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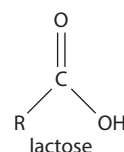
# > Coursebook answers

## Chapter 1

### Test your understanding

- 1 Carbon, hydrogen, oxygen and nitrogen
- 2 Iron to make hemoglobin; copper for protein and enzyme synthesis.
- 3 Industry and agriculture
- 4 Water is essential for chemical reactions, cooling and transport. It is also a habitat.
- 5 Water-loving; a molecule that is able to exist next to a water molecule.
- 6 Tiny molecular forces generated by positive charges of H atoms and negative forces of O atoms hold water molecules together.
- 7 It will freeze and form a surface to live on. It has a maximum density and minimum volume at 4 °C, so animals can dive to avoid the coldest area. It is transparent so permits photosynthesis underwater.
- 8 B
- 9 A planet that is not too hot and not too cold for life.
- 10 4
- 11 A single unit of a polymer such as a carbohydrate.
- 12 Condensation
- 13 Sugar, phosphate, base
- 14 fatty acids and glycerol
- 15 ATP
- 16 A group of atoms in a molecule that has similar chemical properties wherever it appears.

- 17 Carboxyl groups are found in amino acids and fatty acids.



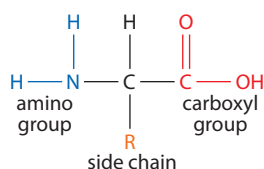
- 18 Sucrose, maltose and lactose
- 19 A
- 20 condensation, disaccharide, polysaccharide
- 21 Glycogen and starch, energy storage molecules
- 22 Glucose is soluble and requires a lot of water to remain inside a cell. This would upset the osmotic balance of a cell, but starch and glycogen are compact molecules that store energy without needing a lot of water.
- 23 Cellulose has straight chains of beta-D-glucose monomers, linked by hydrogen bonding; amylose has linear helical chains of alpha-D-glucose monomers, linked via 1–4 glycosidic bonds.
- 24 A condensation reaction.
- 25 Lipids are compact molecules that do not occupy much space.
- 26 Saturated fatty acids have no double bonds between their carbon atoms and all carbon atoms are linked to hydrogen atoms; unsaturated fatty acids contain at least one double bond between their carbon atoms.
- 27 *cis* – a carbon chain with all the functional groups on the same side of the chain; *trans* – a carbon chain with all the functional groups on the opposite sides of the carbon chain.
- 28 BMI = 35 kg m<sup>-2</sup>, the person is obese and is likely to be affected by diabetes or heart disease.
- 29 Hydrolysis

30 Energy storage, insulation

31 Steroid hormone – contains four fused rings, non-polar

32 Because they are non-polar molecules.

33



34 Peptide bond

35 alpha helix, beta pleated sheet

36 Globular proteins

37 C

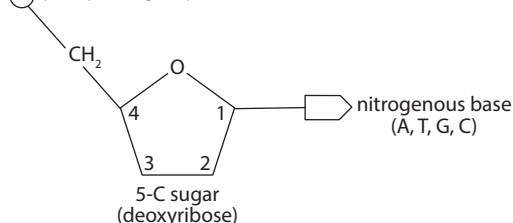
38 A non-protein group that forms part of, or combines with, a protein.

39 Hydrophilic amino acids on the outside of a protein molecule make it soluble in water.

40 A non-conjugated protein does not contain a prosthetic group, e.g. insulin.

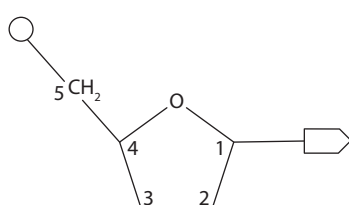
41 DNA, double stranded; RNA, single-stranded; DNA contains ACGT, RNA contains ACGU.

42 phosphate group



43 Nucleosomes control the degree of condensation of DNA and regulate access to genes for transcription.

44



45 Chargaff noticed that DNA contained equal amounts of adenine and thymine, and equal amounts of cytosine and guanine.

46  $8 + 1 = 9$

47 Hershey and Chase showed that the genetic material transferred to bacterial cells by infecting T2 phages is DNA not protein when they labelled DNA and protein with different radioactive isotopes and discovered that only DNA was passed into the bacterial cells.

## Exam-style questions

1 D

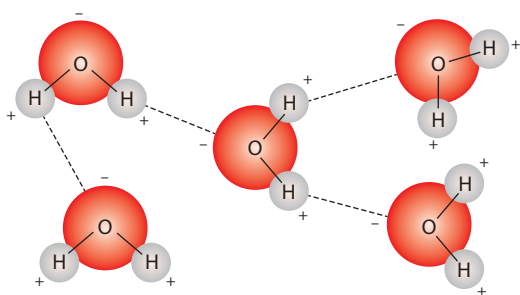
2 a Polar molecules are molecules with one end which is slightly positive, while the other end is slightly negative. Water is a polar molecule. [Student could also draw diagram to explain the answer.]

b Water is a good solvent because its polar nature means that it can surround other charged molecules and prevent them from clumping together. Positively charged ions such as  $\text{Na}^+$  can be surrounded by the negative ends of the water molecule, while negatively charged ions such as  $\text{Cl}^-$  can be surrounded by the positively charged  $\text{H}^+$  ions. The formation of intermolecular bonds between water and ions keeps the ions in solution. Other polar molecules such as amino acids and carbohydrates are also able to dissolve in water.

[Students could draw a diagram to explain this answer.]

Hydrophobic or 'water-hating' substances do not dissolve in water. They are usually uncharged, and examples include fats and oils, cholesterol and some large proteins.

3 Cohesive forces in water are due to hydrogen bonds between hydrogen atoms and oxygen atoms which hold water molecules together. This enables continuous columns of water to travel together, for example in the xylem of plants. It also enables water to act as a transport medium because cohesive forces keep transport fluids such as blood held together.



4 D

5 D

6 B

7 a In plants carbohydrates are structural, e.g. in cellulose cell walls.

They are used to store energy, e.g. starch in plants and glycogen in animals.

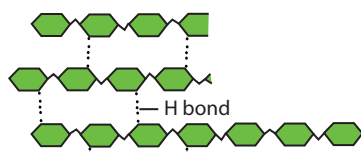
In heterotrophs they are a source of energy, e.g. glucose, lactose.

b glucose

c glycosidic bond

8 a Cellulose is built up of (beta) glucose monomers, linked in unbranched chains by  $\beta$ 1–4 glycosidic linkages.

b Cellulose chains are arranged in parallel bundles that are cross-linked by hydrogen bonds to make up the plant cell wall. Cellulose is a tough, fibrous and water-insoluble polysaccharide that keeps the structure of plant cell walls stable.

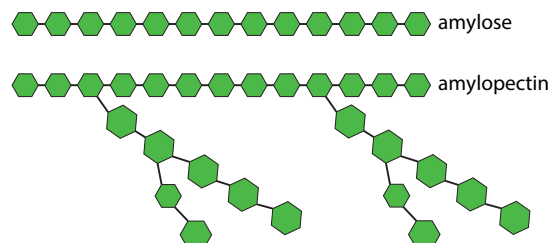


9 Glucose is stored as glycogen in animals. Glycogen is found in muscles and the liver.

10 a Two similarities: Both contain monomers of glucose; both are used as storage carbohydrates in plants and animals respectively.

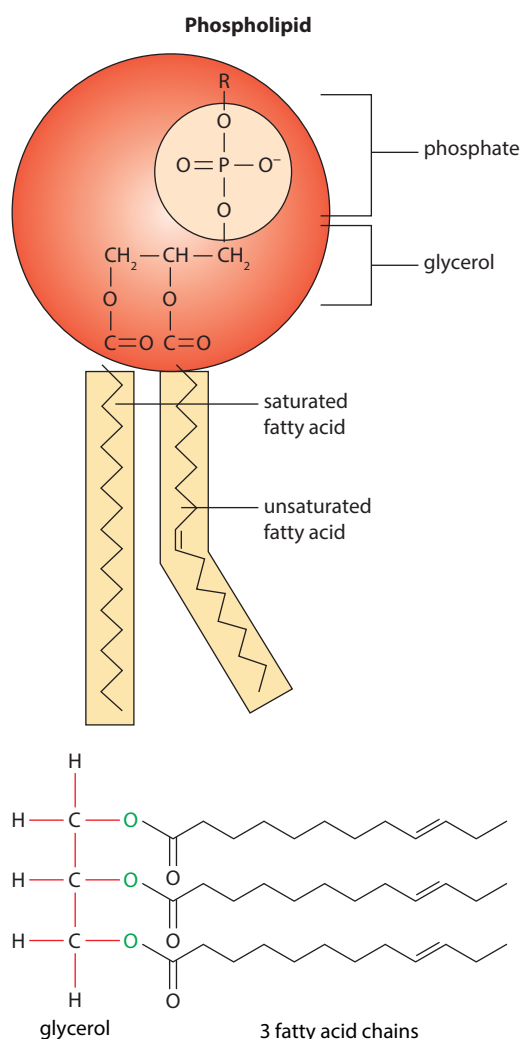
b Amylose and amylopectin

c Starch is made of amylose and amylopectin and the combination of the two molecules gives starch its properties. Starch is a storage molecule in plants and is largely insoluble. Enzymes found in heterotrophs can digest it. Amylose is made up of long chains of glucose molecules linked by  $\alpha$ 1–4 glycosidic linkages. The number of glucose subunits ranges from 300 to 3000 or even more. The long chain of amylose can fold to form a helix held by hydrogen bonds or can bind with other hydrophobic compounds. This is the way amylose is bound to amylopectin in starch. It is insoluble in cold water, it is resistant to digestion and limits the entry of water in starch. The main difference between the structures of amylose and amylopectin is in branching. The amylopectin component of starch shows extensive branching. There is a branch from the chain of glucose molecules every 24–30 subunits. Amylopectin is soluble in both hot and cold water and it does not resist digestion.

