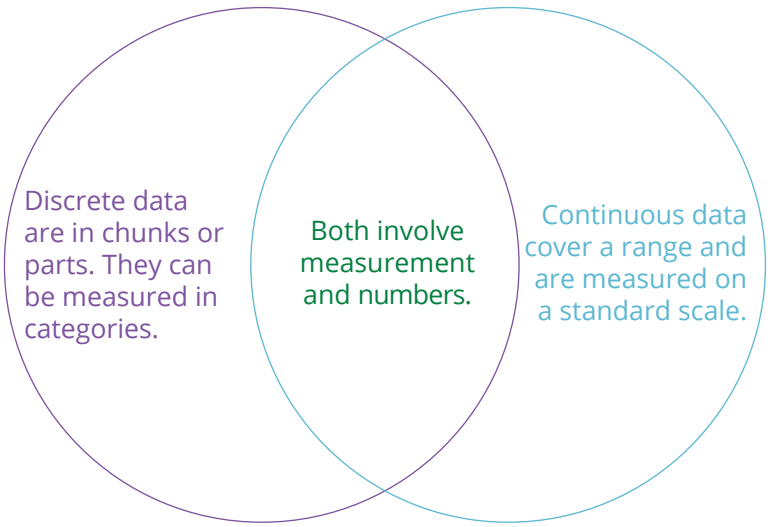
Information	Qualitative	Quantitative
cost $3.95		
robust aroma		
coffee temperature 82 °C		
cup height 9 cm		
frothy appearance		
volume 180 mL		
strong taste		
white cup		

Answer:

Information	Qualitative	Quantitative
cost $3.95		✓
robust aroma	✓	
coffee temperature 82 °C		✓
cup height 9 cm		✓
frothy appearance	✓	
volume 180 mL		✓
strong taste	✓	
white cup	✓	

4 Using a Venn diagram, present the differences and similarities between discrete and continuous data.

Answer:



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5 Both sets of data below contain errors. Identify which set is more likely to contain systematic error and which is more likely to contain random error.

Data set A: 11.4, 10.9, 11.8, 10.6, 1.5, 11.1

Data set B: 25, 27, 22, 26, 28, 23, 25, 27

Answer:

Data set A: random error, because there is one unexpected mistake (1.5) in the data.

Data set B: systematic error, because the error is not obvious and may be due to a consistent equipment or operator error.

6 What type of error is associated with:

a inaccurate measurements?

b imprecise measurements?

Answers:

a systematic errors

b random errors

7 Describe the difference between repeat trials and replication.

Answer: Repeat trials involve collecting of multiple data sets by performing the experiment again after the initial data set has been collected. Replication is the creation of duplicate sets of the experiment, run at the same time.

8 Explain why repeat trials and replication are necessary.

Answer: In any investigation it is important to obtain the most accurate results possible. The reliability of results can be increased through repeat trials or replication of the experiment.

9 Consider the following experiment.

Hypothesis

If seedlings are watered with mineral water, then they will grow more leaves than seedlings watered with tap water.

Experiment

Set up two identical trays of seedlings. They should have the same type of plant, age of plant, type of potting mix, drainage and amount of sunlight and water. Everything should be the same except the type of water given to the plants.

Variables

Anything that could be different in the experiments must be kept the same. This includes everything listed above and even the height of the plants, the depth of potting mix and the intensity of the sunlight. These variables are kept the same—they are the controlled variables.

Only one variable is changed—the type of water. It is the effect of this variable that we are measuring. It is the independent variable. Its measurement should be **objective** (be able to be measured **quantitatively**).

The independent variable—the type of water—may change the number of leaves. The number of leaves is the dependent variable. The number of leaves depends on the type of water.

Results

Measure or count the number of leaves on each plant. This will give you objective results. Your friends could replicate the experiment at their houses. When you and your peers have repeated the experiment many times on different plants, the results can become a **generalisation**.

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a What is the sample size?

b Identify the controlled variables.

c Identify the independent and dependent variables.

d Will the results be objective or subjective? Explain.

e Will the results be valid for all plants? Explain.

Answers:

a The sample size is the number of seedlings in the trays.

b The controlled variables are the type of plant, age of plant, soil, drainage, sunlight, water, height of plants, depth of potting mix and intensity of sunlight.

c The independent variable is the type of water (mineral water or tap water). The dependent variable is the number of leaves.

d The results will be objective, because they involve counting.

e No. The results will be valid only for the specific type of plant seeds that were used in the experiment.

1.6 Review

1 State the median of the following data: 21, 28, 19, 19, 25, 24, 20

Answer: 21 (The median is the middle number when the numbers are placed in order.)

2 State the mode of the following data: 21, 28, 19, 19, 25, 24

Answer: 19 (The mode is the value that occurs most often.)

3 State the average and uncertainty for the following data: 21, 28, 19, 19, 25, 24

Answer: The average is 22. (It is the sum of all the values divided by the number of values.)
The uncertainty is 4.5. (It is difference between the highest and lowest values divided by 2.)

4 Using the student results below, draw an appropriate table and graph.

	Mining temperatures			
Mine A				
Depth	Surface	300 m	700 m	1.0 km
Temperature	15 °C	28 °C	49 °C	62 °C
Mine B				
Depth	Surface	600 m	1.5 km	3.5 km
Temperature	20 °C	25 °C	37 °C	55 °C

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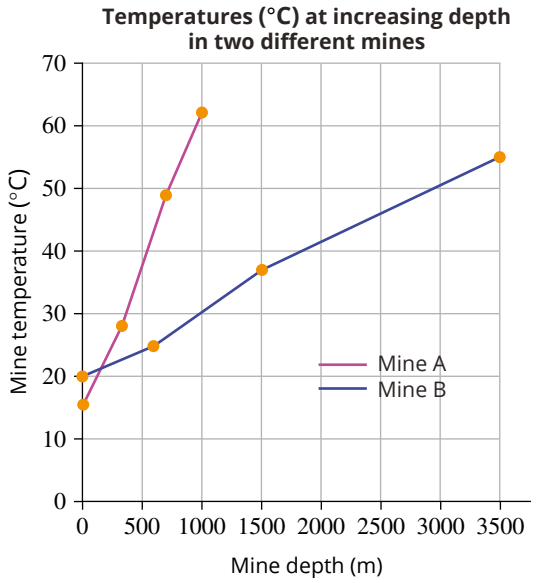
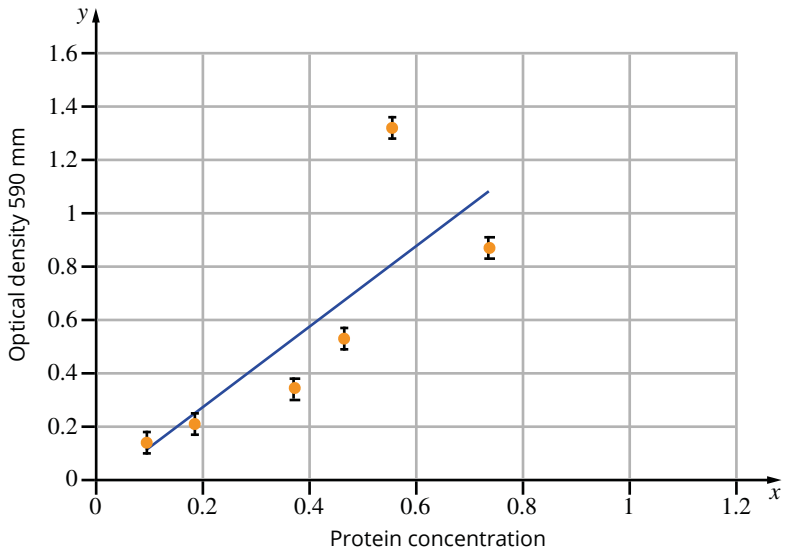
Answer:

The independent variable is depth, so that is measured on the *x*-axis. The dependent variable is temperature, so that is measured on the *y*-axis. 'Surface' means the depth is 0 m. Choose suitable maximum and minimum values for each axis, and a different colour or line style for each set of data.



5 Describe at least four ways the graph below could be improved.



Answer: Add a title. Add units to the *x*-axis. End the *x*-axis units at 0.8 or 1. Exclude the obvious outlier when adding the line of best fit. Remove the labels *x* and *y* on the axes, because they are not required.

6 Distinguish between the times when a line of best fit graph should be used and the times when a ruled graph line from point to point is more appropriate.

Answer: A line of best fit should be used if there seems to be a mathematical relationship between the variables. A ruled line from point to point is more appropriate if there is no obvious trend in the data.

7 What are outliers, and what is the statistical measurement most affected by them?

Answer: Outliers are data points that do not fit with the overall trend of the data and are clearly errors. The statistical measurement most affected by outliers is the mean.

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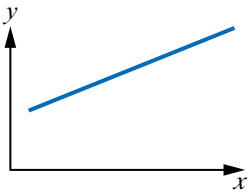
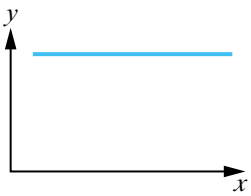
1.7 Review

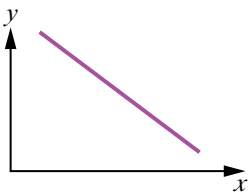
1 **a** Which of the graphs below shows that the rate of transpiration increases as temperature increases?

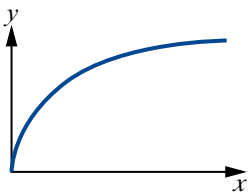
b Which of the graphs below describes the following observation?

You are growing yeast in a low concentration of glucose, and observe that the yeast cells multiply exponentially, then slow down. You interpret this to mean that the energy source has become depleted.

A 

B 

C 

D 

Answers:

a A

b D

2 A scientist designed and conducted an experiment to test the following hypothesis:
An increased consumption of fast food causes a decrease in the function of the liver.

a The discussion section of the scientist's report included comments on the accuracy, precision, reliability, and validity of the investigation. Read each of the following statements and determine whether they relate to precision, reliability or validity.

i Only teenage boys were tested.

ii Six boys were tested.

b The scientist then conducted the fast food study with 50 people in the experimental group and 50 people in the control group. In the experimental group, all 50 people gained weight. The scientist concluded all the subjects gained weight as a result of the experiment. Is this conclusion valid? Explain why or why not.

c What recommendations would you make to the scientist to improve the investigation.

Answers:

a **i** validity

ii reliability

b The conclusion is not valid because it does not relate to the original hypothesis, which was about liver function, not weight. To be valid, the conclusion must state that there is a relationship (or there is no relationship) between eating fast food and a decrease in liver function.

c To improve the validity of the experiment, the hypothesis should be changed to specify the group that is being studied, i.e. teenage boys. A larger sample size should be used to improve reliability. The group must be divided into an experimental group and control group. The experimental group should only eat fast food and the control group should eat a normal diet. To improve the accuracy of results all measurements should be performed using the same calibrated equipment. Using different equipment can also assist in eliminating systematic errors. Repeat readings of the liver function test should be performed on each sample and the average calculated to minimise the effects of random errors.

 ISBN 978 1 4886 1122 3

Chapter 2 Questions and answers

2.1 Review

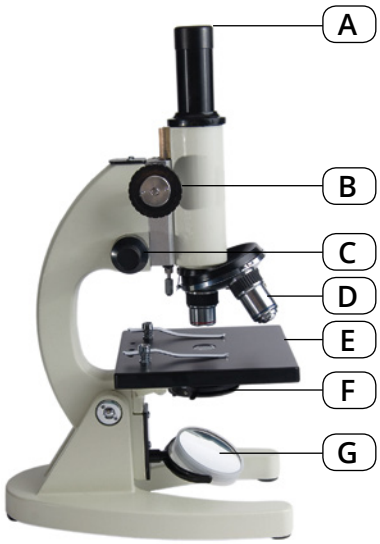
1 State the cell theory.

Answer: Cell theory states that all organisms are composed of cells, that all cells come from pre-existing cells, and that the cell is the smallest structural unit.

2 Describe the main differences between prokaryotic and eukaryotic cells.

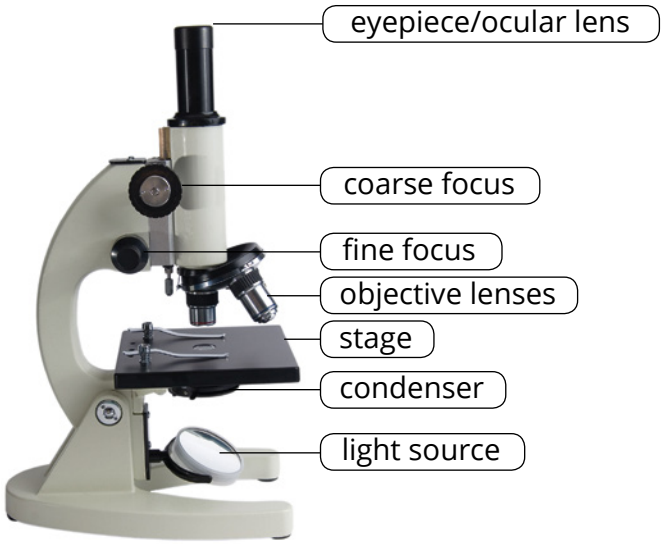
Answer: Prokaryotes are smaller and their genetic material is contained in a nucleoid, which has no membrane. Eukaryotes are larger and their genetic material is contained in a membrane-bound nucleus. Eukaryotes also have membrane-bound organelles, which prokaryotes lack.

3 Identify the parts of the light microscope labelled A–G in the diagram.



Source: © Kirill Kurashov/123rf

Answer:



Source: © Kirill Kurashov/123rf

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4 What is the main difference between light microscopy and electron microscopy?

Answer: Light microscopy uses light to visualise specimens, whereas electron microscopy uses an electron beam. This is why electron microscopy produces images a thousand times more detailed than light microscopy. An electron microscope also has better resolution than a light microscope. This means that an electron microscope can give a clear image of very small structures that cannot be distinguished by a light microscope.

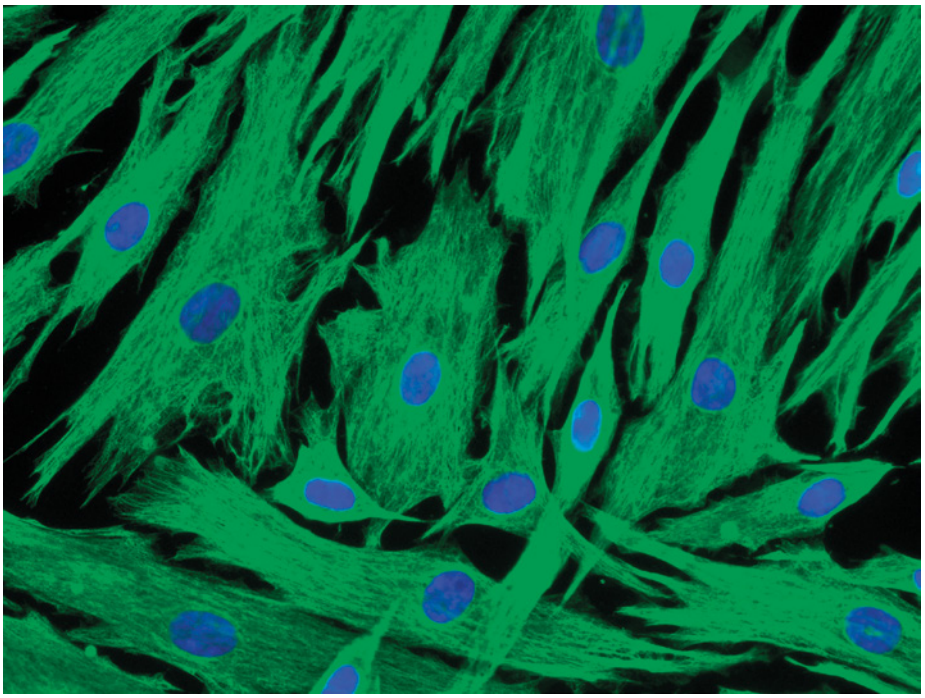
5 What is the difference between transmission electron microscopy and scanning electron microscopy?

Answer: Transmission electron microscopy passes an electron beam through the sample. In scanning electron microscopy the electron beam bounces off the sample instead of passing through it, because the sample is coated with gold. This provides a three-dimensional image of the object's surface.

6 How might fluorescence microscopy be used to visualise the bacterial capsule?

Answer: Fluorescent dyes linked to antibodies specific to the bacterial capsule can be used to tag and visualise the capsule by fluorescence microscopy.

7 The figure below shows an image of hair follicle cells. Which type of microscope was used to take the image? Explain your answer.



Source: © Daniel Schroen, Cell Applications Inc./Science Photo Library

Answer: A fluorescence microscope was used. From the image, it can be seen that fluorescent markers were used to highlight the cell nuclei (in blue).

8 What advantages in structural biology are gained by a synchrotron?

Answer: The synchrotron allows matter to be studied with greater accuracy and precision than has ever been possible, down to the atomic scale. It enables information on the behaviour of proteins to be obtained in a much shorter time compare to previous methods.

9 What advances have been made in science with the help of synchrotron technology?

Answer: Complex protein structures have been determined (e.g. antibodies) and also the technology is central to drug design and development. Tissue samples have been analysed to identify disease.

 ISBN 978 1 4886 1122 3

2.2 Review

1 What function is shared by mitochondria and chloroplasts?

Answer: Energy transformation

2 Which one of the following options lists only membrane-bound organelles?

A nuclei, mitochondria, vacuoles, ribosomes

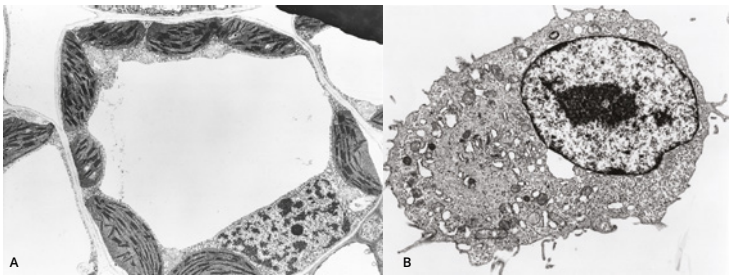
B nuclei, mitochondria, centrioles, ribosomes

C nuclei, mitochondria, vacuoles, chloroplasts

D nuclei, mitochondria, vacuoles, cell walls

Answer: C

3 Which of the images in the following figure is a plant cell? Explain your answer.

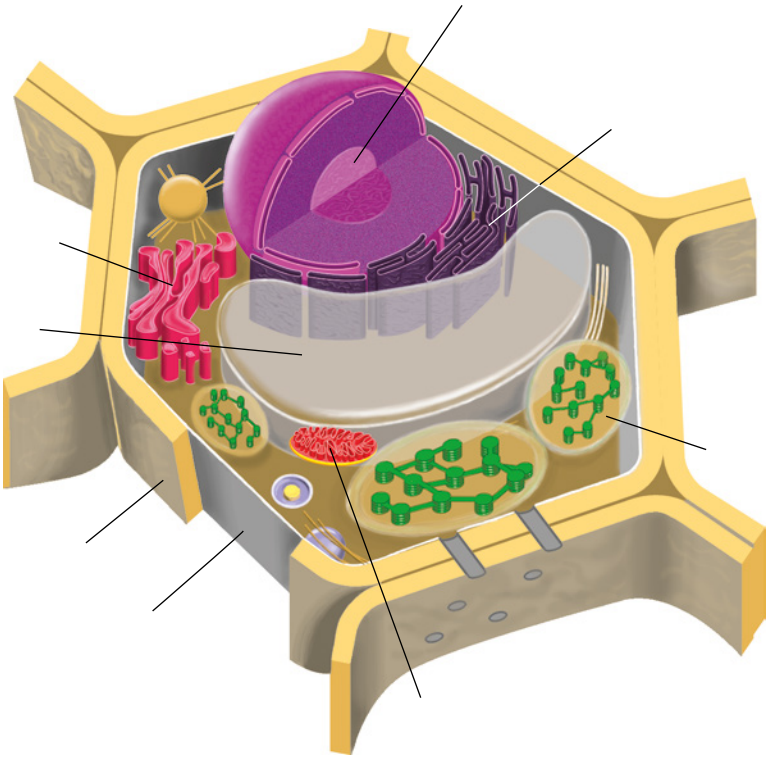


Source: © Biophoto Associates/Getty Images (A)

Source: © Dr. Gopal Murti/Science Photo Library (B)

Answer: Cell A is a plant cell because it has a single large vacuole alongside chloroplasts and a clearly defined cell wall. Animal cells do not have chloroplasts or cell walls.

4 Label the parts of the plant cell in the following diagram.



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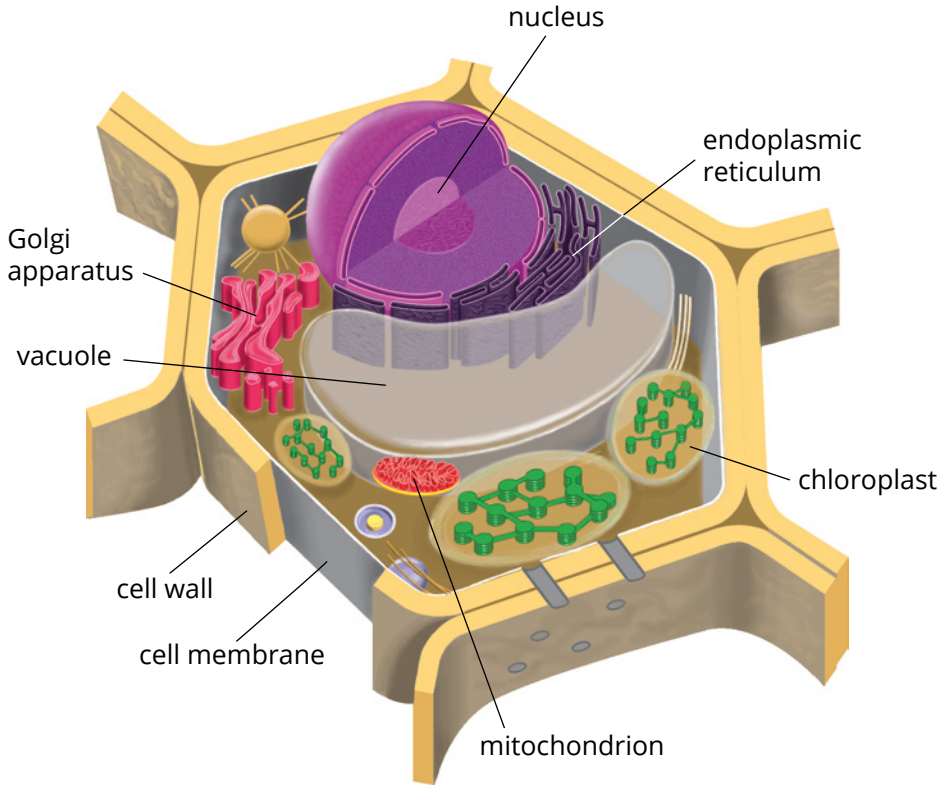
Answer:



5 List the main differences between plant and animal cells.

Answer: Plant cells have a cell wall made from cellulose outside the plasma membrane, whereas animal cells do not have cell walls. Plant cells have a large, permanent vacuole, whereas animal cells have several small, temporary vacuoles. Plant cells contain chloroplasts for performing photosynthesis, whereas animal cells do not posses chloroplasts or perform photosynthesis.

2.3 Review

1 List three functions of the plasma membrane.

Answer: Any three of the following:

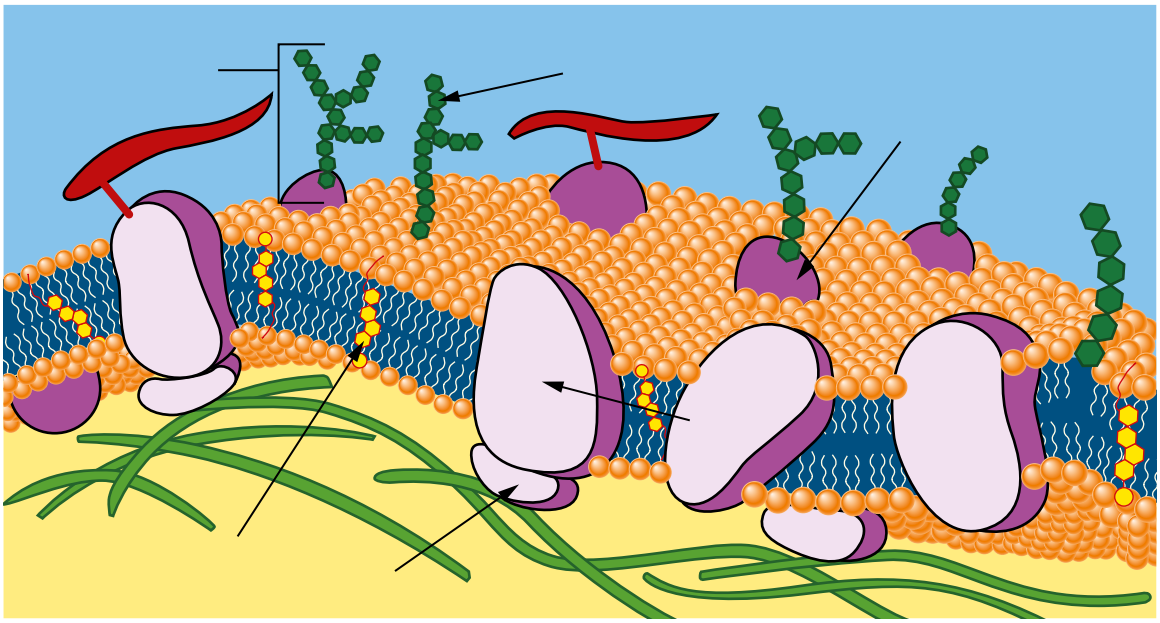
- separate the internal and external environments of the cell
- control the movement of substances into and out of the cell
- absorb nutrients from the extracellular fluid
- secrete wastes into the extracellular fluid
- cell recognition
- communicate with the external environment and other cells
- binding with other cells.

2 Membrane-bound proteins may have carbohydrates attached. What are these proteins and what is their function?

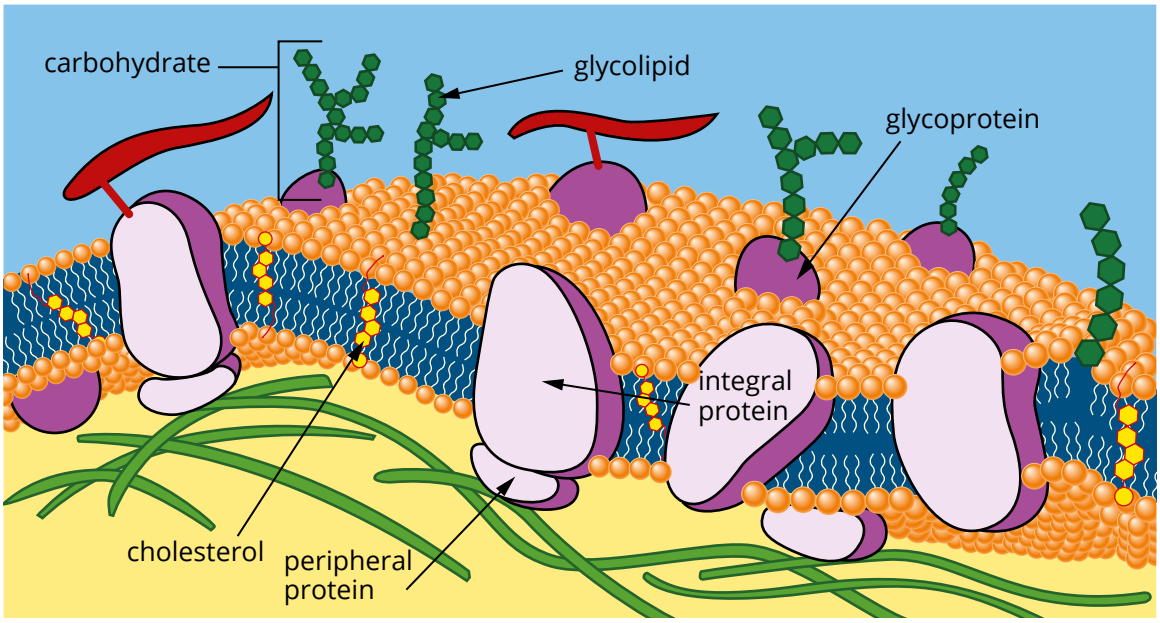
Answer: Carbohydrates attached to protruding proteins on the plasma membrane form glycoproteins. They play a role in the recognition process that occurs between cells and antibodies, hormones, bacteria and viruses.

 ISBN 978 1 4886 1122 3

3 Label the key components of the plasma membrane shown in the following diagram.

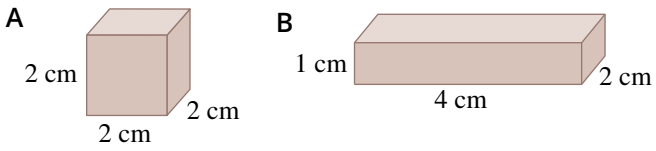


Answer:



4 **a** Explain what is meant by 'surface area to volume ratio'.

b Consider the two objects shown which have the same volume of 8 cm². Which shape has the greatest surface area?



Answers:

a Surface area to volume ratio means the surface area of an object compared to its volume.

b The rectangular prism on the right has the greater surface area:

$2 \times [(4 \times 1) + (4 \times 2) + (2 \times 1)] = 28 \text{ cm}^2$

compared to

$6 \times (2 \times 2) = 24 \text{ cm}^2$

 ISBN 978 1 4886 1122 3

5 With reference to a cell, where is the extracellular fluid found?

Answer: Extracellular fluid is found outside the plasma membrane. The plasma membrane separates the extracellular fluid from the cell contents.

6 **a** What is the main structural component of a plasma membrane, and what other molecules are associated with it?

b What role do (i) proteins and (ii) cholesterol play in the functioning of the membrane?

Answers:

a The two phospholipid layers are the main component. Proteins, carbohydrates and cholesterol are other molecules associated with this component.

b **i** Proteins provide the channels for water-soluble molecules and ions to pass through the membrane. Proteins may also be involved in facilitated diffusion and active transport.

ii Cholesterol molecules provide stability to the membrane without reducing its flexibility.

2.4 Review

1 Complete the following table by stating whether the phospholipid bilayer is permeable, semi-permeable or not permeable to each substance described.

Substance	Examples	Permeability
small uncharged molecule	oxygen, carbon dioxide	
lipid-soluble, non-polar molecule	alcohol, chloroform, steroids	
small, polar molecule	water, urea	
small ion	potassium ion (K^+), sodium ion (Na^+), chloride ion (Cl^-)	
large, polar, water-soluble molecule	amino acid, glucose	

Answer:

Substance	Examples	Permeability
small uncharged molecule	oxygen, carbon dioxide	permeable
lipid-soluble, non-polar molecule	alcohol, chloroform, steroids	permeable
small, polar molecule	water, urea	permeable or semi-permeable
small ion	potassium ion (K^+), sodium ion (Na^+), chloride ion (Cl^-)	not permeable (pass through protein channels)
large, polar, water-soluble molecule	amino acid, glucose	not permeable (pass through protein channels)

2 Describe diffusion and explain the difference between simple and facilitated diffusion. Include an example of each.

Answer: Diffusion is the movement of a substance from an area of high concentration to an area of low concentration. Facilitated diffusion takes place through specific channels in a plasma membrane, and is faster than diffusion. Typical examples for diffusion are small uncharged molecules such as oxygen and carbon dioxide, lipid-soluble non-polar molecules such as alcohol, chloroform and steroids, and some polar molecules such as water and urea. Typical examples for facilitated diffusion are small ions such as potassium, sodium and chloride, amino acids, and glucose.

 ISBN 978 1 4886 1122 3

3 What are the two types of proteins used in facilitated diffusion, and how are they different?

Answer: The two types of proteins used in facilitated diffusion are channel proteins and carrier proteins. Channel proteins do not usually bind the molecules being transported whereas carrier proteins do. Channel proteins resemble pores that open and close to allow the passage of specific molecules, usually water-soluble polar particles like ions. Carrier proteins allow the passage of specific molecules by changing their shape (or conformation) when the molecule binds to the protein. Once the molecule has crossed the membrane, carrier proteins return to their original shape.

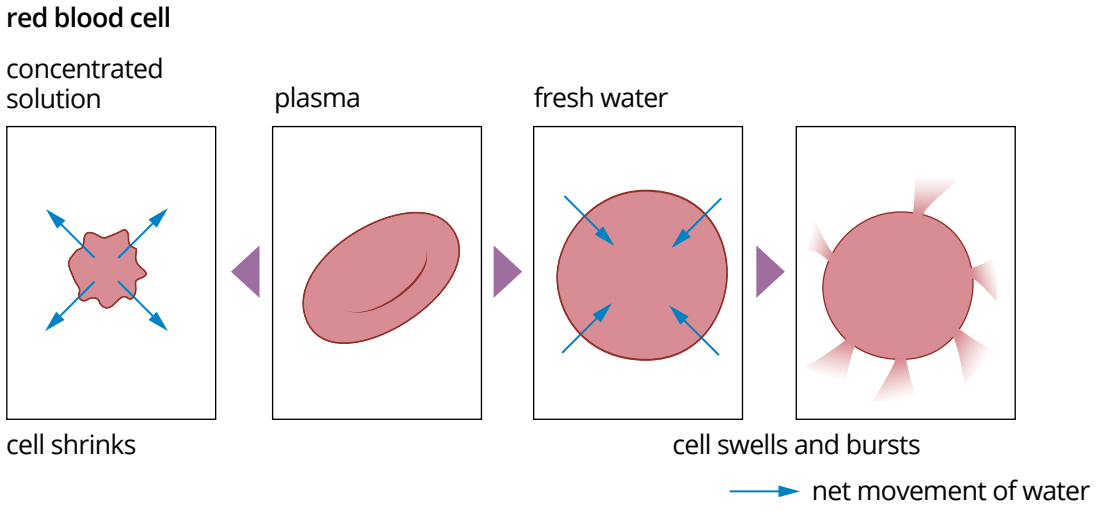
4 What term is used for the net movement of water from a dilute to a concentrated solution down its own concentration gradient?

Answer: The term is osmosis.

5 Define the term 'active transport'. Outline how this process is different from diffusion.

Answer: Active transport is the net movement of molecules against a concentration gradient. It requires an input of energy. Diffusion takes place down a concentration gradient and does not require an input of energy.

6 Consider the images of red blood cells in the following figure. The arrows indicate the direction of net movement of water. Using your understanding of osmosis, explain how red blood cells would (a) shrink, and (b) swell and burst.



Answer: In osmosis the net diffusion of water through a semi-permeable membrane goes from a diluted to a concentrated solution down its own concentration gradient (or osmotic gradient). On one hand, when red blood cells are placed in fresh water they will absorb the water and eventually burst because their cytosol is more concentrated than the water. On the other hand, when red blood cells are placed in a solution that's more concentrated than their cytosol, water will leave the cell and cause it to shrink.

7 For which of the following is energy required?

A diffusion

B facilitated diffusion

C osmosis

D active transport

Answer: D

 ISBN 978 1 4886 1122 3

8 **a** Use all the following terms and phrases to write a definition of diffusion:

area of low concentration, passive, area of high concentration, concentration gradient, particles, process

b Explain why diffusion is called a passive process.

c List the factors that affect the rate of diffusion of different types of substances across membranes.

Answers:

a Diffusion is a passive process in which particles move from an area of high concentration to an area of low concentration along a concentration gradient.

b Diffusion is called a passive process because it does not require an input of energy.

c Factors are the size of the solute molecules, type of solute (lipid soluble, water soluble, insoluble), temperature, and relative concentrations on either side of the membrane.

9 Osmosis is a special kind of diffusion. Write a definition for osmosis. Use a diagram to illustrate your answer.

Answer: Diffusion is the passive movement of molecules along a concentration gradient, from a region of high concentration to a region of low concentration. Osmosis is the net movement of free water molecules through a partially permeable membrane, from a dilute to a more concentrated solution.

Chapter 2 Review

1 Select the statement that accurately describes eukaryotic cells.

A Eukaryotic cells have circular chromosomes and membrane-bound organelles, and some also have cell walls.

B Eukaryotic cells have linear chromosomes but not membrane-bound organelles, and some have cell walls.

C Eukaryotic cells have linear chromosomes and membrane-bound organelles, and some also have cell walls.

D Eukaryotic cells have linear chromosomes and membrane-bound organelles, but not cell walls.

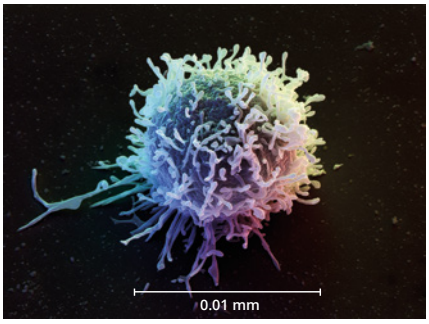
Answer: C

2 The micrometre is the unit used when stating cell sizes. There are 1000 micrometres in a millimetre. Convert 1.6 mm (millimetres) into µm (micrometres).

Answer: 1600 µm

 ISBN 978 1 4886 1122 3

3 Select the answer that is closest to the diameter of the animal cell shown in the following photograph.



Source: © David Scharf/Science Photo Library

A 10 µm

B 100 µm

C 1 µm

D 1000 µm

Answer: A

4 What does cytology study?

A cytosol

B tonoplasts

C cells

D cytoplasm

Answer: C

5 Define cell compartmentalisation, and list three ways that it benefits a cell.

Answer: Compartmentalisation is the formation of specialised compartments within a cell. Membrane-bound organelles are the specialised compartments of eukaryotic cells. The benefits of compartmentalisation include the following:

- It provides optimum conditions for particular reactions involved in specialised functions, made possible by the different environments compartmentalisation creates.
- The separation of chemical processes in different places allows incompatible reactions to occur simultaneously in the same cell.
- It makes eukaryote cells less vulnerable to changes in the external environment, because the contents of the organelles are separated from the extracellular fluid by the cytosol.

6 A cell from an organism has a distinct nucleus, green organelles, and a plasma membrane within a cell wall. In what kingdom is this organism classified?

Answer: It is classified in the plant kingdom (kingdom Plantae).

7 State the difference between endocytosis and exocytosis. Explain what happens to substances as they are transported in each process.

Answer: Exocytosis is the movement of substances out of the cell by transport vesicles. Vesicles fuse with the plasma membrane and the junction breaks down, causing the materials to be released from the cell. Endocytosis is the movement of substances into the cell by them being enclosed by the membrane, which then pinches off to form a vesicle. In eukaryotes, the vesicle can then fuse with a lysosome, which digests its contents. The two types of endocytosis are pinocytosis and phagocytosis. Pinocytosis is the entry of liquid droplets by endocytosis and phagocytosis is the entry of solids by endocytosis.

 ISBN 978 1 4886 1122 3

8 **a** Explain what causes blood cells to burst when a drowning person inhales fresh water.

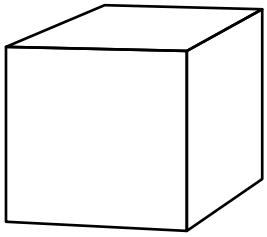
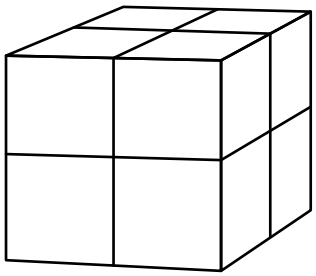
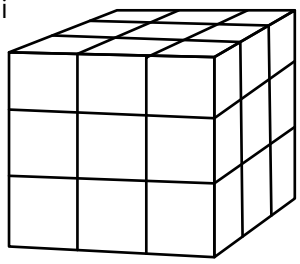
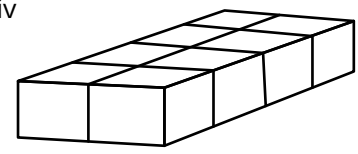
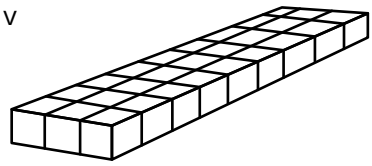
b Explain why a plant does not burst when placed in fresh water.

Answers:

a Fresh water (high free water molecule concentration) in the lungs readily moves into the blood plasma (lower free water molecule concentration) by osmosis. The blood plasma then has a higher free water molecule concentration than the red blood cell, so water will move across the red blood cell membrane by osmosis, causing red blood cells to swell and burst.

b The plant cell membrane is surrounded by a rigid cellulose cell wall. This prevents the membrane from swelling to the point of bursting.

9 **a** Complete the table of surface area to volume (SA : V) ratios. Show your working.

Object	Surface area	Volume	SA : V ratio
i 		1 cm × 1 cm × 1 cm = 1 cm^3	
ii 	4 cm^2 × 6 sides = 24 cm^2		
iii 			
iv 			
v 			

b What happens to the SA : V ratio as objects increase in size, as occurs in examples (i), (ii) and (iii) in the table?

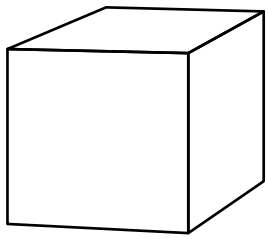
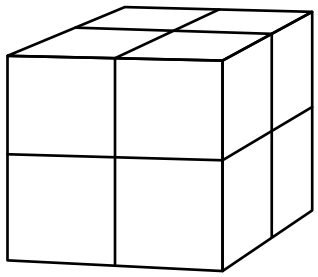
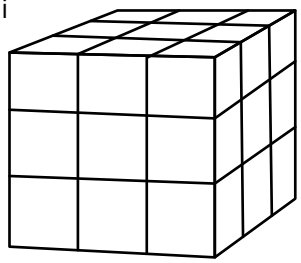
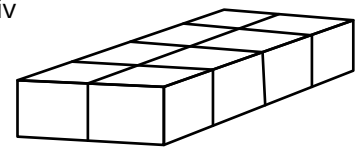
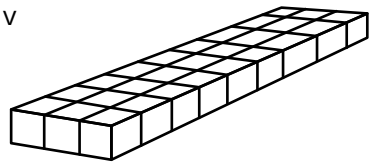
 ISBN 978 1 4886 1122 3

c In the table, objects (ii) and (iv) have the same volume; so do objects (iii) and (v). How does a change in shape affect the SA : V ratio of these objects?

d Explain the significance of the SA : V ratio for organisms and/or exchange organs.

Answers:

a

Object	Surface area	Volume	SA : V ratio
i 	1 cm^2 × 6 sides = 6 cm^2	1 cm × 1 cm × 1 cm = 1 cm^3	6 : 1
ii 	4 cm^2 × 6 sides = 24 cm^2	2 cm × 2 cm × 2 cm = 8 cm^3	24 : 8 = 3 : 1
iii 	9 cm^2 × 6 sides = 54 cm^2	3 cm × 3 cm × 3 cm = 27 cm^3	54 : 27 = 2 : 1
iv 	2 sides × 2 cm × 4 cm + 2 sides × 1 cm × 4 cm + 2 sides × 1 cm × 2 cm = 28 cm^2	1 cm × 2 cm × 4 cm = 8 cm^3	28 : 8 = 3.5 : 1
v 	2 sides × 3 cm × 9 cm + 2 sides × 1 cm × 9 cm + 2 sides × 1 cm × 3 cm = 78 cm^2	1 cm × 3 cm × 9 cm = 27 cm^3	78 : 27 = 2.9 : 1

b As the size of an object increases, its surface area to volume ratio decreases.

c If two objects have the same volume, the flatter of the two will have a greater surface area to volume ratio.

d Heat, nutrients and wastes are exchanged across the surface of organisms. Larger organisms have a lower surface area to volume ratio and are less efficient in exchange than smaller organisms. Larger organisms have exchange organs to assist with the exchange of materials. Exchange organs have high surface area to volume ratios.

 ISBN 978 1 4886 1122 3

10 Root hair cells on the roots of plants use energy to take up some nutrients from the soil, but not others. Describe the circumstances in which energy is expended during nutrient uptake.

Answer: Energy is expended in taking up nutrients that cannot pass through the phospholipid bilayer by diffusion or facilitated diffusion.

11 Give an example of an organism's body shape and surface area to volume ratio that is suited to:

a gaining heat from its environment

b preventing heat loss

c maximising heat loss

Answers:

a A flattened body shape would have a high surface area to volume ratio, and would enable an organism to maximise heat gain when exposed to sunlight.

b A shape in which the width, depth and height are about the same would have a low surface area to volume ratio, and would enable the organism to conserve heat.

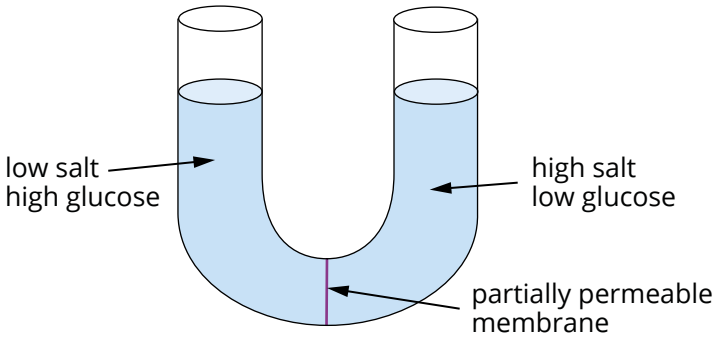
c A flattened body shape would have a high surface area to volume ratio, and would enable an organism to maximise heat loss.

12 Two different solutions with the same volume are placed on either side of a semi-permeable membrane in a U-shaped glass tube, as shown in the following diagram. The membrane is permeable to salt but not glucose. The tube is then left to stand for several days. Explain what you would expect to happen to:

a the salt concentration on each side of the membrane

b the glucose concentration on each side of the membrane

c the fluid levels on each side of the membrane



Answers:

a Because the membrane is permeable to the salt solution, there will be movement of salt ions along the concentration gradient, from the right side to the left side.

b The membrane is not permeable to glucose, so the glucose concentration will not change initially. This will create an osmotic gradient, and water will move across the membrane.

c Because of the movement of salt to the left-hand side, the total solute concentration (glucose and salt) will increase on the left-hand side, and the solvent (water) concentration will decrease in proportion. On the right-hand side, the total solute concentration will decrease, and the solvent concentration will be proportionately higher. Water will therefore move by osmosis across the semi-permeable membrane, from the right-hand side (higher free water molecule concentration), to the left-hand side (lower free water molecule concentration). This means that the fluid level in the left-hand side will go up, and on the right-hand side it will go down. This will change the concentration of glucose on both sides of the tube. Glucose will be more dilute in the left-hand side and more concentrated in the right-hand side than originally, after the flow of water molecules from the right-hand side to the left-hand side.

 ISBN 978 1 4886 1122 3

Chapter 3 Questions and answers

3.1 Review

1 Why are autotrophs also called producers?

Answer: Autotrophs are also called producers because they produce organic matter from inorganic matter. In this way they produce all of the food consumed by consumers in food chains.

2 Phytoplankton are autotrophs.

a Are they photoautotrophs or chemoautotrophs?

b How do they obtain energy?

c What kind of environment do they live in?

Answers:

a Phytoplankton are photoautotrophs.

b They use photosynthesis to obtain energy from sunlight.

c They live in an aquatic (water) environment.

3 Which one of the following is an example of chemosynthesis?

A glucose production by plants

B methane production by methanogens

C carbon dioxide production by organisms

D conversion of nitrites into nitrates by prokaryotes

Answer: B

4 *Euglena* is both a heterotroph and an autotroph. Explain why.

Answer: When it has access to sunlight, *Euglena* is able to photosynthesise, acting as a photoautotroph. When it does not have access to sunlight, *Euglena* is able to gain energy from other organisms, so it acts as a heterotroph.

5 Give an example of how heterotrophs rely both directly and indirectly on autotrophs.

Answer: A squirrel eating a nut from a tree is directly using an autotroph as a food source. However that squirrel might also eat a caterpillar that feeds on the tree's leaves, and therefore as a food source for the squirrel, indirectly depends on the tree.

6 What kind of heterotroph are humans? Explain your answer.

Answer: Humans are omnivores because they are able to eat both plants and other animals.

7 Contrast the way carnivores and saprotrophs obtain their organic compounds, giving an example of each type of organism.

Answer:

Carnivores are animals that feed on other animals. Many examples are possible, e.g. lion, cat, dog, whale, dolphin, tuna, eagle, Tasmanian devil.

Saprotrophs break down dead organic matter into simpler compounds using extracellular enzymes. Various examples are possible, e.g. most fungi (mushrooms), bread mould, many bacteria, and a small number of plants that do not photosynthesise, including some orchids.

 ISBN 978 1 4886 1122 3

3.2 Review

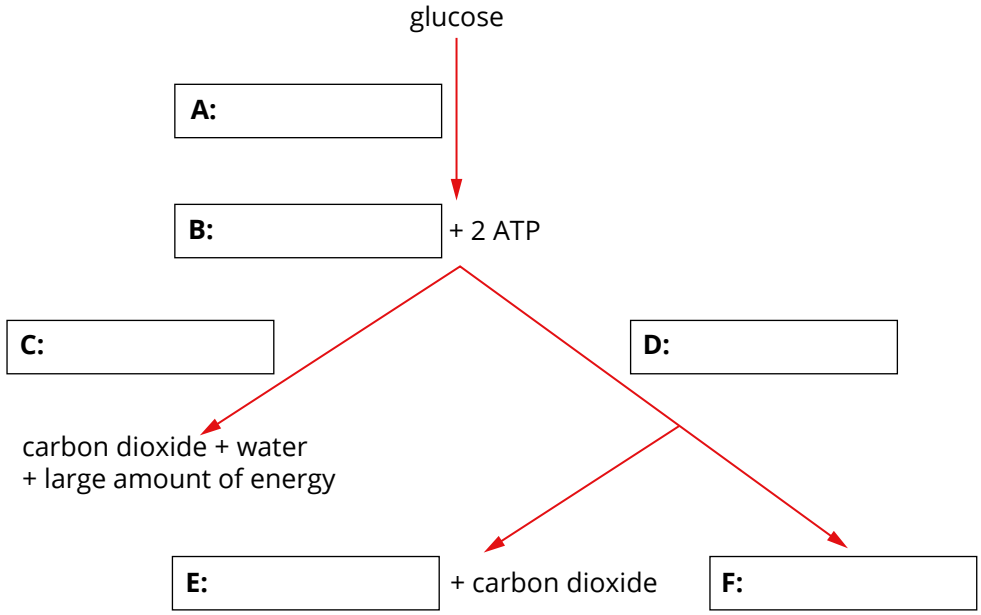
1 What is chemical energy?

Answer: Chemical energy is the energy that is stored in the bonds that join atoms together.

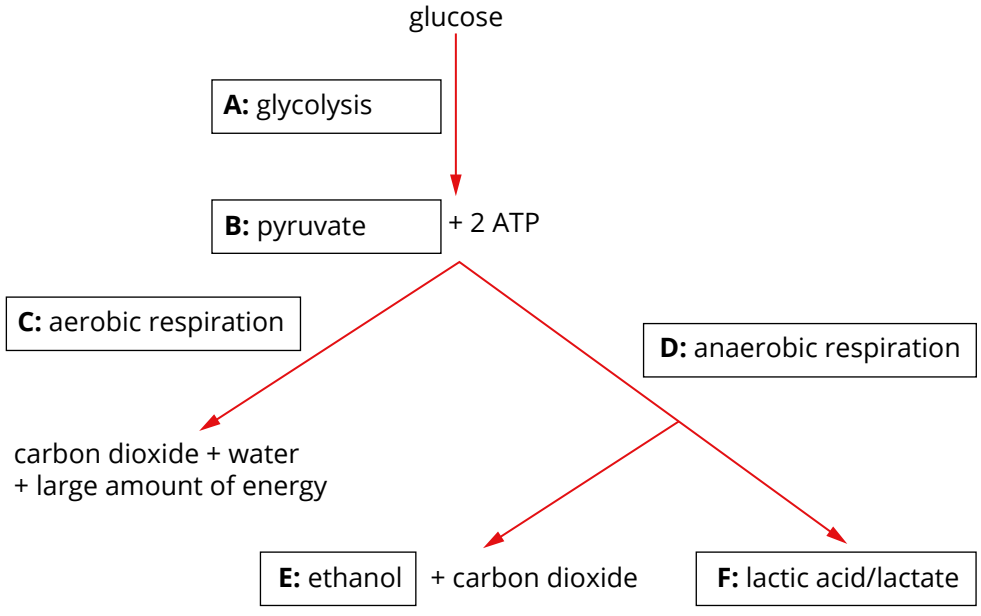
2 In what form is energy available to use in cells?

Answer: It is available in the form of adenosine triphosphate (ATP).

3 The figure below is a summary of the major processes that occur during cellular respiration. Provide the most appropriate labels for A, B, C, D, E and F.



Answer:



4 Define glycolysis and state where it occurs in a eukaryotic cell.

Answer: Glycolysis is the first process involved in cellular respiration and involves splitting glucose into two pyruvate molecules. The energy released is stored in two ATP molecules. Glycolysis occurs in the cytosol.

 ISBN 978 1 4886 1122 3

5 What is the difference between aerobic and anaerobic respiration?

Answer: The key difference between aerobic and anaerobic respiration is that aerobic respiration requires free oxygen and anaerobic respiration does not require free oxygen.

6 What is the major benefit to cells in using aerobic respiration rather than anaerobic respiration?

Answer: Aerobic respiration produces up to 38 molecules of ATP, whereas anaerobic respiration produces only 2 molecules of ATP.

7 Which one of the following describes anaerobic respiration?

A the conversion of pyruvate into ethanol and carbon dioxide in the absence of oxygen

B the conversion of pyruvate into lactic acid in the presence of oxygen

C the production of ethanol and carbon dioxide in the presence of oxygen

D the reaction of yeast and oxygen resulting in lactic acid in the absence of oxygen

Answer: A

8 Some bacteria respire aerobically. Compare the cellular location of bacterial aerobic respiration to that in eukaryotic cells.

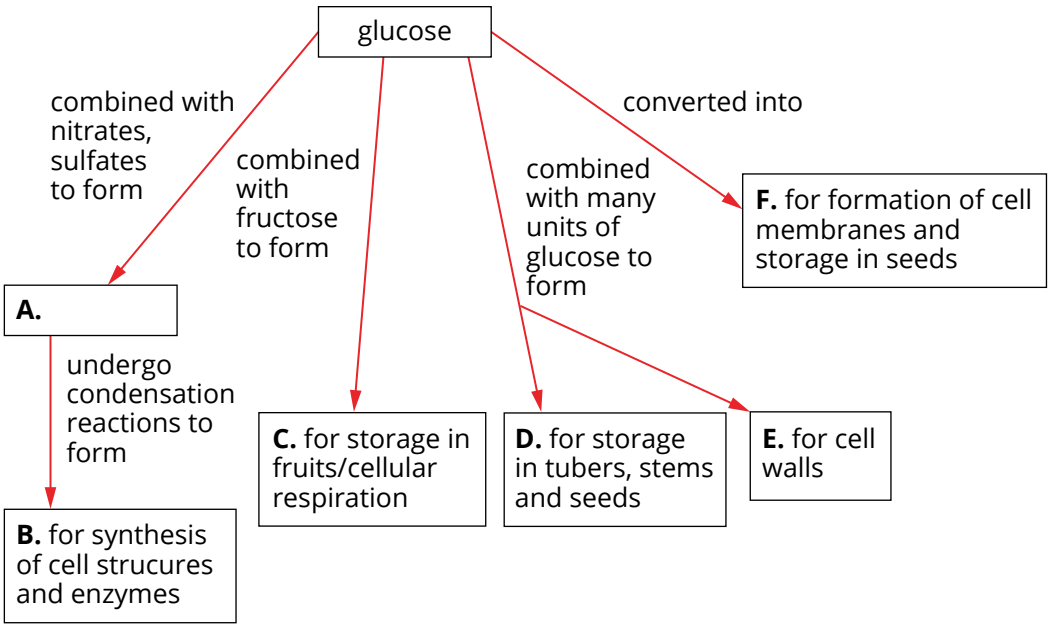
Answer: Unlike eukaryotes, prokaryotes do not contain membrane-bound organelles such as mitochondria. Respiration occurs in the mitochondria in eukaryotes, but in prokaryotes it occurs in the cytosol, with the later stages involving the plasma membrane.

3.3 Review

1 What molecule is broken down using solar energy during photosynthesis?

Answer: The molecule broken down during photosynthesis is water (H_2O).

2 The figure below is a summary of the major processes that occur during photosynthesis. State the correct term for each of letters A, B, C, D, E and F.



Answer: A – amino acids; B – proteins; C – sucrose; D – starch; E – cellulose; F – lipids

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3 State whether each of the following statements is true or false.

a Chlorophyll is a pigment that causes green colouring of leaves.

b Chloroplasts are pigments that absorb light.

c Chlorophyll is located in the thylakoid membranes.

d Chlorophyll absorbs light energy, which is then transformed into chemical energy.

Answers:

a true

b false

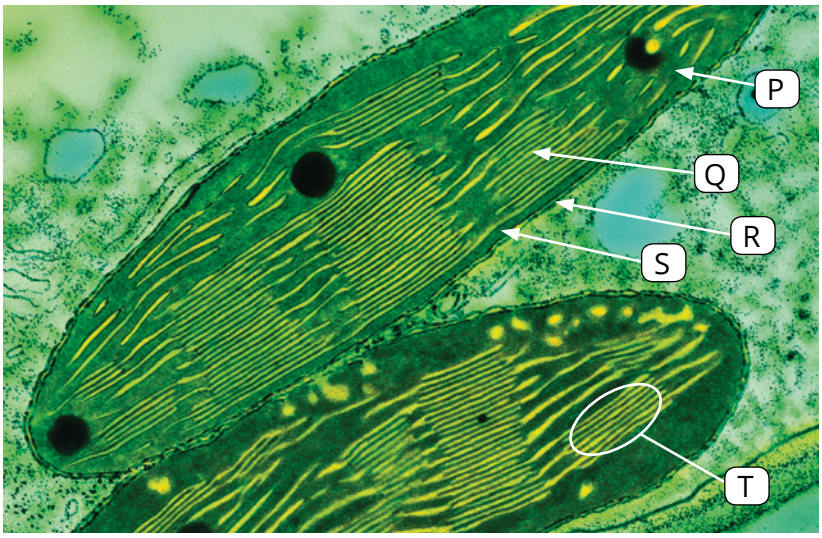
c true

d true

4 How many glucose molecules would be produced if 24 carbon dioxide and 24 water molecules were used in photosynthesis?

Answer: 4 (The overall equation for photosynthesis is $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$). When there are 24 carbon dioxide and 24 water molecules available, every 6 carbon dioxide and 6 water molecules will be used to produce 1 glucose. So 24 ÷ 6 = 4 glucose molecules will be formed.

5 The figure below shows a transmission electron micrograph of a chloroplast. Identify structures P, Q, R, S and T.



Source: © Dr Kari Lounatmaa/Science Photo Library

Answer: P – stroma; Q – thylakoid; R – outer membrane; S – inner membrane; T – granum

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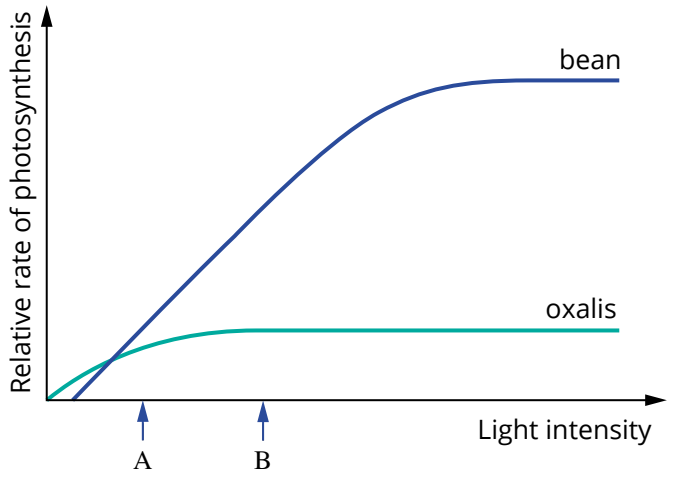
6 The following graph shows the rate of photosynthesis in a bean plant, adapted to high light intensity, and an oxalis plant, adapted to low light intensity.



a What is the limiting factor at point A for each plant?

b What is the limiting factor at point B for each plant?

Answers:

a The limiting factor at point A for both plants is light.

b The limiting factor at point B for the bean plant is light. The limiting factor at point B for the oxalis plant is some other factor, which cannot be identified from the information given.

7 What is the light compensation point, and what happens at this point?

Answer: The light compensation point is the level of light at which the rates of cellular respiration and photosynthesis are equal, so there is no net exchange of oxygen or carbon dioxide. At this point there is no growth.

Chapter 3 Review

1 Distinguish between autotrophs and heterotrophs.

Answer: Autotrophs obtain their organic molecules from simple inorganic substances such as carbon dioxide and nitrates. Heterotrophs obtain organic molecules from other organisms.

2 Contrast photosynthetic autotrophs with chemosynthetic autotrophs.

Answer: Photosynthetic autotrophs fix carbon using solar energy. Chemosynthetic autotrophs fix carbon using energy obtained from inorganic chemical reactions.

3 Chemoautotrophs acquire energy from inorganic chemical reactions.

a Name one chemical conversion used by a chemoautotroph.

b Name one chemoautotroph and the organic compound it produces.

Answers:

a Various answers are possible, e.g. ammonium ions to nitrite ions, nitrite ions to nitrate, or sulfide ions to sulfate ions.

b A methanogen, which produces methane.

4 List the five types of heterotrophs, and then spend 30 seconds writing down as many examples as you can think of for each type.

Answer: The five types of heterotrophs are: carnivore, herbivore, omnivore, saprotroph, parasite. Many answers are possible for examples of each type.

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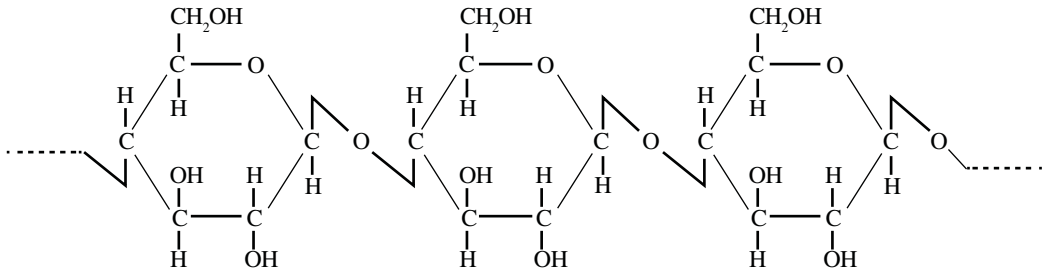
5 Cellulose is a complex carbohydrate that is made up of many individual units of glucose. The molecule shown below, composed of carbon, hydrogen and oxygen, was found in the gut of an animal.



a Describe how an autotroph would have obtained this molecule.

b Which one of the following animals would not have this molecule in its gut?

A human

B cow

C lion

D pig

Answers:

a An autotroph would have produced this organic compound itself using resources obtained from its physical environment. If it was a photosynthetic autotroph, such as a plant, it would have produced glucose using carbon dioxide, water and solar energy (all from its environment).

b C

6 Briefly describe what happens to pyruvate in the two processes that can occur after glycolysis when:

a oxygen is present

b oxygen is absent.

Answers:

a When oxygen is present, aerobic respiration takes place. Pyruvate produced in the cytosol by glycolysis passes into mitochondria. In the mitochondria the pyruvate is broken down into carbon dioxide and water along a complex aerobic pathway. For every two molecules of pyruvate, a further 36 or 38 molecules of ATP are generated.

b When oxygen is not present, anaerobic respiration takes place. Pyruvate is fermented in the cytosol into lactic acid or alcohol and carbon dioxide, with no further release of energy.

7 What is the approximate efficiency of anaerobic respiration compared to aerobic respiration in the release of energy from one glucose molecule?

Answer: $\frac{1}{18}$ (5.3%) or $\frac{1}{19}$ (5.6%). (The 2 ATP molecules produced by anaerobic respiration from one glucose molecule are divided by the 36 or 38 produced by aerobic respiration, which can be multiplied by 100 to give a percentage.)

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8 The following expressions can be used to write a word equation for photosynthesis and cellular respiration.

P carbon dioxide and water

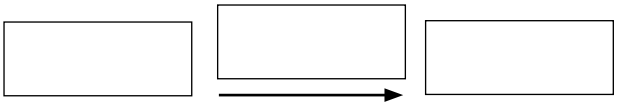
Q carbon dioxide, water and energy

R solar energy and chlorophyll

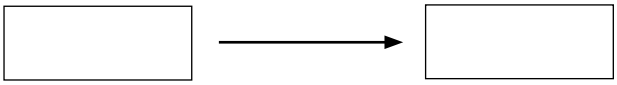
S glucose and oxygen

Complete the word equation for photosynthesis and cellular aerobic respiration using the statements provided.

Word equation for photosynthesis:

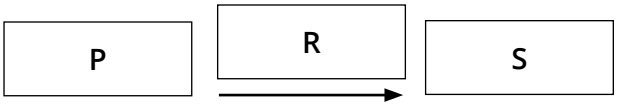


Word equation for cellular respiration:

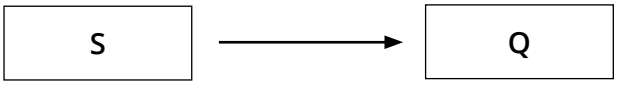


Answer:

Word equation for photosynthesis:



Word equation for cellular respiration:



9 Explain why photosynthesis is not the opposite of aerobic respiration.

Answer: Photosynthesis transforms solar energy into chemical energy and requires light and chlorophyll. Aerobic respiration transforms chemical energy into a different form of chemical energy, and does not require light or chlorophyll.

10 There are two stages of photosynthesis. Outline what occurs in each stage.

Answer: Stage 1 consists of the light-dependent reactions. Chlorophyll traps solar energy, which is used to split water into hydrogen ions and oxygen. During this reaction ATP is also produced.

Stage 2 consists of the light-independent reactions. In these reactions, hydrogen ions and ATP produced by the light-dependent reactions, together with carbon dioxide, react to produce glucose, water and ADP.

11 Pyridazinone herbicides are used in agriculture to reduce the number of pest plant species. Pyridazinone herbicides inhibit enzymes found in the light-dependent stage of photosynthesis. Explain how pyridazinone herbicides might act on a pest plant.

Answer: A herbicide can block the light-dependent reactions of photosynthesis, which would inhibit plants from breaking down water into hydrogen ions and oxygen gas. The herbicide can be sprayed selectively on pest plants to kill them.

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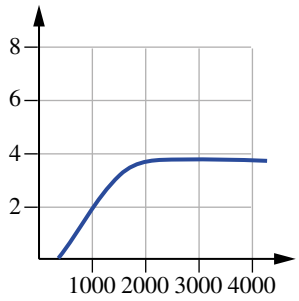
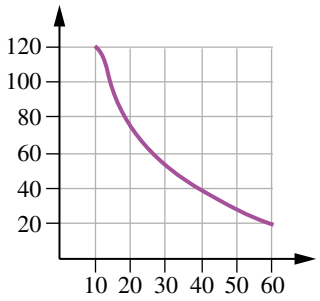
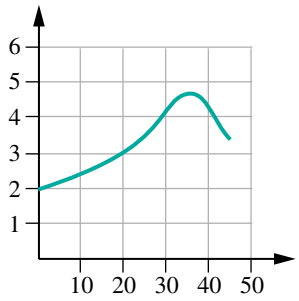
12 The following graphs represent the changes in rate of photosynthesis when temperature, light intensity or distance from light source are increased. Label each graph with its correct factor.



A ☐

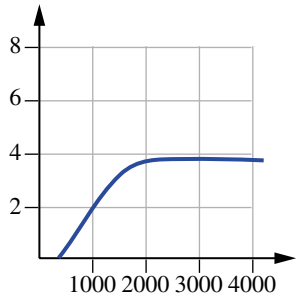


B ☐

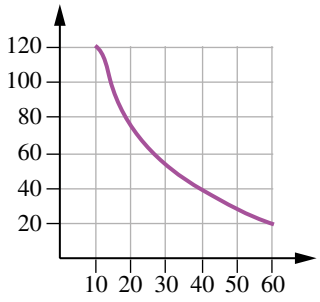


C ☐

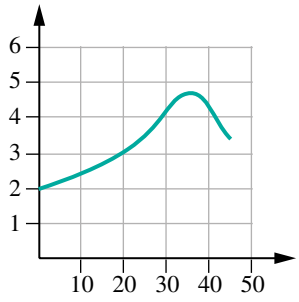
Answer:



A Light intensity

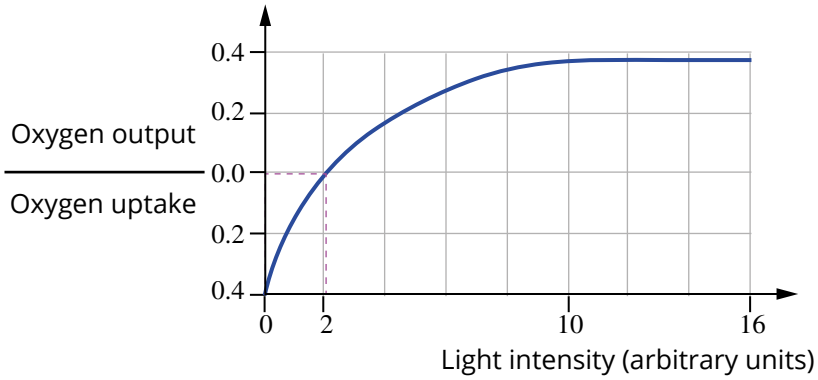


B Distance from light source



C Temperature

13 The following graph shows the relationship between net oxygen uptake or output and light intensity for a green plant.



Explain what is happening when light intensity is at:

a 2 units

b 16 units.

Answers:

a At a light intensity of 2 the plant is at the light compensation point. At this point the amount of oxygen used in cellular respiration and the amount of oxygen used in photosynthesis are equal and there is no net exchange of oxygen.

b At a light intensity of 16, all available photosynthetic cells are at maximum oxygen production. Because of this, the rate of photosynthesis has reached a maximum and levelled off.

 ISBN 978 1 4886 1122 3

14 Draw up tables comparing:

a photosynthetic autotrophs, chemosynthetic autotrophs and heterotrophs

b photosynthesis and cellular respiration.

Answers:

a

Photosynthetic autotrophs	Chemosynthetic autotrophs	Heterotrophs
obtain energy from sunlight	obtain energy from chemical reactions	obtain energy by feeding on other organisms
use photosynthesis	use chemosynthesis	use forms of digestion
example: plants	example: methanogens	example: animals

b

Photosynthesis	Cellular respiration
occurs only in plants, algae and some bacteria	occurs in all living organisms
occurs in chloroplasts	occurs in mitochondria
requires light and chlorophyll	does not require light or chlorophyll
uses ATP and produces ADP	uses ADP and produces ATP

 ISBN 978 1 4886 1122 3

Chapter 4 Questions and answers

4.1 Review

1 What are the four characteristics that an organism must have to be considered truly multicellular?

Answer:

- Cells must have identical DNA.
- Cells must be connected and must communicate and cooperate to function as a single organism.
- The organism must have specialised cells that are responsible for specific functions (one of which must be reproduction).
- Cells must depend on each other for survival.

2 List five differences between unicellular and multicellular organisms.

Answer: Any five of the following differences.

Unicellular organisms	Multicellular organisms
single cell	many cells
mostly prokaryotes	eukaryotes
one cell carries out all the functions to sustain life	cells are specialised to perform specific functions required by the organism
functions are carried out by different organelles within the cell	functions are carried out at cellular, tissue, organ and organ system levels
microscopic size—surface area to volume ratio limits size	macroscopic size—increasing the number of cells allows increased body size
short lifespan due to energetically expensive workload	long lifespan as work is efficiently divided between specialised cells
mostly asexual, clonal reproduction	mostly sexual reproduction
whole organism is involved in reproduction	only cells specialised for reproduction will reproduce (gametes)

3 What is cell differentiation and why is it important for multicellularity?

Answer: Cell differentiation is the process by which a non-specialised stem cell becomes specialised to perform a particular function. It is by this process that cells become specialised.

4 Explain how cell differentiation differs in animal cells and plant cells.

Answer: In most animal cells, the cells do not continue to differentiate throughout the organism's life. Many cells in a plant's meristem tissue are able to continue differentiating and specialising throughout their entire lives.

5 What is it that determines how a cell will differentiate and what functions it will perform?

Answer: The pattern of gene expression within the cell.

 ISBN 978 1 4886 1122 3

4.2 Review

1 Put the following levels of organisation in the correct order, from simplest to most complex.

organ, specialised cells, system, tissue

Answer: specialised cells, tissue, organ, system

2 Why is it important for multicellular organisms to be organised into cell groups, tissues, organs and systems?

Answer: As an organism increases in size and complexity, greater cooperation and coordination is required between its cells. This is because specialised cells are not able to undertake all the necessary functions, and not all cells can directly access the external environment to obtain resources and remove waste products and therefore rely on other cells and systems to carry out these tasks.

3 Define tissue (as used in biology), and give an example of a tissue in vascular plants and animals.

Answer: A tissue is made up of groups of similar cells working together to carry out a particular function in a multicellular organism. Examples of tissues in vascular plants are xylem and phloem. Examples of tissues in animals are connective, epithelial, muscle and nerve.

4 Why are animals such as sponges and sea jellies considered to be tissueless multicellular organisms?

Answer: Because their cells are not organised into discrete, functioning systems within the organism.

5 Give four examples of organs in vascular plants and describe their functions.

Answer: Any four of the following.

Roots – Absorb and store nutrients and water and provide structural support and anchorage for the plant.

Leaves – Carry out photosynthesis, converting light energy into the chemical energy that fuels the organism's cells.

Stems – Transport nutrients and water and support the plant.

Flowers – Facilitate pollination and fertilisation.

Fruits – Protect the developing seeds and help disperse the seeds away from the parent plant.

6 Describe an organ system in vertebrates and how it supports the survival of the organism.

Answer: One organ system in vertebrates is the circulatory system. It consists of the heart and a system of blood vessels through which blood circulates. This system transports nutrients and oxygen to cells, carries away wastes, and helps maintain the body's internal temperature.

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7 Match each specialised cell with its function.

red blood cell	transports water
white blood cell	gives rise to specialised cells
nerve cell	increased surface area for uptake of water
guard cell	protects against pathogens
muscle cell	carries oxygen around the body
epidermal cell	barrier against environmental stressors
meristem cell	carries signals around the body
xylem cell	allows movement of body parts
root hair cell	prevents water loss and regulates gas exchange

Answer:

red blood cell	carries oxygen around the body
white blood cell	protects against pathogens
nerve cell	carries signals around the body
guard cell	prevents water loss and regulates gas exchange
muscle cell	allows movement of body parts
epidermal cell	barrier against environmental stressors
meristem cell	gives rise to specialised cells
xylem cell	transports water
root hair cell	increased surface area for uptake of water

4.3 Review

1 What are the two types of vascular tissue in plants and their functions?

Answer: The two types of vascular tissue in plants are xylem and phloem. Xylem transports water and inorganic nutrients (mineral ions) absorbed from the soil to the living plant cells. Phloem transports glucose produced in the leaves by photosynthesis, and other organic substances such as amino acids, throughout the plant.

2 Why is there a limit to the size non-vascular plants can grow?

Answer: Non-vascular plants do not have lignin in their cell walls, so they cannot form large structural systems such as xylem to support them. Without xylem for structural support, the plants are unable to grow very high. For these reasons, non-vascular plants usually sprawl horizontally, with most only growing 1–2 cm in height.

3 How does ring-barking affect translocation? What impact does this have on the health of a tree?

Answer: Leaves produce carbohydrates (sugars) during photosynthesis. The non-photosynthetic tissues of the plant also need these carbohydrates and other organic compounds and so these nutrients are transported from the sources (the leaves) to the sinks (regions where the nutrients are needed, such as roots, stems, flowers and fruits). Ring-barking removes the bark of the tree, which contains the phloem tissue that is essential for the transport of these nutrients. This cuts off the food supply to the roots of the tree and eventually the tree dies.

4 What are the two possible pathways for the movement of water and mineral ions, absorbed from the soil, through the roots?

Answer: The two possible pathways are the extracellular pathway and the cytoplasmic pathway.

 ISBN 978 1 4886 1122 3

5 How is it possible for the tallest trees to transport water from their roots to their uppermost branches, sometimes over 100 metres high?

Answer: Thousands of leaf cells draw water from the xylem tissue, creating a suction that pulls water up xylem vessels from the roots. Water evaporates from open stomata (transpiration), creating a continuous one-way flow of water from roots to leaves called the transpiration stream. The pull of transpiration can be strong enough to draw water to the top of the tallest tree.

6 Why is transpiration vital to plants?

Answer: Transpiration is vital to plants because it enables them to:

- absorb the water necessary for the process of photosynthesis
- transport mineral salts to leaf cells and fruits
- cool down and not become overheated.