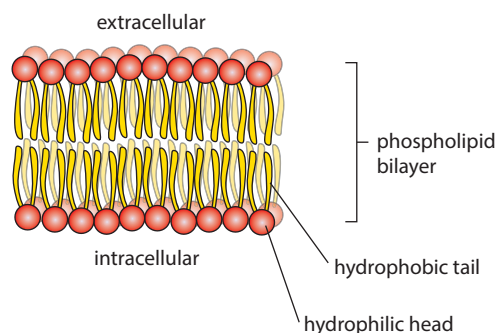


11 a 3

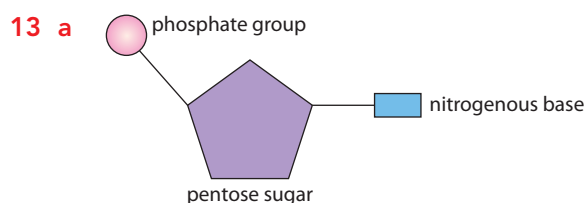
b A phospholipid contains a phosphate group with two lipid molecules attached to it; it contains only one glycerol. A triglyceride consists of a three fatty acids combined with glycerol, but it has no phosphate group. Triglycerides are a source of energy whereas phospholipids form part of the cell membrane.



- c** Phospholipids form bilayers in the membranes of all cells. The hydrophilic heads are aligned on the inside and outside of the cell while the hydrophobic tails are aligned inside the membrane. The membrane forms a barrier that separates the inside of the cell from the surroundings and controls what can enter the cell.



- 12 a** Lipids are used in membranes, for storage of energy, and for insulation and padding.
- b** carbon, hydrogen and oxygen
- c** Fat metabolism is the breakdown of fats in the mitochondria. Fatty acids are oxidised in mitochondria producing ATP, carbon dioxide and water. Overall, 100 g of fat produces about 110 g of water, which is why camels store fat rather than glycogen.
- d** A phospholipid is made up of two fatty acid tails and a phosphate group head. Phospholipids consist of a hydrophilic (or 'water loving') head and a hydrophobic (or 'water-hating') tail. Phospholipids line up in two parallel layers, called a phospholipid bilayer. The double layer is formed with phosphate group heads on the outside, and fatty acid tails on the inside and forms the main part of the cell membrane.



- b** Covalent bond
- 14 a** The two strands can be unwound and both can serve as a template for DNA replication. Because each type of base can only bond with its respective complementary base, the helical structure leads to the lowest energy of the available configurations. For heredity, the complementary nature of each strand and the evolution of the proofreading mechanisms of replication are more important.
- b** adenine, guanine, cytosine and thymine
- c** thymine
- 15 B**
- 16** Amino acids are linked together to form a polypeptide by peptide bonds. The polypeptide chain forms the primary structure of a protein but is folded into the three-dimensional shape that makes up a functional protein.

Some amino acids have nonpolar side chains, others have side chains with positive or negative charges, while others have polar but uncharged side chains. These side chains can bond with one another to hold a length of protein in a certain shape or conformation. Charged amino acid side chains can form ionic bonds, and polar amino acids are capable of forming hydrogen bonds. Hydrophobic side chains interact with each other via weak van der Waals interactions. Because of side chain interactions, the sequence of amino acids in a particular protein guides where the protein folds.

The primary structure of a protein drives the folding and intramolecular bonding of the linear amino acid chain, which ultimately determines the protein's unique three-dimensional shape. Hydrogen bonding between amino groups and carboxyl groups in neighbouring regions of the protein chain fold the polypeptides into  $\alpha$  helices and  $\beta$  sheets; these make up the secondary structure of a protein. Most proteins contain multiple helices and sheets, which are formed into a three-dimensional shape known as the tertiary structure of a protein.

- 17** Denaturation is a process in which proteins lose their quaternary structure, tertiary structure and secondary structure when exposed to heat or a substance such as a strong acid or base which breaks the bonds in the molecule.

Proteins such as enzymes have regions known as active sites that accept reactants so that reactions can take place.

If the shape and active sites of proteins are destroyed the protein can no longer carry out its function.

- 18** Hydrogen bonding is responsible for water's unique solvent capabilities. Hydrogen bonds hold complementary strands of DNA together, and they are responsible for determining the three-dimensional structure of folded proteins including enzymes and antibodies.
- 19** D
- 20** Proteins are made up of different units (amino acids) whereas lipids and carbohydrates are made up of the same or similar monomers. Amino acids must be assembled in specific ways that are coded for in the genetic code, whereas lipids and carbohydrates are always assembled in the same way with repeated sequences of the same monomers.

## Chapter 2

### Test your understanding

- 1 All the chemical reactions that take place in a living organism.
- 2 Anabolic reactions combine molecules to form new substances. Catabolic reactions break down large molecules.
- 3 globular, catalysts
- 4 As temperatures increase, molecular motion within a substance also increases. This increases the likelihood of collisions between an enzyme and its substrate, which can then interact.
- 5 At a certain substrate concentration all the active sites of the enzymes involved will be occupied, so that more substrate will have to 'wait' until an enzyme becomes available.
- 6 The minimum amount of energy needed for an enzyme-catalysed reaction to begin.
- 7 The product of an enzyme controlled reaction may inhibit a reaction further back in the metabolic pathway. This inhibition switches off the pathway until the product has been used or removed.
- 8 Penicillin interferes with cell wall production, so that as susceptible bacteria reproduce they die because their cell walls are not formed correctly.
- 9 Competitive inhibitors are similar to the substrate, but non-competitive are structurally different.

Competitive inhibitors block the active site; non-competitive inhibitors bind elsewhere.

In low concentrations of a competitive inhibitor, increasing the concentration of substrate reduces inhibition; at low concentrations of a non-competitive inhibitor there is no effect if substrate concentration is increased.

- 10 The conversion of glucose to pyruvate (glycolysis).
- 11 In mitochondria
- 12 Anaerobic respiration of yeast breaks down sugar to release carbon dioxide, which becomes trapped in the gluten fibres of bread flour, making the dough rise.

- 13 Gaining electrons, gaining hydrogen, losing oxygen.
- 14 ATP
- 15 It turns unreactive glucose into a more unstable phosphorylated compound that can be split to form two three-carbon sugars.
- 16 Link reaction – mitochondrial matrix; Krebs cycle – mitochondrial matrix
- 17 Acetyl-CoA
- 18 Attached to the inner mitochondrial membrane.
- 19 a *Spirogyra* photosynthesises in red light and produces oxygen. Bacteria move towards the oxygen-rich areas.  
b 500–600 nm is green/yellow light, photosynthesis does not occur at these wavelengths and bacteria do not have oxygen to move towards.
- 20 Blue or red light
- 21 The plant would not grow well, as it cannot photosynthesise in green light.
- 22 In the membranes of the thylakoids
- 23 Rate of oxygen production or rate of carbon dioxide uptake, or rate of increase in biomass.
- 24 Thylakoid membranes
- 25 Green light
- 26 As part of the molecules of chlorophyll
- 27 ATP and NADPH + H<sup>+</sup>
- 28 Ribulose biphosphate (RuBP)

### Exam-style questions

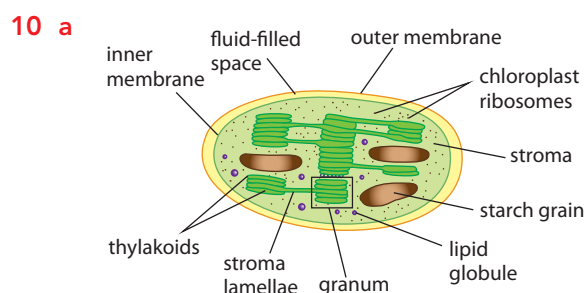
- 1 B
- 2 B
- 3 C
- 4 A
- 5 D
- 6 A
- 7 B
- 8 a Many grana are found in chloroplasts because they are the site of photosynthesis reactions.



**b** Plants that grow beneath trees will be shaded by the leaves of the tree and will receive less sunlight. Their rate of photosynthesis may be limited by this. The tree may also take water and nutrients from the soil leaving the undertree plants with insufficient water and nutrients and thus they may grow poorly.

**c** RuBP carboxylase or Rubisco is the enzyme involved in the first major step of carbon fixation in photosynthesis. In this process carbon dioxide from the air is (fixed) converted by plants and other photosynthetic organisms to glucose. It is one of the key steps in photosynthesis, which occurs in the chloroplasts.

**9** The light-dependent reactions use light energy to make two molecules needed for the next stage of photosynthesis: the energy storage molecule ATP and the reduced electron carrier NADPH. In plants, the light reactions take place in the thylakoid membranes of organelles called chloroplasts. The light-independent reactions take place in the stroma of the chloroplasts and require the products of the light-dependent reactions to supply energy (ATP) and  $H^+$  ions (NADPH) to produce glycerate 3-phosphate from carbon dioxide and RuBP.

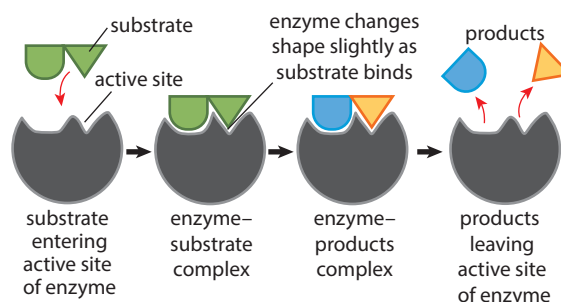


Folded membranes of the grana (thylakoids) provide a large surface area and site for the light-dependent reactions. Photosystems are fixed in these membranes. The liquid part of the chloroplast (stroma) provides a site for the light-independent reactions (Calvin cycle).

**b** Chlorophyll in photosystem II absorbs light and energises an electron. A carrier molecule transports the electron out and on down the electron transport chain. A water molecule is split and a new electron is released in the system with oxygen being released into the air. Chlorophyll in

photosystem I absorbs light, energising an electron. A carrier removes the electron and the electron from photosystem II replaces it. The electron is accepted by  $NADP^+$  at the end of the enzyme-catalysed reaction. A gradient of  $H^+$  ions pushes ions through ATP synthase producing ATP. ATP and NADPH go on to the Calvin cycle.

**11 a** The substrates involved in enzyme-controlled reactions bind to a special area of an enzyme known as the active site. Reactions occur here. Substrates enter the active site forming an enzyme substrate complex as the active site changes shape. Reactions occur as the enzyme catalyses either formation of a new molecule or separation of the parts of one molecule. Once the reaction has occurred the products leave the active site, which is then available for more molecules to enter it.



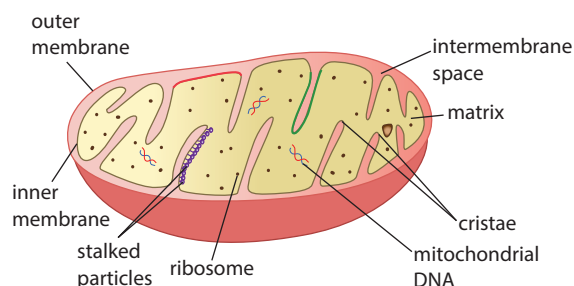
**b** A competitive inhibitor binds to the active site of an enzyme and blocks access to the substrate of that enzyme. Competitive inhibitors are usually similar in shape to substrates for a given enzyme.

**c** An increase in the concentration of substrate can overcome a competitive inhibitor because, with more substrate present, more substrate molecules will encounter the active site in preference to the competitor.

**d** End-product inhibition enables a cell to control a metabolic pathway because accumulation of the end product will inhibit an earlier reaction in the pathway and switch off the reaction until the product has been used or removed.

12 A

13 a



Reactions of respiration take place in the matrix and on the folded inner cristae.

- b** The early stages of respiration take place in the cytoplasm.
- c** Anabolic reactions involve the formation of molecules from simpler ones. Catabolic reactions involve the breakdown of large molecules into smaller ones, e.g. in digestion.

**14 a** Phosphorylation is the chemical addition of a phosphoryl group ( $\text{PO}_3^-$ ) to an organic molecule. Oxidative phosphorylation takes place in the inner mitochondrial membrane and is part of the reactions of respiration.

- b** The link reaction connects glycolysis to the citric acid (Krebs) cycle. The reaction converts the two molecules of the 3-carbon pyruvate from glycolysis into two molecules of the 2-carbon molecule acetyl coenzyme A (acetyl-CoA) and two molecules of carbon dioxide.
- c** As one glucose molecule is converted into  $2\times$  pyruvate molecules, the link reaction happens twice for every glucose molecule. Each molecule of glucose produces two molecules of acetyl-CoA and two molecules of carbon dioxide.



## Chapter 3

### Test your understanding

- 1 When DNA replicates the new double helix consists of one original strand and one new strand.
- 2 Helicase unwinds DNA for replication by breaking hydrogen bonds.
- 3 Paternity tests; in forensic investigations
- 4 Antiparallel strands have the 5' and 3' ends of their molecules at opposite ends of the double helix.
- 5 Replication occurs in a 5' to 3' direction.
- 6 DNA primase catalyses the production of a short length of RNA that is base paired to the DNA strand. The primer is replaced by DNA when replication is complete.
- 7 The leading strand is copied continuously, whereas the lagging strand is copied in fragments that are joined up later.
- 8 Transcription is the production of RNA from DNA in the nucleus.
- 9 Prokaryotes – in the cytoplasm; eukaryotes – in the nucleus.
- 10 It has two subunits made of protein and rRNA and three binding sites.
- 11 On the endoplasmic reticulum
- 12 Introns are sections of RNA that are removed before translation; exons are translated.
- 13 Repeated sequences (variable number tandem repeats); regulator sections – promoters and enhancers.
- 14 Telomeres occur at the end of DNA and protect the ends from erosion and genes from being lost when DNA is replicated.
- 15 Polysomes enable translation to occur at many places along an mRNA molecule at the same time.
- 16 The modification of DNA during an organism's lifetime to produce new characteristics.
- 17 Methylation changes the structure of DNA and determines whether a gene will be expressed.
- 18 Pollution may affect epigenetic markers and causes changes in gene expression.

19 Coat colour in agouti mice

20 Monozygotic twins have identical DNA profiles, although their epigenetic make-up may be different.

### Exam-style questions

1 D

2 a i A triplet of three nucleotides that specifies the position of an amino acid in a polypeptide.

ii Each strand of DNA acts as a template for the production of a new strand so that any double strand of DNA consists of a new single strand and a conserved single strand from an original molecule.

b i mRNA consists of just the section of DNA that is required for translation. It is also single stranded and small enough to pass through the pores in the nuclear envelope.

ii Each tRNA molecule can bind to one specific amino acid. The tRNA brings this amino acid to the mRNA molecule in the cytoplasm and the two RNAs bind by complementary base pairing. A peptide bond forms between the amino acid and the adjacent amino acid in the sequence and the tRNA detaches and moves back to collect another amino acid.

iii mRNA = UAG GAC AUA C

tRNA = AUC CUG UAU G

3 DNA replication is bidirectional; DNA polymerase enzymes work from the 5' to 3' end; RNA primers are attached to exposed DNA close to the replication fork: this is required to start the process; by RNA primase; one strand is copied continuously (the leading strand); the other (the lagging strand), in sections that are joined later by the enzyme DNA ligase; the process is semi-conservative; DNA is unwound by the enzyme helicase so that two strands are exposed for replication; RNA primers are removed when replication is complete by DNA polymerase 1 which adds in the appropriate bases. *[Any 6 of the above points or a correctly annotated diagram is acceptable.]*

- 4 B**
- 5 B**
- 6 a** It amplifies the DNA to make billions of copies so it can be studied. Only small samples of the original DNA are needed for the PCR process.
- b** It does not, denature at 95 °C (needed during DNA strand separation) (1)  
so PCR can be cycled repeatedly without stopping (to reload with enzyme) (1)
- c D**
- 7 a** Child 2
- b** Because the child's DNA profile has no matches to the father.
- 8** Most people have similar genomes / most genes are the same (1)  
using coding sequences would not provide unique profiles (1)  
(parts of) non-coding DNA contains variable numbers of, short tandem repeats STRs / repeating sequences which vary between individuals (1)
- 9** Hemoglobin is made up of four subunits, two alpha and two beta polypeptide chains; sickle-cell disease occurs when the beta chain is abnormal; to form a normal polypeptide each amino acid in the chain is specified by a triplet on the coding chain of DNA; the series of triplets is transcribed and translated to form the polypeptide; if a point mutation occurs in one of the triplets an incorrect amino acid may be inserted in the polypeptide; this means that when the polypeptide folds into its tertiary shape, the shape is not correct and the hemoglobin formed is a different shape; valine replaces glutamic acid; sickle cells carry less oxygen and are rapidly taken out of circulation leading to anemia and other serious health consequences. *[Any 6 of the points listed are acceptable.]*
- 10 a** Epigenetics is the study of changes to the activation of genes in differentiated cells.
- b** Epigenetic changes can be caused by environmental factors such as pollution and in some cases the maternal diet can cause epigenetic changes in her offspring.
- c** DNA methylation inhibits transcription, which reduces the expression of certain genes. Histone modification: histone methylation and histone demethylation are modifications that can reduce or enhance gene expression, as a result of altering chromatin structure. A histone is a protein that makes up part of the structure of chromatin, which is a complex of DNA-wrapped proteins. Genes for transcription can either be exposed or covered and concealed by modifications to histones.
- 11 a** Arrows pointing from left to right.
- b** Alanine
- c** The tRNA collects the amino acid that matches its anticodon in the cytoplasm. The amino acid attaches to the anticodon by complementary base pairing.
- d** A peptide bond
- 12 a** DNA methylation is the most common type of epigenetic modification. It involves attaching methyl groups to segments of DNA. When methyl groups are added to a particular gene, that gene is turned off or silenced, and no protein is produced from it.  
  
The enzyme DNA methyl transferase adds methylation markers to the base cytosine. Inserting methyl groups here changes the appearance and structure of DNA, and modifies the interactions between transcription factors that determine whether the gene will be expressed. Promoter regions of genes often lie within areas known as 'CpG islands' and, if CpG is methylated, the gene will not be expressed.
- b** Example 1 Agouti mice – A high degree of methylation inactivates the gene so the mouse has a dark coat. Without methylation, the gene is active and the coat is yellow. An active gene is also linked to an increased likelihood of obesity and diabetes.  
  
Example 2 – The environment can influence human health, and some of these effects can be inherited. In Sweden, scientists showed that nutrition affected the death rate associated with cardiovascular disease and diabetes. If a father did not have sufficient food in his pre-pubescent years, his sons were less likely to suffer from cardiovascular disease.

## Chapter 4

### Test your understanding

- 1 Genome – all the genetic material in an organism; diploid – having two sets of chromosomes; homologous – a pair of chromosomes that carries the same genes.
- 2 A locus is a specific place on a chromosome where homologous genes are found; a gene is a sequence of DNA that codes for a protein; an allele is the form of a gene.
- 3 Prokaryotic – single strand of genetic material not in a nucleus; eukaryotic chromosomes are paired within a nucleus.
- 4 Karyograms are visual displays of chromosomes; they can indicate if chromosomes are missing, duplicated or damaged.
- 5 X inactivation – only one of the pair of X chromosomes in a human female is active; the other is ‘switched off’.
- 6 Genotype is the genes that an organism has; phenotype describes an organism’s appearance.
- 7
  - a Genotype – genes an organism has.
  - b Phenotype – an organism’s appearance.
  - c Dominant allele one that always appears in the phenotype.
  - d Recessive allele – expressed if two copies are present.
  - e Homozygous – having two copies of the same allele.
- 8
  - a Red
  - b Red
  - c Yellow
- 9
  - a R
  - b r
  - c Either R or r

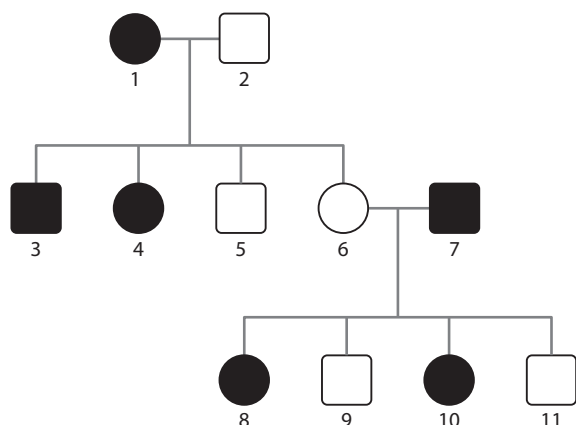
10

|                           |   | gametes from green parent |              |
|---------------------------|---|---------------------------|--------------|
|                           |   | G                         | g            |
| gametes from green parent | G | GG<br>green               | Gg<br>green  |
|                           | g | Gg<br>green               | gg<br>purple |

- 11  $I^A i I^A I^A$
- 12 Sex-linked condition – a characteristic or condition that has its alleles on the sex chromosomes.
- 13  $X^h X^h$ .
- 14 Temperature, nutrient availability and location
- 15 Linked genes are always inherited together.
- 16 Degrees of freedom = number of categories minus 1

### Exam-style questions

- 1 C
- 2
  - a The pattern of inheritance of genes carried on one of the sex chromosomes.
  - b Red/green colour blindness, Duchenne muscular dystrophy [*or other suitable example*].
  - c Chart like the one below:  
females = circles, males = squares,  
affected individuals are shaded.  
  