7 State whether each of the following environmental factors increases or decreases transpiration rates in plants.

a high temperature

b high humidity

c darkness

d strong wind

Answers:

a high temperature – increases

b high humidity – decreases

c darkness – decreases (Stomata would usually be closed, and it is cooler. An exception might be a CAM plant whose stomata are open at night.)

d strong wind – increases

4.4 Review

1 What system in multicellular organisms provides cells with nutrients and removes wastes from the cell?

Answer: The system in multicellular organisms that provides cells with nutrients, and removes cellular wastes is the circulatory system.

2 Describe the two pathways through which blood is circulated in mammals.

Answer: The two pathways are pulmonary circulation and systemic circulation.

Pulmonary circulation transports blood between the heart and lungs. Deoxygenated blood is pumped from the heart to the lungs, where it is oxygenated before returning to the heart.

Systemic circulation transports blood to and from the rest of the body. This system is larger than the pulmonary circulatory system because the heart must pump blood to all the organs in the body. Oxygenated blood is pumped from the heart to the organs, where it gives up its oxygen to the cells, before returning to the heart.

 ISBN 978 1 4886 1122 3

3 Match each of the following heart structures with its function.

Structure	Function
aorta	deoxygenated blood is pumped by the right ventricle and flows to the lungs
left atrium	deoxygenated blood returns from the body to the right atrium
left ventricle	oxygenated blood is pumped from the left ventricle and flows to the rest of the body
pulmonary artery	oxygenated blood returns from the lungs to the left atrium
pulmonary veins	receives deoxygenated blood from the right atrium and pumps it to the lungs
right atrium	receives deoxygenated blood returned from the body
right ventricle	receives oxygenated blood from the left atrium and pumps it to the rest of the body
venae cavae	receives oxygenated blood from the lungs

Answer:

Structure	Function
aorta	oxygenated blood is pumped from the left ventricle and flows to the rest of the body
left atrium	receives oxygenated blood from the lungs
left ventricle	receives oxygenated blood from the left atrium and pumps it to the rest of the body
pulmonary artery	deoxygenated blood is pumped by the right ventricle and flows to the lungs
pulmonary veins	oxygenated blood returns from the lungs to the left atrium
right atrium	receives deoxygenated blood returned from the body
right ventricle	receives deoxygenated blood from the right atrium and pumps it to the lungs
venae cavae	deoxygenated blood returns from the body to the right atrium

4 What are the fluid and cellular components of blood?

Answer: The fluid portion of blood is plasma, which is a pale yellow liquid containing ions, dissolved gases, proteins, hormones, nutrients and wastes. The cellular elements of blood include red blood cells (erythrocytes), white blood cells (leukocytes) and platelets.

5 Which two forces result in filtration of fluids into and out of capillaries? In which direction do each of these exert pressure, and what impact does this have on fluid filtration in capillaries?

Answer: Hydrostatic pressure (blood pressure) results in an outward force, and osmotic pressure results in an inward force on the capillaries. Overall, the pressure outward (hydrostatic pressure) is greater and results in a loss of fluid from the capillary to the extracellular environment.

6 Describe how the circulatory system supports the functions of the digestive system in mammals.

Answer: All of the tissues and organs of the digestive system rely on the circulatory system for blood supply, and to absorb and deliver nutrients produced by digestion to the cells of the body. The circulatory system also sends chemical signals to the digestive system from the endocrine system to regulate digestion.

7 What is the name of the protein that binds with oxygen in red blood cells? What condition can result if this protein is deficient?

Answer: Haemoglobin is the protein that binds with oxygen in red blood cells. Anaemia can result if this protein is deficient.

 ISBN 978 1 4886 1122 3

8 Outline the functions of the lymphatic system.

Answer: The lymphatic system:

- delivers fluid to tissues, or removes fluid from them, as required to maintain fluid balance
- helps defend the body against foreign particles such as bacteria, fungi and viruses
- serves as a temporary reservoir for fluids and releases them gradually, thus reducing the workload of kidneys
- absorbs fat from the digestive system, moving it through lacteals to blood stream.

9 Blood is a liquid tissue containing glucose, urea, plasma, proteins and other components. List the other components of blood.

Answer: Your answer should include most of the following components.

- dissolved gases (carbon dioxide/oxygen)
- erythrocytes (red blood cells)
- leucocytes (white blood cells)
- lymphocytes
- phagocytes
- platelets
- hormones
- amino acids (albumin, antibodies).

10 Describe the features and functions of the circulatory system and lymphatic system.

Answer: The circulatory system is a closed system that uses blood as the circulatory fluid. It consists of the heart, arteries, veins, capillaries and blood. This system provides most of the fluid and nutrient transport needs in mammals.

The lymphatic system is an open system that circulates lymph fluid. It consists of the thymus, lymph glands and lymphatic vessels. This system maintains fluid balance in tissues and supports immune defences.

11 Arrange the following structures in the respiratory system in order, from the largest in diameter to the smallest: alveolus, trachea, bronchiole, bronchus

Answer: trachea, bronchus, bronchiole, alveolus

12 Outline the features of the alveoli that make them highly effective for gaseous exchange.

Answer: Alveoli have a large surface area, which allows a fast rate of diffusion. Their cells are also extremely thin (less than 5 μm thick), which increases the rate of diffusion into blood capillaries because of the shorter distance for the molecules to travel.

There is a dense capillary network (made up of single layer of cells) to maintain a concentration gradient for faster rates of diffusion.

13 What are two differences between the digestive systems of herbivores and carnivores?

Answer: Carnivore stomachs consist of a single chamber. Herbivore stomachs have two or more chambers. The small intestine in carnivores is 3–6 times the body length. In herbivores the small intestine is 10 or more times the body length.

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14 The small intestine is a site of absorption.

a Describe the features of the small intestine that make it well suited to its absorptive role. Use diagrams to illustrate your answer.

b What is different about the absorption of the products of fat digestion compared with the absorption of other products?

Answers:

a The features of the small intestine that make it well suited to its absorptive role are:

- a large overall length and large surface area to volume ratio
- an internal surface consisting of millions of folds or villi, including microvilli, which occur on the exposed surface of the cells lining the lumen of the small intestine
- a thin lining that allows for the rapid transfer of nutrients
- a good supply of blood and lymphatic vessels, which aids the transport of nutrients.

b The products of fat digestion (fatty acids and glycerol) are absorbed into the lacteals of the lymphatic system. They go to the heart first, rather than to the liver.

15 Relate the relative sizes of the stomach, small intestine, caecum and first part of the large intestine of hindgut fermenters to foregut fermenters.

Answer: Hindgut fermenters have a much smaller stomach, similar length small intestine, and a much larger caecum/colon when compared to foregut fermenters.

16 What is the difference between foregut fermentation and hindgut fermentation?

Answer: In foregut fermentation, the fermentation chamber is located before the stomach and is often referred to as the rumen in cattle and sheep. Food is regurgitated back into the mouth and chewed as cud, allowing for additional mechanical digestion before being returned to the rumen for chemical breakdown by microorganisms. Hindgut fermentation occurs in the caecum at the junction of the small and large intestine, or in the first part of the colon, or both. Unlike foregut fermentation, these regions are located after the small intestine where most absorption of digested food takes place.

17 **a** From a nutritional point of view, what is the problem for hindgut fermenters?

b How do some hindgut fermenters overcome this problem?

Answers:

a In hindgut fermenters, the symbiotic microorganisms only make a contribution after the food has passed through the small intestine (where most absorption takes place). So hindgut fermenters get little, if any, nutritional value from these microorganisms. Undigested plant material can often be observed in the faeces of animals such as horses, which demonstrates the inefficiency of their digestive system.

b Some species of animals that are hindgut fermenters, such as possums and rabbits, overcome this problem by producing two types of faeces. During the night one type of faeces comes directly from the caecum and then is re-ingested by the animal. In this way the partially digested material passes through the small intestine again, maximising the absorption of vitamins and products of cellulose digestion.

18 **a** Name the structural and functional unit of the kidney.

b Describe the function of the glomerulus, Bowman's capsule, proximal and distal convoluted tubule, the loop of Henle and the collecting tubule.

Answers:

a The structural and functional unit of the kidney is the nephron. A nephron is composed of a Bowman's capsule surrounding a glomerulus and a tubular region (consisting of the proximal tubule, loop of Henle, and distal convoluted tubule), leading to a collecting tubule.

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b The glomerulus is a clump of looping capillaries embedded in the Bowman's capsule. Blood is filtered from the glomerulus into the Bowman's capsule. Only small molecules and water can pass through; cells and large proteins remain in the glomerular capillaries. This primary filtrate in the Bowman's capsule has the same composition as blood plasma, without the large proteins.

The proximal and distal convoluted tubules reabsorb glucose, amino acids, salts and water. In the loop of Henle, sodium chloride is actively transported out of the primary filtrate. But the walls of the loop of Henle are impermeable to water, so water does not follow. Sodium chloride is retained in the medulla of the kidney, producing a very high salt concentration.

When the urine passes down the collecting tubules towards the ureter, it passes through the region of high salt concentration in the medulla. The collecting tubule is permeable to water, but not salt, so water passes from the collecting tubule back into the kidney and into blood vessels. As a result the urine becomes concentrated.

19 Explain why it is important that the permeability to water of the collecting tubule of the mammalian kidney can be regulated.

Answer: The permeability to water of the collecting tubule of the mammalian kidney is regulated by hormones. This enables mammals to keep the osmotic concentration of body fluids stable. For example, if a lot of salt has been consumed, the salt concentration of blood increases and more water must be reabsorbed to return the salt level to normal. The water permeability of the collecting tubules is increased so that more water is reabsorbed from the urine into the blood.

20 Explain the process of ultrafiltration.

Answer: Ultrafiltration occurs when hydrostatic pressure forces blood through a semi-permeable membrane. This delivers fluid plasma and small molecules to the kidney tubule, while large molecules and blood cells remain in the blood vessels. For ultrafiltration to occur, hydrostatic pressure and a semi-permeable membrane must be present.

Chapter 4 Review

1 Why is the colonial theory thought to be the most likely mechanism by which multicellular organisms evolved and what evidence is there to support it?

Answer: The colonial theory proposes that during cell division of a single cell, the two new cells did not completely separate. The cells continued to divide, resulting in multiple cells forming a colony and eventually a functioning unit. Over time the colonial cells differentiated, developing specialisations for the survival and reproduction of the organism. This is considered the most likely theory for the evolution of multicellular organisms, because it explains how the DNA in somatic cells is the same. Evidence to support this theory is the observation of organisms such as *Volvox* forming colonies.

2 Match each of the following specialised cells with its function.

epidermal cell	carries oxygen around the body
guard cell	protects against pathogens
meristem cell	carries signals around the body
muscle cell	prevents water loss and regulates gas exchange
nerve cell	allows movement of body parts
red blood cell	barrier against environmental stressors
white blood cell	gives rise to specialised cells

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Answer:

epidermal cell	barrier against environmental stressors
guard cell	prevents water loss and regulates gas exchange
meristem cell	gives rise to specialised cells
muscle cell	allows movement of body parts
nerve cell	carries signals around the body
red blood cell	carries oxygen around the body
white blood cell	protects against pathogens

3 Describe the process of cell differentiation and specialisation, mentioning at least five key terms from above.

Answer: Cell differentiation is the process in which unspecialised cells become specialised to perform a particular function. Unspecialised cells occur in animal embryos and are called embryonic stem cells. In flowering plants, meristem cells generate every different cell type required by the organism. The zygote contains all the genes required to produce every type of cell, but it is the pattern of gene expression that determines how a cell will differentiate and what functions it will perform. In specialised cells, specific sets of genes are activated, or expressed, for the cell to perform its specific functions.

4 Which organisms are multicellular (M) and which are unicellular (U)?

a paramecium (protist)

b bat (mammal)

c earthworm

d amoeba (protist)

e diatom (protist)

f human

g yeast (fungi)

h eucalypt tree (plant)

i salmonella (bacterium)

j grasshopper

Answer:

a paramecium – unicellular

b bat – multicellular

c earthworm – multicellular

d amoeba – unicellular

e diatom – unicellular

f human – multicellular

g yeast – unicellular

h eucalypt tree – multicellular

i salmonella – unicellular

j grasshopper – multicellular

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5 List five advantages of being multicellular.

Answer: Any five of the following:

- increased size
- increased mobility
- can perform more complex functions
- more energy-efficient
- longer lifespan
- less vulnerable to environmental changes
- increased complexity over generations.

6 Referring to your answers in question 5, explain how being multicellular provides each of these advantages compared to unicellular organisms.

Answer:

1 increased size – Unicellular organisms' sizes are restricted because their surface area to volume ratio must be minimal to allow the supply of nutrients and removal of waste via diffusion.

2 increased mobility – Increased size and specialisation of limbs means multicellular organisms are more mobile and more efficient at locating resources and avoiding predators and other negative stimuli.

3 can perform more complex functions – Being multicellular enables cells to specialise for particular functions.

4 more energy-efficient – Cellular specialisation allows functions to be conducted more efficiently by many cells, rather than one cell undertaking all functions.

5 longer lifespan – Because multicellular organisms are more energy-efficient, they live longer.

6 less vulnerable to environmental changes – There are more systems to cope with the changes, and cell death does not necessarily affect the whole organism.

7 increased complexity over generations – Sexual reproduction and genetic recombination promotes increasing complexity and specialisation over generations, compared to asexual reproduction in unicellular organisms.

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7 Identify the image that represents:

a a single cell

b a simple colony

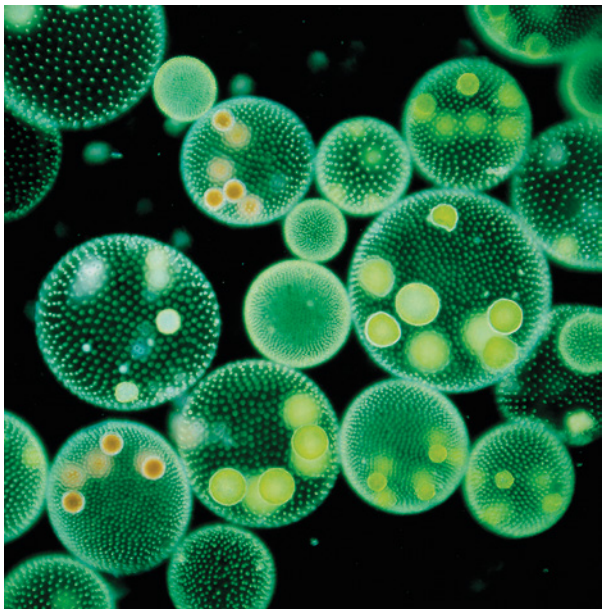
c a multicellular organism without tissues

d a multicellular organism with tissues, organs and organ systems.

A

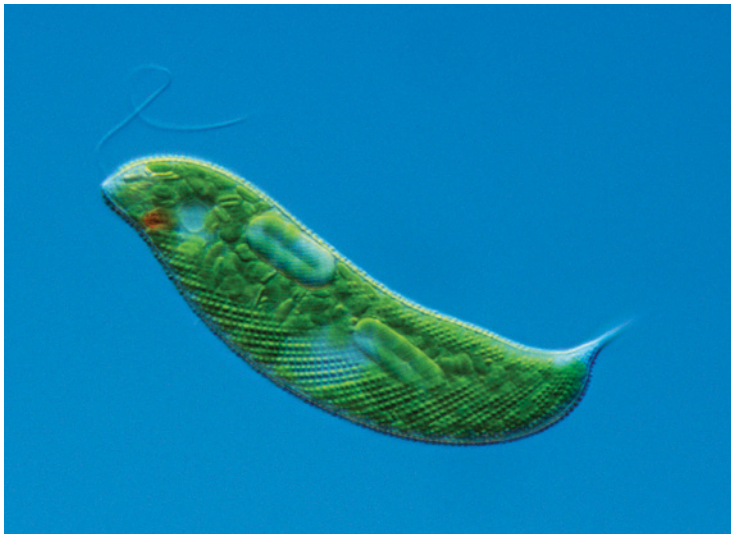
Source © Michael Nichols/National Geographic Society (a)

B



Source © Manfred Kage/Science Photo Library (b)

C



Source © Wim Van Egmond/ Science Photo Library (c)

D

Source © Charles V Angelo/Getty Images

Answers:

a image C

b image B

c image D

d image A

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8 **a** Explain how a tree is killed by ring-barking.

b How does unintentional ring-barking occur, and how can it be treated.

Answers:

a The bark is removed in ring-barking, taking the phloem and thus preventing sucrose moving into the roots. Water can still be taken up from the roots, which eventually die and the tree then dies.

b Ring-barking can occur when animals eat the bark, when wire or rope is tied around a tree (e.g. for a fence), or the bark is cut when mowing around the tree base. Bark bridges can be used to link the phloem and re-establish translocation in the cut area.

9 In autumn, the leaves of deciduous trees change colour and eventually fall. The change in colour is due to the movement of nutrients out of the leaves for storage. This involves:

A xylem and phloem

B only the xylem

C only the phloem

D diffusion

Answer: C

10 Define each of the levels of organisation in multicellular organisms.

Answer:

Cellular level: Individual, specialised cells performing functions. Cells are the building blocks of the higher levels of organisation in multicellular organisms.

Tissue level: Tissues are groups of similar cells working together to carry out a particular function in a multicellular organism.

Organ level: An organ consists of two or more tissues that work together to perform one or more specialised tasks.

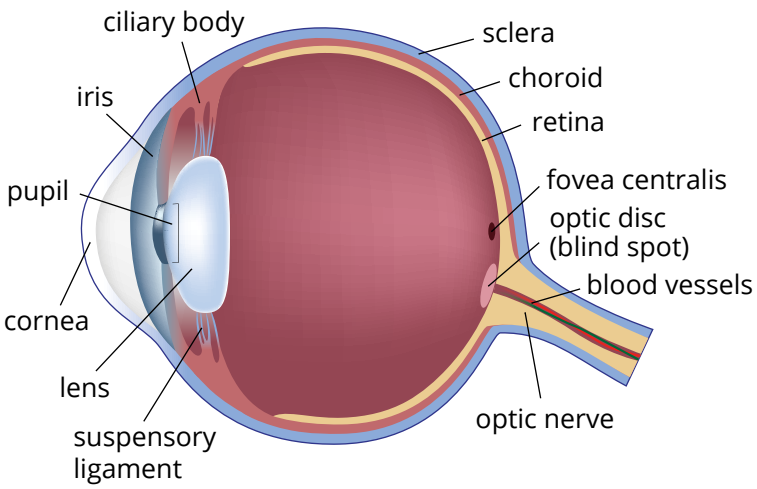
System level: A system is a group of organs that work together to perform a vital task.

11 State the level of organisation that each of the following illustrations shows: tissue, organ, system or organism.

A

Source © Laurie Knight/Getty Images

B



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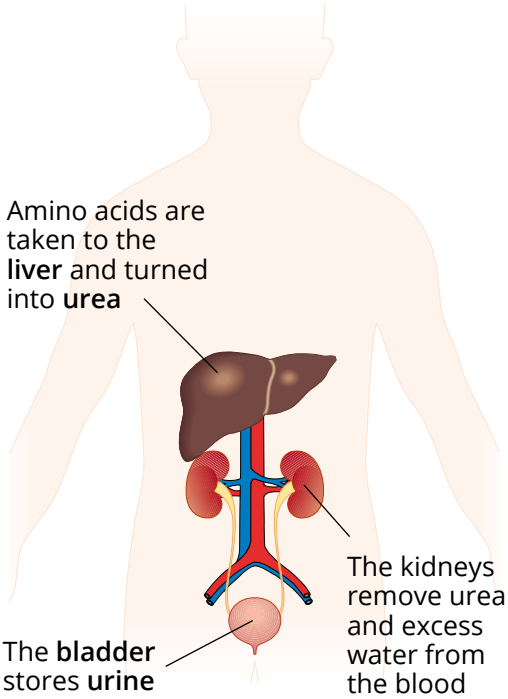
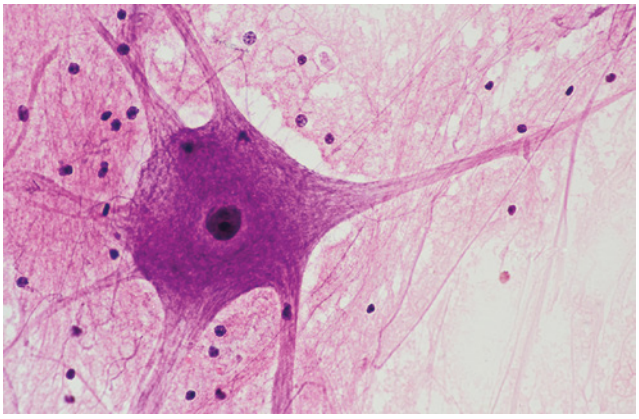
C



D



Source © Ed Reschke/Getty Images

Answers:

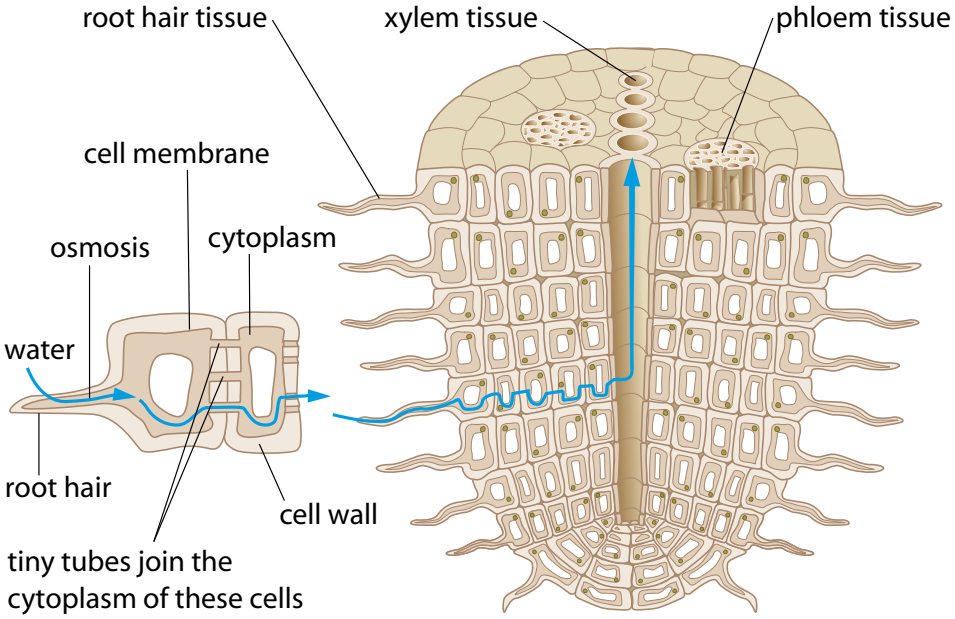
A – organism

B – organ

C – organ system

D – tissue

12 Describe the pathway of water absorption in the diagram of plant root tissue below.



Answer: This diagram illustrates the cytoplasmic pathway of water absorption. Water and mineral ions are absorbed into the root hair cells and move from cell to cell through tubes called plasmodesmata that join the cytoplasm of adjacent cells. Once the water and mineral ions reach the xylem, they are pulled up towards the leaves by transpiration.

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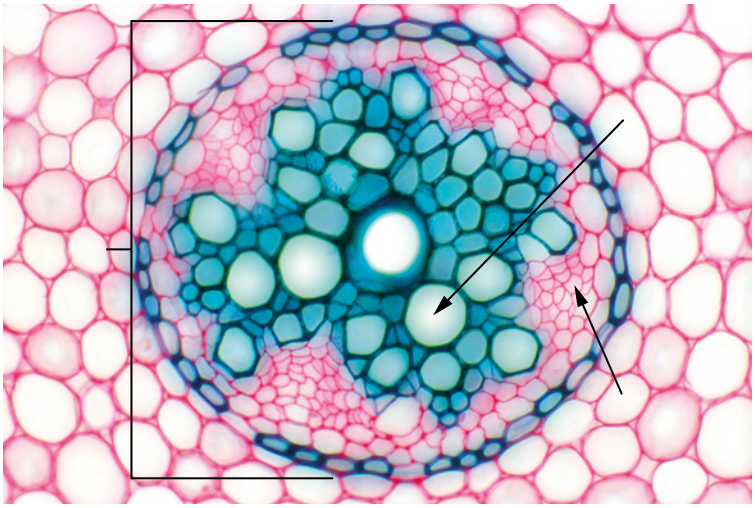
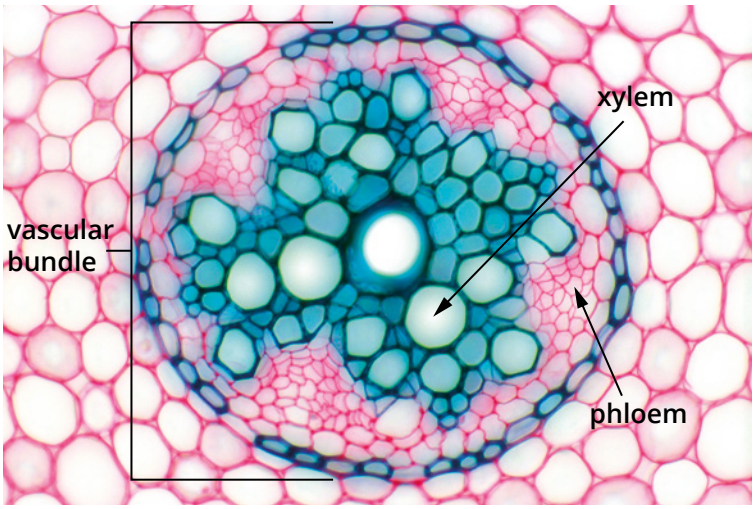
13 The image below is a cross-section of the root of a buttercup plant viewed under a light microscope. Label the parts of the root.



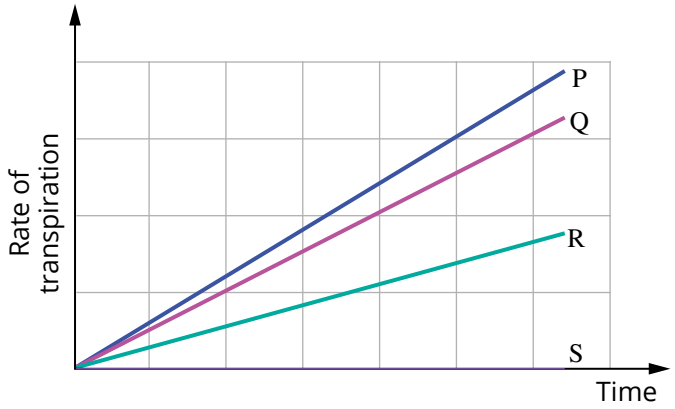
Source © Herve Conge/Science Photo LIbrary

Answer:



Source © Herve Conge/Science Photo LIbrary

14 An experiment was conducted to determine the effects of applying a sticky gel onto a leaf on the rate of transpiration. The graph below shows the results of the experiment.



Match each line labelled on the graph to the correct experimental condition from the list below.

a no gel applied

b gel applied to the lower side of the leaves

c gel applied to the upper side of the leaves

d gel applied to both the lower side and upper side of the leaves

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Answers:

a no gel applied – P

b gel applied to the lower side of the leaves – R

c gel applied to the upper side of the leaves – Q

d gel applied to both the lower side and upper side of the leaves – S

15 Discuss some of the adaptations that plants living in harsh environments, such as deserts, have developed to achieve water transport.

Answer:

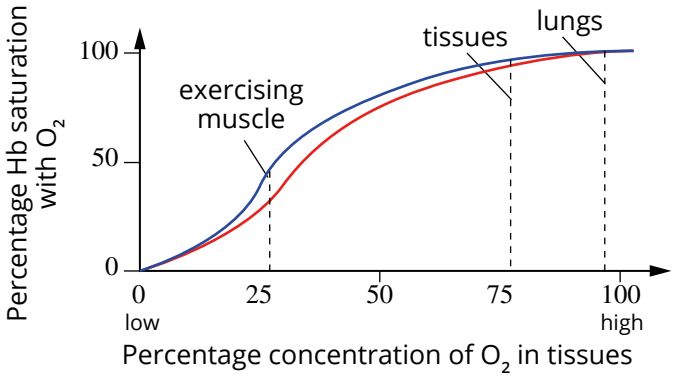
- Many desert plants are succulents. That is, they are are specialised to hold large volumes of water in their fleshy leaves, stems and roots.
- Roots are shallow and cover a large area, to ensure that they can harvest as much water from the soil as possible.
- Many desert plants are spiny, bitter tasting or toxic to deter thirsty animals.
- Thick, waxy cuticles protect the leaves from damage and prevent water evaporation.
- Many plants use CAM photosynthesis, which enables them to keep the stomata closed during the day.

16 Which side of the heart has thicker muscular tissue, and why? How does this affect the blood pressure in the different areas of the heart?

Answer: The muscular wall of the left ventricle is almost twice as thick as that of the right ventricle. This is because the left ventricle has to pump blood to all the organs, while the right ventricle pumps blood to the lungs only. The right ventricle therefore contracts with less force, resulting in lower blood pressure in the right ventricle and pulmonary arteries, compared with the pressure produced by the more muscular left side of the heart.

17 Using the information in the following graph, discuss the relationship between oxygen, haemoglobin and the circulatory system.

Haemoglobin–oxygen dissociation curve for human blood



Answer: Haemoglobin is the molecule in red blood cells that binds to oxygen. In areas of high oxygen concentration, such as in the blood in vessels in the lungs, haemoglobin combines with oxygen to form oxyhaemoglobin. In areas of low oxygen concentration, such as in exercising muscles, oxygen is released from oxyhaemoglobin.

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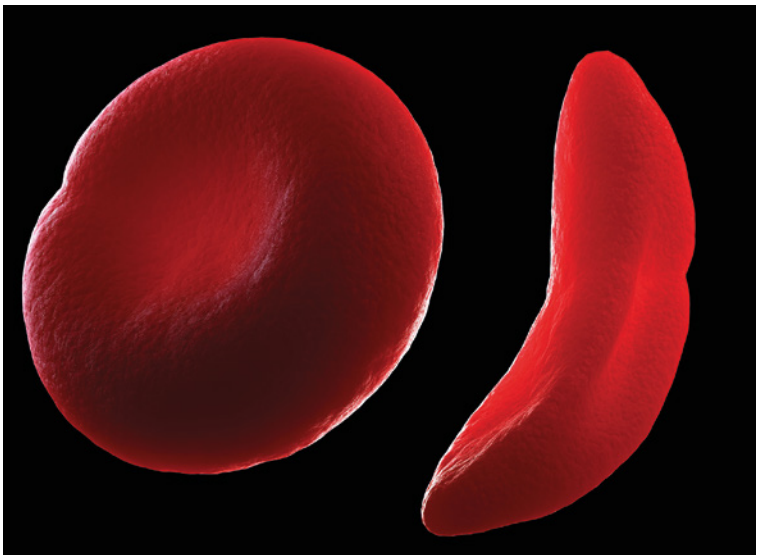
18 Sickle cell disease is a red blood cell disorder. People with sickle cell disease have abnormal haemoglobin in their red blood cells. As a consequence, the red blood cells become sickle-shaped and inflexible.



Source © Sciepro/Getty Images

Based on your understanding of the functions of red blood cells, what are the effects of having sickle-shaped red blood cells on the functioning of the circulatory system?

Answer: A normal red blood cell has a biconcave shape, which allows it to be flexible and move through blood vessels especially capillaries. Sickle-shaped red blood cells are not flexible and may slow down or stop the flow of blood. When this happens, it prevents oxygen from being transported to nearby tissues. The prevention of oxygen being delivered can cause tissue and organ damage and over a lifetime can result in permanent damage to various organs.

19 A common problem for passengers on a long plane trip is that, upon arrival, their feet have become so swollen that they will not fit into their shoes. Airlines recommend exercises to help reduce this problem.

a Explain what causes feet to swell during air travel.

b How could exercise help?

c Deep vein thrombosis is a major concern for long-distance travellers. Explain why clots are likely to form and how this can be prevented.

Answers:

a Passengers on long plane trips often suffer swollen feet as a result of being in a sitting position for a long period of time without exercising. The lymphatic system relies on the activity of skeletal movement to move lymphatic fluid. With little muscular movement, the fluid settles in the body tissues resulting in swelling. Also, blood may accumulate in the veins.

b Exercise would help to move the lymphatic fluid back towards the heart by squeezing the thin-walled vessels.

c The lack of movement while sitting for long periods can cause blood to pool in the legs, where clots can form in veins. Clots can move to the heart or lungs and block arteries, causing serious problems. Their incidence can be reduced by drinking water and not alcohol on flights, doing exercises during the flight, and taking aspirin to thin the blood before flying.

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20 Identify three specialised cells in the respiratory system and state their functions.

Answer:

- Goblet cells – They secrete mucus, a viscous fluid composed primarily of highly glycosylated proteins called mucins suspended in a solution of electrolytes.
- Ciliated columnar epithelial cells – They have fine hair-like outgrowths, cilia on their free surfaces. These cilia are capable of rapid, rhythmic, wavelike beatings in a certain direction. This movement of the cilia in a certain direction causes the mucus, which is secreted by the goblet cells, to move (flow or stream) in that direction.
- Pneumocytes – These are cells lining the alveoli (the air sacs) in the lung. Type 1 pneumocytes exchange gases (oxygen and carbon dioxide) between the air in the lungs and the blood. Type 2 pneumocytes produce and secrete a surfactant, which reduces the surface tension of pulmonary fluids and contributes to the elastic properties of the lungs.

21 Coeliac disease causes the destruction of the villi cells. Which one of the following is most likely to happen to people with coeliac disease?

A damage in the oesophagus caused by increase in acid reflux

B incomplete digestion of proteins

C increased levels of glucose in blood

D poor absorption of calcium

Answer: B (Because of destruction of the villi cells, there is less secretion of enzymes needed for breakdown of substances such as proteins, so some proteins will not be digested. Calcium and minerals are absorbed in the large intestine, hence it is not affected.)

22 Which one of the following statements relating to fermentation in herbivores is true?

A In foregut fermenters, cellulose is digested in the caecum.

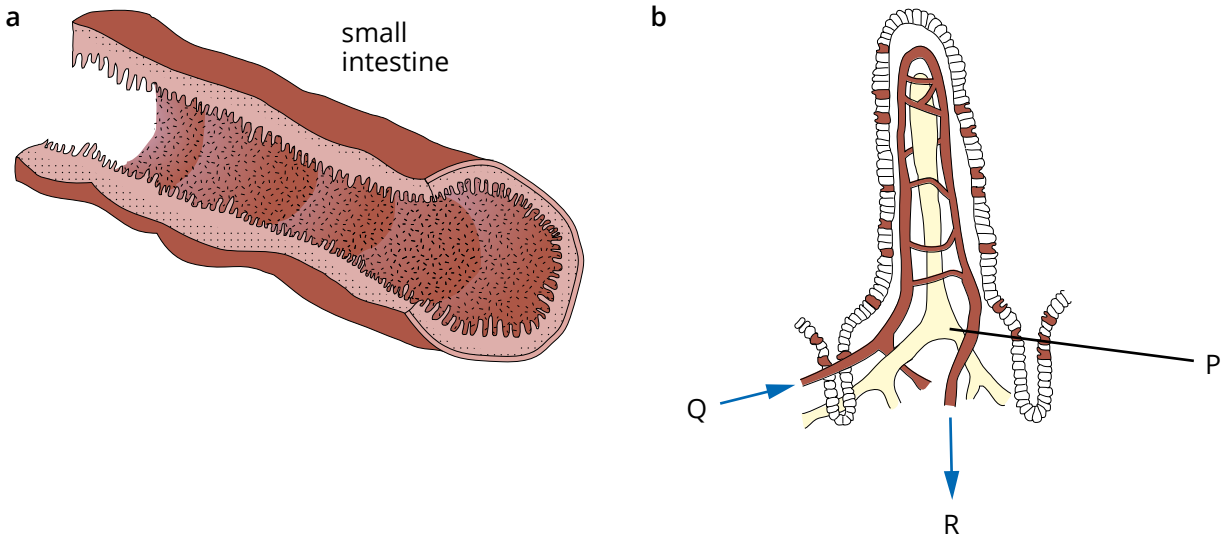
B Fermentation in the gut required oxygen.

C The rumen is located between the oesophagus and the stomach.

D All native Australian mammals are hindgut fermenters.

Answer: C

23 Figure a below shows a cross-section through the small intestine. Figure b shows a longitudinal section through a villus.



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a Using figures a and b, outline three ways in which the structure of the small intestine is related to its function of absorbing products of digestion.

b Referring to figure b, identify structure P and state its function.

c The arrows in figure b indicate the direction of blood flow. State how the composition of blood entering from Q would be different from blood leaving R.

Answers:

a The surface of the villus (epithelium) is close to the lymph vessels so lipids can be absorbed easily.

The surface of the villus (epithelium) is close to the blood vessels so materials can be absorbed easily.

The surface of the villus (epithelium) consists of a single layer of cells so materials can be absorbed easily.

The intestinal wall has many folds to increase surface area to volume ratio, which allows for a greater rate of diffusion.

b Lymph vessel. Transport of fats (lipids).

c Compared to blood entering at Q, blood leaving R will have:

- a higher concentration of glucose and amino acids
- a lower concentration of oxygen
- a higher concentration of carbon dioxide.

24 The table below shows the relative concentrations of urea, glucose, amino acids, salts and proteins in the primary filtrate and urine of mammals as a percentage of the concentration in blood plasma.

Substance	Primary filtrate (%)	Urine (%)
Urea	100	700
Glucose	100	0
Amino acids	100	0
Salts	100	200
Proteins	0	0

a What is the explanation for each value, for both primary filtrate and urine?

b Suggest how the values would be different in persons suffering from diabetes, or from kidney damage due to a heavy blow.

Answers:

a Glucose and amino acids in the primary filtrate are reabsorbed by active transport in the proximal convoluted tubule, so they are absent in urine. Proteins in blood are too large to pass across cell membranes in the glomerulus, so they are not found in the primary filtrate or the urine. Reabsorption of water by the collecting tubules increases the concentrations of urea and salts in urine compared with that in the primary filtrate.

b Diabetes is a disorder in which there is a higher than normal concentration of glucose in the blood. The kidney tubules cannot absorb all of the excess glucose, so it will be present in the urine in varying concentrations. A heavy blow to the kidneys could damage the glomerular blood vessels. This would affect the normal filtration process, resulting in blood leaking from the glomerulus into the Bowman's capsule. This would result in the presence of amino acids and proteins in the urine.

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Chapter 5 Questions and answers

5.1 Review

1 Describe how adaptations are beneficial to the survival of an individual organism and to a species.

Answer: Those organisms that are best suited to their environment survive and reproduce, passing on their advantageous adaptations to their offspring. Adaptations help individual organisms survive and they are also critical for the survival and reproduction of populations and species. Adaptations are inherited characteristics and are the qualities that natural selection, and therefore survival of the fittest, work on.