Chart should show individual 1 =  $X^h X^h$ ,  
male = XY  
  
Female annotated ‘affected’  
Male ‘normal’  
  
Male 3 =  $X^h Y$ , Female 4 =  $X^h X^h$



- 3 a The genotype of the plant will be Yy and the seeds will be yellow.

b

|   |    |    |
|---|----|----|
|   | y  | y  |
| Y | Yy | Yy |
| y | yy | yy |

- c The predicted ratio is 50:50 green to yellow seeds. [Answer must be given as a ratio.]

4 C

5 a 250,0000

- b Loss of a base; so that the triplet for amino acid is changed to a stop codon or forms an intron
- c It may change the tertiary structure of protein [1]; so that a non-functional protein or enzyme is formed [1].

- 6 a Both alleles are expressed in the phenotype
- b Males only have one allele, the Y chromosome does not carry the allele; [1] males can only have black fur or ginger fur. [1]
- c Possible genotypes.  $X^G X^B$   $X^B X^B$ .  $X^G Y$ .  $X^B Y$

Phenotypes: tortoiseshell female, black female, ginger males, black male

Ratios: 1:1:1:1

- 7 a Cells in mitosis have visible chromosomes; [1] so it is possible to see where the DNA probe is attached [1].
- b To compare the results with those for resistant flies; to see the death rate in non-resistant flies.
- c Other factors are involved because some resistant flies die; [1] but with inhibitor they still have greater resistance than non-resistant flies. [1]

PM is involved because: few resistant flies die without inhibitor; [1] more inhibited flies die than resistant flies; PM inhibited flies die faster [1]

## Chapter 5

### Test your understanding

- 1 Water, methane, ammonia, hydrogen
- 2 A system or organism that has different properties from those of the components that make it up.
- 3 Cells can perform all the functions of life: metabolism and the ability to replicate.
- 4 Phospholipids have hydrophilic and hydrophobic areas, placed in water they form micelles, vesicles and bilayers.
- 5 Cells are the smallest unit of life; living organisms are composed of cells; cells come from pre-existing cells.
- 6 Inputs: water, methane, hydrogen, ammonia, spark. Outputs: amino acids.
- 7 RNA – formed as a single strand of nucleotides, can replicate and act as an enzyme.
- 8 Universal genetic code and shared genes across all organisms.
- 9 Prokaryotes have single-stranded genetic material, no nucleus, no membrane-bound organelles, 70S ribosomes, no endoplasmic reticulum. Eukaryotes have double-stranded DNA within a nucleus, organelles are present, 80S ribosomes, endoplasmic reticulum present.
- 10 Chemical reactions within the cell can be separated from each other.
- 11 Endoplasmic reticulum is the site of protein synthesis by ribosomes.
- 12 Theory is supported by the fact that mitochondria and chloroplasts have structures that are similar to prokaryotes, have genetic material, ribosomes and can replicate by fission.
- 13 10
- 14 They absorb light at specific wavelengths and re-emit it at a longer wavelength and produce coloured images.
- 15 Viruses are obligate parasites and can only live within a host cell. They cannot metabolise or replicate themselves.

- 16 Capsids are made of viral proteins, whereas envelopes are derived from the membranes of the virus host cell.
- 17 Viral envelopes help the virus bind to and enter host cells, and survive for longer outside a host cell.
- 18 *Chlamydia* – has evolved from a free-living form and has its own metabolism, but must replicate inside a host cell.
- 19 Virus first proposes that viruses existed before cells and may have been the first structures capable of replication.

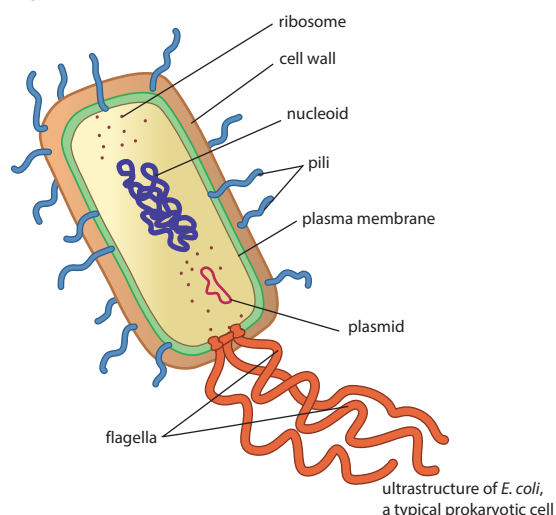
### Exam-style questions

- 1 B
- 2 B
- 3 a a mitochondrion  
b Compartmentalisation increases the efficiency of many cellular processes by concentrating the components that are needed to a confined space in the cell. The components may be enclosed by membranes such as in the cases of mitochondria and chloroplasts.
- c Resolution is the ability of a microscope to distinguish between two closely spaced structures and reveal details of adjacent structures clearly.
- 4 a Cell theory proposes that: all cells come from pre-existing cells; cells are the smallest unit of life; DNA is passed between cells during cell division; cells of all organisms within a similar species are mostly the same, both structurally and chemically.  
b An emergent property is one that is seen in a system or part of an organism that is functioning together, but not in any one part of that system on its own.  
c respiration, reproduction, response to stimulus, movement, growth, excretion, nutrition

5 a 1 = vacuole, 2 = nucleus, 3 = cell wall

b The cell wall encloses the plant cell and gives it shape. It surrounds the plasma membrane and provides strength and protection against mechanical and osmotic stress. It also allows cells to develop turgor pressure (the pressure of the cell contents against it).

6 a



7 D

8 A viral envelope is an outer layer found in many types of viruses. It protects the virus genetic material when they pass between host cells. The envelopes are often derived from portions of the host cell membranes and this may make enveloped viruses able to infect cells more easily. But, because envelopes can be fragile, non-enveloped viruses are sometimes more resistant to changes in temperature, pH and some disinfectants than enveloped viruses.

9 C

10 C

11 B

12 Xylem consists of long tubes made of dead plant cells arranged end to end; once mature they have no organelles or cytoplasm. Movement inside the xylem is passive, so there is no need for plasma membranes or transport proteins. Phloem is made up of tubular cells that have no organelles of their own, but are alive and have companion cells alongside them. These companion cells contain organelles such as mitochondria. Both these arrangements make xylem and phloem atypical cells. [Students could use an annotated diagram to cover the points above.]

13 Miller and Urey mimicked the conditions that they thought existed on the early Earth. They sealed gases that they suggested would have been present on the early Earth into a flask and used electrical sparks to imitate lightning. The gases were water vapour, methane, hydrogen and ammonia. After some weeks amino acids were formed inside the sealed flasks.

14 Endosymbiosis theory proposes that mitochondria and chloroplasts were once free-living prokaryotic organisms that became engulfed by a larger cell and remained inside them forming symbiotic relationships. Evidence includes: they have their own strand of genetic material which is naked and circular and can divide independently; they have their own double membranes; they have their own 70S ribosomes.



## Chapter 6

### Test your understanding

- 1 Hydrophilic – can exist in an aqueous medium; hydrophobic – water hating, are repelled by water.
- 2 Nucleus, mitochondria, endoplasmic reticulum, lysosome
- 3 As enzymes or receptors on the cell surface
- 4 So that different chemical reactions can be separated from one another as photosynthesis takes place.
- 5 Rough endoplasmic reticulum is the site of protein synthesis; it has ribosomes attached to it.
- 6 Simple diffusion – molecules diffuse freely; facilitated diffusion, molecules pass through specific protein channels.
- 7 Simple diffusion, facilitated diffusion, active transport
- 8 Active transport requires ATP but diffusion does not.
- 9 Differences: one moves substances into the cell, the other moves them out.  
Similarity: both involve infolding of the cell membrane.
- 10 Gated ion channels are stimulated by a change in membrane potential.
- 11 Myelin speeds up the transmission of impulses.
- 12 Mass in water is greater than the mass in sucrose solution because in sucrose solution water leaves the cell by osmosis.
- 13 Turgid
- 14 Three samples enable an average to be taken to improve the reliability of the results.
- 15 Samples may be different sizes at the start of the experiment and % change avoids inaccuracies due to this.
- 16 Hypotonic solutions will enter cells by osmosis and cause a plant cell to swell to full turgor and an animal cell to burst.

17 Both occur as cells lose water to a hypertonic solution outside their membrane. Plasmolysis occurs when a plant cell membrane begins to pull away from the cell wall. Animal cells shrivel or crenate as they lose water.

18 Isotonic solutions have the same water potential as human body fluids and so maintain equilibrium when they are used.

19

| Radius | Surface area | Volume               | Surface area: volume ratio |
|--------|--------------|----------------------|----------------------------|
| 1      | $4\pi r^2$   | $\frac{4}{3}\pi r^3$ | 4.8 : 1                    |
| 2      | 50           | 33.5                 | 1.5 : 1                    |
| 3      | 113          | 113                  | 1 : 1                      |

Surface area to volume ratio of a sphere =  $\frac{3}{r}$  where  $r$  is the radius. The ratio decreases as the sphere's ratio increases.

20 The thin cylinder will provide the greatest surface area. If any of the shapes have folds added the surface area will be increased.

21 Surface area to volume ratio changes as cell size increases. A larger cell has a relatively smaller surface area through which to absorb materials.

22 A cell may increase its surface area by becoming long and thin or by developing folds (such as villi) in its surface.

23 Glucose and oxygen enter; carbon dioxide leaves.

24 Growth factors stimulate the increase in the size of a cell. Mitogens cause cells to begin the process of mitosis.

25 Because it has grown too large; because the organism is growing and needs more cells; more cells are needed for repair.

26 Chromosomes are replicated during interphase.

27 Cytokinesis in animals – new plasma membranes meet to separate the cell into two new separate cells. In plants, a cell wall builds up along the cell plate to separate the cytoplasm.

28 Because the number of chromosomes in a cell after meiosis is half the diploid number of the original cell.

29 Four

- 30** Each one of a homologous pair of chromosome may line up at any position on the spindle independently of the other chromosomes.
- 31** One cell produced during meiosis will contain an extra chromosome.

### Exam-style questions

- 1** D
- 2** A
- 3** A
- 4** C
- 5** C
- 6** **a** 0.25 M  
**b** 108 mm
- 7** As an organism becomes larger its surface area to volume ratio decreases. This means that the organism has less surface area through which to absorb the substances it needs. A cuboid organism with side length of 1 cm has a volume of  $1 \text{ cm}^3$  and surface area of  $6 \text{ cm}^2$  and so a surface area:volume ratio of 6:1, but a cube with a side length of 3 cm has a surface area of  $9 \times 6 = 54 \text{ cm}^2$  and a volume of  $27 \text{ cm}^3$ . Its surface area:volume ratio is only 2:1.
- 8** D
- 9** C
- 10** C
- 11** **a** Telophase 2 – at this stage chromatin decondenses, nuclear envelopes are forming and a cell plate is beginning to form.
- b** When gametes are formed the separation of one pair of alleles is independent of the separation of another pair of alleles.

- 12** **a** ATP is being used to move Na and K ions.
- b** Resting potential is established by the active transport of sodium ions out of the axon cell. Potassium ions are transported into the cytoplasm. This leads to a net positive charge outside the axon and negative charge inside the axon membrane. [1 mark for each statement.]

- 13** **a** B
- b** D
- c** Because any of the phospholipid molecules can occupy any position in the membrane, e.g. molecules C + D could be on either side of the bilayer or at any position in its present layer.

**14** B

- 15** **a** Some glycoproteins in the membrane are antigens; antigens stimulate antibody production by the immune system; antigens of the ABO blood groups stimulate antibody production if a person receives a transfusion from someone with an incompatible blood group; antigens on the membranes of bacteria stimulate the immune system to attack them.

- b** Lysosome – the membrane allows the cell to separate potentially damaging enzymes within a separate compartment so the cell is not harmed

OR mitochondrion – membrane enables the reactions of respiration to take place in a separate compartment within the cytoplasm.

Other organelles and explanations are acceptable.

## Chapter 7

### Test your understanding

- 1 Hormones, neurotransmitters, ions
- 2 Emergent properties are new properties that emerge in a cell as the cell's components interact, so that the cell or organism can carry out a range of more complex functions.
- 3 Cell signalling enables cells to work together and coordinate responses within an organism.
- 4 Production of insulin or control of body temperature.
- 5 A
- 6  $-70 \text{ mV}$
- 7 4 ms
- 8 The recovery phase ensures that impulses pass in only one direction. It occurs as ions are restored to the different sides of the membrane to restore the resting potential.
- 9 Sodium ions are exchanged with potassium ions across a neuron membrane so that  $\text{K}^+$  ions are inside and  $\text{Na}^+$  are outside, giving a potential difference across the membrane of about  $-70 \text{ mV}$ .
- 10 Action potential is the depolarisation of the membrane, so that an impulse can spread along a neuron.
- 11 Acetylcholine (neurotransmitter)
- 12 Arrival of impulse at the pre-synaptic membrane, release of neurotransmitter, diffusion of neurotransmitter across the synapse, depolarisation of postsynaptic membrane to instigate action potential, deactivation and reabsorption of neurotransmitter.
- 13 Presence of myelin, diameter of the neuron, temperature.
- 14 Excitatory: make depolarisation more likely; inhibitory: make it less likely to occur.
- 15 In the upper layers of the skin.
- 16 A chemical messenger, released by an endocrine gland, that is carried in the blood to a target cell.
- 17 Peptides, tyrosine derivatives, steroids

- 18 Insulin stimulates the uptake of glucose from the blood into muscle cells and the liver, so sugar in the blood decreases.
- 19 Glucagon is produced in the alpha cells in the islets of Langerhans in the pancreas.
- 20 Type I diabetes is an autoimmune condition in which insulin is not produced, Type II diabetes is a failure of the cells to respond to insulin.
- 21 Steroid hormones enter target cells and bind to receptors, forming a complex that regulates the process of transcription.
- 22 Peptide hormones do not enter cells but bind to cell surface receptors and activate a second messenger (cAMP), which inhibits or stimulates cell metabolism.
- 23 Auxin, cytokinin
- 24 Growth of the shoot of a plant towards a source of light.

### Exam-style questions

- 1 D
- 2 A
- 3 C
- 4 C
- 5 A
- 6 Blood glucose level is kept constant by homeostasis so that cell functioning is not upset. Blood glucose levels rise as glucose is absorbed from the intestine, the blood flows in the hepatic portal vein to the liver where hepatocytes are influenced by the hormones insulin and glucagon. Insulin released from the beta cells of the pancreas is secreted into the bloodstream when blood glucose levels are high and stimulates liver cells to take up glucose and convert it to stored glycogen. Glucagon, produced by the alpha cells in the pancreas, is released when blood glucose levels fall and stimulates liver cells to hydrolyse glycogen into glucose and release it into the blood to raise blood sugar levels back to normal. This process is called negative feedback. *[Suitable annotated diagram of feedback including the above points is acceptable.]*

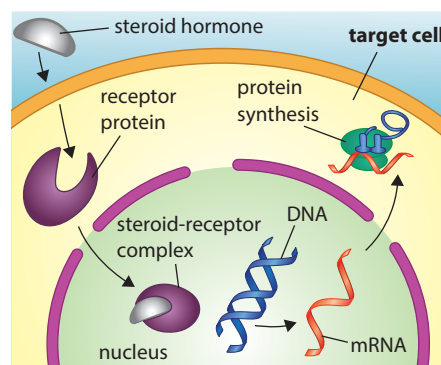
- 7** An increase in auxin concentration stimulates shoot growth to increase from the starting point to 200%, whereas increasing the auxin concentration inhibits the growth of roots to 65% below the starting point.

At auxin concentrations above 1 ppm there is no further effect on root growth whereas shoot growth continues to increase as auxin concentration increases. [Answer must include comparisons and use data from the graphs for full marks.]

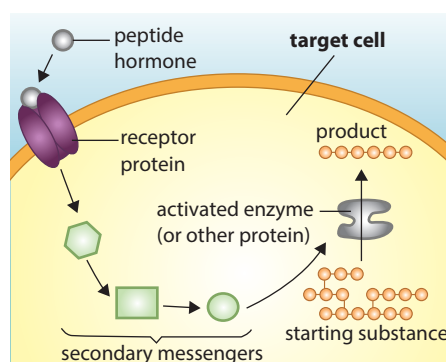
- 8 a** Auxin increases the flexibility in cell walls of young plants so that elongation on the side of the shoot, necessary to cause growth, can occur. The herbicide structure is similar to that of auxin so it will interact with the auxin receptors on plant cells and have a similar effect.
- b** Plants grow rapidly because the very similar 2,4,D promotes cell elongation. Plants are distorted because parts of the plant grow too quickly for the remainder of the plant to support them.
- 9 a** Neonicotinoid pesticides act on certain receptors in the nerve synapses. They increase transmission at these synapses. They are much more toxic to invertebrates, like insects, than they are to mammals and birds.
- b** These pesticides do not kill bees directly but affect their foraging behaviour and the health of bee colonies. Bees are vital for pollination of crops and plants and their numbers have been falling in recent years. Some governments have banned neonicotinoid pesticides to prevent this.
- 10 a** Stimulant psychoactive drugs such as nicotine and cocaine mimic the neurotransmitter ACh. These molecules cannot be broken down by the enzyme acetylcholinesterase in the same way as is ACh, so this leads to overstimulation of the post-synaptic neuron.

- 11 a** Diagram similar to those shown here. Must include:

- i** Steroid hormone enters the cell; binds to protein receptor; complex in the nucleus and protein synthesis.



- ii** Peptide hormone does not enter the cell; hormone forms complex with receptor on cell membrane; secondary messengers activate enzymes in cytoplasm to produce product.

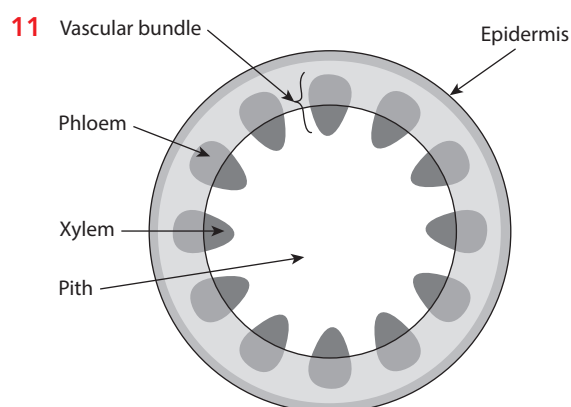


- b** Steroid hormone – oestrogen; peptide hormone – insulin

## Chapter 8

### Test your understanding

- 1 Tissue: a group of similar cells working together. Organ: a group of tissues working together to carry out a specific function.
- 2 Stem cells are undifferentiated and can become many different kinds of cell.
- 3 Differentiation occurs when certain genes are activated or deactivated so that a cell begins to produce, or not produce, different substances or take up different positions or shapes.
- 4 Adult stem cells can divide to produce new cells which can differentiate into different cell types for repair of the body.
- 5 The person was stressed as a result of the blood pressure check.
- 6 Blood pressure falls when a person sleeps.
- 7 This person has high blood pressure.
- 8 Approximately 50 bpm
- 9 As the horse's activity increases its heart rate increases to supply muscles with food and oxygen. Trotting requires less energy than cantering, which requires less energy than a fast gallop.
- 10 Because it takes time for the heart rate to return to normal after exercise, the horse may have to 'cool down' and remove carbon dioxide or lactic acid from its bloodstream.