2 What are the three main types of adaptations in animals and plants?

Answer: The three main types of adaptations in animals and plants are structural, physiological, and behavioural.

3 List and describe two adaptations from each of the three main types described in Question 2, and state whether they are found in plants or animals.

Answer:

Examples of structural adaptations of plants include:

- pneumatophores
- aerial roots
- buttress roots
- cladode shape
- leaf shape (large, small, reduced)
- leaves that hang down
- waxy coatings
- leaf colour (dark green in rainforests; pale green/white in deserts)
- lenticels.

Examples of structural adaptations of animals include:

- large ears (desert) or small ears (arctic)
- thick hair or fur
- fat or blubber
- coloured body covering
- surface area/volume ratio
- different types of teeth
- opposable thumbs
- prehensile tails
- binocular vision
- mimicry.

Examples of physiological adaptations of plants include:

- CAM in plants
- frost tolerance
- salinity tolerance
- drought tolerance.

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Examples of physiological adaptations of animals include:

- the ability to produce concentrated urine
- counter-current heat exchange mechanisms
- dormancy, hibernation, torpor and aestivation
- production of venom or poisons
- ability to withstand high temperatures
- sweating
- shivering thermogenesis
- embryonic diapause
- freezing during winter.

Examples of behavioural adaptations of plants include:

- phototropism
- gravitropism
- hydrotropism
- thigmotropism
- nastic movements.

Examples of behavioural adaptations of animals include:

- huddling for warmth
- panting, licking skin, covering the body in water, gular fluttering
- seeking shade or sunlight
- nocturnality
- burrowing in the sand
- building elaborate nests
- courtship displays
- making themselves look bigger
- 'playing' dead.

4 What environments would each of the adaptations you mentioned in Question 3 be suited to? Explain your answers.

Answer: Answer depends on answer to question 3.

5 What is biomimicry? Can you think of an example of biomimicry that isn't mentioned in this book?

Answer: Biomimicry is a discipline in which scientists, engineers and designers look to the structures and systems in nature to inspire the innovation and design of products. Answers for the second part of the question will vary.

5.2 Review

1 What is homeostasis and why is it important?

Answer: Homeostasis is the process of an organism or cell regulating and maintaining stability in its internal environment. Homeostasis is achieved by a variety of mechanisms that work to keep internal environments constant within a very narrow range. It is important to maintain conditions at a level at which they can function effectively regardless of changing conditions in the internal and external environment. Organisms that cannot regulate their internal environment and maintain homeostasis may die.

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2 How do negative feedback loops function? Explain using an example.

Answer: Negative feedback loops are stimulus–response mechanisms in which the response produced reduces the effect of the original stimulus by reversing its direction. In other words, if a level of something in the body is too high, a negative feedback loop will lower it. If something is too low, a negative feedback loop will increase it. An example of a negative feedback loop is the maintenance of blood sugar levels by insulin. When blood sugar levels are high, receptors detect the change and the pancreas secretes insulin. This lowers the blood sugar levels until homeostasis is reached, at which point the pancreas stops releasing insulin.

3 Which two systems are the most important in regulating the internal environment of animals?

Answer: Endocrine and nervous systems.

4 What are the two main types of hormones? Give an example of each and describe how they interact with cells.

Answer: Steroid hormones and protein hormones. Steroid hormones include testosterone and oestrogen. They are derived from cholesterol, are small and lipid-soluble, and pass easily through membranes into the cytoplasm, where they bind specifically to receptor molecules. They then pass into the nucleus where they act directly on particular genes.

Protein-based hormones include insulin and growth hormone. They are water-soluble and cannot pass through membranes. They bind to a specific receptor in the plasma membrane, triggering physiological responses within the cell.

5 Describe the two main parts of the vertebrate nervous system, and state the primary function of each part.

Answer: The central nervous system (CNS) and the peripheral nervous system (PNS). The CNS is made up of the brain and the spinal cord. This system has a major role in controlling the activity of the other organs. It does this by communicating with the peripheral nervous system. The PNS is made up of the system of nerves that branch throughout the body to and from the receptors and effectors. These are nerves that originate in the CNS and connect to all body parts, along with nerves that originate in the organs and connect to the CNS.

6 Which type of nervous system response protects the body from further pain and injury?

Answer: The reflex response.

7 Complete the table below by placing each of the following stimuli next to the receptor that it responds to.

body position, temperature, internal stimulus, electrical current, touch and pressure, chemical stimulus, external stimulus, blood pressure

Receptor	Stimulus
baroreceptor	
chemoreceptor	
electroreceptor	
exteroreceptor	
interoreceptor	
mechanoreceptor	
proprioreceptor	
thermoreceptor	

 ISBN 978 1 4886 1122 3

Answer:

Receptor	Stimulus
baroreceptor	blood pressure
chemoreceptor	chemical stimulus
electroreceptor	electrical current
exteroreceptor	external stimulus
interoreceptor	internal stimulus
mechanoreceptor	touch and pressure
proprioreceptor	body position
thermoreceptor	temperature

8 Explain how hormones that circulate throughout the blood can act only on a specific type of target cell.

Answer: Hormones can only act on a specific target cell type because hormonal communication is specific. Specific cells detect a particular stimulus and produce a particular hormone, and specific cells respond to the hormone.

9 Name the types of neurons involved in a simple monosynaptic reflex, and outline their function.

Answer:

Sensory neuron – detects a change and sends a signal

Motor neuron – transmits the signal sent from sensory neuron to an effector cell

10 Why is it beneficial for the neural circuit entering a body joint to contain interneurons?

Answer: The movements of joints operate by the action of opposing sets of muscles: one set causes flexion, the other causes extension. When one muscle is stimulated to contract, the interneurons in the spinal cord carry a message inhibiting the contraction of the opposing muscle. This prevents both opposing sets of muscles from contracting at the same time, placing the body joint under severe strain.

11 Which section of the peripheral nervous system—somatic or autonomic—is involved in unconscious control of internal organs?

Answer: The autonomic nervous system.

5.3 Review

1 How do organisms exchange heat with their environment? Explain each of the four methods of heat exchange using examples.

Answer:

Conduction – Occurs when the temperature of the organism and the environment are different. Heat exchange is a result of direct contact (e.g. a lizard basking on a warm rock).

Convection – Transmission of heat from a warmer region to a colder region, resulting from the movement of liquid or gas (e.g. heat moves from the inside of living organisms to the body surface by convection).

Radiation – Occurs all the time, without direct contact, regardless of temperature differences between the organism and their environment (e.g. heat radiating from dark coloured surfaces).

Evaporation – Heat loss by water evaporation. This occurs most rapidly when the air is hot and dry (e.g. sweating).

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2 What are three mechanisms humans use to produce heat?

Answer:

Voluntary movement/physical exercise

Shivering thermogenesis

Non-shivering thermogenesis

Increasing rate of cellular respiration (metabolism)

3 What are three mechanisms humans use to lose heat?

Answer:

Sweating or perspiring (evaporative cooling).

Rate of cellular respiration decreases in internal organs, decreasing body temperature.

Covering your body with water. Spraying water on your skin has the same effect as sweating.

Swimming will cause heat loss through conduction across the skin when you are in cool water. Further cooling occurs when you are out of the water (evaporative cooling).

Vasodilation (dilation of the blood vessels in the skin). Dilation means more blood is sent to the extremities. Heat is lost to the environment by radiation and convection (especially if it is windy).

Changing body shape to increase surface area.

Removing clothing will reduce the layer of insulation and allow heat to escape.

4 What is the main role of insulin, and how does it do this?

Answer: The overall effect of insulin is to lower blood glucose levels. It does this by:

- increasing conversion of glucose to fat in fat cells
- increasing uptake of glucose in muscle and fat cells
- increasing the conversion of glucose to the storage compound glycogen for storage in the liver.

5 Describe the role of glucagon in glucose homeostasis.

Answer: Glucagon is released by pancreatic alpha cells in response to low blood glucose. It acts on the liver, causing glycogen breakdown to glucose. Glucose moves from liver cells to blood, thus raising blood glucose into the normal range.

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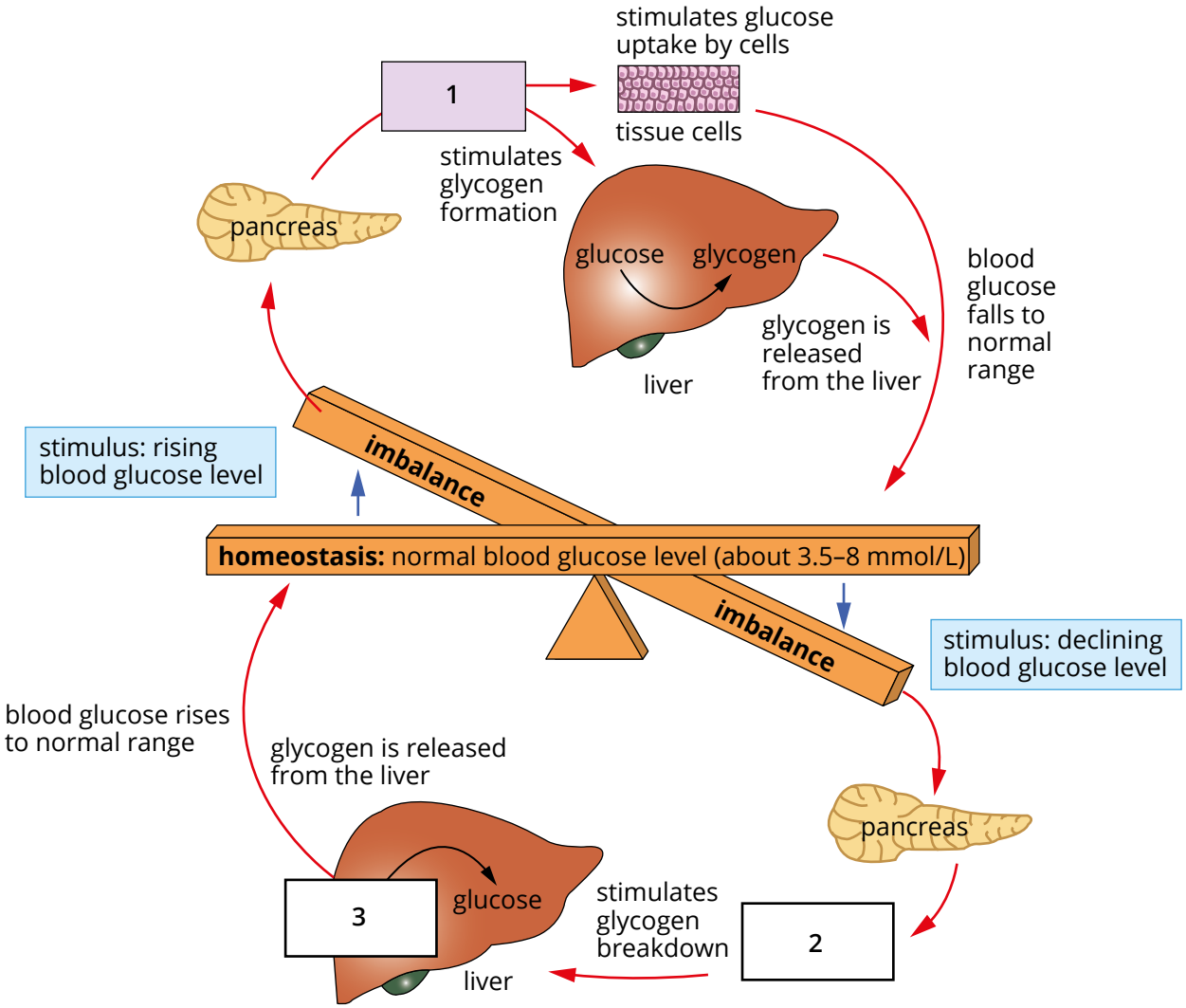
6 Provide labels for points 1, 2 and 3 on the diagram below to explain the regulation of blood glucose levels in the human body.



Answers:

1 insulin

2 glucagon

3 glycogen

7 **a** What does osmolality measure?

b Which two receptors detect changes in osmolality in the blood?

Answers:

a Osmolality measures the solute concentration in blood (plasma) and extracellular fluid.

b Osmoreceptors in the hypothalamus and baroreceptors in the atria of the heart detect the osmolality of the blood. Osmoreceptors are sensitive to blood solute concentrations, while baroreceptors detect changes in the volume of blood.

8 What is ADH and what is its role?

Answer: ADH is antidiuretic hormone. It is responsible for the regulation of water reabsorption. ADH acts on the kidneys to increase the permeability of the distal tubules and collecting ducts. The collecting ducts run through the medulla of the kidney, which has high salt levels (and therefore a higher osmotic potential). This causes absorption of water from the tubules back into the blood by osmosis, decreasing urine output. As the blood returns to a normal concentration, negative feedback stops the production of ADH.

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9 What change in the blood acts as a stimulus for ADH release?

Answer: Decreased water content of blood or increased concentration of blood.

10 Describe how negative feedback is involved in ADH action and water balance.

Answer: ADH action results in water reabsorption in the kidney and increased blood volume. This change is detected by osmoreceptors in the hypothalamus, which decreases production of ADH, so that less ADH is released from the posterior pituitary gland.

5.4 Review

1 Discuss how malfunctions in homestatic mechanisms can lead to disease, using an example.

Answer: Homeostatic mechanisms are extremely sensitive to shifts in internal conditions. Prolonged exposure to stressors and ageing of the organism can lead to a decline in the efficiency of homeostatic mechanisms. Reductions in efficiency can lead to unstable internal environments and malfunctions in homeostatic mechanisms. An example is Graves' disease, of which hyperthyroidism is a symptom. In patients with Graves' disease, the immune system makes thyroid stimulating immunoglobulin (TSI), which is an antibody that mimics TSH, stimulating the thyroid to make more T3 and T4 hormones than the body needs. The hypersecretion of thyroid hormones leads to a range of problems, such as increased heart rate, weight loss, goitres, fatigue and anxiety.

2 Why do people with diabetes sometimes need to have sweet drinks or food?

Answer: First aid treatment for diabetics should always assume hypoglycaemia (low blood sugar) and administer fruit juice or a lolly such as barley sugar to quickly increase the blood glucose level. It is important to rapidly increase blood glucose levels to prevent the person losing consciousness. Once the patient is more alert, this can be followed by foods that contain more substantial carbohydrates.

3 Why does type 1 diabetes cause high blood glucose levels?

Answer: Individuals with type 1 diabetes are unable to respond to high levels of blood glucose by producing insulin. As a result, blood glucose levels are high because glucose is not converted into glucagon.

4 Explain how brown fat might be important in diabetes management.

Answer: Increased brown fat stores contribute to heightened insulin sensitivity. This means that people with more brown fat need less insulin to bring their blood glucose levels down. Research has shown that in cool climates, levels of brown fat increase. This means that people with diabetes may be able to increase their brown fat deposits, making themselves more sensitive to insulin and therefore less reliant on large doses of insulin by injection.

5 How is thyroid disease diagnosed? How would blood test results differ between someone with hyperthyroidism and hypothyroidism?

Answer: Thyroid disease is diagnosed by looking at symptoms and blood test results. Blood test results of someone with hyperthyroidism would have elevated levels of triiodithyronine (T3) and thyroxine (T4) and low levels of TSH. In someone with hypothyroidism, blood tests would reveal low levels of T3 and T4, and raised levels of TSH.

6 Why do disruptions to homeostatic mechanisms of the thyroid gland affect so many different systems in the body?

Answer: The thyroid hormones interact with cells throughout the whole body, regulating growth, development and metabolic rate. Malfunction of the thyroid can therefore have widespread and serious effects on a range of organs and bodily functions.

 ISBN 978 1 4886 1122 3

Chapter 5 Review

1 What are adaptations? Describe how they benefit individuals, populations and species.

Answer: Adaptations are inherited characteristics that increase the likelihood of survival and reproduction of an organism in a particular environment. They have a genetic basis and are passed from generation to generation. Adaptations are the result of the evolutionary process of natural selection. Organisms that are best suited to their environment (the fittest) are more likely to survive and reproduce, passing on their advantageous adaptations to their offspring. While adaptations help individual organisms survive, they are also critical for the survival and reproduction of populations and species. Populations and species that are well suited to their environment will be more successful, with higher rates of survival and reproduction.

2 Complete the following table, where S = structural (the way it is built), P = physiological (the way it functions) and B = behavioural adaptation.

Organism	Feature	S, P or B	Benefits to organism
Mangrove	pneumatophore		
Honey possum	long, brush-like tongue		
Kangaroo	sleeps in shade during the day		
Echidna	goes into torpor		
Saltbush	salt-secreting glands in leaves		

Answer:

Organism	Feature	S, P or B	Benefits to organism
Mangrove	pneumatophore	S	enables the mangrove to exchange gases at low tide
Honey possum	long, brush-like tongue	S	enables the honey possum to obtain nectar from flowers
Kangaroo	sleeps in shade during the day	B	reduces water loss from the body
Echidna	goes into torpor	P and B	reduces the animal's need for energy
Saltbush	salt-secreting glands in leaves	P	minimises water loss

3 The ability of the male southern pygmy perch to change colour in the breeding season and establish a territory is best interpreted as:

A structural adaptation

B behavioural adaptation

C physiological adaptation

D limiting factor in reproduction

Answer: C

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4 Complete the following table with adaptations that animals and plants have to survive in these different environments.

Environment	Adaptation		
	Structural	**Physiological**	**Behavioural**
Desert			
Snow			
Salty soil or water			
Deep underwater			
Long, cold winter			
Intertidal zone			

Answer:

Environment	Adaptation		
	Structural	**Physiological**	**Behavioural**
Desert	waxy cuticle on leaves	carotid rete heat exchange	burrowing underground
Snow	thick fur and fat layer	antifreeze proteins	hibernation
Salty soil or water	regulate opening of stomata	salt-excreting glands	shedding leaves loaded with salt
Deep underwater	streamlined body shape	high levels of haemoglobin and myoglobin	reduced breathing rate
Long, cold winter	thick fur and fat layer	hibernation; brown fat stores	migration, hibernation
Intertidal zone	hard, thick shell	lower metabolic rate during periods of exposure	shelter seeking

5 Jack rabbits, which are often found in deserts, have disproportionately large ears that have a rich network of blood vessels close to the skin. Kangaroos have a special network of capillaries that lie near the surface of the skin on the inside of the forearms. On very hot days, kangaroos can often be seen licking their forearms.

State the type of adaptation and how this common feature might help each animal regulate its temperature.

Answer: The type of adaptation is functional adaptation. The adaption enables the organism to divert blood to its extremities which then lose heat and cool the organism by convection and radiation.

6 Describe how an emperor penguin is adapted to life in the harsh Antarctic climate, mentioning at least one structural, one physiological and one behavioural adaptation.

Answer:

Structural: Emperor penguins have four layers of thick, scale-like feathers that form a windproof and waterprooof coat. A thick layer of blubber keeps them warm while swimming in the icy ocean. Penguins and other animals in cold climates tend to have bodies with a small surface area to volume ratio, which helps them conserve body heat.

Physiological: A complex heat exchange system allows the penguins to recapture around 80% of heat in their breath through their nasal passages. They are also able to go without food for long periods (up to 100 days).

Behavioural: Penguins huddle in large groups to produce and conserve body heat. Thousands of male penguins will huddle together to protect their eggs during winter. By huddling, penguins decrease the surface area of the group exposed to the harsh environment. They continually rotate the animals on the outside, each taking a turn in the freezing cold winds.

 ISBN 978 1 4886 1122 3

7 Describe how CAM (crassulacean acid metabolism) photosynthesis is a beneficial adaptation for plants living in the dessert.

Answer: In plants that use CAM photosyntheis, the stomata open only at night to collect carbon dioxide. Rather than using the carbon dioxide immediately, as non-CAM photosynthesising plants do, CAM plants store it as malic acid in cell vacuoles. During the day the malic acid is transported to the chloroplasts, where it is converted back to carbon dioxide, and then used during photosynthesis. By storing the carbon dioxide required for photosynthesis at night, the plant is able to close its stomata during the heat of the day to reduce water loss. This physiological adaptation allows plants to survive in environments of extreme heat and aridity.

8 Why is it important for an organism to be able to regulate its internal environment?

Answer: The internal environment of an organism must always remain within tolerable limits, even when conditions in the external environment are fluctuating widely. When a change occurs in the external environment, an adjustment must be made in the internal environment. This enables the organism to adapt to the changing conditions and maintain a stable internal environment even while external conditions fluctuate. If an organism is not able to adapt to its external environment, it will suffer cellular damage and possibly death when conditions change.

9 How do receptors and effectors maintain homeostasis?

Answer:

A disturbance acts as a stimulus that is detected by an appropriate receptor.

Activation of the receptor results in a signal being sent to a control centre.

The control centre or specific organ receives the signal.

The signal then stimulates effectors in the nervous and/or hormonal systems, or other tissues.

An appropriate response in the animal's physiology or behaviour is triggered that reduces the impact of the disturbance on the receptor.

10 Arrange the following terms from first to last in the order of their involvement in a physiological response: control centre, effector, receptor, response, stimulus.

Answer: stimulus, receptor, control centre, effector, response

11 Indicate which statements are true or false.

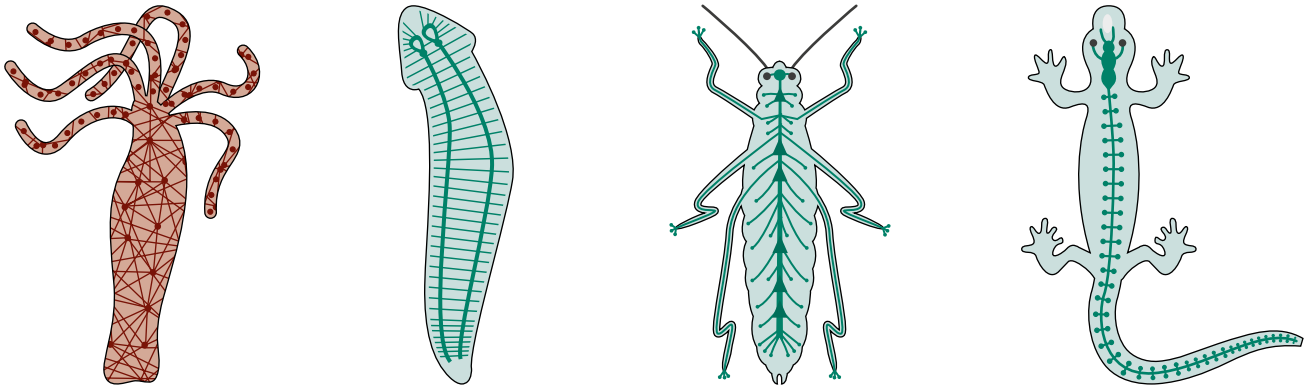
- One hormone can affect every cell
- Hormones affect target cells
- Target cells contain receptors
- Receptors recognise hormones specific for them
- Receptors recognise groups of hormones that are specific for them, e.g. peptide hormones
- Receptors for steroid hormones are located in the cytoplasm and receptors for peptide hormones are located in the cell surface membrane

Answer:

- One hormone can affect every cell – false
- Hormones affect target cells – true
- Target cells contain receptors – true
- Receptors recognise hormones specific for them – true
- Receptors recognise groups of hormones that are specific for them, e.g. peptide hormones – false
- Receptors for steroid hormones are located in the cytoplasm and receptors for peptide hormones are located in the cell surface membrane – true

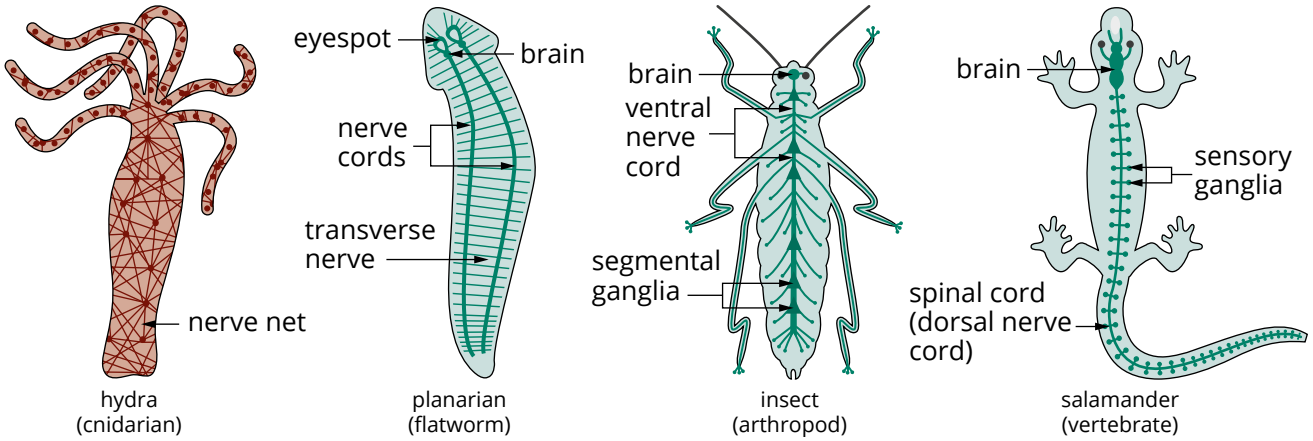
 ISBN 978 1 4886 1122 3

12 Label the parts of the nervous systems of these organisms.



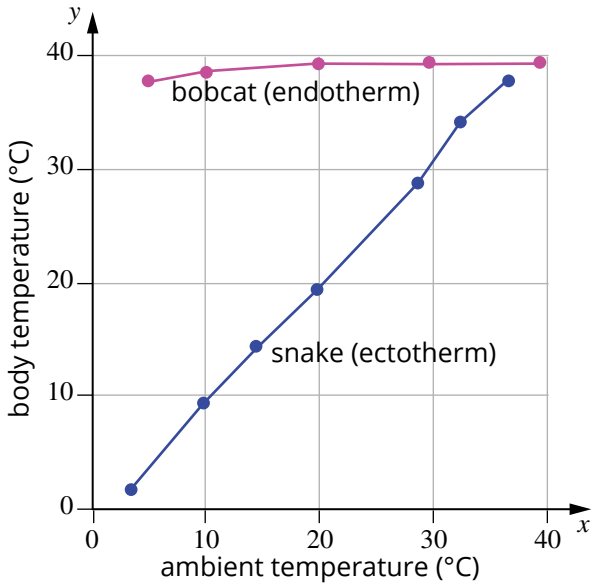
hydra (cnidarian) | planarian (flatworm) | insect (arthropod) | salamander (vertebrate)

Answer:



hydra (cnidarian) | planarian (flatworm) | insect (arthropod) | salamander (vertebrate)

13 Endothermic and exothermic animals regulate their body temperatures in different ways. Consider the following graph, which shows the body temperatures of a bobcat (pink line) and a snake (blue line) for different ambient environmental temperatures.



Source: © Eric Isselee/Shutterstock.com

Source: © Vasiliy Vishnevskiy/123rf

a When the ambient temperature is 30 °C, what is the body temperature of the snake?

b Why does the body temperature of the snake continue to increase as the ambient temperature increases, but the body temperature of the bobcat does not?

 ISBN 978 1 4886 1122 3

Answers:

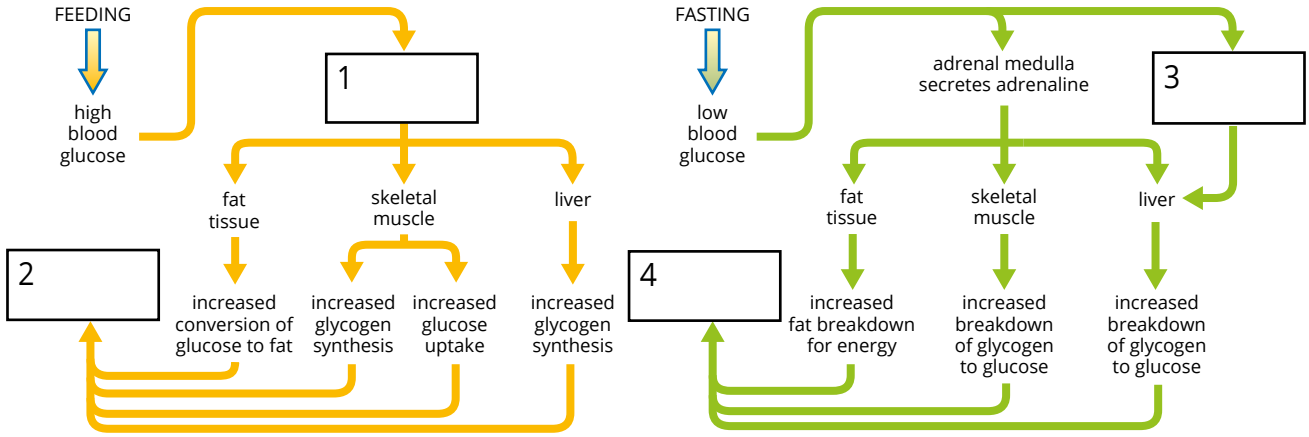
a 31 °C

b Because it is an endotherm, the snake is not able to internally regulate its body temperature. When the ambient temperature increases, the snake's body temperature also increases. The bobcat is an ectotherm and is able to regulate its own body temperature, so it is not so affected by the changes in the environment.

14 Describe the thermoregulatory mechanisms that occur during and immediately after a fever.

Answer: Pyrogens in bacteria and viruses induce fever by triggering the body's immune response, signaling the hypothalamus to increase your body's temperature. The body responds to these signals from the hypothalamus by initiating warming activities that generate and retain heat. Peripheral blood vessels are constricted to reduce blood flow and heat loss through the skin. The reduction in blood flow to the skin makes the skin pale and feel cold, even though the body is working to retain heat. If the body temperature is still too low, you might start shivering to generate more heat. The body temperature will continue to increase until it reaches the new higher set-point of the hypothalamus. The fever is maintained until the invading organisms are eliminated, and their effect on the hypothalamus ceases. The fever is then broken and the mechanisms that were used to warm your body are reversed; blood vessels dilate, shivering stops and sweating works to cool your body back to the normal temperature range.

15 Provide labels for boxes 1, 2, 3 and 4 in the following diagram to complete the steps of the feedback mechanisms that regulate glucose levels in the blood.



Answers:

1 beta cells in the pancreas secrete more insulin

2 lowers blood glucose

3 alpha cells in the pancreas secrete glucagon

4 raises blood glucose

16 What are the primary functions of the kidneys? Which structures in the kidney are responsible for these functions?

Answer: The primary functions of the kidneys are filtration, reabsorption and secretion to maintain water balance in the organism. The nephrons carry out these functions in the kidneys.

 ISBN 978 1 4886 1122 3

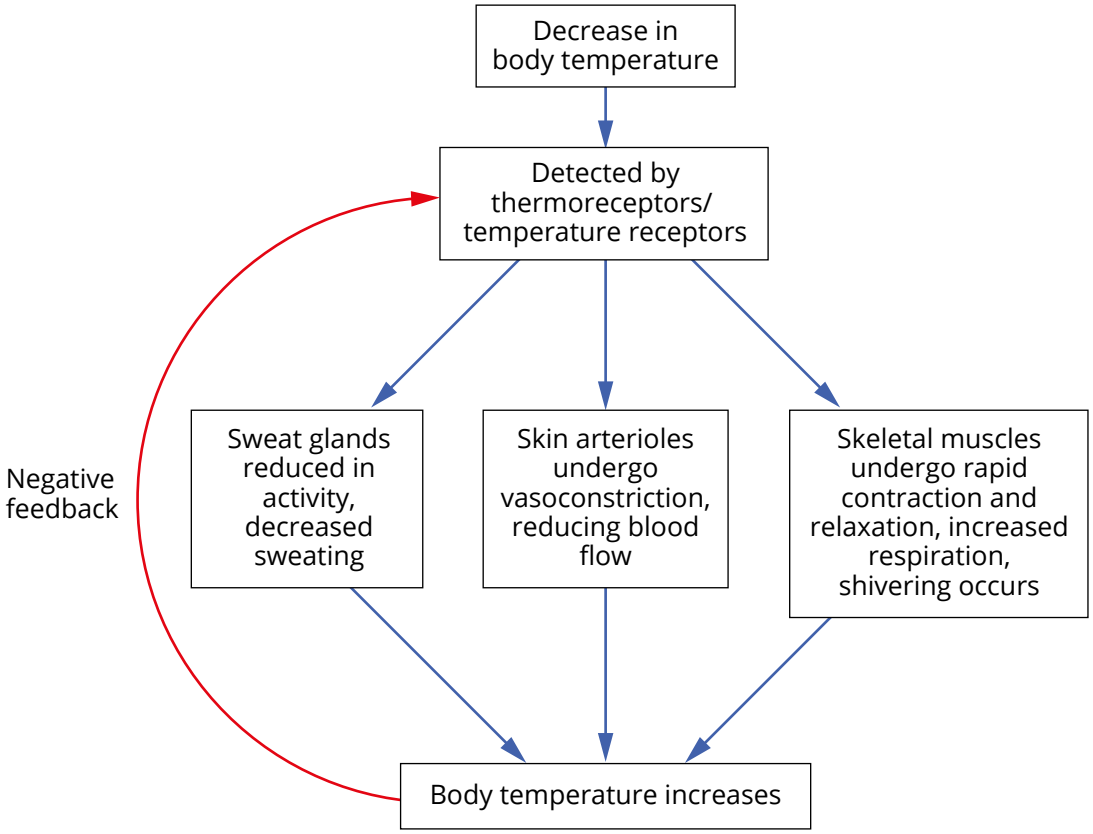
17 **a** Explain the principle of negative feedback in homeostasis.

b Using the aid of a diagram, explain how a decrease in body temperature can be brought back up again. In your diagram, draw and label an arrow to show where negative feedback occurs.

Answers:

a When a change in the environment is detected, a response takes place to bring the system back to normal state/within limits. When the normal state is reached, the response is stopped so as to prevent over reaction.

b



18 Diseases of the endocrine system fall into three groups. What are they? Provide an example of each.

Answer:

Endocrine hyposecretion – hypothyroidism

Endocrine hypersecretion – excessive growth hormone release resulting in gigantism

Cancers of endocrine glands – thyroid or pancreatic cancer

19 Using either type 1 diabetes or hyperthyroidism as an example, discuss how chronic disease can occur when there is a malfunction of homeostatic mechanisms in the body.

Answer: Answers will vary. Answer should include:

- a named chronic disease
- a description of the chronic disease (cause, symptoms, treatment and control)
- an explanation of the particular homeostatic mechanism that has broken down or failed and a reason why it has caused the disease.

 ISBN 978 1 4886 1122 3

Chapter 6 Questions and answers

6.1 Review

1 Define 'biodiversity'.

Answer: Biodiversity is the variety of living organisms on Earth.

2 List four benefits of classifying and naming organisms.

Answer: Being able to classify organisms such as parasites enables scientists to accurately record and recall information about particular species (e.g. host organisms, incubation periods, life cycle). Knowing this information and being able to relate this to particular species enables scientists to intervene in the life cycle of parasites and thus control them. Other benefits include being able to identify weeds and invasive species, toxic plants and fungi, and venomous animals; identify, propagate and harvest useful species; catalogue biodiversity in specific locations and monitor populations; and identify when species are at risk.

3 The scientific naming of species is based on a binomial system.

a What does 'binomial' mean?

b What classification groups are used in the name of a species?

c What conventions are used when writing the name of a species? Give an example.

Answers:

a Binomial means 'two names'.

b Genus and species.

c The genus name (generic name) and species name (specific epithet) are Latinised words. The genus name starts with a capital letter, and the specific name starts with a lower-case letter. The whole name is written in italics. For example, *Canis familiaris*, the domestic dog.

4 Write a definition of 'species'.

Answer: Members of the same species:

- look alike (they are more alike in appearance than other organisms)
- are able to interbreed in nature and their offspring are fertile (if they reproduce sexually)
- have the same, or very similar, habitat requirements.

5 In the Linnaean system of classification, what characteristics are used in the classification of organisms?

Answer: In the Linnaean system of classification, morphological characteristics are used in the classification of organisms.

6 Rewrite the following list of taxon names from the most general taxon to the least general taxon:

class, domain, family, genus, kingdom, order, phylum, species

Answer: domain, kingdom, phylum, class, order, family, genus, species

7 What does a phylogenetic tree show?

Answer: A phylogenetic tree shows the evolutionary relationship between species. That is, which species are more closely related to each other.

 ISBN 978 1 4886 1122 3

6.2 Review

1 Outline why maintaining biodiversity is important.

Answer: We rely on the biodiversity of the planet for our existence. We need plants and animals for food, and wood for building materials and other purposes. We also use plants to discover and make many medicines and other products. Maintaining the Earth's biodiversity is essential because it is a reservoir for bioprospecting new food sources and medicines.

2 List the types of values possessed by a species that warrant its conservation, and give one example of each.

Answer:

Species possess aesthetic, ecological and practical values.

Aesthetic value – People appear to need the beauty and harmony of natural landscapes of trees, mountains, lakes and wildlife.

Ecological value – Plants are producers of food. During photosynthesis they release the oxygen that we breathe. Plants also provide shelter and nest sites for animals.

Practical value – Organisms are used for food, medicine, industrial materials, crop pollination and bioprospecting.

3 Describe the two main conservation strategies outlined in this chapter (*in situ* and *ex situ*).

Answer:

In situ is where the species is kept in its natural environment. This involves:

- preserving the habitat through private purchase or government action
- eliminating alien species from the protected area
- managing protected areas to sustain native flora and fauna
- restoring degraded ecosystems.

Ex situ is where the animal is bred in captivity, such as zoological gardens. This involves:

- legally protecting the endangered species
- managing the habitat
- propagating the endangered species in captivity
- reintroducing the species to the managed habitat.

4 Explain the ways in which an invasive species can have a significant impact on the survival of a native species.

Answer:

They can out-compete native species for resources such as food, and shelter. They can also directly kill them as native species might not have evolved the natural defenses against the invasive species.

5 Outline some methods for controlling invasive species.

Answer: The two main ways for controlling invasive species are prevention and control.

The main aim of prevention is to prevent the organism from becoming established. The Department of Agriculture and Water Resources is responsible for the protection of biological invaders into Australia. Australia has some of the strictest quarantine laws to try to stop invasion from alien species and diseases.

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Control measures depend on the species being eradicated. Weeds can be controlled with herbicides, and insect pests with insecticides. However, the cost is usually high and there are problems with poisons moving through food chains and affecting native species. An alternative is to use biological control.

6 What does 'biological control' mean?

Answer: Biological control means the use of a natural predator or parasite to limit the growth of a pest species.