12

| xylem                                    | phloem  |
|--|---|
| Composed of dead cells without end walls | Composed of living cells with companion cells and end walls |
| Carries water and minerals up the stem   | Carries sugars, amino acids up and down the stem            |
| Lignin strengthens xylem tubes           | Companion cells supply energy for active transport          |

- 13 Water and mineral salts
- 14 Light, humidity and wind
- 15 Positive hydrostatic pressure controls movement through the phloem, high concentration of sugar loaded at the source draws in water from the xylem and creates a high pressure potential (turgor pressure) in the phloem.
- 16 Large surface area, thin membrane and rich blood supply
- 17 Blood carries away oxygen, which diffuses from the alveoli so that the concentration in the blood is always lower than that in the alveolus. It applies in the opposite direction for carbon dioxide.
- 18 Surfactant keeps the alveoli moist; and reduces surface tension so that they slide easily against one another and do not collapse during exhalation.
- 19 Partial pressure is the pressure of one gas in a mixture.
- 20 Bohr shift makes hemoglobin release oxygen more easily when the partial pressure of carbon dioxide is higher.
- 21 Fetal hemoglobin will pick up oxygen at lower partial pressures (has a higher affinity for oxygen) than adult hemoglobin, so can do so in the placenta.
- 22 Waxy cuticles prevent water loss through the surface of the leaves.
- 23 The measurements should be repeated several times and an average value calculated.

**24** Asexual involves only one individual, sexual there are two parents; asexual involves mitosis, meiosis is needed for sexual reproduction.

**25** LH, FSH, estrogen and progesterone

**26** Positive feedback increases the deviation from the normal state; negative feedback returns a system to the normal state if there is a deviation from it.

**27** hCG maintains the corpus luteum, so that it continues to produce progesterone until the placenta is established.

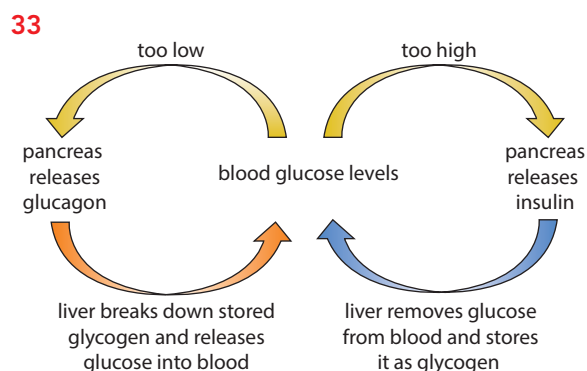
**28** Two of estrogen, progesterone and hCG fall; prolactin rises

**29** Stigma and style

**30** To ensure cross pollination and promote genetic diversity.

**31** The maintenance of constant internal conditions in the body.

**32** Blood flow to the skin surface, sweating, decrease metabolic rate.



**34** Birth

**35** The maintenance of salt and water balance in the body.

**36** Loop of Henle reabsorbs water from the kidney tubule

**37** ADH prevents too much water being lost from the body/controls the permeability of the collecting duct

**38** Raises blood pressure

## Exam-style questions

**1** A

**2** C

**3** B

**4** A

**5**

| Artery  | Vein   |
|---|--|
| Thick muscular walls                                | Thin walls with little muscle                            |
| Narrow lumen  | Wide lumen   |
| No valves, except pulmonary artery                  | Valves present in many veins                             |
| Large amounts of muscle and elastic fibres in walls | Only small amounts of muscle and elastic fibres in walls |

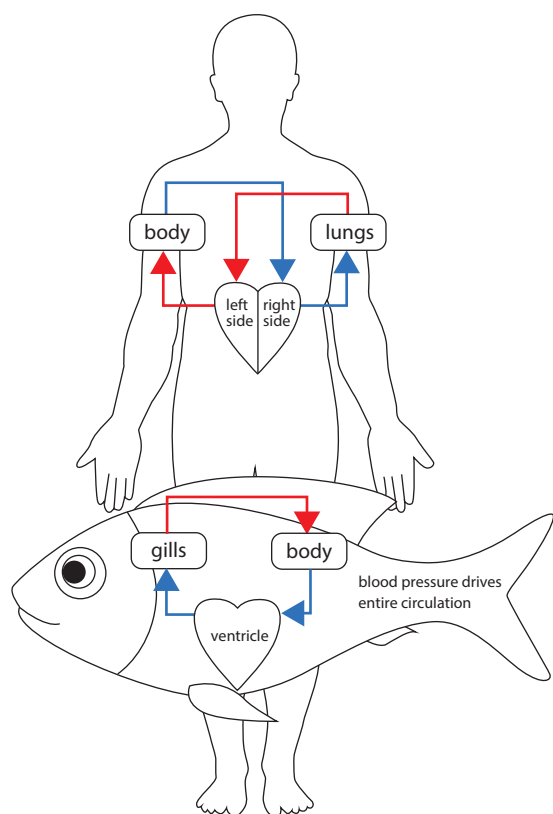
**6** Gas exchange is maintained by having a concentration gradient between the alveoli and the blood capillaries that surround them; oxygen enters the blood and carbon dioxide diffuses into the alveoli; the gradient is maintained by ventilation of the lungs; during exhalation carbon dioxide rich air is breathed out; during inhalation oxygen-rich air is breathed in to ensure that oxygen levels remain high inside the alveoli while carbon dioxide levels remain low. Breathing rate is increased during vigorous exercise so that this occurs.

**7 a** Mammals have a double circulation, blood passes twice through the heart on a journey round the body; blood is pumped out of the ventricles of the heart either to the lungs or to the rest of the body; the left ventricle is larger than the right ventricle and pumps blood at higher pressure to the body via the aorta; the aorta and major arteries are muscular and can contract to maintain pressure and blood flow; arteries divide into small arterioles, which divide into smaller vessels called capillaries that supply tissues and organs of the body.

**b** Differences: Humans have a double circulation, whereas fish have a single circulation; fish have the same blood pressure throughout, whereas humans have lower blood pressure in the blood that flows to the lungs.

Similarities: Both have blood as a transport fluid; both have a heart to maintain flow and pressure gradient; both have vessels to contain the blood. [Student can use a simple diagram in explanation.]





- c** Chemoreceptors in the large arteries and the medulla respond to an increase in carbon dioxide (lowering of pH) in the blood passing through them; the medulla oblongata sends messages to the sinoatrial node; in the right atrium; the sinoatrial node fires more frequently than at its myogenic rate and thus the heart rate is increased.
- 8 a** Translocation is the movement of organic materials through the phloem (from where they are formed to where they are required).
- b i** Sucrose is soluble so can be transported in sap (1); but relatively metabolically inactive so it is not, used during transport (1)
- ii** similarities – involves mass flow of substances through the plant  
differences – substances travel up and down the phloem; but only upward in the xylem. substances move from sources to sinks in the phloem; but water and salts travel in the transpiration stream in the xylem.
- 9** water potential; osmosis; partially permeable; turgor; pressure/turgidity
- 10 a** 12 breaths per min
- b** 18 breaths per min + or – 2
- c** Between the times 0 and 60 s the student was breathing more slowly and exchanging approximately 0.5 dm<sup>3</sup> per breath; during exercise this increased to approximately 2.2 dm<sup>3</sup>.
- d** Ventilation is controlled by the medulla oblongata; chemosensors in the aorta and carotid arteries respond to an increase in carbon dioxide (decrease in pH of the blood); these send messages to the breathing centre in the medulla; action potentials are sent to the diaphragm and intercostal muscles to increase the rate and depth of breathing as muscle activity and the need for extra oxygen increases.
- 11 D**
- 12 a** Thermoregulation is the maintenance of body temperature within certain boundaries, even if the temperature of the environment is different.
- b** 37 °C is the optimum temperature for enzyme reactions in the human body.
- c i** Both groups will attempt to maintain a constant body temperature of 37 °C by losing heat by sweating and vasodilation; in a hot desert the humidity is low so sweating is possible but in the rainforest humidity is very high so it is difficult to lose sweat to the saturated air; in the desert, the wind speed is higher and this also assists the evaporation of sweat, whereas in the rainforest sweat is not evaporated as the windspeed is very low.
- ii** Behavioural methods include: hiding in burrows or the shade during the hottest part of the day (e.g. jerboa); reducing activity; gular flutter (certain birds); mud baths (pigs and elephants).  
[Any other suitable examples are acceptable.]

**13 a**  $5.45 - 4.9 = 0.55 \text{ mmol dm}^{-3}$

**b** Person A had a much higher level of glucose (above the normal level of around  $6.25 \text{ mmol dm}^{-3}$ ) at the start of the experiment indicating that he/she may be unable to control glucose levels; after drinking the glucose drink person A's glucose level increased substantially more than person B rising to  $7.5 \text{ mmol dm}^{-3}$  of blood after 30 min; it took 2.5 h for the level to return to normal whereas for person B the level returned to normal in approximately 1 h.