7 Define bioprospecting.

Answer: Bioprospecting is the exploration of biodiversity for new resources that have social and commercial value.

8 Our native plant and animal species are a priceless resource.

a Explain the argument that species should be saved because they have ecological value.

b Name an Australian species that is endangered, and explain why it should be saved using the three reasons listed in the text as a guide.

c For the Australian species that you have named in part b, outline the strategies currently used to conserve the species.

Answers:

a This means that species should be saved because they have important roles in ecosystems. The loss of a species from an ecosystem could cause the system to become unbalanced and unsustainable. The survival of humans depends on the continuing functioning of ecosystems to provide the resources we need, especially clean air, water and food.

b Any of a large number of species could be selected for this question. Plants would probably be easier to discuss than animals. It will be necessary to look up a list of endangered species, possibly on the internet, and design an answer around this.

A sample answer might be: The southern cassowary (*Casuarius casuarius*) is currently listed as vulnerable. The fall in numbers is due to clearing and fragmentation of rainforest, and increased mortality from cars and dogs. The southern cassowary is of ecological importance as cassowaries play an important role in the ecology of rainforests. They are one of the only animals that can disperse the seeds of large rainforest fruits over long distances.

c Answers will vary. However, the answer should be centred around the following points, depending on which species was chosen.

Conservation of species which can be carried out through:

- *in situ* conservation where the species is kept in its natural environment
- *ex situ* conservation where the animal is bred in captivity
- establishing protected areas
- prevention and control of invasive alien species
- reducing pollution to protect species
- combating climate change
- regulation to counter overexploitation.

 ISBN 978 1 4886 1122 3

Chapter 6 Review

1 Outline the value of classifying organisms.

Answer:

Classification of organisms allows:

- the organisation of information, which helps to identify organisms
- the effective communication between scientists
- the prediction of characteristics shared by members of a group (taxon)
- the suggestion of evolutionary relationships between organisms
- the suggestion of the closeness of evolutionary relationship between organisms, based on amount of similarity between organisms.

2 In the binomial system, which two taxa (groups) are used to identify a type of organism?

Answer: Genus and species

3 What are *Avicularia metallica* and *Poecilotheria metallica*?

A different subspecies of one species

B different species in the same genus

C the same species with two names

D different species in different genera

Answer: D

Even though both species have the same 'species name' – *metallica*, they do not belong to the same genus. Hence they are not the same species, and are in fact two different species with a similar 'descriptive' name given.

4 Fill in the blanks with the most suitable term:

Organisms classified at the level of _____ are most alike. Organisms in different _____ are most different. Species in different families are more _____ related to each other than species in the same genus.

Answer: Organisms classified at the level of (**species**) are most alike. Organisms in different (**domains or kingdoms**) are most different. Species in different families are more (**distantly**) related to each other than species in the same genus.

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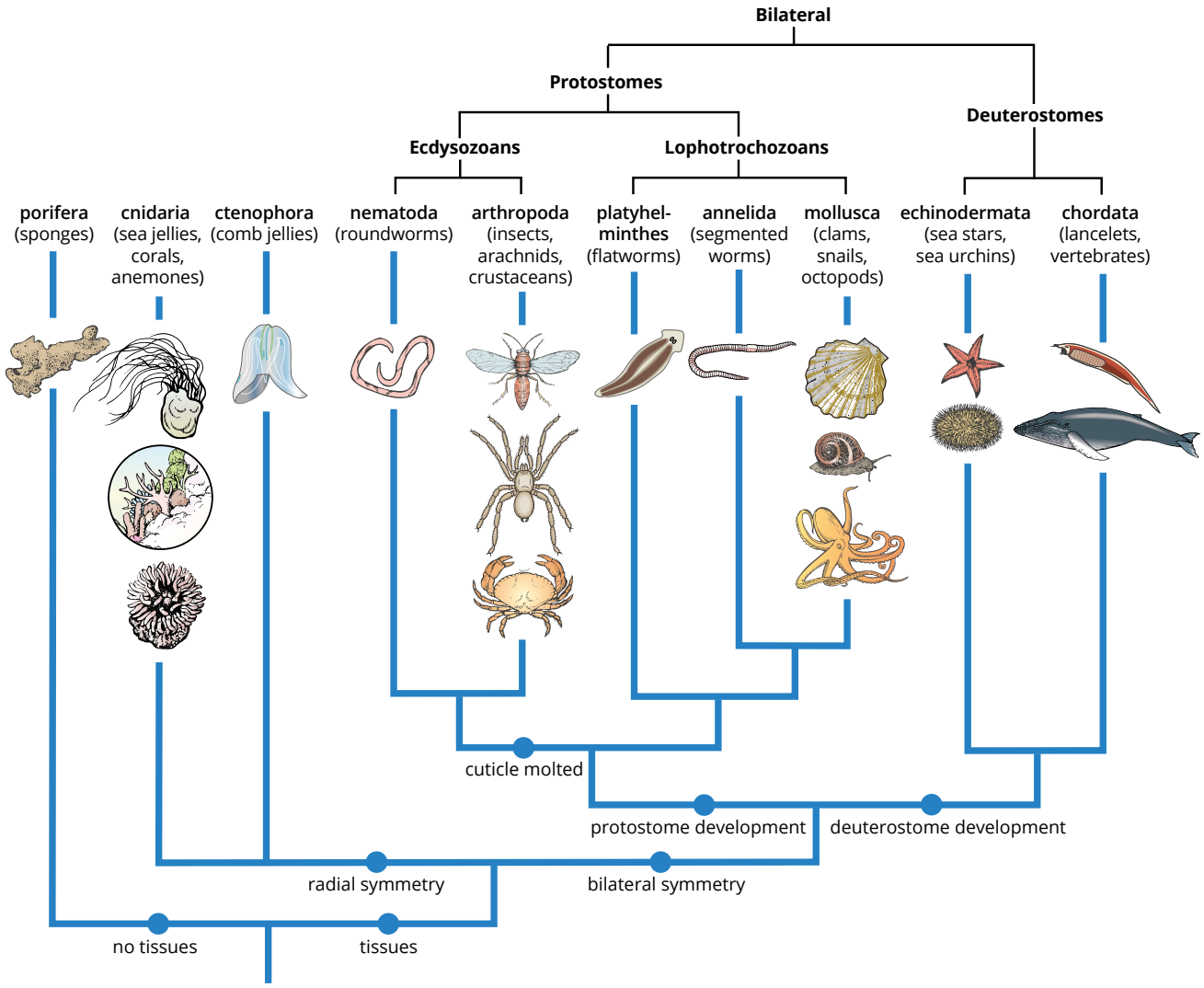
5 The figure below shows a phylogenetic tree of some major animal phyla.



a Which animals are most closely related?

- **A** sponges and corals
- **B** roundworms and segmented worms
- **C** molluscs and flatworms
- **D** echinoderms and crustaceans

b Name one morphological characteristic that would enable a biologist to separate the following pairs into separate categories:

- **i** a comb jelly and a platyhelminth
- **ii** a comb jelly and a sponge

Answers:

a C

b **i** radial versus bilateral symmetry

ii sponge has no specialised tissues, comb jellies do

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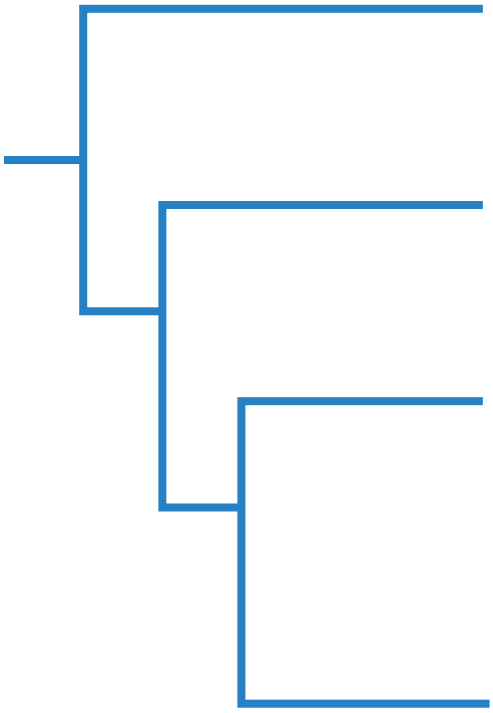
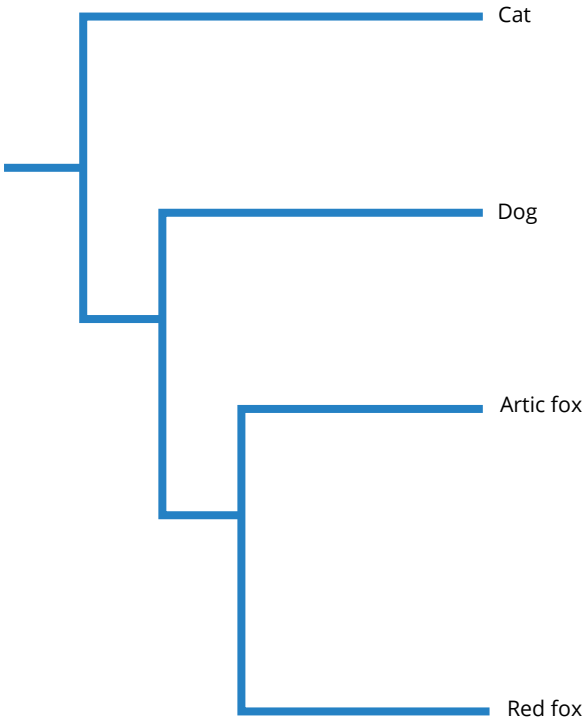
6 The following table compares the group names for red fox, arctic fox, dog and cat.

Group	Red fox	Arctic fox	Dog	Cat
Kingdom	*Animalia*	*Animalia*	*Animalia*	*Animalia*
Phylum	*Chordata*	*Chordata*	*Chordata*	*Chordata*
Class	*Mammalia*	*Mammalia*	*Mammalia*	*Mammalia*
Order	*Carnivora*	*Carnivora*	*Carnivora*	*Carnivora*
Family	*Canidae*	*Canidae*	*Canidae*	*Felidae*
Genus	*Vulpes*	*Vulpes*	*Canis*	*Felis*
Species	*Vulpes vulpes*	*Vulpes lgopus*	*Canis lupus*	*Felis catus*

Label the phylogenetic tree below, correctly indicating the relationships between these four animals.



Answer:

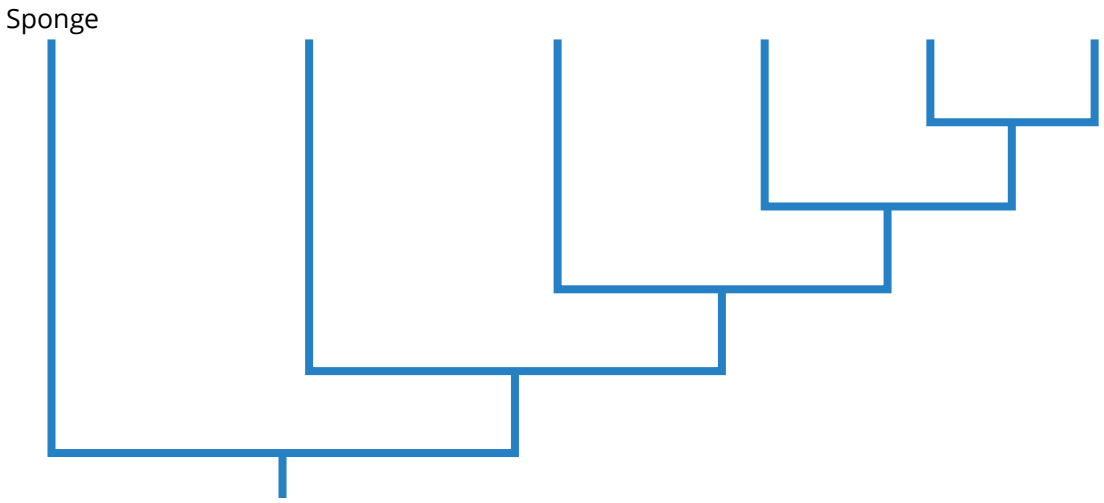


 ISBN 978 1 4886 1122 3

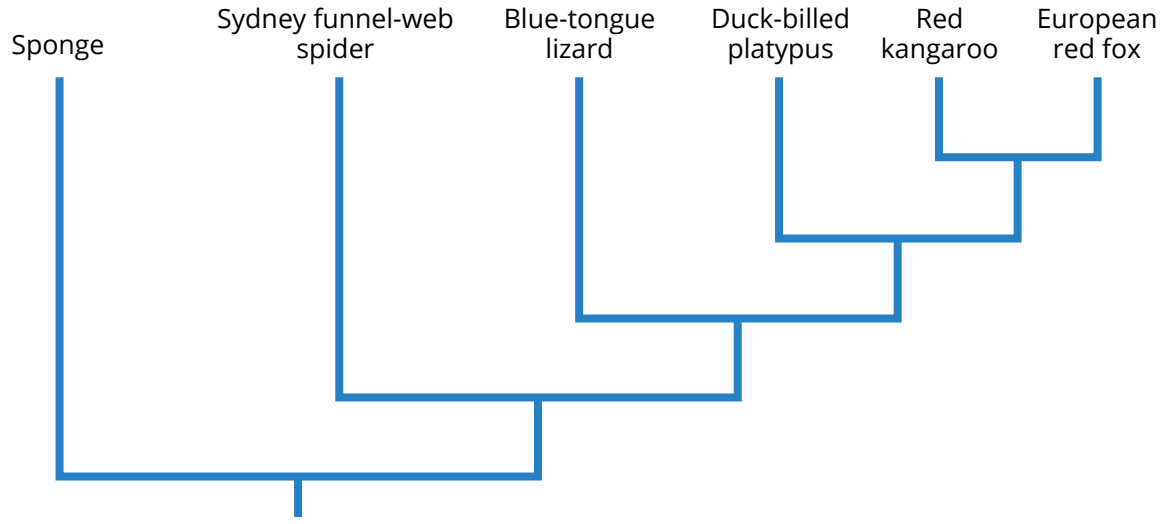
7 The following table is a character matrix that lists six animals and four morphological characteristics. A tick (✓) indicates that the animal has this characteristic while a cross (✗) indicates that the characteristic is absent. (Hint: Organisms with more similar characteristics will be more closely related on the phylogenetic tree.)

Animal	Spinal cord (vertebra)	Legs	Hair	Placenta present during pregnancy
Blue-tongue lizard	✓	✓	✗	✗
Platypus	✓	✓	✓	✗
Red fox	✓	✓	✓	✓
Sponge	✗	✗	✗	✗
Funnel-web spider	✗	✓	✓	✗
Red kangaroo	✓	✓	✓	✓

Based on the features above, complete the phylogenetic tree below.



Answer:



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8 The world's human population is more than 7 billion. By 2100 the human population could be 12 billion. In order to sustain this number of people, more land will have to be used to grow crops that are consumed directly by humans, or fed to stock that are used to produce food for humans.

a What are the implications of human population growth and activities for the biodiversity of the planet?

b Outline two reasons why biodiversity is important.

Answers:

a More people need more land and more of the Earth's finite resources. This means more habitat destruction and therefore reduced biodiversity. The industrialisation of countries such as China and India, with their large populations, will also increase the pressure on resources and habitats. An increase in inputs of carbon dioxide into the atmosphere will accelerate climate change, which will probably accelerate species extinctions.

b Biodiversity promotes stability in ecosystems. It ensures that we have a range of organisms for food and medicines. Clean air, water and healthy soil all depend on a diverse range of organisms. A diverse range of organisms can also be a source of pleasure and enjoyment for us.

9 Discuss the reasons for *ex situ* conservation of endangered species.

Answer: *Ex situ* conservation is carried out outside the natural habitat; for example, captive breeding of mountain gorillas in zoos, cultivation of plants in botanic gardens. It can prevent the extinction of species, protect the genetic pool and maintain biodiversity. Species that have been bred in captivity/cultivated can be reintroduced back into their natural habitat. *Ex situ* conservation can also be used for education and research. Conserving animals in captivity allows the use of modern technology such as assisted reproductive methods.

10 Discuss the reasons for *in situ* conservation of endangered species.

Answer: *In situ* conservation involves keeping endangered species in their natural habitats. It is less expensive because there is no need to maintain or specially design habitats to meet the needs of the species. It also allows more individuals to interbreed, providing more genetic variation. Interactions with other organisms within the habitat will also continue, so they will not be affected.

11 Outline one example of biological control of invasive species.

Answers will vary. Likely answers are:

Rabbits controlled by the release of myxoma virus or rabbit calicivirus.

Prickly pear controlled by larvae of the cactoblastis moth.

12 Discuss reasons for conserving the biodiversity of a rainforest ecosystem.

Answers will vary. A sample answer is:

Aesthetic value: Humans value the beauty of rainforests.

Ecological value: Species in the rainforest are interdependent, so loss of species affects many other species.

Ecosystem services: Deforestation of rainforests increases soil erosion/flooding/increased carbon dioxide atmospheric levels.

Practical value: Potential of undiscovered medicines (bioprospecting) and ecotourism.

Cultural value: Rainforests are important in the cultures of many people.

 ISBN 978 1 4886 1122 3

Chapter 7 Questions and answers

7.1 Review

1 What is an ecosystem? Give two examples of an ecosystem.

Answer: An ecosystem is a self-sustaining community of living organisms and their physical environment. A rainforest and a rock pool are examples of ecosystems.

2 Compare and contrast the two types of mutualism. Use that information to identify the type of mutualism that exists between a plant being pollinated by an insect, when the plant has other potential pollinators.

Answer: In both obligate and facultative mutualism, both species involved benefit from the interaction. In obligate mutualism, the interaction is necessary for both species' survival. In facultative mutualism, both species can survive without the mutualistic relationship.

The type of mutualism in which the insect disperses the pollen of the plant is facultative mutualism. The two species are not entirely dependent on each other. The plants may have their seeds or pollen dispersed by other means, although perhaps not as efficiently, and the insects or birds may find food from other sources.

3 The spotted jelly, *Mastigias papua*, needs to incorporate free-living algae called zooxanthellae, because it obtains its energy mainly from the carbon fixed by the algae. The spotted jelly is also able to obtain energy by feeding on phytoplankton, tiny invertebrates and microbes. What type of interspecific relationship do the spotted jelly and algae have?

A predatory

B commensalism

C obligate mutualism

D facultative mutualism

Answer: B

4 The pilot fish, *Naucrates ductor*, eats ectoparasites that live on the skin of white-tipped sharks, *Carcharhinus longimanus*. What type of interspecific relationship do the pilot fish and sharks have?

A predatory

B commensalism

C obligate mutualism

D facultative mutualism

Answer: D

5 Explain how parasitism differs from mutualism. Give examples of specific organisms.

Answer: Parasitism is when one organism benefits while the other organism suffers. Mutualism, on the other hand, is when both organisms benefit and neither suffers.

An example of parasitism is the tapeworm (parasite) and human (host). The tapeworm gains digested food from human, while the human suffers from weight loss/cysticercosis.

An example of mutualism is the interaction between the sea anemone and hermit crab. The sea anemone gains mobility while the hermit crab gains protection and camouflage.

 ISBN 978 1 4886 1122 3

6 The flame robin builds its nest on a tree branch. What type or types of relationships could this be? Why?

Answer: This is likely to be commensalism, as the bird benefits from building its nest in the tree, but the tree doesn't benefit. However, there may be other factors at work, where the tree may be harmed or benefitted by the relationship, in which case the relationships would be a harmful interaction or mutualism respectively.

7 *Penicillium* species produce penicillin. Explain how this is an example of both allelopathy and amensalism.

Answer: *Penicillium* secretes a chemical known as penicillin that kills certain bacteria. Allelopathy is when an organism produces and secretes chemicals that affect the growth, reproduction or survival of other organisms. In this case the *Penicillium* is affecting the survival of bacteria. As *Penicillium* is unharmed in this process, but the bacteria is harmed, this is an example of amensalism.

8 State whether each of the following interactions is parasitism, mutualism or predation.

a lice living in human hair and feeding on human blood

b orangutan feeding on durian fruits

c a sea eagle catching and eating a fish

d a lizard eating an earthworm

e clownfish feeding among sea anemones

f vampire bats feeding on the blood of live birds or mammals

g bees feeding on a flower and taking pollen to other flowers

h a crown-of-thorns sea star feeding on coral polyps

i *Plasmodium* protozoans living in humans and causing malaria

Answers:

a parasitism

b mutualism

c predation

d predation

e mutualism

f parasitism

g mutualism

h predation

i parasitism

9 On a seashore rock platform, a marine biologist notices bare patches in an area covered by sea lettuce (a seaweed). She covers some of these patches in fine mesh that allows light to penetrate and sea water to flow over it. The sea lettuce grows again where the mesh has been placed, but not in the other bare patches. How do you explain this? What relationship is occurring?

Answer: The most likely cause for the original bare patches is grazing by an animal. This would be an example of predation, which is a harmful relationship.

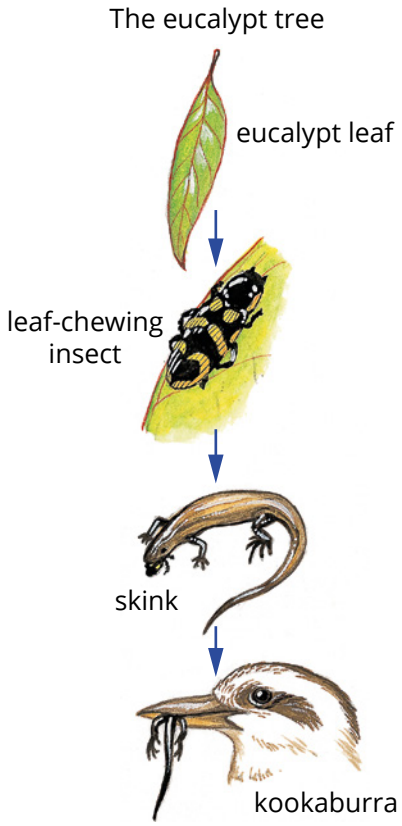
 ISBN 978 1 4886 1122 3

7.2 Review

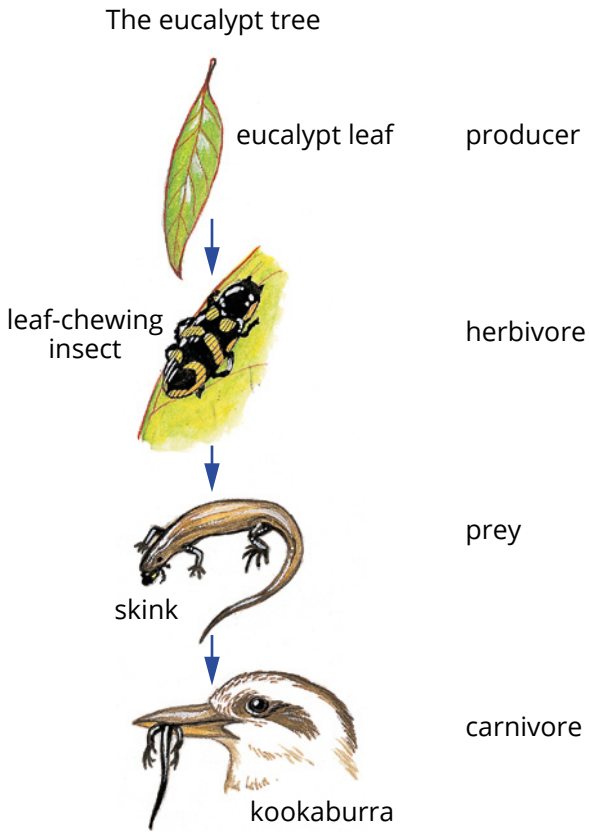
1 What kind of organism is always the first link in a food chain? Why?

Answer: Autotrophs (producers) are at the first trophic level in any food chain because they produce the food for all consumers.

2 What is the best description for the role of each organism in the following food chain?



Answer:



 ISBN 978 1 4886 1122 3

3 Select the list that contains only decomposers and detritivores.

A algae, bacteria, termites, echidnas

B vultures, ticks, earthworms, fungi

C millipedes, earthworms, bacteria, fungi

D snails, maggots, dung beetles, crows

Answer: C

4 Explain with an example how a species might be at more than one trophic level in a food web.

Answer: If there is a terrestrial food web in which a bird feeds on insects that feed on nectar, the bird may also feed on nectar. In this way the bird is at the third trophic level because it is the top predator, but it is also at the second trophic level because it feeds on a plant that produces flowers, which is a producer.

5 Make up a table that lists the six different types of consumers and what they eat, and include two examples of each type of consumer. The first has been done for you.

Type of consumer	What it eats	Examples
herbivore	plant matter such as leaves, seeds and fruits	koala, mouse

Answer:

Type of consumer	What it eats	Examples
herbivore	plant matter such as leaves, seeds and fruits	mouse/koala
carnivore	eats other consumers	crocodile/eagle
parasite	lives and feeds on or in a live host organism	tapeworm/mistletoe
scavenger	eats other dead animals	vulture/hyena
detritivore	feeds on non-living organic matter	snail/termite
decomposer	breaks down non-living organic matter, converting it to inorganic compounds and feeding on it	bacteria/fungi

6 **a** What is the difference between a food chain and a food web?

b What is the advantage of a complex food web over a simple one?

Answers:

a A food chain shows a simple sequence of feeding relationships between organisms; for each organism only one food source is shown. A food web shows the multiple feeding relationships between organisms, in which one species might rely on several species for a food source and vice versa.

b A complex food web is more stable than a simple one. In a food web, all organisms rely on each other for food, so the loss of a species would have a large effect. For example, in a simple food web a carnivore might feed only on one herbivore, and that herbivore might feed only on one plant. If the plant is eradicated, the herbivore and the carnivore will die out. However if the food web is more complex, the herbivore and carnivore may have other food sources that enable them to survive.

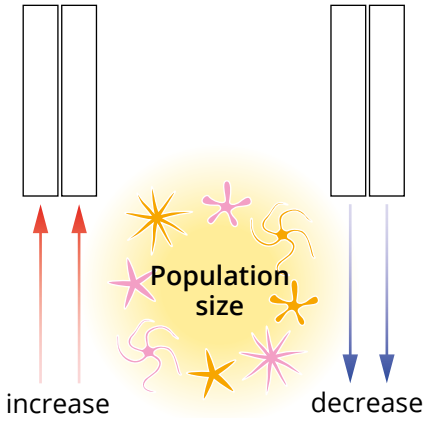
 ISBN 978 1 4886 1122 3

7 A keystone species is critical to the stability of a whole ecosystem. Give one example of a species like this and explain what makes it a keystone species.

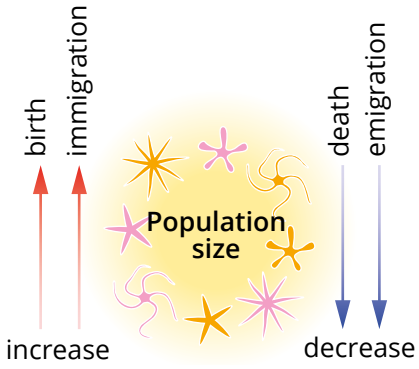
Answer: Elephants are a keystone species because they prevent the grasslands from being taken over by shrubs and trees, by eating the young plants. This maintains the grasses that grow in the ecosystem, which are the food source of the grazing herbivores. Without elephants, less grass would grow and the number of grazing herbivores would be greatly reduced.

7.3 Review

1 Label the blanks in this diagram with the four processes that affect population size for every species.



Answer:



2 **a** Describe an exponential growth pattern.

b In what kinds of organisms and under what conditions could this kind of population growth occur?

c Name two reasons why the crown-of-thorns sea star undergoes population explosions.

Answers:

a A population increase that becomes more rapid with time and is represented in a graph by a J-shaped upward growth curve.

b Populations of organisms that have a short generation time and give rise to large numbers of offspring are likely to give rise to exponential growth when conditions are most favourable and resources are abundant.

c The crown-of-thorns sea star reproduces in great numbers; up to a million eggs are produced in a spawning season by a female. Heavy rain and floods wash nutrients into the sea, increasing phytoplankton, which provides food for the sea star.

3 Compare the concepts of distribution and abundance of a species.

Answer: The abundance of a species relates to how many individuals there are, whereas the distribution relates to where the species can be found, and in which habitats.

 ISBN 978 1 4886 1122 3

4 Below is a list of factors that influence ecosystems. State whether each one is a biotic or abiotic factor.

a water

b algae

c pH

d soil

e trees

f animals

g salinity

h hawk

Answers:

a water – abiotic

b algae – biotic

c pH – abiotic

d soil – abiotic

e trees – biotic

f animals – biotic

g salinity – abiotic

h hawk – biotic

5 Use a specific example to explain how one abiotic factor can affect population growth.

Answer: Water is one example of an abiotic factor that affects population size. During a drought, which is a density-independent factor, carrying capacity of the environment is affected. When water availability is reduced by drought, the number of individuals of a species that the environment can support will also be reduced.

6 Which answer lists only density-independent factors?

A predation; water depth; availability of sunlight

B competition for food; loss of habitat; drought

C competition for water; bushfire; over-crowding

D temperature; pH of soil or water; salinity levels

Answer: D

7 **a** Compare interspecific and intraspecific competition and give an example of each.

b Name three limiting factors that affect population growth.

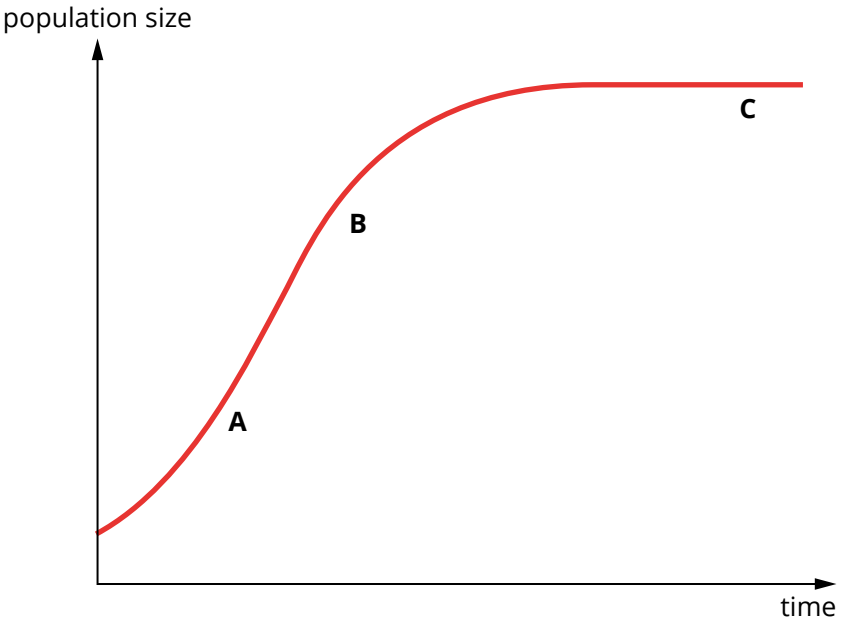
Answers:

a Interspecific competition occurs when members of different species compete for the same resources. Intraspecific competition occurs when members of the same species compete for the same resources. An eagle and a hawk hunting in the same area for the same type of prey is an example of interspecific competition. Two male sea lions fighting for dominance is intraspecific competition.

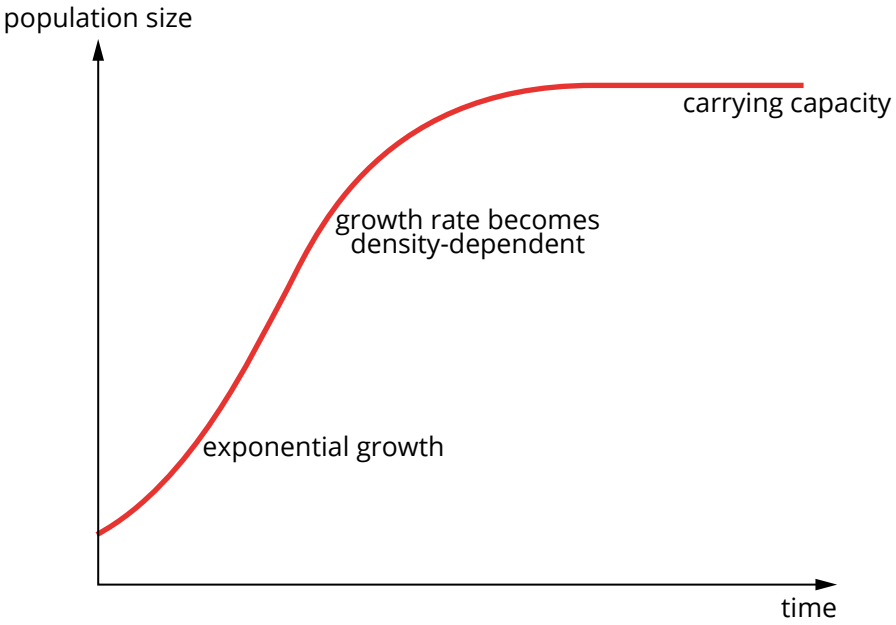
b Any three of the following: light, food, water, nest sites, shelter.

 ISBN 978 1 4886 1122 3

8 Name the parts of the following logistic growth graph, at points A, B and C.



Answer:



Chapter 7 Review

1 **a** What is the biosphere, and why can it be regarded as an ecosystem?

b The birds in a backyard aviary include galahs, corellas and sulphur-crested cockatoos. Is the aviary an ecosystem? Explain your answer.

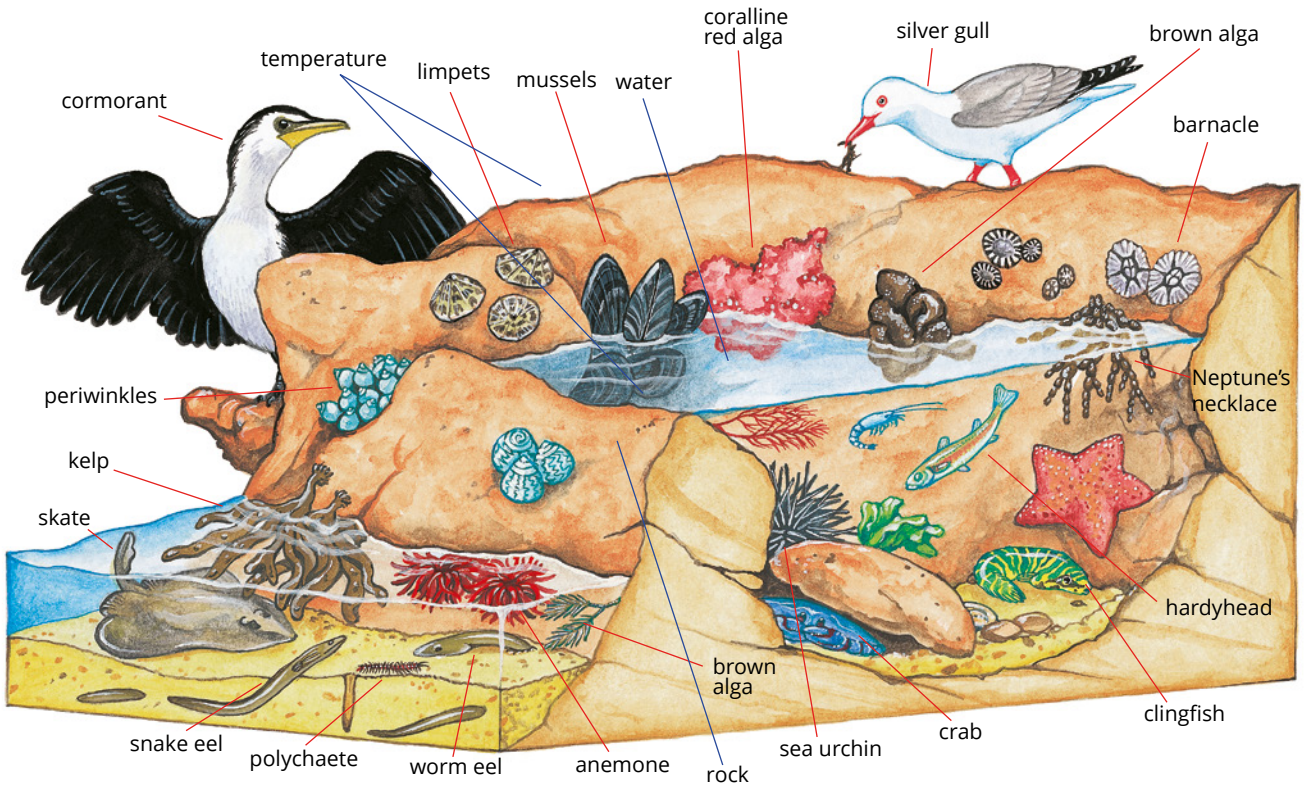
Answers:

a The biosphere is the sum of all the ecosystems on Earth. It includes all those parts of the world that are accessible to living organisms. It can be regarded as an ecosystem because it is self-sustaining; it doesn't require inputs from outside the system. Technically, all living organisms in the world are a community interacting with one another together with their physical surroundings, which is how an ecosystem is defined.

b The aviary is not an ecosystem because there are no producers. The food and water for the birds comes from outside the system, i.e. the birds' owners need to feed the birds and provide water. Wastes are also removed from the system when the cage is cleaned, so there is no recycling of nutrients.

 ISBN 978 1 4886 1122 3

2 The illustration below shows the organisms in a rock pool environment.



a List the ways that the sea anemone might depend on the physical surroundings of the rock pool.

b Explain why the rock pool can also be considered to be part of a larger marine ecosystem.

Answers:

a The ebb and flow of the ocean would be important for the anemone's survival, because the tide brings in cooler, cleaner water and food. As the tide goes out the pool is calm and warmed by the sun, maintaining an optimum temperature for the anemone.

b Because the rock pool receives inputs of organisms that can be either food or new recruits from the broader marine ecosystem, the rock pool can be considered part of the larger ecosystem.

3 **a** What is a ruminant? Give one example of a ruminant species.

b Rumination is a form of mutualism. Explain how both organisms involved in rumination benefit.

Answers:

a A ruminant is a herbivore that depends on microorganisms in their digestive tract to break down cellulose—a process called rumination. Cellulose is a major part of plants, which are the food of ruminants.

b Ruminants benefit from having their food broken down so that they can absorb the nutrients. The microorganisms benefit by gaining shelter and food.

4 Apart from mutualism, what is another form of interspecific interaction in which an organism lives inside another organism? Give an example.

Answer: Parasitism. One example is a parasitic worm. (Many other examples would be suitable.)