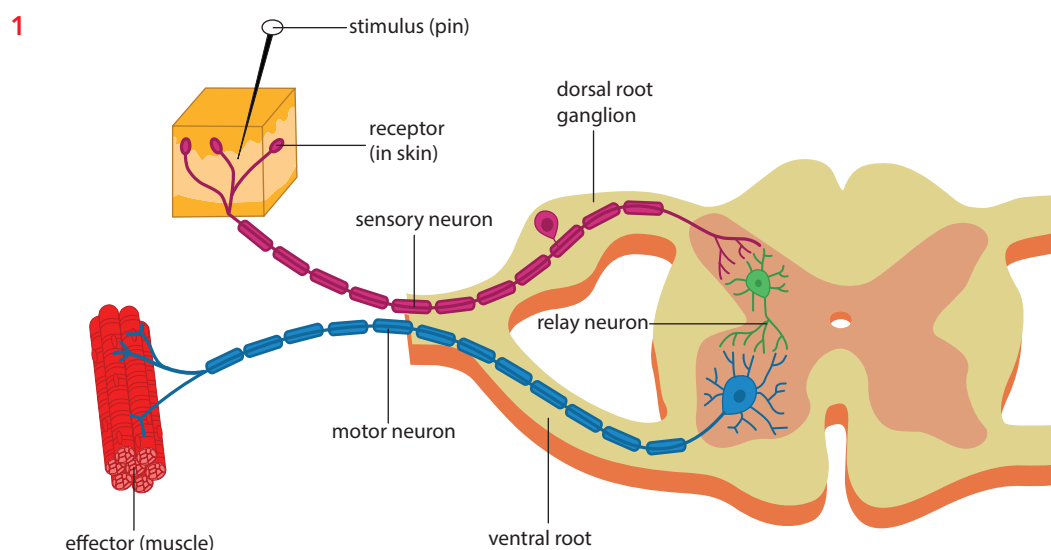
**c** The increase in blood glucose levels of person B was sensed by the pancreas, which released insulin; insulin stimulated the cells of the liver to take up the excess glucose and store it as glycogen.

## Chapter 9

### Test your understanding

- 1 Receptor, sensory neuron, intermediate neuron, motor neuron, effector.
- 2 Central nervous system comprises the brain and spinal cord; the peripheral nervous system comprises all the nerves and sensory structures outside the brain and spinal cord.
- 3
  - i in the voluntary muscles, such as those in the limbs
  - ii in the heart
  - iii in the digestive system, bladder and lining the body cavity
- 4 In antagonistic pairs of muscles, one of the pair causes flexion (bending) at a joint as it contracts and the other of the pair causes the joint to extend as it contracts. Only contraction can cause movement.
- 5 Cartilage – covers the ends of bones to reduce friction at a joint. Synovial fluid - lubricates joints to reduce friction and enable smooth movement of a joint.
- 6 A hinge joint allows movement in one plane e.g. the bending of the elbow joint; whereas a ball and socket joint allows circular movements e.g. rotation of the hip joint.
- 7 Actin and myosin are the protein fibres found in striated muscle. In uncontracted muscle, actin proteins produce light bands and myosin proteins produce darker bands. In contracted muscle the proteins overlap and produce relatively wider dark bands leaving narrower light bands.
- 8 ATP binds to myosin heads during muscle contraction, this prepares them in an erect position, after calcium ions are bound to actin filaments, myosin heads can bind to actin filaments and form cross bridges.
- 9 Movement involves the change in position of a part of an organisms body whereas locomotion involves a change in location of the organism.
- 10 Locomotion enables animals to find food, mates and escape from danger or predators.
- 11 Marine mammals have streamlined body shapes to move through water, their limbs are adapted to form paddles and they have flattened tails for swimming, they have adaptations to breathe at the water surface e.g. blowholes on the top of their heads.

### Exam-style questions



- 2 D
- 3 a Receptor cells receive a stimulus and transmit it to the CNS examples include touch, light and temperature receptors  
  
Effector cells receive a stimulus from the CNS – they are muscles or glands which respond to the stimulus and cause a response.  
  
b ANS is part of the peripheral nervous system that regulates involuntary processes such as heart rate, blood pressure, respiration and digestion
- 4 Both have a cell body containing cytoplasm and a nucleus; both have fibres (dendrites and axons) which extend from the cell body; both are depolarised to transmit nerve impulses;
- 5 B
- 6 a the I-band (1) it shortens  
b the A-band (1) it remains unchanged
- 7 Calcium ions bind to actin filaments causing troponin and tropomyosin to change shape; and expose myosin binding sites.
- 8 a The motor neuron axon and all the muscle fibres it stimulates  
  
b i T  
ii T  
iii F
- 9 Movement can occur in a stationary (sedentary) organism whereas locomotion involves movement from place to place
- 10 Streamlined shape; flippers for propulsion;
- 11 Mating journeys or behaviours; hunting for food; migrations; escaping from predators or other dangers.
- 12 a Locomotion enables organisms to move further afield to find hunt and food; moving into a new territory can enable an animal to avoid competition with its own species or locate a new source of food; longer journeys (migrations) can enable species to follow the rain and obtain food (wildebeest) or avoid harsh weather conditions (swallows).  
  
b Swallows migrate away from the European winter to spend the summer months in South Africa; migration takes about 10 days; birds feed on flying insects on their journey; the birds arrive in South Africa in January and arrive at their summer feeding areas when the temperature is in the mid 20 °C. They return to Europe to breed at the end of the South African summer. *Other examples are acceptable.*

## Chapter 10

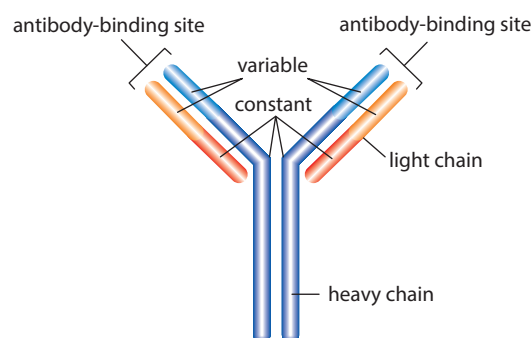
### Test your understanding

- 1 Pathogen – an organism or virus that causes disease.
- 2 Antigen is a molecule from a pathogen that stimulates the immune response.
- 3 Antibiotics interfere with bacterial metabolism; viruses have no metabolism of their own.
- 4 Phagocytes engulf harmful particles in the body in a non-specific way. Lymphocytes are part of the targeted immune response and produce antibodies and memory cells.
- 5 A disease that can cross the species barrier, e.g. bird flu, COVID-19.
- 6 Because blood group O red blood cells do not have any A or B antigens that cause an immune reaction if introduced to a person with an incompatible blood group.
- 7 Memory cells quickly cause clones of plasma cells to form if a pathogen carrying an antigen that has been encountered before enters the body.

### Exam-style questions

- 1 **a** A type of white blood cell.  
**b** Chemotaxis, adhesion, fusion of lysosomes, exocytosis  
**c** The reaction is the same no matter what pathogen is encountered.
- 2 **a** Mucous membranes line the entrances to the body including in the respiratory, urinogenital and digestive systems; mucous is secreted by the membranes and contains a mucopolysaccharide, mucin; harmful particles and pathogens become stuck in the mucus and are prevented from entering deeper into the body.  
**b** Lymphocytes are a type of white blood cell in the immune system. They include T-cells and B-cells; T-cells and B-cells recognise specific ‘non-self’ antigens and initiate responses to eliminate specific pathogens or pathogen-infected cells. B cells produce antibodies which neutralise bacteria and viruses.

- c** Antibodies are produced by B-cells and are specific to one pathogen; antibodies have a structure with constant and variable regions and so each one can be specific to the antigen on the surface of a pathogen.



Antigens may attach to pathogens and disable them, causing them to clump together so that phagocytosis is easier or they may destroy the pathogen.

- 3 Sequence: blood vessel is damaged and chemicals are released; platelets are attracted to the area to seal the break; platelets release clotting factors that convert inactive prothrombin to thrombin, an active enzyme; thrombin converts soluble fibrinogen to insoluble fibrin; fibrin forms a mesh which interacts with the platelet plug, forming a clot and preventing further blood loss.
- 4 A
- 5 B
- 6 B
- 7 B
- 8 B
- 9 C
- 10 **a** So that accurate comparisons can be made between different populations in different parts of the world.  
**b**  $\frac{50 - 8}{50} \times 100 = 84\%$   
**c** In the past antibiotics used to kill tuberculosis (TB) bacteria killed most of the bacteria, but some bacteria had genes that made them less susceptible to antibiotics. These strains survived and reproduced and a greater quantity of antibiotic was needed to kill them. Antibiotic treatment was needed for much

longer periods of time. Eventually the antibiotic of choice was not able to kill TB bacteria and other antibiotics had to be used. Today some strains of TB bacteria have evolved resistance to all antibiotics.

**11** B

**12** C

**13** A disease that can pass from one species to another and cause infection; Examples include: rabies, bird flu, Japanese encephalitis

**14** D

**15** A suspension of weakened microorganisms or parts of them that is deliberately introduced into the body to produce an immune response.

The initial response to a vaccine causes an increase in B-cells (primary response) and an increase in antibody levels and the production of memory cells. A secondary response occurs when a second or booster vaccination is given. The body responds more quickly and produces more antibodies and memory cells, which give lasting protection. The memory cells for some diseases last for many years, e.g. rubella. Other diseases require further vaccinations, e.g. yellow fever.