 ISBN 978 1 4886 1122 3

5 Most interactions are categorised by the effect they have on each of the two species involved. Below is a list of interactions between organisms found in the chapter. For each interaction, state the type of interaction and whether there is no effect, a harmful effect or a beneficial effect on each organism. (The first one has been done for you.)

a European bream and tapeworm in its gut–parasitism, European bream (harmful effect), tapeworm (beneficial effect)

b desert quandong and an emu feeding on its fruit

c owl nesting in a tree hollow

d zoozanthellae and coral polyps

e cattle trampling on grass

f stick insect and a fungus growing inside it

g lion feeding on an antelope

Answers:

a parasitism, European bream (harmful effect), tapeworm (beneficial effect)

b mutualism, desert quandong (beneficial effect), emu (beneficial effect)

c commensalism, owl (beneficial effect), tree (no effect)

d mutualism, zoozanthellae (beneficial effect), coral polyps (beneficial effect)

e amensalism, cattle (no effect), grass (harmful effect)

f parasitism, stick insect (harmful effect), fungus (beneficial effect)

g predation, lion (beneficial effect), antelope (harmful effect)

6 Describe an example of a benign relationship involving a tree and another species.

Answer: In a benign relationship, one species benefits while the other species is unaffected. Examples include animals finding shelter or nesting on trees, plants such as orchids growing on tree branches, and lichens growing on tree trunks. In these cases the tree is unaffected.

7 **a** An epiphyte growing on a tree is an example of which kind of interaction? Explain your answer.

b If the tree becomes so laden with epiphytes that the branches could break, is this still the same kind of interaction? Explain your answer.

Answers:

a Commensalism. The epiphyte benefits from receiving sunlight and rainwater, but the tree is unaffected.

b Although the tree would be harmed in this relationship, the harm is accidental and not part of the normal interaction between the organisms. The relationship would still be commensalism.

8 **a** Define the term 'food chain'.

b Arrange the following organisms in order from producer to highest-order consumer.

seabird, alga, small fish, Inuit, zooplankton

c Explain how decomposers complete the cycle of matter in a food chain.

Answers:

a A food chain shows a sequence of organisms that feed on each other.

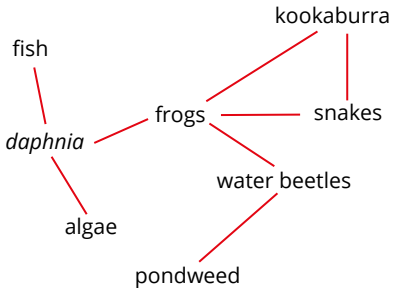
b alga, zooplankton, small fish, seabird, Inuit

 ISBN 978 1 4886 1122 3

c They are able to use the materials left by all the other organisms in a food chain. All organisms eventually die, leaving carcasses. They also discard materials while they're alive. Decomposers can use these materials and transform the tiny amount of energy still fixed in them. Their metabolic transformations result in the production of simple inorganic compounds such as carbon dioxide, water, hydrogen sulfide and ammonia. These compounds can then be used by autotrophs. In this way, decomposers complete a cycle of matter. The inorganic matter taken up by autotrophs goes through producers and consumers and decomposers and back to inorganic matter.

9 **a** What do the arrows in a food web represent?

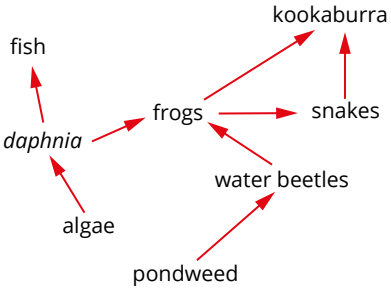
b Draw in the arrowheads to complete this food web.



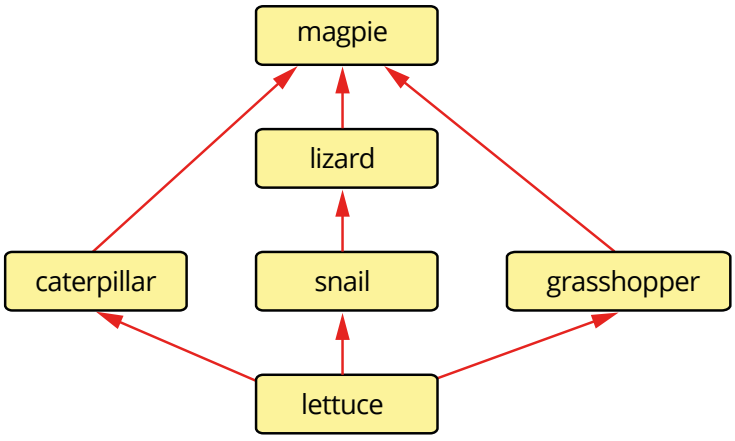
Answers:

a The arrows represent the direction of energy being transferred, or which species is being consumed. For example, kookaburras eat snakes, so the arrow points from the snake toward the kookaburra; the kookaburra receives energy from the snake.

b



10 For the food web depicted below, describe the short-term and long-term effects of the magpie leaving the ecosystem.



Answer: In the short term the populations of the magpie's prey (caterpillars and grasshoppers) will increase, and they will compete to eat more lettuce plants. The population of the magpie's other prey (lizards) will also increase, and they will eat more snails. So less lettuce will be eaten by snails, but not enough to balance the increased amount of lettuce eaten by caterpillars and grasshoppers.

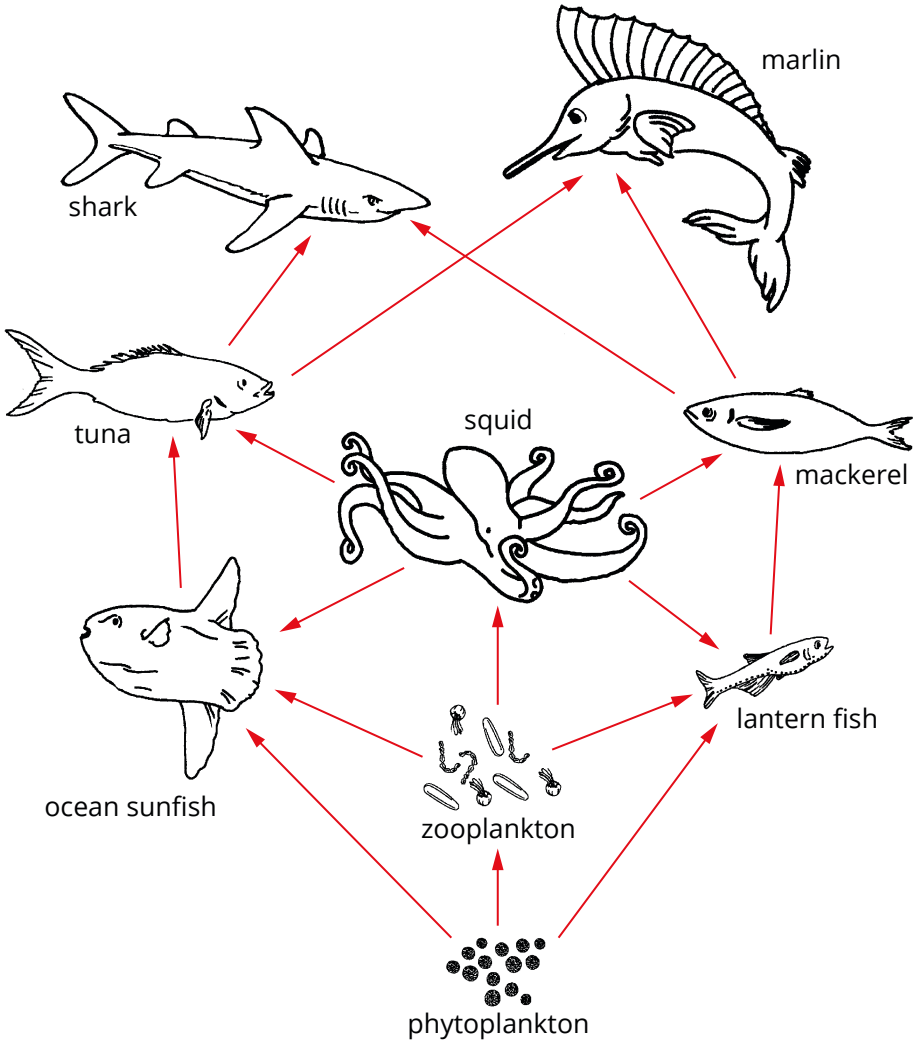
In the long term the amount of lettuce will decrease and there will not be enough to feed the three herbivore species (caterpillars, snails and grasshoppers). The snail population will

 ISBN 978 1 4886 1122 3

probably be reduced considerably because there will be less lettuce and more predators. These three species will attempt to migrate to other areas to find food or will die out.

The magpie leaving will destabilise the ecosystem on a long-term basis.

11 Examine the following food web and then answer the questions that follow.



a What is the highest number trophic level in this food web?

b What role do the phytoplankton, zooplankton and tuna play in this food web and why?

Answers:

a The highest trophic level shown in this food web is six. In certain food chains within this food web, the shark and the marlin are both tropic level six. One example is phytoplankton (trophic level 1) → zooplankton (trophic level 2) → ocean sunfish (tropic level 3) → squid (tropic level 4) → mackerel (trophic level 5) → shark (trophic level 6)

b The phytoplankton is the producer—it is the first trophic level and feeds off no other organisms so must be able to produce its own food. The zooplankton feeds off the producer phytoplankton and so is a herbivore. The tuna feeds off both squid and ocean sunfish, and so is a carnivore.

12 What is a microhabitat? Give two examples, and describe the kinds of organisms that might live in each.

Answer: A microhabitat is a small-scale, local area where an organism experiences a slightly different environment compared to the overall habitat. The moist trunk of a tree fern could be a microhabitat home to small mosses, liverworts, filmy ferns, fungi, spiders and insects. The carcass of a deceased animal could be a microhabitat utilised by insects.

 ISBN 978 1 4886 1122 3

13 What type of measurement would you use to describe the density of species in each of these situations? Explain your answer in each case.

a sheep in a paddock

b grass in a field

c leaves on a plant

Answers:

a Use the number of individuals, because this would be easy to count.

b Use biomass, because it would be difficult to count all the blades of grass.

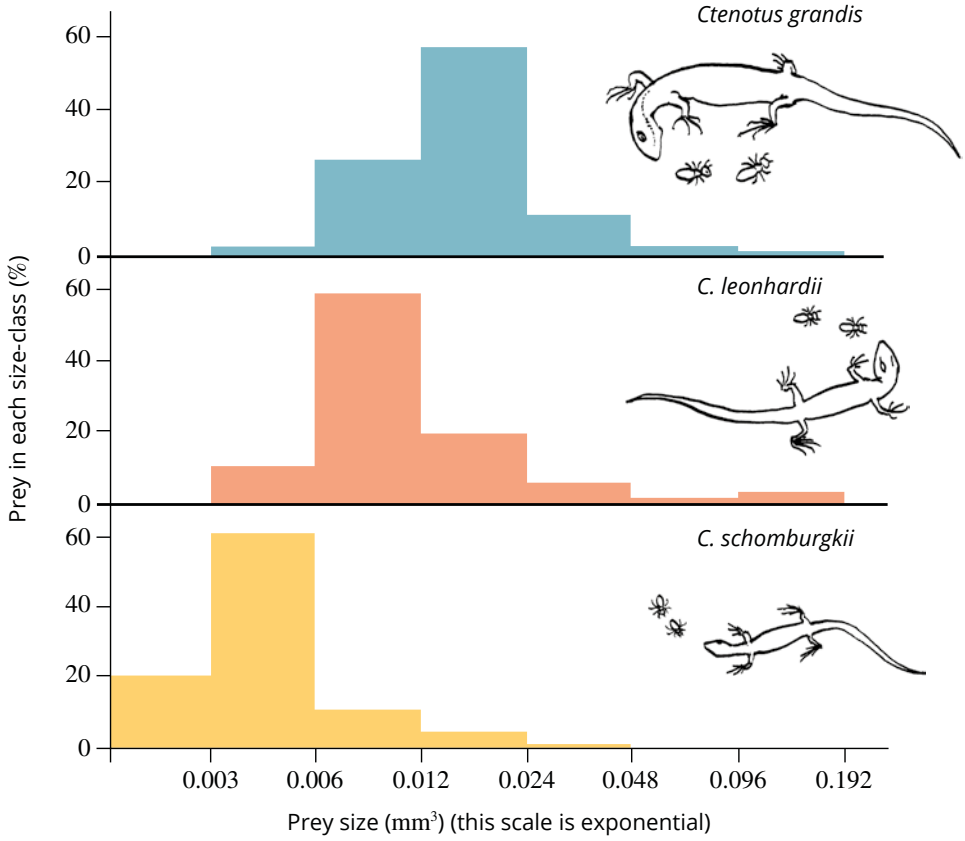
c Use the number of leaves on a branch, because counting all the leaves would take too long.

14 A species of fish on a coral reef undergoes a rapid decline in population growth after the arrival of another species of fish that uses the same sources for food. What kind of competition is this? Why would the population growth of the first fish decline?

Answer:

This is intraspecific competition, which is density-dependent regulation. The more individuals there are of a fish species living in the same area, the more competition there will be among them for resources. This intraspecific competition will lead to starvation and an inability to breed.

15 The following graph gives information about three lizards and the termites that are their prey. Using the information in the graphs, explain how the three lizard species are able to exist together in an ecosystem.



Answer: The graph shows that each lizard hunts different size-classes of termites. The largest lizard eats the largest termites, and the smallest lizard the smallest termites. By eating different sizes of prey, the lizards are using a different part of the environmental food resource, and avoid competing with one another. Each lizard has its own niche.

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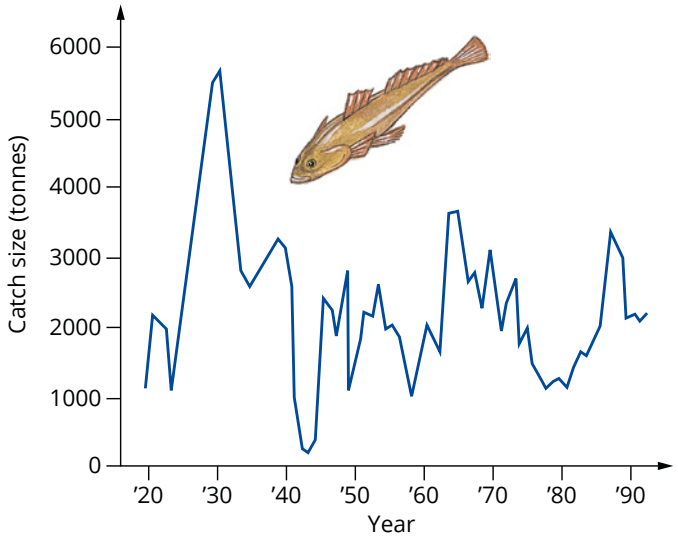
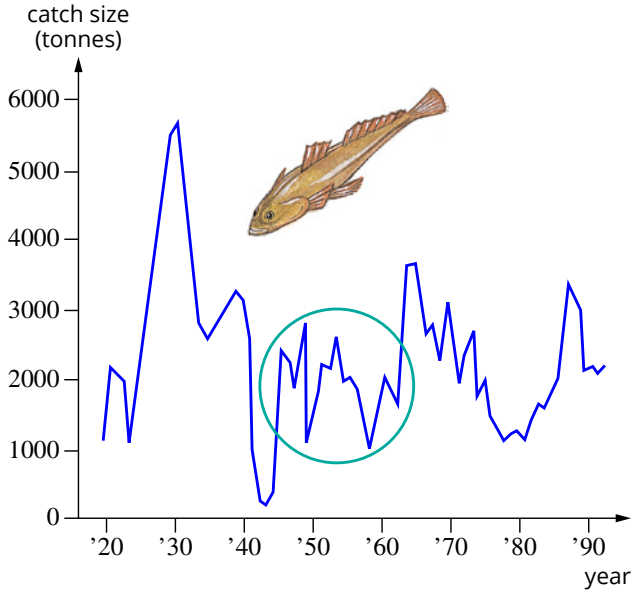
16 Consider the following graph, which shows the annual catch of tiger flathead from 1920 to 1992. During which period was the tiger flathead population most stable? Explain your answer.



Answer:



Between about 1945 to 1962 there were increases and decreases in the range of catch sizes, but these ranges were relatively steady compared to the more dramatic increases and decreases in catch size for the rest of the period.

17 Discuss the reasons for *ex situ* conservation of endangered species.

Answer: *Ex situ* conservation is carried out outside the natural habitat; for example, captive breeding of mountain gorillas in zoos, cultivation of plants in botanic gardens. It can prevent the extinction of species, protect the genetic pool and maintain biodiversity. Species that have been bred in captivity/cultivated can be reintroduced back into their natural habitat. *Ex situ* conservation can also be used for education and research. Conserving animals in captivity allows the use of modern technology such as assisted reproductive methods.

18 Discuss the reasons for *in situ* conservation of endangered species.

Answer: *In situ* conservation involves keeping endangered species in their natural habitat. It is less expensive than *ex situ* conservation because there is no need to maintain or specially design habitats to meet the needs of the species. It also allows more individuals to interbreed, providing more genetic variation. Interactions with other organisms within the habitat will also continue, so they will not be affected.

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19 Outline one example of biological control of invasive species.

Answers will vary. Likely answers are:

Rabbits controlled by the release of myxoma virus or rabbit calicivirus.

Prickly pear controlled by larvae of the cactoblastis moth.

20 Discuss reasons for conserving the biodiversity of a rainforest ecosystem.

Answers will vary. A sample answer is:

Aesthetic value: Humans value the beauty of rainforests.

Ecological value: Species in the rainforest are interdependent, so loss of species affects many other species.

Ecosystem services: Deforestation of rainforests increases soil erosion/flooding/increased carbon dioxide atmospheric levels.

Practical value: Potential of undiscovered medicines (bioprospecting), and ecotourism.

Cultural value: Rainforests are important in the cultures of many people.

21 Which of the following situations describes a population that is increasing in size?

(B = birth, D = death, I = immigration, E = emigration)

A (B + D) > (I + E)

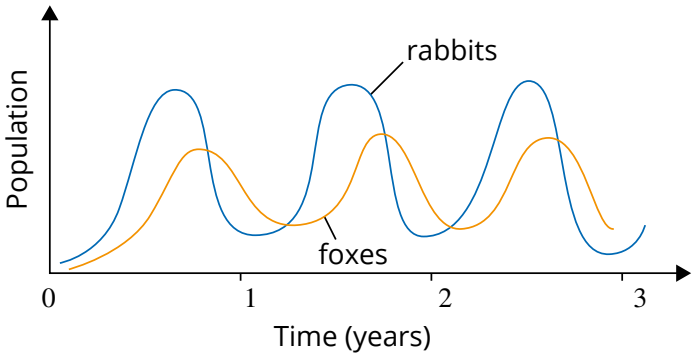
B (B + E) > (D + I)

C (D + E) < (B + I)

D (B + E) < (D + I)

Answer: C

22 Consider the following graph, which shows changes in the rabbit and fox populations on an isolated area of open farmland in western Victoria.



a What factors might have caused the initial growth in the rabbit population?

b Why does the growth in fox numbers follow that of rabbits?

c What factors could cause the decline in the rabbit population?

d How is it that rabbit numbers are able to build up again in the following year?

e What would happen to the fox population if the rabbit population suddenly crashed, for instance from the effects of calicivirus? Show this by extending the graph.

Answers:

a Abundant food and lack of predators would cause an increase in the rabbit population.

b Rabbits are a source of food for foxes. Fox numbers build up when there is an adequate supply of food; that is, when the rabbit population has increased.

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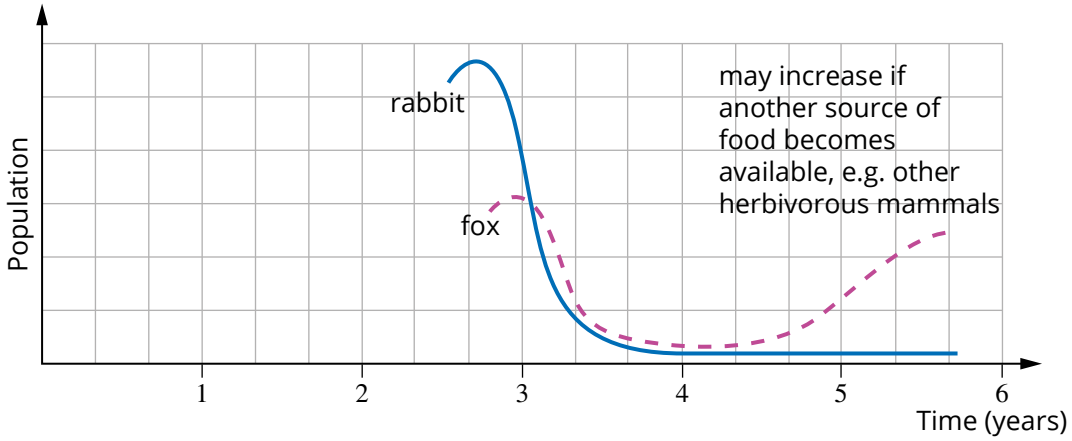
c The rabbit population may decline because of a lack of food. Food availability is most probably seasonal. To a lesser extent, predation and disease could have an effect.

d A small breeding population is able to survive over winter, and quickly reproduce when food sources become more plentiful. Hence the overall number of rabbits will increase again.

e The graph should be extended to show that the fox population would also crash, because of the loss of its major prey. An example is shown here.



23 Consider a simple ecosystem consisting of a single food chain, in which a crop plant is eaten by an insect (such as a grasshopper), which is eaten by a bird (such as a kestrel).

a What might happen to the number of grasshoppers if the kestrels were killed?

b What subsequent effect might there be on the crop?

c If the ecosystem were more complex, with more food chains cross-linked in a food web, would the effect of shooting one species of bird be the same as it is in the simple ecosystem? Explain your answer.

Answers:

a If the kestrels were killed, there would be an increase in the population of grasshoppers, provided there was enough food for them, as their predator is no longer present in this ecosystem.

b An increase in grasshopper numbers would have an increased negative effect on the crop.

c If the ecosystem were more complex, there would most likely be a variety of different predators of the grasshopper. Removal of kestrels would mean that the other predators would still eat the grasshoppers, so numbers would probably be kept in check. Also, the population of other predators might increase.

24 Consider the following information. Cacti and sagebrush absorb sunlight for photosynthesis. Ants and rats both feed on cacti and sagebrush. Tarantulas feed on ants. Rats are a common food source for hawks, snakes and coyotes. Hawks and coyotes also feed on snakes. Coyotes will occasionally eat sagebrush.

a Construct a food web using the information given.

b Write down the longest food chain for this food web.

c State the trophic level for cacti and coyotes.

d State the type of consumer for ants and snakes.

e Suggest which organism is the keystone species. Give an explanation for your answer.

f A parasite that feeds on ants was introduced into the food web.

i State whether the introduction of the parasite is a biotic or abiotic factor.

ii Outline the effects of the parasite on the food web.

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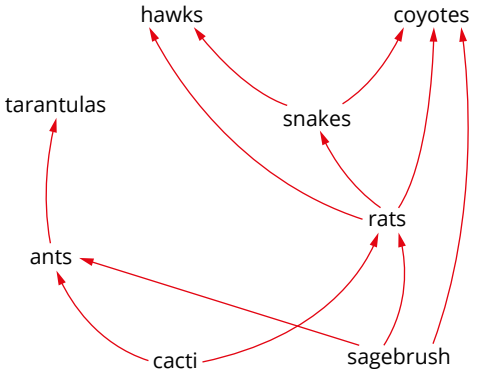
Answers:

a



b cacti → rats → snakes → hawks

c cacti – trophic level 1

coyotes – trophic levels 2, 3 and 4

d ants – herbivore

snakes – carnivore

e The coyote is the keystone species because it is part of five food chains.

f **i** biotic

ii There will be a decrease in the ant population, which will cause the population of tarantulas to fall.

It is not known if the increase in cacti and sagebrush populations will increase as they are dependent on the type of relationship between ants and the plants. If ants do kill the plants, then the fall in ant population can result in increased cacti and sagebrush populations, which will in turn increase the rat population due to increased food availability. The increase in rat population will in turn increase the population of hawks and coyotes.

 ISBN 978 1 4886 1122 3

Chapter 8 Questions and answers

8.1 Review

1 Which of the following is **not** a purpose of cell replication by mitosis in multicellular organisms?

A growth

B repair

C reproduction

D restoring the nucleus-to-cytoplasm ratio

Answer: C

2 Which of the following statements is true?

A Cytokinesis is also called binary fission.

B Cytokinesis involves the division of the nucleus.

C Cytokinesis occurs during meiosis.

D Cytokinesis occurs after mitosis.

Answer: D

3 **a** Outline the purposes of cell replication.

b Give an example of a specific tissue or cell type in both plants and animals that illustrates each point in part a.

Answers:

a The purposes of cell replication are:

- restoring the nucleus-to-cytoplasm ratio, from fertilisation of an egg to a normal-sized egg
- growth and development to produce more cells, growing in size and becoming multicellular
- maintaining and repairing old or damaged cells.

b Examples to match the order above include:

- development of birds' eggs, frogs and mammals
- specialisation of cells for muscles, blood and bone in animals, or photosynthesis and transport in plants
- replacement of cells lining the gut, the growth of many plants from only a few cells, the regrowth of tissues in sea stars.

4 Classify the examples of cell replication into the correct purposes.

- toddler's height increasing by 2 cm
- cut healing
- bacteria cell dividing
- embryonic cell dividing
- seed germinating
- unicellular Protista organism dividing

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Answer:

Purpose	Example
reproduction	bacteria cell dividing; unicellular Protista organism dividing
repair and maintenance	cut healing
growth and development	toddler's height increasing by 2 cm seed germinating
restoring nucleus-to-cytoplasm ratio	embryonic cell dividing

5 State the two types of cell division and the number of daughter cells produced at the end of each type of cell division.

Answer:

mitosis – 2 daughter cells

meiosis – 4 daughter cells

6 Describe the key events in binary fission in bacteria.

Answer:

The circular DNA molecule is duplicated within the nucleoid.

The cell grows until it has almost doubled in size.

A new cell wall and membrane form between the separating chromosomes, dividing the cell into two relatively equal halves (Figure 8.1.14, page 356).

These halves eventually separate, forming two daughter cells from the single parent cell.

7 If a bacterial organism undergoes binary fission in ideal conditions every 30 minutes, calculate how many organisms there would be after four hours.

Answer: $2^8 = 256$

8.2 Review

1 Which organelle divides into two during mitosis?

A nucleus

B vacuole

C mitochondrion

D chloroplast

Answer: A

2 Which of the following statements is **not** correct?

A Although it is divided into stages, mitosis is a continuous process.

B Cytokinesis marks the beginning of two new cells.

C DNA is replicated during interphase.

D Mitosis is the longest phase of the cell cycle.

Answer: D

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3 Distinguish between a chromatid and a chromosome. When are they visible?

Answer: Chromatids are replicates of the chromosome, joined at the centromere. When they separate at anaphase they are again called chromosomes. Chromosomes and chromatids become visible under the microscope when they condense in prophase (and stay visible through metaphase, anaphase and telophase).

4 What events occur during interphase of the cell cycle?

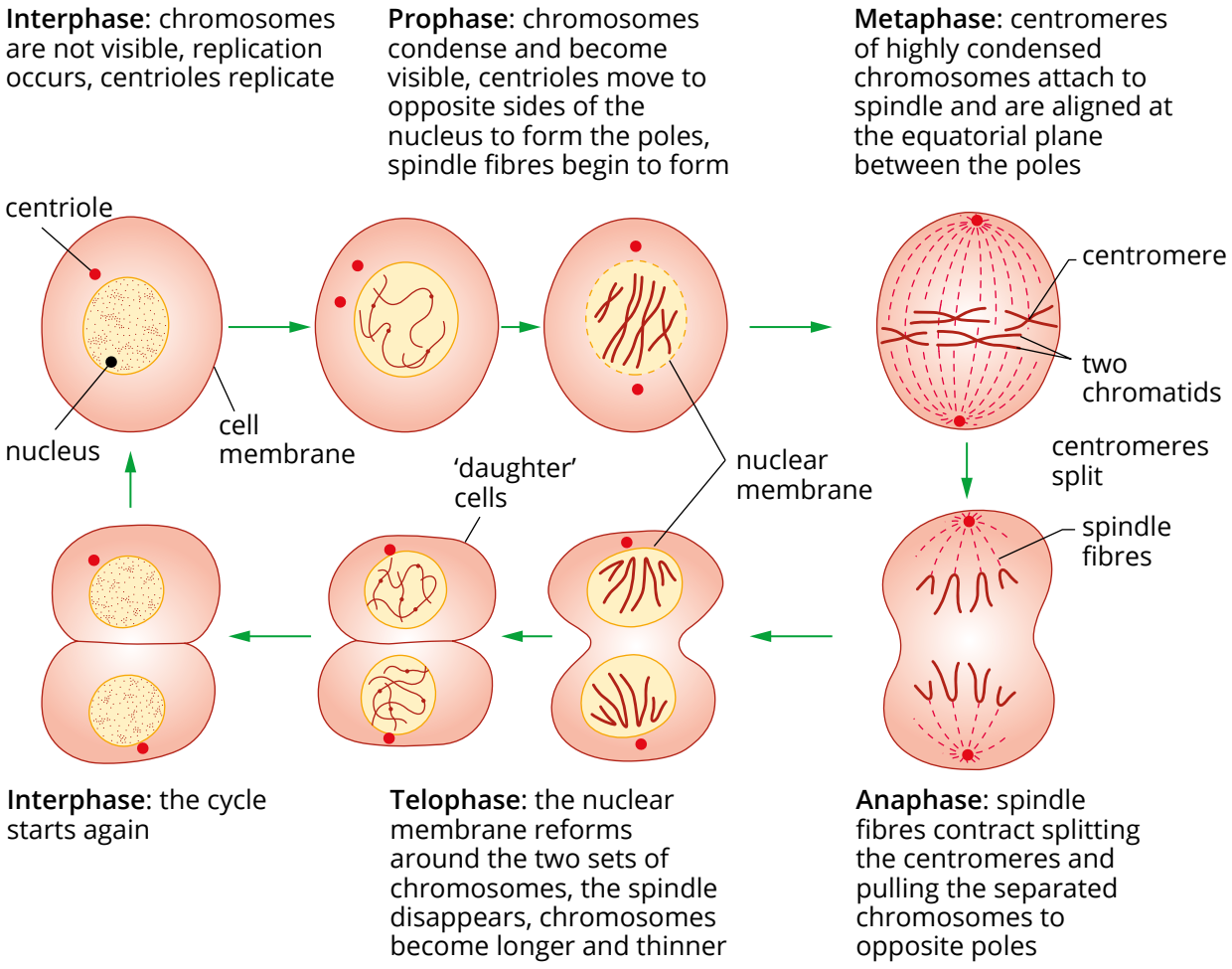
Answer: During interphase, DNA is synthesised (chromosomes are replicated), normal functioning of the cell occurs, the cell increases in size and replicates organelles, and materials are accumulated for mitosis.

5 Does every cell go through the G0 phase? What is the result if a cell does not move out of this phase?

Answer: Only some cells enter the G0 phase. Some cells enter G0 permanently, i.e. do not move out of G0 phase, and cease to divide in order to carry out a highly specialised task. Other cells may enter G0 temporarily if there are not enough nutrients to undergo cell division, and will undergo division once the nutrients become available.

6 Use diagrams to show the events that occur at each phase of mitosis.

Answer: The diagram should resemble Figure 8.2.8 on page 360, which shows the major features of mitosis.



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The following information should be included in the answer:

interphase – replication occurs, chromatids form

prophase – chromosomes shorten, thicken and become visible; nuclear membrane disappears; spindles form from the centrioles/centrosome

metaphase – chromosomes attach to the spindle fibres at the centromere; they line up along the equator

anaphase – spindles contract and chromatids are pulled apart, forming single chromosomes

telophase – nuclear membrane forms around both sets of chromosomes

cytokinesis – new cell membranes and cell walls form

7 **a** Cell replication involves two processes. Name the two processes and describe them.

b Explain why it is necessary for the nuclear division to be exact, but not the division of the cytoplasm.

Answers:

a Mitosis is a process of division of the nucleus. Genetic material is accurately copied and passed on to two daughter cells. Cytokinesis is the division of the cytoplasm into two daughter cells.

b It is important that each daughter cell is an exact genetic copy of the parent cell. The nucleus needs to contain all the DNA, information present in the parent cell. The division of the cytoplasm does not need to be as precise because the initial function of the nucleus is to program the synthesis of missing organelles.

8 Explain how cell division in plants is different from cell division in animals.

Answer: Plant cells do not usually have a centriole; they form spindle fibres by a different mechanism, so chromosomes align and chromatids separate as in other eukaryotic cells. During cytokinesis the membrane does not constrict but a new division (the cell plate) forms, making a new cell wall, then new plasma membranes for each daughter cell.

9 How do cells ensure that the DNA is copied correctly to the daughter cells?

Answer: A strand of the parent DNA molecule is used as a template strand on which the new strand is synthesised. As each daughter DNA molecule consists of one old and one newly synthesised strand, the exact DNA pattern can be conserved accurately.

8.3 Review

1 Which of the following is **not** checked during the G1 checkpoint of the cell cycle? Select the correct answer.

A DNA

B the attachment of the spindle fibres to the centromeres

C the amount of resources in the cell

D the size of the cell

Answer: B

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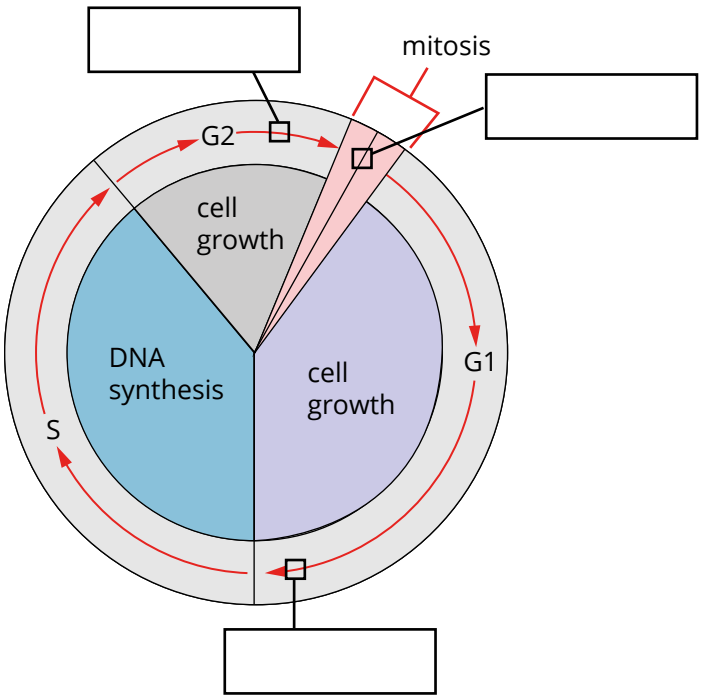
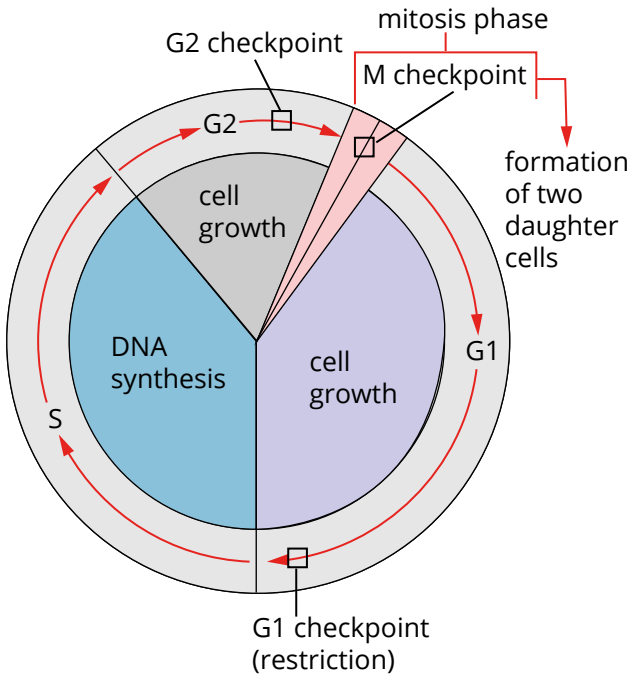
2 Label the parts of the following diagram.



Answer:



3 Classify each of the following as either internal or external controls of the cell cycle.

- temperature
- DNA quality
- telomere length
- contact inhibition
- size of cell

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Answer:

- temperature – external
- DNA quality – internal
- telomere length – internal
- contact inhibition – external
- size of cell – internal

4 **a** Which section of the chromosome is important for attachment to spindle fibres and thus progression of cells through the M checkpoint?

b Which section of the chromosome do scientists believe has a function in controlling the number of mitotic divisions that a cell can undertake? Where is this section located?

Answers:

a centromeres

b The central section that joins the two chromatids in a chromosome is called the centromere, which is involved in cell division. At the tip of each chromatid are the telomeres. Scientists believe the end section of the chromosome has a function in controlling the number of mitotic divisions that a cell can undergo.

5 When a tadpole develops into a frog, the cells in the tail die. What is name given to this type of cell death?

Answer: The type of cell death that causes the cells in a tadpole's tail to die is known as apoptosis.

6 **a** State the two types of cell death.

b How do the two types of cell death differ?

Answers:

a Apoptosis and necrosis

b Apoptosis is programmed cell death where enzymes are released inside the cell so that it is broken down in a highly regulated way and the cell contents are not released to the external environment. Apoptosis has important biological and developmental purposes. Necrosis is cell death caused by a variety factors such as toxins and pathogens, where proteins degrade, the cells swell and burst, releasing the contents into the extracellular space, causing inflammation.

7 Give an example for each of the chemical, physical and biological factors that cause neoplasms.

Answer:

Chemical: factory pollution, tobacco compounds and smoke, alcohol, heavy metals

Physical: ionising radiation such as X-rays, and non-ionising radiation such as ultraviolet light

Biological: oncogenic viruses such as the human papillomaviruses, hepatitis C or HIV

8 Explain how proto-oconogens and tumour-suppressor genes can cause cancer.

Answer:

Proto-oncogenes stimulate cell growth. When these genes are unregulated, cell growth increases, causing tumours/cancers/neoplasms.

Tumour-suppressor genes inhibit cell division. If these genes are damaged, cell division can go unregulated, causing tumours/cancers/neoplasms.

 ISBN 978 1 4886 1122 3

8.4 Review

1 **a** What is the name given to embryonic cells that self-renew and remain undifferentiated when removed from the embryo.

b What advantages do these cells have for the body?

Answers:

a Embryonic stem cells are the embroyonic cells that remain undifferentiated.

b Stem cells are capable of replacing themselves and can differentiate into distinct cell types. They can then be used to develop or repair the body, to replace any damaged cells.

2 Name the three germ layers, from outermost to innermost.

Answer: ectoderm, mesoderm and endoderm

3 **a** What are adult stem cells?

b What is their role?

c How do they differ from embryonic stem cells?

Answers:

a Adult stem cells are stem cells that exist in some mature tissues, such as in bone marrow.

b They supply mature tissues with replacement cells as required.

c Unlike embryonic stem cells, they may only be able to replace the cells of only one type of tissue.

4 Classify the following cell types with their correct potency.

- zygote/morula cell
- embryonic stem cell
- adult stem cell

Answer:

- zygote/morula cell – totipotent
- embryonic stem cell – pluripotent
- adult stem cell – multipotent

5 State the four types of stem cells. How do the different types of stem cells differ?

Answer:

The four types of stem cells are totipotent, plutipotent, multipotent and unipotent stem cells.

Totipotent stem cells are capable of giving rise to any cell type or even another embryo.

Pluripotent stem cells have the ability to give rise to cells derived from all three germ layers: endoderm (e.g. lungs and gut lining), mesoderm (e.g. muscle, bone, blood) or ectoderm (e.g. skin and nervous system).

Multipotent stem cells have the ability to give rise to multiple, but limited, cell types.

Unipotent stem cells can only differentiate into one cell type for a specific tissue, but can divide repeatedly.

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6 Planarians (flatworms) retain a population of totipotent stem cells throughout their life. How does this observation explain why a planarian, when cut in half, can regenerate the missing part?

Answer: Totipotent stem cells have the ability to differentiate into many cell types. Having a population of these stem cells means that the planarian is able to replace all of the missing tissue that has been lost—including skin, nerve, muscle and gut.

7 Which one of the following conditions is necessary for successful stem cell therapy?

A The stem cells must be embryonic.

B The stem cells must be able to replicate themselves within a laboratory.

C The stem cells must be able to produce embryos.

D The stem cells must be able to repair themselves.

Answer: B

8 Skin stem cells replicate rapidly, so how could they be useful in stem cell therapies?

Answer: Epidermal skin cells harvested from a patient can be used to grow epidermis within a laboratory. These new layers of epidermis can then be grafted onto patients who have lost significant amounts of skin, especially people who have suffered from third-degree burns or genetic disorders that affect the skin.

9 Outline the ethical and biological advantages and disadvantages concerning adult stem cell research.

Answer:

Advantages:

- People who are donating the stem cells are able to give their consent.
- There may be fewer adverse side effects. For example, if the cells are used on the donor there is no immune rejection.
- No embryos are used in the collection of adult stem cells.
- There is a larger potential supply compared to embryonic stem cells.

Disadvantages:

- Harvesting stem cells can be painful; for example, in drawing bone marrow directly from the bone.
- If used on a different person, adult stem cells must be matched to the recipient's immune system, otherwise they will be rejected.
- Adult stem cells may have less ability to differentiate into the required cell type.
- Adult stem cells may not live as long as embryonic stem cells, because the telomeres are shorter.

Chapter 8 Review

1 Which process is **not** associated with cell division?

A cytokinesis

B DNA replication

C pairing of homologous chromosomes

D formation of two diploid daughter cells

Answer: C

 ISBN 978 1 4886 1122 3

2 Which of the following statements shows a correct sequence of events for mitosis?

A chromatids separate, chromosomes duplicate, cytokinesis occurs

B cytokinesis occurs, chromosomes duplicate, chromosomes line up at the equator

C chromosomes line up at the equator, chromatids separate, cytokinesis occurs

D chromosomes duplicate, cytokinesis occurs, chromatids separate

Answer: C

3 Describe the importance of cell division to an organism.

Answer: There are three types of cell division: binary fission, mitosis and meiosis. Binary fission is the basis of reproduction in prokaryotes. It enables prokaryotes to reproduce quickly, and is the reason why bacteria are so abundant. Mitosis is the basis of cell replication in unicellular eukaryotes. In multicellular eukaryotes mitosis is used for growth, cell replacement and tissue repair, and also for asexual reproduction in many species. Meiosis is the basis of sexual reproduction in multicellular eukaryotes. It is essential for the production of gametes, and enables two parents to contribute genetic information to the offspring and maintain genetic diversity in new generations of offspring.

4 Consider a defect in a multicellular organism resulting in the inability to complete mitosis correctly all the time. Outline some of the possible consequences for the organism.

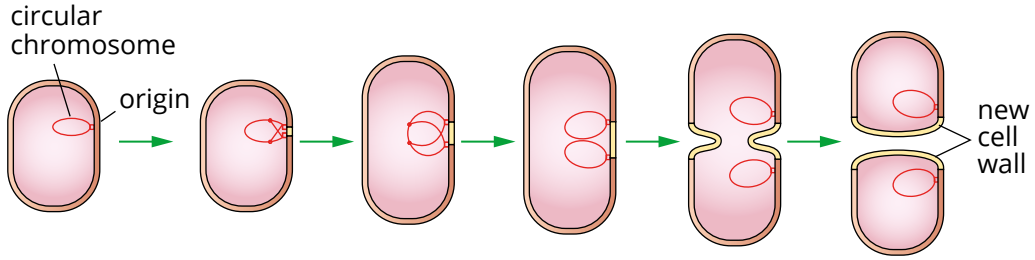
Answer: If cells were unable to perform mitosis correctly all the time, the organism would not grow to a normal size, and it might not be able to replace damaged or dead cells.

5 Different organism vary in how much repair their cells can carry out. Describe how three different organisms vary in their ability to carry out replication and, therefore, repair.

Answer: Various answers are possible. The following is a sample answer:

A sea star can produce an entire new individual from a single arm by cell replication and subsequent specialisation. Humans can repair many tissues, but they cannot grow new limbs. A nematode worm, once hatched, cannot produce any new cells at all and therefore cannot repair itself.

6 Consider the following diagram.



a What process does this diagram show?

b Explain the steps involved in this process.

c What is one advantage and one consequence of this process when it is used as a form of reproduction?

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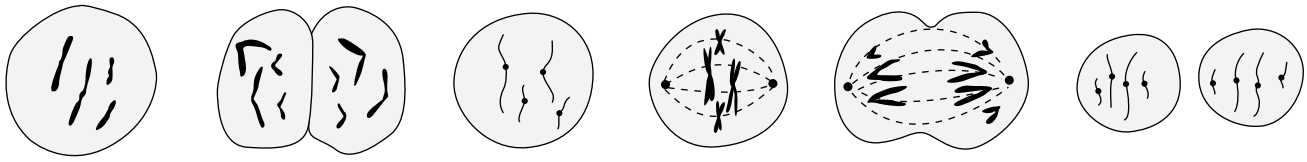
Answers:

a The diagram shows binary fission.

b
- The chromosome replicates and attaches to the cell wall.
- The cell grows until it has almost doubled in size.
- A new cell wall and membrane forms between the separating chromosomes, dividing the cell into two more or less equal halves.
- These halves eventually separate, forming two daughter cells from the single parent cell.

c Advantages: Binary fission is a very efficient and rapid process of cell replication, and therefore reproduction, in prokaryotes. The result is that all organisms in a prokaryote population are genetic equals, so if the species is well adapted to the conditions the population will survive and grow well. A disadvantage is that the population has little or no genetic diversity, so it might not survive a sudden change in environmental conditions, such as a change in temperature or salinity, or the presence of an antibiotic.

7 The diagram below represents the stages of mitosis, but they are not in the correct order. Determine the correct sequence and add labels for the name of each stage of mitosis.



A B D C E F

Answer:

D – early prophase

A – prophase

C – metaphase

E – anaphase

B – telophase

F – completion of mitotic division

8 Mitosis in unicellular eukaryotes has a different function to mitosis in multicellular organisms. Explain the purposes of mitosis in:

a unicellular eukaryotes

b multicellular eukaryotes

Answers:

a For unicellular eukaryotes, mitosis is a form of reproduction.

b For multicellular eukaryotes, the purposes of mitosis are:
- restoring the nucleus–cytoplasm ratio
- growth and development
- maintenance and repair.

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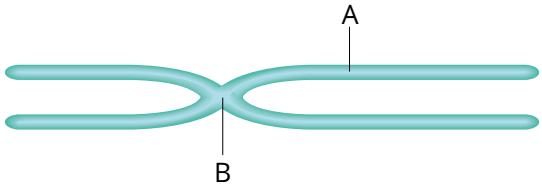
9 Examine the following diagram of a chromosome.



a Name structures A and B.

b During what phase of mitosis does the chromosome first appear in this state? Explain what happens to cause this appearance.

c Chromosomes do not always look like the one shown in the diagram. Describe the changes in the appearance of chromosomes during the different phases of the cell cycle.

d Draw a typical representation of an animal cell in interphase.

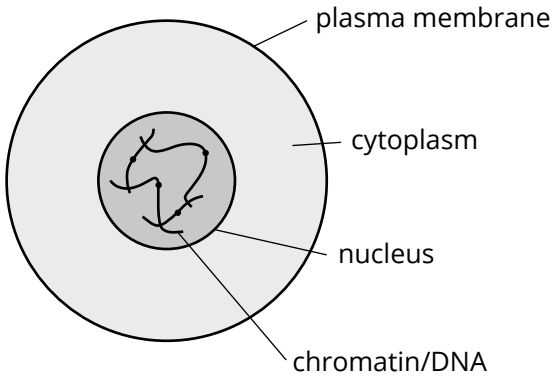
Answers:

a A – chromatid; B – centromere

b During prophase, when chromosomes shorten and thicken.

c During interphase, chromosomes appear as dispersed masses called chromatin. After DNA replication the chromosomes shorten and thicken. In anaphase they appear bent as they are pulled to opposite poles of the cell. After chromatids separate, the chromosomes would appear thinner.

d



10 Use a table to summarise the different phases of the cell cycle and what occurs during each phase.

Answer:

Phase	What occurs
interphase G1, S, G2	During interphase, the cell grows, changes shape and takes on specialist functions. During S, chromosomes replicate, forming sister chromatids that remain joined at the centromere.
prophase	The chromosomes condense, and the centrioles move to opposite ends of the cell to form the poles.
metaphase	The centromeres of the chromosomes attach to spindle fibres. Chromosomes line up at the equator of the cell.
anaphase	Spindle fibres contract and pull the chromatids apart, towards opposite poles.
telophase	The chromosomes move to the opposite poles of the cell. New nuclear membranes start for form.
cytokinesis	The plasma membrane divides the cell into two (animal cells). A cell plate and new cell wall and membranes form between daughter cells (plant cells).

 ISBN 978 1 4886 1122 3

11 Contrast cytokinesis in plant and animal cells.

Answer: Cytokinesis is division of the cytoplasm and occurs after or towards the end of mitosis (nuclear division). In animal cells the plasma membrane pinches in, forming two daughter cells. In plant cells, a cell plate forms in the middle of the cell during telophase. It grows out from the centre and divides the cell into two daughter cells.

12 **a** Explain what is meant by apoptosis.

b Why is programmed cell death important in embryo development?

Answers:

a Apoptosis is programmed cell death of some of an organism's cells as part of its natural growth and development.

b Programmed cell death is responsible for some aspects of foetal development, in which excess tissue is removed. For example, there is excess skin present between the digits of limbs early in foetal development. Apoptosis removes this skin so that normal, separated digits are formed.

13 Describe where mitosis would be occurring in a pregnant woman.

Answer: Mitosis would be occurring in somatic cells of the mother (growth and development, maintenance and repair) as well as in the somatic cells of the developing embryo/foetus (growth and development, maintenance and repair, restore nucleus : cytoplasm ratio).

14 The cell cycle is regulated by the cell cycle control system, which ensures that no abnormalities occur.

a Name the checkpoint at which the process would cease if the following occurred:

i Some of the spindle fibres have not attached to the sister chromatids.

ii The cell is too small to divide.

iii The DNA has not been correctly copied.

b Name the phases of the cell cycle associated with the three checkpoints.

Answers:

a **i** M checkpoint

ii G1 and G2 checkpoints

iii G2 checkpoint

b M checkpoint – metaphase

G1 checkpoint – interphase

G2 checkpoint – interphase

15 Explain the origin and behaviour of HeLa cells.

Answer: HeLa cells are a line of cells obtained from a human cervical carcinoma that have been grown in culture continuously since 1952. Normal cells usually have a limited number of cell divisions before they die (apoptosis), but continued replication is common in malignant neoplasm cells.

 ISBN 978 1 4886 1122 3

16 List three differences between malignant and benign neoplasms.

Answer:

Answers will vary, but might include the following.

- Cells divide uncontrollably in malignant neoplasms, and to a lesser extent in benign neoplasms.
- With benign neoplasms the organism controls the growth of the neoplasm to a certain extent, but this is not the case with malignant neoplasms.
- Malignant neoplasms destroy the surrounding tissues, but benign neoplasms do not.
- The neoplastic cells in malignant neoplasms can spread to other tissues (i.e. they metastasise). This does not occur in benign neoplasms.

17 Some cancers are at least partially hereditary; the genetic predisposition can be passed down in a family line.

a Give one example of a hereditary predisposition to cancer.

b If one family member has a particular type of hereditary cancer, do all other relatives develop the cancer? Why/why not?

c What other factors can influence the development of a neoplasm?

Answers:

a Some forms of breast cancer (e.g. BRCA1/BRCA2)

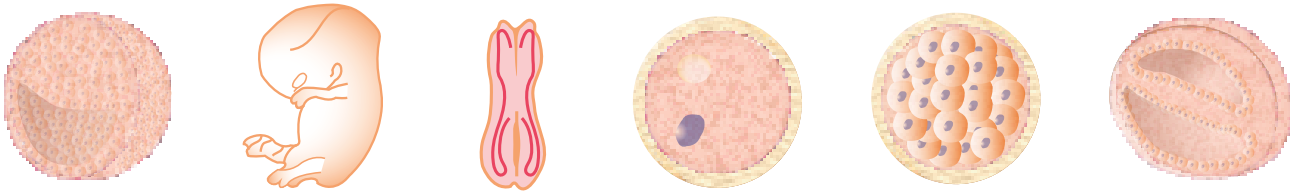
b It does not necessarily mean that all family members with that gene will develop the cancer. They may not have inherited the allele that causes the cancer. Also, often more than one mutation in a gene must occur before cancer is developed. Nevertheless, individuals who inherit the particular gene have a higher chance of developing the cancer because they have one such mutation.

c Some environmental factors, such as exposure to tobacco smoke or ultraviolet light, can influence the development of neoplasms. They do this by damaging DNA, which can disrupt the control of cell division.

18 Suggest how the cell cycle may differ in stem cells and in fully differentiated cells.

Answer: Stem cells are self-renewing cells that will continue to progress through the cell cycle and continually divide. Fully differentiated cells have exited the cell cycle; they are in G0, a non-replicating state, performing specialised cell functions. Some differentiated cells in G0 may return to the cell cycle if required for cell replacement or tissue repair. Others, such as neurons, do not return to the cell cycle.

19 Name the developmental stages of an embryo shown below and number them to indicate the order in which they occur.



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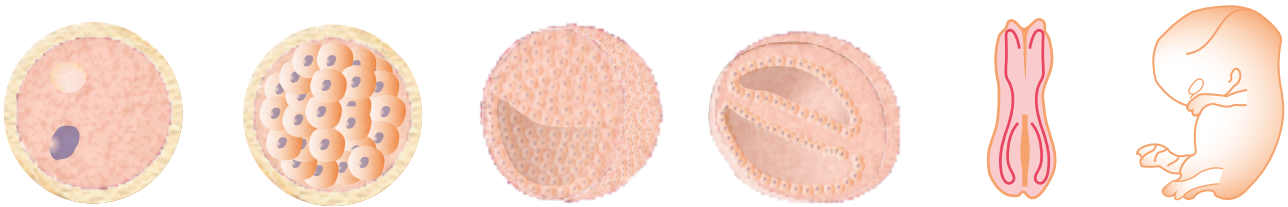
Answer:



fertilised egg (1) | morula (2) | blastocyst (3) | gastrula (4) | embryo (5) | foetus (6)

20 Name one type of stem cell therapy already in use and what it is used to treat.

Answer: Answers will vary. The following is a sample answer:

Skin stem cells are already being used to treat patients. Epidermal skin cells harvested from a patient can be used to grow epidermis within a laboratory. These new layers of epidermis can then be grafted onto patients who have lost significant amounts of skin due to third-degree burns, for example.

21 It has been suggested that human embryos should be used as a source of stem cells to grow replacement tissues for their donors in case they develop diseases such as Parkinson's disease and Alzheimer's disease. Discuss some of the practical and ethical issues surrounding the development and use of embryos for this purpose.

Answer: Answers will vary. The following is a sample answer:

Acquiring the embryonic stem cells needed would commonly involve destroying the blastocysts from which they were harvested. However, improving methods allow removal of a single embryonic cell for culture. Practical issues include:

- having enough cells differentiated to the correct cell type
- getting those cells into the correct part of the body
- getting the cells to stay alive and functioning in their new location
- making sure the cells remain differentiated and do not revert to stem cells and grow out of control
- the new cells being accepted by the donor's immune system.

Ethically, only donated embryos could be used, and these can be in short supply, which is a practical concern. Using adult stem cells or induced pluripotent stem cells would avoid this particular ethical issue.

 ISBN 978 1 4886 1122 3

Chapter 9 Questions and answers

9.1 Review

1 Define ‘asexual reproduction’.

Answer: Asexual reproduction is the production of offspring from one parent. Because of the lack of genetic recombination between two genomes (as in sexual reproduction), offspring are genetically identical to their parent; that is, they are clones.

2 What sort of nuclear division is involved in asexual reproduction?

Answer: The nuclear division involved in asexual reproduction is mitosis.

3 What are the ideal environmental conditions for asexual reproduction?

Answer: Stable and uniform environments provide ideal conditions for asexual reproduction.

4 Match each type of asexual reproduction to its correct description.

budding	Separation of structures from a parent plant to form a new, independent plant, without the formation of seeds or spores.
fission	Form of asexual reproduction in which the new organism arises as an outgrowth or bud from the parent.
fragmentation	Development of an egg in the absence of a fertilisation by sperm; a normal part of the life cycle of some insects and crustaceans.
spore formation	Form of asexual reproduction of unicellular organisms where the parent cell divides into two approximately equal parts.
parthenogenesis	Formation of structures that are resistant to adverse environmental conditions and can give rise to complete organisms when conditions become favourable.
vegetative reproduction	Form of asexual reproduction of multicellular organisms in which an organism breaks into two or more parts, each of which regenerates the missing pieces to form a complete new organism.

Answer:

budding	Form of asexual reproduction in which the new organism arises as an outgrowth or bud from the parent.
fission	Form of asexual reproduction of unicellular organisms where the parent cell divides into two approximately equal parts.
fragmentation	Form of asexual reproduction of multicellular organisms in which an organism breaks into two or more parts, each of which regenerates the missing pieces to form a complete new organism.
spore formation	Formation of structures that are resistant to adverse environmental conditions and can give rise to complete organisms when conditions become favourable.
parthenogenesis	Development of an egg in the absence of a fertilisation by sperm; a normal part of the life cycle of some insects and crustaceans.
vegetative reproduction	Separation of structures from a parent plant to form a new, independent plant, without the formation of seeds or spores.

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5 State three advantages and three disadvantages of asexual reproduction.

Answer (three advantages and three disadvantages required):

Advantages	Disadvantages
Efficient form of reproduction.	Rapid population growth can lead to overcrowding and increased competition for resources.
The amount of time and energy to produce offspring is minimal.	There is a lack of genetic variation.
Population sizes can increase rapidly in optimal environments.	The lack of genetic diversity in a population can cause death of the entire population if conditions change (e.g. pathogen or temperature).
There is no need to find a sexual partner.	
Offspring are genetically identical to the parent cell.	

6 What must connect for a grafting on a plant to be successful?

Answer: The vascular tissues of the rootstock and the graft must connect in order for the graft to grow successfully.

7 What is tissue culture used for, and what are two advantages of using this technique?

Answer: Tissue culture is used commercially to generate large numbers of plants with desirable characteristics. It is also being used in research and recovery programs for endangered plant species. Two advantages of using this technique are:

- the rapid rate of plant growth allows a large number of plants to be produced in a short time
- growth and development of plants can be tightly controlled, enabling the growth of desired characteristics.

8 Define 'embryo splitting' and explain why it is not possible to do this after the 32-cell stage of embryonic development.

Answer: Embryo splitting is the process by which cells of the early stage embryo are naturally or artificially divided. During the early stages of embryonic development, each cell is capable of developing into a complete organism. This is possible up until the 16-cell stage of development, as all the cells of the embryo are undifferentiated stem cells. After that the cells begin to undergo cellular specialisation.

Embryo splitting can occur naturally during the early stages of embryonic development, resulting in identical twins or other multiple births.

Embryo splitting is used in livestock breeding, where embryos are split *in vitro* and transferred into surrogate mothers, to increase the number of offspring born in each breeding season.

9.2 Review

1 What is the difference between a somatic cell and a gamete? Give an example of each.

Answer: Somatic cells are all the cells in the body of an organism, apart from the sex cells (gametes). Examples of somatic cells include skin cells, muscle cells and nerve cells.

Gametes are the haploid sex cells (egg/ovum and sperm cells) that combine in sexual reproduction. They are produced from germ cells.

 ISBN 978 1 4886 1122 3

2 In which phase of meiosis does crossing over occur?

A prophase I

B anaphase I

C metaphase II

D anaphase II

Answer: A

3 Which one of the following processes does **not** occur in meiosis?

A cytokinesis

B DNA replication

C pairing of homologous chromosomes

D formation of two diploid daughter cells

Answer: D

4 Outline how:

a prophase I differs from prophase II

b metaphase I differs from metaphase II

c anaphase I differs from anaphase II

d telophase I differs from telophase II

Answers:

a During prophase I synapsis and recombination occurs between homologous chromosomes. During prophase II chromosomes move toward the middle of the cell.

b During metaphase I homologous chromosomes line up along the metaphase plate. During metaphase II chromosomes line up at the equator.

c During anaphase I the spindle draws the chromosome pairs to opposite poles of the cell. During anaphase II the centromeres split, separating sister chromatids, and the single-stranded chromosomes move to opposite poles of the cell.

d During telophase I the cell divides and two haploid daughter cells are formed. During telophase II daughter cells divide and four haploid daughter cells are formed.

5 Explain how an error in meiosis can lead to Down syndrome.

Answer: An error in meiosis is caused by non-disjunction of chromosomes/chromatids, where chromosomes/chromatids do not separate. Non-disjunction can occur between homologous chromosomes during anaphase I or between chromatids during anaphase II. Errors in meiosis occur during gamete (sperm or egg) formation. Down syndrome is due to an extra chromosome 21 where a gamete receives two chromosome 21. As a result the zygote (offspring) has three copies of chromosome 21 (trisomy 21) instead of two, and a total of 47 chromosomes instead of 46.

6 **a** When a cell with chromosome number $n = 24$ undergoes mitosis, how many daughter cells are produced, and what is their chromosome number?

b When a cell with chromosome number $2n = 24$ undergoes meiosis, how many daughter cells are produced, and what is their chromosome number?

Answers:

a Two daughter cells are produced cells, both diploid ($n = 24$).

b Four daughter cells are produced, all haploid ($n = 12$).

 ISBN 978 1 4886 1122 3

7 List three advantages and three disadvantages of sexual reproduction.

Answers (three advantages and three disadvantages required):

Advantages	Disadvantages
It provides long-term evolutionary potential.	The reproductive rate is slower than in asexual reproduction; fewer offspring are produced over a longer time.
Unfavourable (deleterious) genetic variation is eliminated from the population more efficiently.	Recombination can break apart beneficial genomic combinations and introduce unfavourable variation to populations.
Generates genetic variation and selects for beneficial genetic variation more efficiently.	There is potential for the spread of sexually transmitted diseases in a population.
Populations are better able to adapt to and survive changing environmental conditions.	It is energetically costly; that is, takes a lot of ongoing energy input from the parent.
	It requires finding a mate (except for hermaphrodites), which may be difficult in scattered populations.

Chapter 9 Review

1 Which of the following statements about chromosomes in mammalian gametes is correct?

A They are all identical to those in the parent cell.

B They are different to those in the parent cell but only because of mutation.

C The are all identical to those in the parent cell because crossing over and recombination between homologues does not create new combinations of alleles.

D They are different to those in the parent cell partly because of the effects of independent assortment.

Answer: D

2 Why is meiosis a necessary process in living organisms?

A It happens in the reproductive organs.

B It is necessary for the growth of an organism.

C It produces new cells to replace dead or dying cells.

D It enables each parent to contribute genetic information to the offspring.

Answer: D

3 Why is asexual reproduction more likely to be successful in the short term rather than the long term?

Answer: Asexual reproduction enables a rapid increase in population size, due to shorter gestation and generation times of organisms and because organisms do not need to find a mate. This is successful in the short term. However each generation is a clone of the one before. The lack of genetic variation in asexual populations means there is less adaptability and evolutionary potential in the face of changing conditions in the long term, such as environmental change and new diseases.

4 Which type of reproduction is common in many invasive species? Discuss why this strategy makes organisms successful invaders of a new habitat and what impact this has on the native species in that environment.

 ISBN 978 1 4886 1122 3

Answer: Asexual reproduction is the common reproductive strategy in many invasive species. This form of reproduction gives species a competitive edge—a rapid increase in numbers with very little energy expenditure. This means if conditions are favourable for a species, their population can explode in a new area, making them invasive, and displacing native species. Organisms that have slower reproduction rates are less likely to be invasive species.

5 A farmer grows a range of plants. The table below outlines the reproductive strategies of the plants.

Plant	Type of reproduction
tulip	asexual
poppy	sexual
lily	asexual
strawberry	asexual and sexual

If a virus infects all of the plants, which plants are most likely to survive?

A poppy and strawberry

B tulip and lily

C tulip, lily and strawberry

D poppy only

Answer: A

(Both poppy and strawberry plants are reproduced sexually, so populations of these plants are more likely to include plants with resistance to the virus.)

6 What type of reproduction and reproductive structures are responsible for the mouldy bread in your pantry?

Answer: Asexual reproduction of fungus via spores produced in sporangia. Black bread mould is a fungus called *Rhizopus stolonifer*.

7 What are four methods of cloning currently used in horticulture and agriculture? Discuss one of these methods, using an example of its application in horticulture or agriculture.

Answer: The cloning methods used in agriculture and horticulture are:

- cuttings and grafting
- plant tissue culture
- embryo splitting
- nuclear transfer.

(Answers for the second part of question will depend on the method chosen. The following are sample answers.)

Grafting

This method involves connecting mature rootstock tissue to the tissue of desired plant varieties. It enables efficient and rapid growth of desired plant varieties because they do not need to be grown from seeds. The qualities of the cultivar have been carefully selected over many generations and grafting ensures these qualities can be cloned for future propagation. Grafting is commonly used in horticulture to grow fruiting and ornamental trees.

Plant tissue culture

This method is used to rapidly grow large numbers of plants. As well as being used commercially to generate large crops with ideal characteristics, such as wheat with large grains, the technique is also being used in research and recovery programs for endangered plant species.

 ISBN 978 1 4886 1122 3

Embryo splitting

This method is used in livestock breeding programs to increase the number of offspring born in each breeding season. Rather than allowing livestock to breed naturally, farmers use *in vitro* fertilisation techniques. By fertilising eggs in a Petri dish, embryos can be split in the early stages of embryonic development (up to the 16-cell stage) to create multiple genetically identical embryos, which can then be implanted into surrogate mothers.

Nuclear transfer (e.g. Dolly the sheep)

This method has been used in many organisms, including sheep, dogs, cats and horses. It involves removing the nucleus from an unfertilised egg and replacing it with a nucleus from an adult somatic (body) cell. The egg is then transplanted back into a host mother, or a surrogate mother, where it can develop into a new individual. The new individual will be genetically identical to the donor of the somatic cell.

8 Arrange the following stages of plant tissue culture in the correct order, from first to last.

- New shoots are removed and placed on another culture medium.
- Plant hormones promote the rapid growth of shoots and roots.
- A sample of the ideal stock plant is removed.
- The sample is sterilised and placed on a culture medium.

Answer:

1 A sample of the ideal stock plant is removed.

2 The sample is sterilised and placed on a culture medium.

3 Plant hormones promote the rapid growth of shoots and roots.

4 New shoots are removed and placed on another culture medium.

9 What are four ethical issues associated with cloning?

Answer:

- Susceptibility to disease, because all the individuals in a population are clones.
- High failure rate: With current techniques the majority of embryos and foetuses do not progress to birth.
- Adverse health effects: Many cloned animals have organ malformations, impaired immune systems and reduced lifespans.
- Cloned food products entering the food system without knowledge of consumers because of insufficient regulation and labeling.

10 Arrange the following stages of meiosis in the correct order, from first to last.

- metaphase II
- telophase II
- prophase I
- anaphase I
- metaphase I
- anaphase II

 ISBN 978 1 4886 1122 3

Answer:

1 prophase I

2 metaphase I

3 anaphase I

4 metaphase II

5 anaphase II

6 telophase II

11 What is the significance of crossing over in meiosis?

Answer: It produces chromosomes with new combinations of genetic information; a process called recombination. This process creates genetic variation in the offspring, resulting in greater adaptability and evolutionary potential in populations.

12 How are monozygotic twins produced, and are they truly identical? Explain your answer.

Answer: Identical (monozygotic) twins develop from one fertilised egg, so they have the same set of genes and alleles. However, environmental and epigenetic differences that occur from the moment of conception mean that identical twins are actually not exactly identical.

13 Do hermaphrodites reproduce via asexual or sexual reproduction? Explain your answer.

Answer: Hermaphrodites are sexually reproducing species because they produce male and female gametes that combine to produce offspring.

14 The diploid number of chromosomes in horses is 64. How many chromosomes would you expect in a horse's:

a fertilised ovum?

b sperm cell?

c somatic cell?

Answers:

a 64

b 32

c 64

15 *Paramecium* protists can reproduce sexually. Arrange the following events that occur during sexual reproduction in *Paramecium* in order, from first to last.

- three haploid micronuclei (*n*) degenerate
- separation of mating partners
- micronucleus undergoes meiosis
- mating partners become attached
- exchange of micronuclei
- fusion of micronuclei (2*n*)

Answer:

1 mating partners become attached

2 micronucleus undergoes meiosis

3 three haploid micronuclei (*n*) degenerate

4 exchange of micronuclei

5 separation of mating partners

6 fusion of micronuclei (2*n*)

 ISBN 978 1 4886 1122 3

Chapter 10 Questions and answers

10.1 Review

1 Outline the structure of the DNA molecule. In your answer, include:

- the name and components of the unit (building block) of DNA
- the names of the four bases found in DNA
- how nucleotides are joined to build a single stranded DNA molecule
- how a double stranded DNA molecule is formed
- what is meant by 5' and 3' ends of a DNA strand, and the two strands of DNA being antiparallel.

Answer:

DNA is made up of nucleotides. Each nucleotide consists of a phosphate group, a five-carbon deoxyribose sugar and one of four nitrogen-containing bases.

The four bases are: adenine (A), guanine (G), thymine (T) and cytosine (C).

One nucleotide is joined to the next nucleotide by a covalent phosphodiester bond between the phosphate group on the 5' carbon and the 3' carbon of another nucleotide. When many nucleotides are joined together, a polynucleotide chain is formed.

The bases in two polynucleotide chains form complementary base pairs (A pairs with T; C pairs with G) by hydrogen bonding. The shape of the double stranded DNA is an alpha-helix, like a twisted ladder.

One end of each strand is called the 5' end (where the phosphate group is attached). The other end of the strand has the 3' carbon (without a phosphate group). The two polynucleotide chains of DNA are antiparallel, running in different directions with one strand running from 5' to 3' and the other from 3' to 5'. The two polynucleotide strands need to run antiparallel to each other to allow complementary bases to form hydrogen bonds.

2 A strand of DNA has the sequence ATTCCGTA. Write this out, and under it write the sequence of the complementary strand.

Answer:

ATTCCGTA

TAAGGCAT

3 Distinguish between DNA, genome, gene and allele.

Answer:

DNA is the chemical that contains the genetic information of organisms and determines their inherited characteristics.

The genome of an organism is described as being the sum total of an organism's DNA, measured in the number of base pairs, contained in a haploid (*n*) set of chromosomes and the mitochondria and chloroplasts.

A gene is a segment of DNA that codes for a protein that gives a particular characteristic to an organism.

An allele is one of two or more forms of a gene.

 ISBN 978 1 4886 1122 3

10.2 Review

1 What was the original goal of the Human Genome Project?

Answer:

The original goal was to determine the complete human genome, the precise order of nucleotides within a DNA molecule and the number of genes in one human individual.

2 Outline three outcomes of the Human Genome Project.

Answer (any three of the following):

- We now know the number of nucleotide base pairs (genome), DNA sequence, and the locations and sequences of many human genes.
- We are now able to detect carriers of genetic diseases.
- DNA sequencing technology from the Human Genome Project has allowed for DNA sequencing of other organisms.
- Through the comparison between organisms, new proteins and functions have been discovered, which has allowed for improved treatments in humans.
- We are able to better decide which model organism to use for various diseases.
- We are able to determine evolutionary relationships between organisms.

3 What major question does the Human Genome Project not answer?

Answer: The project does not tell us what genes do or how they function together.

4 The statements below describe the process of DNA sequencing. Reorder the statements in the correct order, from first to last.

- a chromatogram is produced
- DNA is replicated and the test tube mixture ends up with a range of fragments of DNA of different sizes (lengths)
- DNA is added to a mixture containing DNA polymerase, nucleotides, and terminating nucleotides that are tagged with fluorescent markers
- gel from gel electrophoresis is read by computers
- terminating nucleotides fluoresce as they pass through a laser beam

Answer:

- DNA is added to a mixture containing DNA polymerase, nucleotides, and terminating nucleotides that are tagged with fluorescent markers
- DNA is replicated and the test tube mixture ends up with a range of fragments of DNA of different sizes (lengths)
- gel from gel electrophoresis is read by computers
- terminating nucleotides fluoresce as they pass through a laser beam
- a chromatogram is produced

 ISBN 978 1 4886 1122 3

10.3 Review

1 Using the terms chromosome, histone, DNA and nucleosome, describe how DNA is packaged into a cell nucleus.

Answer

A long thread of DNA is tightly packed up so that it fits into the nucleus of every cell. The DNA in each chromosome is tightly coiled many times around proteins called histones that support its structure. The combined loop of DNA and protein is called a nucleosome. Next the nucleosomes are packaged into a thread, which is sometimes described as 'beads on a string'. The end result is a fibre known as chromatin. The chromatin is looped and coiled again to produce a thread-like structure called a chromosome.

2 Outline the variations seen in eukaryotic chromosome structure.

Answer:

Chromosome size varies because of differences in the number of genes and intergene spacers.

Chromosomes vary in the location of centromeres.

Chromosomes vary in number and size because different species have different numbers of genes and spacer DNA.

3 Distinguish between the following terms:

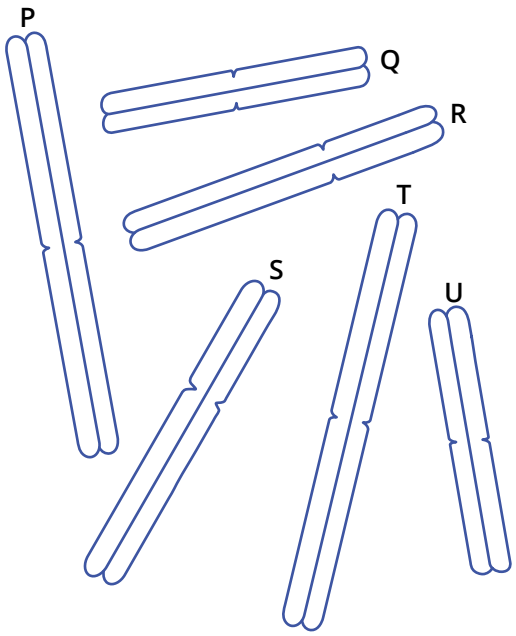
- autosome and sex chromosome (allosome)
- sex chromosome and homologues

Answer:

Autosomes are chromosomes that do not determine sex of the individual, while sex chromosomes are chromosomes that are involved in determining the gender of individuals.

Sex chromosomes are chromosomes that determine the sex of an individual, while homologues refer to matching pairs of chromosomes that have the same genes found at the same loci.

4 The figure below shows 6 chromosomes belonging to 3 homologous pairs.



a Identify the three pairs of homologous chromosomes.

b Explain which features you used to match the chromosomes.

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Answers:

a P and T

R and S

Q and U

b Chromosomes P and T are the same length, and centromeres are in the same position (metacentric).

Chromosomes R and S are the same length, and centromeres are in the same position (submetacentric).

Chromosomes Q and U are the same length, and centromeres are in the same position (metacentric).

5 How many homologous pairs of chromosomes would you expect to find in the cells of most

a human females?

b human males?

Answers:

a 23 pairs. In humans, females have 22 homologous autosomes and homologous sex chromosomes (two copies of the X chromosome).

b 22 pairs. In humans, males have 22 homologous autosomes and an X chromosome and a Y chromosome.

6 For each of the conditions listed below, state which chromosome is affected and whether the chromosome is in excess or missing.

a Down syndrome

b Turner syndrome

c Klinefelter syndrome

Answers:

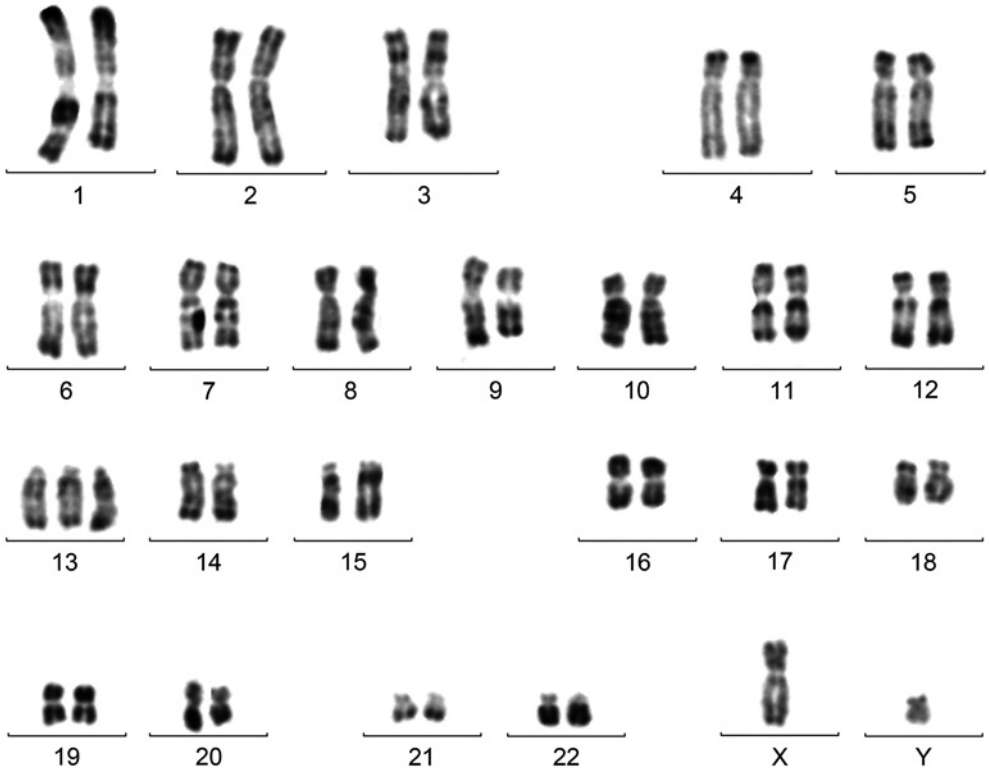
a chromosome 21; one additional copy (trisomy 21)

b X or Y sex chromosome; one missing (X0 monosomy)

c X chromosome in males; one extra copy (XXY)

 ISBN 978 1 4886 1122 3

7 The figure below shows a human karyotype.



Source: © Pr Phillipe Vago, ISM//Science Photo Library

a State whether this individual is male or female.

b Is there any evidence of aneuploidy in this person? Explain your answer.

Answers:

a Male (X and Y sex chromosomes present)

b Yes. He has an additional chromosome 13. Instead of two copies of chromosome 13 (normal), he has three copies of chromosome 13 (abnormal).

10.4 Review

1 Explain the difference between the genotype and phenotype of an individual.

Answer: A genotype is the combination of alleles that an individual has for the characteristic being investigated. The phenotype of the individual is the trait that a given genotype expresses. The environment also plays a role in the expression of the phenotype.

2 What factors contribute to an individual's phenotype? Give an example.

Answer: Answers to the second part of the question will vary. A sample answer is given here:

Both genetic and environmental factors contribute to the phenotype of individuals.

For example, the presence of skin pigment is controlled by genes for the production of melanin, but the degree of colour or tan of the skin can also be influenced by the amount of exposure an individual has to the sun. Other examples include the influence of both genetic and environmental factors on honeybees and hydrangeas.

3 *E* and *e* are alleles of a particular autosomal gene. Write down the possible combinations of these alleles and state whether each is homozygous or heterozygous.

Answer:

Homozygous – *EE* and *ee*

Heterozygous – *Ee*

 ISBN 978 1 4886 1122 3

4 Use an example to explain how two organisms can have the same phenotype but different genotypes.

Answer: Answers will vary. The following is a sample answer:

In blowfly individuals with genotypes *Ww* and *WW*, both individuals will have the same eye colour or phenotype even though they have different genotypes. This results when the expression of one allele is dominant over another. In this case, *W* refers to red eye colour and *w* refers to white. If *Ww* alleles are present, the expression of the *W* allele masks the effect of the *w* allele.

5 Use an example to distinguish between dominant and recessive phenotypes.

Answer: Answers will vary. The following is a sample answer:

A recessive phenotype is expressed only in a homozygote. For example blowflies show white eye colour only when the genotype *ww* is inherited at the *W* gene locus; blood type O in humans is present only when an individual has the genotype *ii* at the *I* gene locus.

6 Describe an example where an organism's phenotype can be affected by the environment in which it is raised.

Answer: Answers will vary. The following is a sample answer:

Flower colour in hydrangeas is affected by the pH of the soil, which affects the availability of aluminium in the soil to the plant. Therefore, plants with the same genotype can have different colour phenotypes.

7 Mutations are changes in a DNA sequence, and can result in new alleles for a gene. Outline the difference between epigenetic events affecting phenotypes and mutations affecting phenotypes.

Answer: Epigenetic factors affecting phenotypes do not involve changes to the DNA sequence. The DNA molecule is modified by the addition of methyl groups, not by a change in the sequence, which affects the expression of certain genes. Mutations result in changes in the DNA sequence, resulting in the expression of genes.

Chapter 10 Review

1 What is the difference between the alleles of a gene?

A their locus on the chromosome

B their amino acid sequence

C the type of sugar on the nucleotides

D the sequence of bases

Answer: D

2 A human cell has approximately 25 000 genes and *E. coli* has approximately 4000 genes. Explain why the number of genes is not an indicator of the size of the genome.

Answer: The genome is the number of base pairs in a DNA molecule, which includes genes and DNA segments (intergene spacers) that are not genes. An organism may have many genes and little non-coding DNA, or have few genes but a lot of non-coding DNA. Therefore the number of genes is not an indicator of the size of the genome.

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3 What was the aim of the Human Genome Project?

A to identify human infectious diseases

B to make improvement to the human genome

C to allow transfer of genes from other species to humans

D to sequence genetic information in humans

Answer: D

4 What does a nucleosome consist of?

A DNA and histones

B DNA and chromatid

C Chromatid and nucleotides

D RNA and histones

Answer: A

5 Most of the DNA of a human cell is contained in the nucleus. Distinguish between unique and spacer DNA sequences in DNA found in the nucleus.

Answer:

Unique sequences (may be) genes that code for proteins while spacer DNA regions are not genes, that is they do not carry code for protein.

6 State the number of autosomes and homologous chromosomes in a human

a female somatic cell

b male somatic cell.

Answers:

a autosomes – 22 pairs

homologous chromosomes – 23 pairs

b autosomes – 22 pairs

homologous chromosomes – 22 pairs

7 Explain what is meant by DNA being coiled and supercoiled within a chromosome. Include a diagram in your answer. What benefit is there in DNA being packaged in this way in a cell?

Answer: DNA is an exceedingly long molecule. It first forms a double helix structure (twisted). DNA is then wound around histones that are further coiled (supercoiled) that result in a compact package of information that fits into the nucleus of cells.

8 In mice, coat colour is controlled by a single gene. Black coat colour is dominant to white coat colour.

a Assign allele symbols for the gene responsible.

b How many genotypes are possible with respect to these alleles? State the genotypes and phenotypes.

Answers:

a *W* for black coat phenotype and *w* for white coat phenotype.

b *WW* – black coat

Ww – black coat

ww – white coat

(The letter used for allele symbol can be different from the one used here, but you must use upper case for the dominant phenotype and lower case for the recessive phenotype.)

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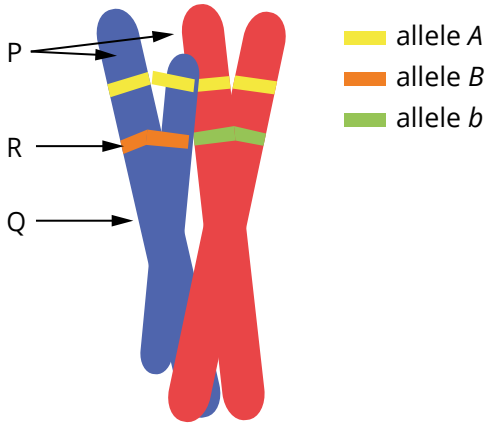
9 The diagram below shows a pair of chromosomes during meiosis to form a human sperm. The position of the alleles of some of the genes is shown.



a Identify the chromosome structures labelled P, Q and R.

b Suggest with reasons, whether the chromosomes are:

i sex chromosomes or autosomes

ii homologous or non-homologous

iii homozygous, hemizygous or heterozygous with respect to the *B* gene locus?

Answers:

a P – sister chromatids

Q – centromere

R – gene locus

b **i** Autosomes. (The individual is male because sperm is being formed. If they were sex chromosomes there would be one X chromosome and one Y chromosome.)

ii Homologous chromosomes. The chromosomes have the same genes on both chromosomes (although there might be different alleles in the case of allele *B* and *b*).

iii They are heterozygous with respect to the *B* gene locus.

10 Describe karyotyping and one application of its use.

Answer:

Karyotyping involves photographing chromosomes of cells undergoing mitosis. The photographs are arranged in chromosome pairs (homologous chromosomes) according to their location in relation to the centromere.

Karyotyping allows for abnormalities in the chromosome number or appearance to be seen. It also enables the detection of disorders involving damaged, missing or extra chromosomes, such as Down syndrome, Klinefelter syndrome and Turner syndrome. Karyotyping can be used to determine gender, and to compare the genetic makeup of different species.

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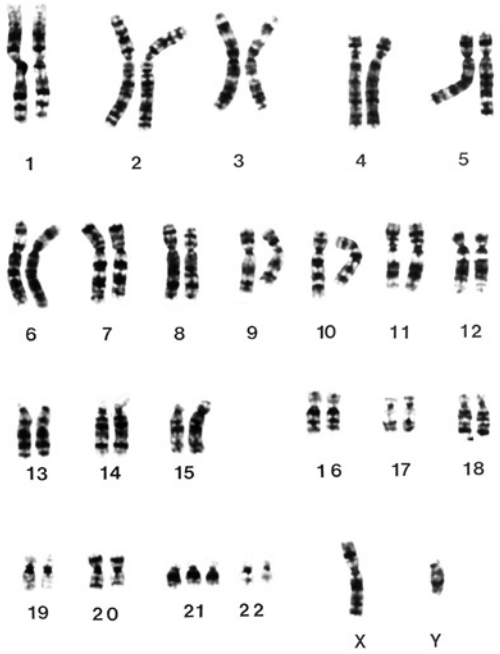
11 The figure below shows a human karyotype.



Source: © Science Photo Library/Getty Images

What conclusions can be deduced from the karyotype?

Answer:

Individual is a male because there is a Y chromosome.

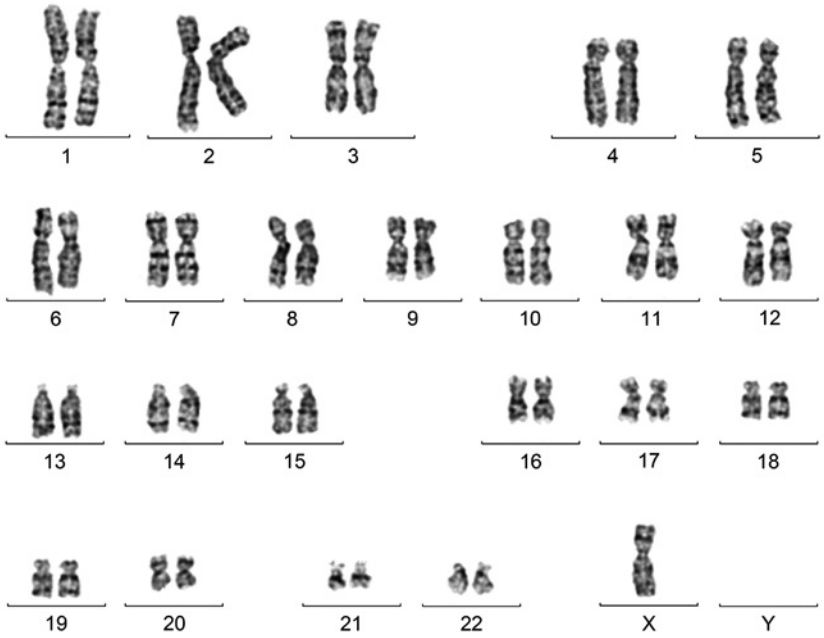
Individual has Down syndrome because there are three copies of chromosome 21 (trisomy 21).

12 Describe how human skin colour is determined genetically.

Answer: Human skin colour is an example of polygenic inheritance. It is determined by the amount of melanin produced in the skin. More than four genes contribute to a person's skin colour. The combinations of alleles of each of the genes determines the phenotype and allows for a range of skin colours. An individual with more alleles that promote melanin production will have darker skin.

13 Consider the following images of karyotypes. In each case identify the sex of the individuals and the conditions that they have.

a



Source: © Pr Philippe Vago/Science Photo Library

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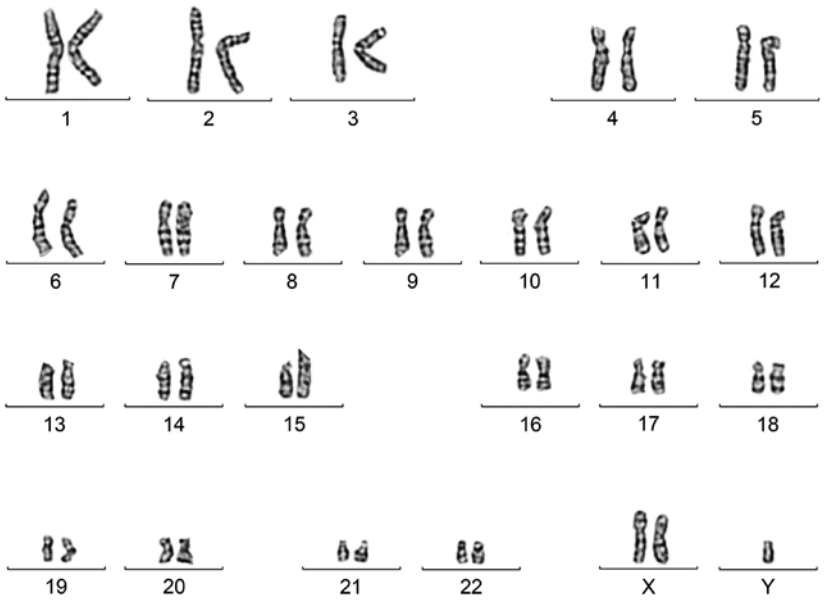
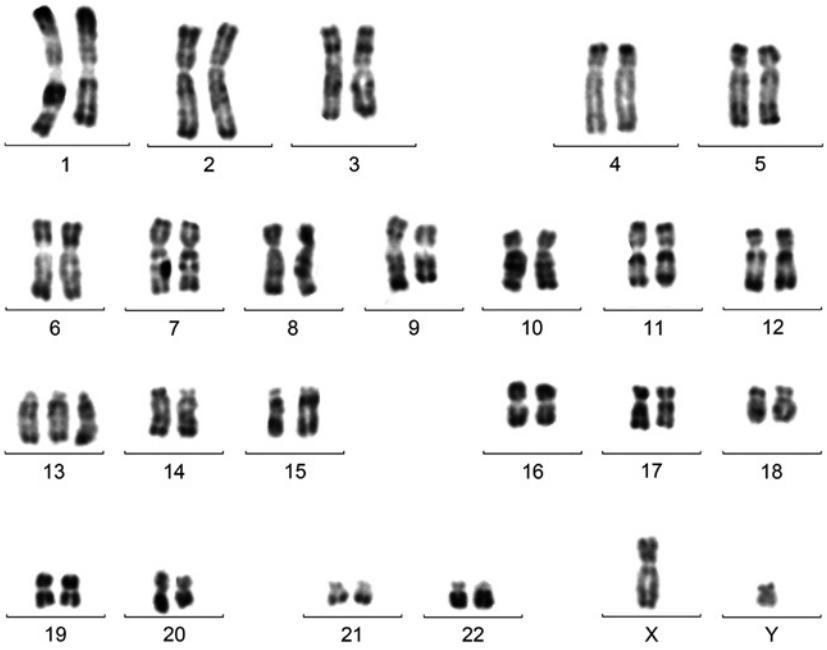
b



Source: © Pr Philippe Vago/Science Photo Library

c



Source: © Pr Philippe Vago/Science Photo Library

Answers:

a female, Turner syndrome

b male, Klinefelter syndrome

c male or female, Patau syndrome

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Chapter 11 Questions and answers

11.1 Review

1 What is meant by the term 'monohybrid cross'?

Answer: Monohybrid crosses are crosses between two individuals with different alleles at a single genetic locus. These crosses are performed to determine which trait is dominant.

2 Why might the results of a monohybrid cross differ from the expected ratio of 3 : 1? Select the correct answer.

A mutations

B alleles not segregating

C chance

D incomplete meiosis

Answer: C

3 Freckles are an inherited trait which results in the formation of spots on fair skin. It is found on chromosome 4 and shows a dominant inheritance pattern.

a State the type of inheritance (autosomal/sex-linked, dominant/recessive).

b Using suitable symbols, draw a full genetic diagram to show how a mother and father, who have freckles, can have a child that does not have freckles. State the probability for the child not to have freckles.

Answers:

a Autosomal dominant inheritance.

b Let *F* represent the allele that results in the phenotype freckles and *f* represent the allele that does not result in the phenotype freckles.

Since the child does not have freckles, both the mother and father are heterozygous and have the genotype *Ff*.

Parents		**Father with freckles**	
		F	*f*
Mother with freckles	*F*	*FF* freckles	*Ff* freckles
	f	*Ff* freckles	*ff* no freckles

From the genetic diagram/Punnett square, the probability for the child not to have freckles is 0.25 (or 25%)

4 Robert has blood type A and Lee has blood type B. Is it possible for them to have a baby of blood type O? What is the probability of this occurring? Draw a Punnett square to explain your answer.

Answer:

Yes. If Robert and Lee are heterozygous and both carry the allele for O blood type, there is a 25% chance that their baby will have blood type O.

	I^A	*i*
I^B	I^AI^B	I^Bi
i	I^Ai	*ii*

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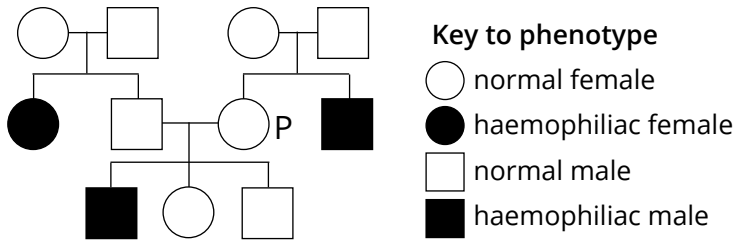
5 The figure below shows the inheritance of haemophilia in a family. Haemophilia is a recessive X-linked inheritance.



What is the genotype of P? Show your working using a Punnett square and appropriate symbols.

Answer:

Let X^h represent the allele on the X chromosome that causes haemophilia.

P's partner genotype is *XY* as he does not have haemophilia.

P does not have haemophilia, however, her son suffers from haemophilia.

Hence P is a carrier and her genotype is XX^h. The genetic diagram/Punnett square shows how P being a carrier can result in her son and daughters being normal or her son having haemophilia.

Parents		**P's partner (normal male)**	
		X	*Y*
P (normal female)	X^h	XX^h haemophiliac female	X^hY haemophiliac male
	X	*XX* normal female	*XY* normal male

6 Why do sex-linked disorders affect males more than females?

Answer:

X-linked recessive traits are predominantly expressed in males, as males only carry one X chromosome. Females are likely to be carriers of an X-linked recessive trait without expressing, or only showing mild expression of, the particular characteristic. This is because the second X chromosome that females carry can mask the recessive trait. The probability in humans of a female carrying the same two X-linked recessive alleles is very low.

7 Why are there fewer Y-linked disorders than X-linked disorders?

Answer:

The X chromosome is much larger than the Y chromosome and has many more genes. Most of the genes on the Y chromosome are involved in male sex determination and fertility. Therefore, there are far fewer Y-linked than X-linked traits.

11.2 Review

1 Why is pedigree analysis often the easiest way to investigate inheritance patterns in humans?

Answer:

Experimental 'crosses' cannot be set up as required.

The environment in which humans live cannot be controlled experimentally.

There are strict legal and ethical limits around human experimentation.

Humans tend not to have large families, so there are rarely large numbers of offspring to score.

Each generation of humans takes many years to reach sexual maturity and produce offspring.

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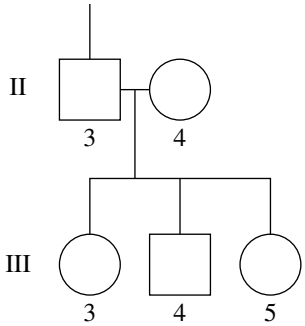
2 Which technology is changing the way we investigate inheritance?

Answer:

Gene technology (e.g. DNA and whole genome sequencing).

3 The figure below shows part of a family pedigree.



If individual III-3 was shaded, which of the following best describes the trait?

A dominant

B sex-linked

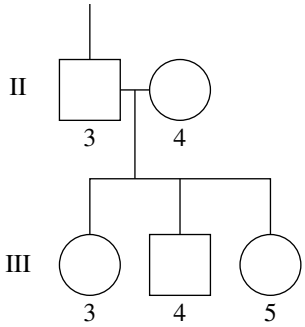
C recessive

D co-dominant

Answer:

C Both parents must carry the allele yet do not show the allele, so the trait must be recessive.

4 If individual III-5 was shaded, what would the genotypes of the parents be? Choose from options A–D and draw a Punnett square to show your reasoning.



A *BB, BB*

B *Bb, Bb*

C X^BX^B, X^BY

D X^BX^B, X^bY

Answer:

Option B is correct (*Bb, Bb*). Both parents must carry the allele yet do not show the trait, so the trait must be recessive.

II4 \ I3	*B*	*b*
B	*BB*	*Bb*
b	*Bb*	*bb*

III5

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5 What does 'carried on the X-chromosome' and 'occurs more in males than females' suggest?

A a monohybrid cross

B a dihybrid cross

C Mendel's experiments

D sex-linked inheritance

Answer: D

6 Explain why Y-linked disorders are rare.

Answer:

Y-linked disorders are rare because the Y-chromosome is small and cannot carry many genes.

7 What type of inheritance is shown in the pedigree below? Give three reasons for your choice of inheritance pattern.

Answer:

The trait is X-linked recessive. Reasons for this are:

The trait occurs in males (no affected females are seen in this pedigree).

Affected fathers do not pass the trait on to their sons, so the condition is not Y-linked.

Females can be carriers and not show the condition, females pass the trait on to their sons.

OR the trait could be autosomal recessive, because unaffected parents have affected child (3 occasions) as it could be just by chance that it's always a boy.

11.3 Review

1 What is Mendel's second law, and what does it state?

Answer:

Mendel's second law of inheritance, the Law of Independent Assortment, states that the alleles of a gene controlling one trait assort independently of alleles of another gene controlling a different trait.

2 Complete the sentences below about the principle of linkage.

The tendency for two or more _____ located on the same _____ is that they are inherited _____ . The _____ the _____ are to each other, the more likely they are to be _____ together, and appear to be _____ .

Answer:

The tendency for two or more (**genes**) located on the same (**chromosome**) is that they are inherited (**together**). The (**closer**) the (**genes**) are to each other, the more likely they are to be (**inherited**) together, and appear to be (**linked**).

3 What are the possible outcomes of meiosis in a heterozygote individual with the genotypoe *AaBb*? List all the gametes that this individual could produce.

Answer:

The possible outcomes of meiosis (gametes) in a heterozygote individual with the genotype *AaBb* (for unlinked genes, or linked genes after crossing over) are *AB*, *Ab*, *aB*, *ab*.

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4 For each of the following statements, state whether it is true or false.

a Genes are linked when the percentage of recombinant gametes falls below 50%.

b Recombinant gametes are observed in the offspring.

c If A and B loci are very close together, the probability of a random cross over event is very low.

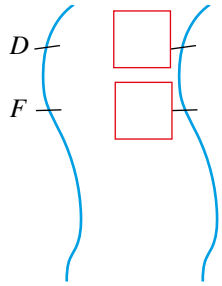
Answers:

a false

b false

c true

5 Sheep blowfly chromosome 5 carries genes for resistance to the insecticide dieldrin (gene *D*). The same chromosome carries a gene called furrowed eyes (*F*).



a Complete the allele symbols for a fly that is heterozygous at both loci.

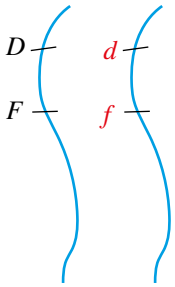
b If no crossing over occurs in meiosis, the gametes will carry either *DF* or *df* alleles. What combinations of alleles will be present in gametes if crossing over does occur?

c Construct a Punnett square for a cross between the fly shown above (genotype *DdFf*) (after recombination has occurred in meiosis) and a homozygous recessive fly (*ddff*).

d If dieldrin resistance is a dominant trait and furrowed eye is recessive, what proportion of the offspring with normal (wild type) eyes are resistant to the chemical dieldrin?

Answers:

a



b *DF, Df, dF, df*

c

Heterozygote → **Homozygous rec ↓**	*DF*	*Df*	*dF*	*df*
Df	*DdFf*	*Ddff*	*ddFf*	*ddff*

d 50% the wild type flies are *DdFf* and *ddFf*; they need to inherit a *D* allele for dieldrin resistance.

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11.4 Review

1 Define genetic testing.

Answer:

Genetic testing is a type of medical test used to detect specific alleles, mutations, genotypes or karyotypes that are associated with heritable traits, diseases or predispositions to diseases.

2 What are the three main methodologies used in genetic testing?

Answer:

Molecular genetic testing; Cytogenetic testing-karyotyping and molecular cytogenetic testing via FISH; Biochemical testing.

3 Outline the social and ethical issues associated with genetic testing and screening.

Answer:

There are limitations to genetic testing. Some genetic tests do not identify all possible gene mutations that can cause a particular condition, or they may have limited predictive value. As a result, the tests may require difficult decisions such as early termination of a pregnancy without full information.

Genetic testing can lead to specific treatments for some conditions but not all conditions, as some conditions have no known cure or treatment.

Genetic testing of some conditions can identify individuals at risk for certain diseases, but this does not mean for certain that those individuals would develop the disease.

Privacy concerns are one of the main areas of ethical consideration in genetic testing. There is debate over access rights to DNA samples and profiles.

There is the possibility of discrimination based on genetic testing; for example, by employers or health insurers.

4 Define gene therapy and discuss some of the ethical issues surrounding this technology.

Answer:

Gene therapy is the management of serious inherited disorders by inserting the 'normal' gene into a patient who has a mutant allele.

Some of the ethical issues related to gene therapy include the potential increased risk of dying from the therapy, the potential effect of the gene therapy on patient's offspring and other related issues as to whether we should be able to make choices that will impact the genetic health of future generations.

Chapter 11 Review

1 The shape of a human earlobe is determined by a single autosomal gene. Free lobe is dominant to attached lobe.

- **a** Write appropriate allele symbols for this gene.
- **b** How many genotypes are possible with respect to these alleles? How many phenotypes are possible?
- **c** A homozygous man with free lobes married a heterozygous woman. Show the genotypes and phenotypes possible in their children.
- **d** Can two people with free lobes have a child with attached lobes? Explain your answer.
- **e** Two parents heterozygous for earlobe shape have a child. What is the probability that the child has attached lobes? Write your answer as a percentage, and as a ratio.

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Answers:

a *F* – free lobes; *f* – attached lobes

b Three possible genotypes: *FF*, *Ff*, *ff*. Two phenotypes: free lobes – *FF* and *Ff*; attached lobes – *ff*

c Homozygous man with free lobes – *FF*; Heterozygous woman – *Ff*

Male \ Female	*F*	*f*
F	*FF*	*Ff*
F	*FF*	*Ff*

All of the children will have free lobes, although, expect 50% to be homozygous and 50% to be heterozygous.

d Two people who both have free lobes could have children with attached lobes if they are heterozygous.

Male \ Female	*F*	*f*
F	*FF*	*Ff*
f	*Ff*	*ff*

Expect $\frac{3}{4}$ offspring to have genotype that confers dominant phenotype of free lobes (either homozygous dominant or heterozygous) and $\frac{1}{4}$ to have attached lobes (homozygous recessive).

e The chance of having a child with attached lobes is 25% or 0.25 or attached lobes : free lobes = 1 : 3.

2 In mice, black coat colour is dominant to white coat colour. Calculate the expected genotypic and phenotypic ratio for a cross between two heterozygotes. Use appropriate notation.

Answer:

B – black coat (dominant); *b* – white coat (recessive)

	B	*b*
B	*BB*	*Bb*
b	*Bb*	*bb*

Expect a genotypic ratio of *BB : Bb : bb* of 1 : 2 : 1, which equates to a phenotypic ratio of $\frac{3}{4}$ black offspring: $\frac{1}{4}$ white offspring, i.e. 3 : 1.

3 A genetics student undertakes a study of inheritance patterns of feather colour in domestic chickens. The student observes the following:

- Matings between black-feathered adults always result in black-feathered offspring.
- Matings between white-feathered adults always result in white-feathered offspring.
- Matings between black-feathered adults and white-feathered adults produce only blue/grey-feathered offspring.
- Matings between blue/grey-feathered adults results in black, blue/grey and white offspring in a ratio of 1 : 2 : 1.

a Describe the mode of inheritance of this trait. Outline the evidence that leads you to this conclusion.

b How many genes and alleles control this trait? Outline the evidence that leads you to this conclusion.

c Use appropriate notation to set up a model that explains the student's observations.

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Answers:

a Incomplete dominance. The phenotypic ratio of 1 : 2 : 1 is typical for the F2 generation where the mode of inheritance is incomplete dominance.

b, c The characteristic of feather colour is controlled by a single gene with two alternative alleles. This is evident by the fact that three different phenotypes are produced when heterozygotes are crossed. Example: C^B – black feather colour; C^W – white feather colour $C^B C^B \times C^W C^W$ produces all intermediate coloured grey-feathered offspring. A cross between these intermediate heterozygotes:

	C^B	C^W
C^B	$C^B C^B$	$C^B C^W$
C^W	$C^B C^W$	$C^W C^W$

$\frac{1}{4}$ offspring are black : $\frac{1}{2}$ offspring are grey : $\frac{1}{4}$ offspring are white. This model explains the observations.

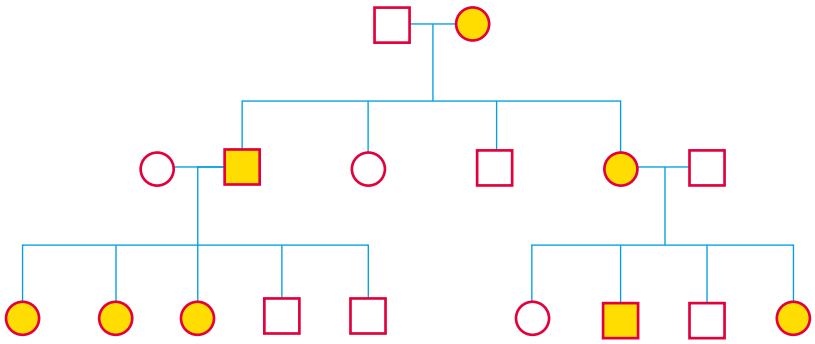
4 Using the key terms that relate to different sorts of crosses (testcross, monohybrid cross and other crosses), make a poster that distinguishes between the different crosses.

Answer:

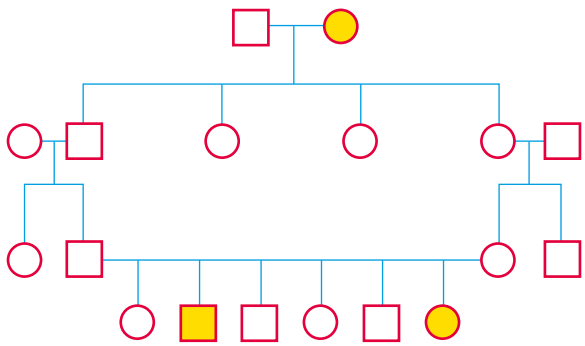
Students' own answers.

5 What is the most likely mode of inheritance for each of the diseases shown in the following pedigrees? Explain your choices.

(a)



(b)



Answers:

a *Autosomal dominant*: There are female and male sufferers and the trait occurs in every generation. OR This could also be *X-linked dominant* since it could be argued that X-dominant is the MOST likely mode because the affected father (gen II) passed it to ALL daughters; this could of course be a chance event, but it is suggestive.

b *Autosomal recessive*: Two unaffected parents (gen III) have affected children (gen IV), there are female and male sufferers and a generation was skipped.

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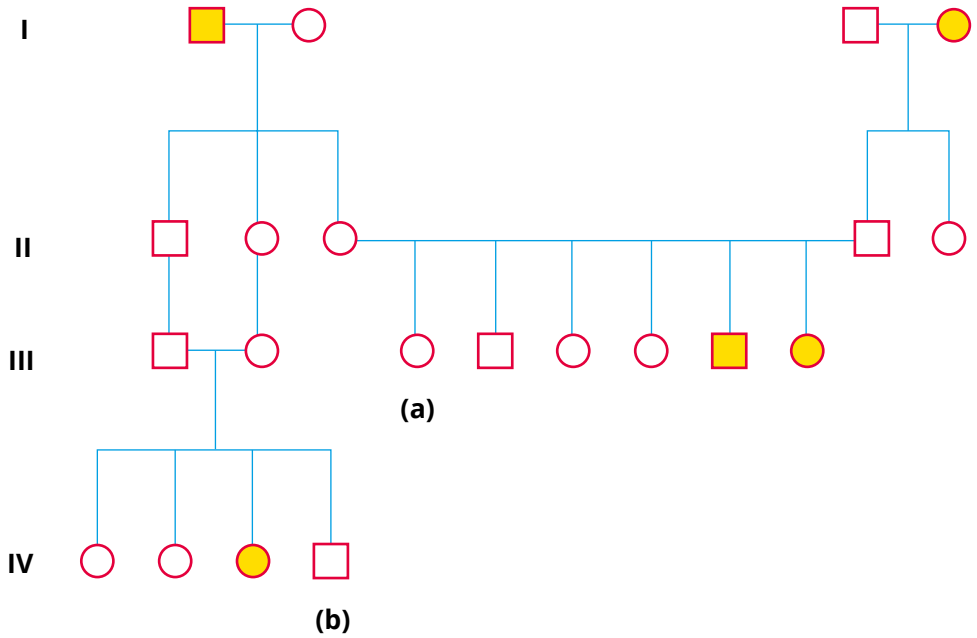
6 The following pedigree shows the inheritance of albinism.



a What is the most likely mode of inheritance of the condition? Explain.

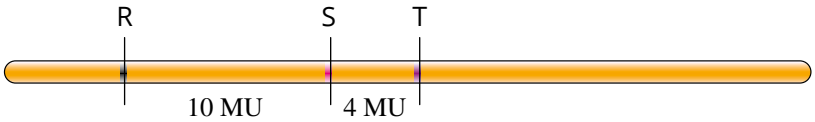
b If III(a) and IV(b) were to have offspring, what would you need to know about these individuals in order to calculate the chances of their offspring having albinism?

Answers:

a Autosomal recessive. Two unaffected parents (gen II and III) have affected children (gen III and IV), the condition is not observed in every generation of the family, it is not seen mainly in males and affected daughters do not necessarily have an affected father.

b Whether they are homozygous *AA* or heterozygous *Aa*.

7 This diagram represents a linkage group on a chromosome from a common crop plant. R, S and T represent different loci on the chromosome. MU = map units (this distance between loci).



Would you expect the greatest percentage of recombination to occur between RS, ST or RT? Explain your reasoning.

Answer:

The greatest percentage of recombination would occur between R and T because these two loci are the furthest apart.

8 If a woman is a carrier for a sex-linked recessive disease, only a son can suffer from the disease if the father does not have the disease. In vitro fertilisation enables the sex of the embryo to be determined very early in development. It is therefore possible to implant only female embryos into the woman's uterus so that the disease will not occur in her children.

a Does this approach mean the disease will not occur in subsequent generations of the family? Explain.

b Discuss the short-term and long-term benefits and disadvantages of implanting only female embryos of a mother who is a carrier for a sex-linked recessive disease.

 ISBN 978 1 4886 1122 3

Answers:

a If only female embryos were implanted in the mother's uterus, the disease could still appear in subsequent generations, as the female embryos may be carriers like the mother.

b The short-term benefit is that the embryo would not be a sufferer of the trait. The long-term benefit is that future generations could also use the technology to reduce the likelihood of the trait appearing in the offspring. The short-term disadvantages are that male embryos are destroyed, the female must use an invasive technique to become pregnant and there would be a reduced pregnancy success rate. The long-term disadvantages are that no males will be produced in future generations, the disease still exists in the family tree and each female who is a carrier may feel they need to again use IVF to become pregnant.

9 Which one of the following best describes restriction enzymes?

A enzymes that cut DNA at particular base sequences

B enzymes that replicate DNA

C enzymes involved in gene expression

D digestive enzymes involved in protein breakdown

Answer: A

10 Which one of the following lists chemicals used in polymerase chain reactions?

A restriction enzymes and a primer to copy a DNA sequence

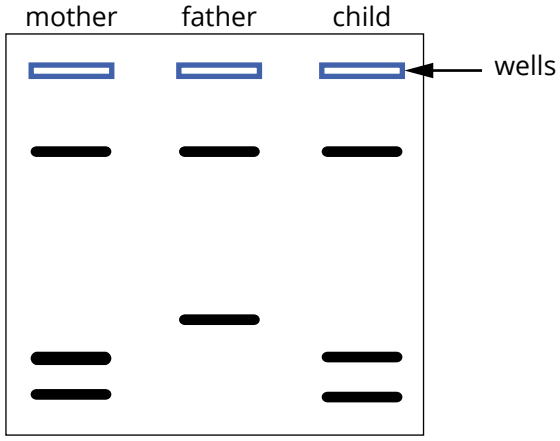
B DNA polymerase to produce a primer

C DNA polymerase and a primer to produce many copies of DNA

D restriction enzymes to produce a primer

Answer: C

11 A couple wishes to find out if their unborn child has sickle cell anaemia. The figure below shows the results from the gel electrophoresis of the restriction fragments of the sickle cell gene (located on chromosome 11) for the family. The mother carries the mutation, which results in sickle cell anaemia, while the father is normal.



a How does the restriction fragment analysis of the alleles of a gene result in different banding patterns?

b Does the child carry the mutation for sickle cell anaemia? Explain your answer.

c Using this scenario, outline some of the ethical implications of genetic testing of embryos.

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Answers:

a Two alleles of a gene have slight differences in nucleotide sequence. If the nucleotide difference occurs at a restriction site, it will prevent a restriction enzyme from cutting there. As a result, there will be a difference in the banding patterns between the two alleles.

b Yes. The child has the exact same banding pattern as the mother who carries the mutation for sickle cell anaemia.

c Possible Answers:

Now that the parents are aware that the child will have the disorder, they have the dilemma of having to choose whether to continue or terminate the pregnancy.

There are limitations to the genetic testing. Even though it is known that the child carries the mutation for sickle cell anaemia, it does not give an indication on the severity of the condition that the child might experience. Hence a termination of the pregnancy could have been unnecessary.

Application for health insurance requires full disclosure. Now that it is known that the child has the genetic condition, there is a possibility that health insurance for common conditions associated with sickle cell anaemia can be denied. If the child had not been tested, this issue would not have occurred.

There is a possibility that the child might be discriminated against in the future at school or at work due to the knowledge of the disorder.

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