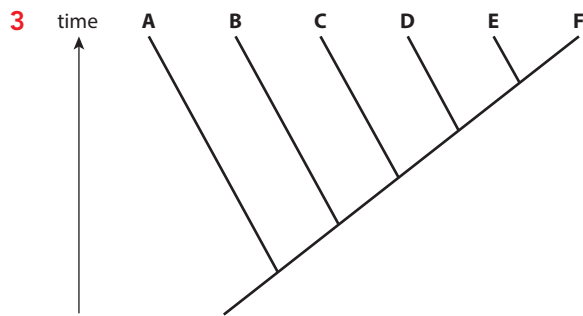
## Chapter 11

### Test your understanding

- 1 Kingdom, phylum, class, order, family, genus, species
- 2 Genus and species
- 3 Size changes with an organism's age and varies between individuals.
- 4 Clade: contains an ancestor and all the organisms derived from it.
- 5 DNA profiles are not as subjective as appearance and recognition of other features can be, DNA is universal and the genetic code is conserved.
- 6 If observable features are used to establish relationships, some features are not identified. Cladograms use molecular evidence, which means that some previously unknown relationships can be recognised and new classifications can be made as a result.
- 7 Sexual reproduction leads to variation, which is essential for natural selection and hence evolution.
- 8 Limited resources such as food, shelter or mates.
- 9 Natural selection
- 10 The process by which new species are formed.
- 11 Changes can lead to separation of populations which then develop independently of one another.
- 12 Peacock's tail – attracts females to the male with the best display, who may also be 'fitter' in other respects.
- 13 Chimpanzees and humans
- 14 Repeated sequences are non-coding regions of DNA that do not often mutate and remain over many generations because there is less selection pressure on them.
- 15 A group of organisms that can interbreed and produce fertile offspring.
- 16 Fossils, DNA evidence and selective breeding
- 17 Isolation exposes individuals to different conditions and those that are best adapted will survive and develop different characteristics to the original population.
- 18 Hybrids have parents from different species. Most are unable to produce viable offspring because of incompatible chromosome numbers or faults in the chromosomes in their gametes.
- 19 Mountain range, river
- 20 Gradual evolution occurs over many generation with the accumulation of small changes; punctuated evolution occurs in large steps with little change occurring from long periods.
- 21 Gene pool: all the genes and their alleles present in an interbreeding population.
- 22 Niche: the role an organism plays in a community. It includes both the physical and environmental conditions the organism needs and the interactions it has with other species.
- 23 Fundamental: the ideal niche; realised: the actual niche given the constraints of the environment.
- 24 Convergent evolution: similar phenotypes that develop in very different species; divergent evolution: a species appearance becomes different over time if two or more species develop from an original population.
- 25 The pentadactyl limb
- 26 Because they will compete for limited resources.
- 27 Males incubate the egg when the females are feeding at sea; males huddle together to conserve body heat.
- 28 Fewer species can survive in the habitat because they lack the physiological or behavioural adaptations to do so.

### Exam-style questions

- 1 D
- 2 B



A = frog, B = chicken, C = horse, D = rhesus monkey, E = gorilla, F = chimp [E and F may be reversed]

4 A

5 B

6 B

7 A

8 D

9 D

10 a Speciation is the formation of new species from an existing population. For it to occur members of the species must be separated by a barrier that may be spatial (such as a body of water or a mountain range), temporal (they breed at different times) or related to their reproductive behaviour. Separated groups will be exposed to different conditions and selection pressures and will eventually evolve so that reproduction with individuals in the other group is no longer possible and two new species are formed.

b The pattern of bones in the limbs of all vertebrates is similar. They include the same bones in the same positions even though the limbs appear different on the outside and have different functions, e.g. a whale's fin and a human leg. They provide evidence that vertebrate animals had a common ancestor, which had a pentadactyl limb. They have become different by adaptive radiation (or similar explanation) because they perform different jobs.

11 a Divergent evolution occurs when a species becomes separated into two or more populations and new species arise from a common ancestor. Examples include pentadactyl limbs of vertebrates and

Galápagos finches. [1 mark for explanation and 1 mark for suitable example]

Convergent evolution occurs as two species with different ancestors develop analogous structures to carry out similar functions so that their appearances become similar over time. Examples include wings in birds and insects, and adaptations to dry conditions in euphorbia and cacti (or other suitable examples). [1 mark for explanation and 1 mark for suitable example]

b Cladograms are used to construct evolutionary relationships and demonstrate common ancestry. Analogous characteristics do not arise from a common ancestor and so are not suitable to produce a cladogram.

12 a Gene pool – all the genes and their alleles present in a breeding population.

b Female (usually) animals choose their mating partners based on a mating display that is unique to their species. This might be a colourful body (e.g. peacock), a mating dance (bower birds), fighting skills (deer) or a well constructed nest [or other suitable example]. The best males may be stronger or 'fitter' in some other way and will pass on their genes to their offspring.

Variation is achieved by sexual reproduction because meiosis in the production of gametes produces new combinations of genes and alleles; crossing over during meiosis increases this affect.

c A species will be resilient to change if it has sufficient variation in alleles to enable a substantial number of individuals to survive and thrive if conditions change and the species is subjected to selection pressure. If there is little diversity in the population all members are likely to be affected by a change, for example if all members of a population are susceptible to a disease, all or many will be affected.

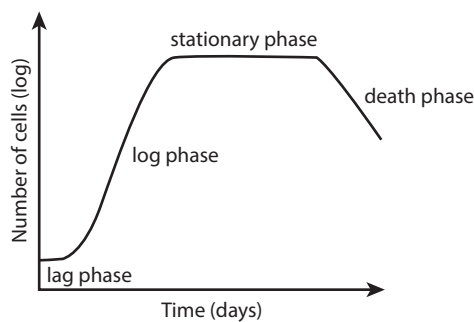
13 a None of the cultivated potatoes had alleles that enabled them to survive the blight, so all were susceptible and the blight spread rapidly.

b A mutation in the gene must have occurred.

- c** A horticulturalist can select any plants that do survive an attack of blight. These will have resistant genes. These plants can be bred together and then exposed to the blight again. Those which survive can be bred again. If this process is repeated for several generations, a population with resistance to blight will be produced.
  - d** Possible steps might include: breeding plants with wild types to maintain genetic variations, treatment with fungicides, planting a range of varieties rather than a monoculture of just one variety so that variation is maintained.
- 14 a** Niche – the habitat an organism occupies, its feeding activities and its interactions with other species.
- b** Fundamental niche – the potential way of life of a species given its features and adaptations.
  - c** Realised niche – the actual niche occupied by a species which is smaller than a fundamental niche due to competition with other species or predation.

## Chapter 12

### Test your understanding

- 1 Autotrophs make their own food from inorganic materials; heterotrophs must eat to obtain nutrients.
- 2 Detritivores feed by taking in food and digesting it; saprotrophs digest their food externally and then take it into their bodies.
- 3 Trophic level is decided by counting the number of transfers of energy and nutrients that occur from the primary producer (level 1).
- 4 Producers = leaves, grass, pond algae; consumers = snails, mice, owl, earthworm
- 5 Three primary consumers, five secondary consumers
- 6 Predators may have good eyesight for hunting; strong claws/teeth for capturing prey; speed to chase prey; camouflage to conceal themselves; any other useful suggestions.
- 7 Herbivores have sharp incisors to cut plant material and flat molars to grind food. Carnivores have pointed canines to kill and cutting premolars to slice meat.
- 8 Parasites: fleas feeding on the blood of a mammal; tapeworms living inside the gut of animals such as cows and pigs.
- 9 Students' answers will vary; example of a food chain: grass → mouse → cat → eagle.
- 10 Arrows represent the transfer of energy and nutrients.
- 11 Light energy from the Sun
- 12 Through respiration; by being used by the organism for movement, reproduction, etc.; as heat; not eaten by the next consumer.
- 13 Less than one-tenth of the leaves energy =  $2000 \text{ J} \cdot \text{m}^{-2} \cdot \text{year}^{-1}$
- 14 Energy flows through a system and is lost as heat, while nutrients are cycled and used over and over again.
- 15 To assess the health of an ecosystem and study the survival chances of organisms in it.
- 16 soil type, rainfall, temperature
- 17 It may outcompete the existing species for limited resource.
- 18 greater availability of food resources
- 19 Population must not be affected by immigration or emigration; the population must be small animals to ensure territories are not too large; marking the organisms must not harm them or make them conspicuous.
- 20 Quadrats or a line transect
- 21 Rabbits: fast movement, good all round vision; skunks: release of foul smelling chemicals to repel predators; snails: shells for protection.
- 22 Feeding on green plants.
- 23 Bad tasting leaves, spines, tough needles (conifers)
- 24 Carrying capacity: the maximum number of a species that an ecosystem can support.
- 25 Density-dependent factors: food availability; predator numbers
- 26 Advantages: additional protection from predators, easier access to mates.  
Disadvantages: competition for resources, risk of infections.
- 27 
- 28 stable climate, no interference, sufficient energy supply, genetic diversity
- 29 Harvest wood but leave sufficient trees to replenish the woodland
- 30 industrial = large scale farming over huge areas using chemicals and fertilisers  
Monoculture = the same crop grown over large areas
- 31 Agriculture, cutting and maintaining grassland, trampling or disturbing land.
- 32 Alien species may have no natural predators and may over run a habitat they may outcompete natural populations.
- 33 Microplastic may release chemicals into the ocean, or be mistaken for food by organisms, which then starve, and become included in the food chain.

- 34** Keystone species are vital to maintain community structure and have a disproportionate effect on the system. They are top-down limiting factors.
- 35** Nitrate fertilisers are artificially produced and upset the natural recycling of nutrients (nitrogen) by adding it to one section of the system, they can also cause eutrophication and damage to waterways.
- 36** Warming heats surface waters, so nutrient upwelling can be prevented and primary production in the oceans is reduced.
- 37** Coral may become bleached and die if temps increase or the sea becomes acidic
- 38** The study of seasonal events with respect to the climate

### Exam-style questions

- 1** C
- 2** A
- 3** D
- 4** **a** algae → fish → sea lions  
**b** 1 → 2 → 3  
**c** detritivore
- 5** **a**  $D = \frac{150(150-1)}{(20 \times 19) + (80 \times 79) + (10 \times 9) + (30 \times 29) + (10 \times 9)}$   
 $D = 2.88$   
**b** A higher diversity index indicates that the second sand due is more diverse. It has a higher diversity index because it has a higher number of different species.
- 6** **a** A sample of mobile small organisms is collected and marked with a suitable, harmless marking; the sample is released and allowed to mix with the population; later on a second sample is taken and the proportion of marked individuals is recorded, using the formula an estimate of the total population can be obtained.  
**b** Limitations: marking the individuals captured must not harm them or make them more susceptible to predators; the method assumes that the population has no immigration or emigration; it is only suitable if the sample size is greater than 20 and preferably as high as possible.
- 7** D
- 8** Distribution of species is affected by: access to food resources (water and light for a plant) so that they can grow and repair their bodies; access to mates for reproduction; shelter (animals) to build a nest or hide, or suitable terrain and weather (plant) in which to live so that roots can grow, minerals are available and the temperature and weather are suitable for growth.
- 9** **a** 32, 64, 128, 256  
**b** Graph with axes labelled, the curve shows exponential growth.  
**c** The curve would level off; as nutrients became limiting and growth could not continue; it would then show a fall in the numbers of bacteria as excretory products built up in the flask and would lead to the death of the bacteria.
- 10** **a** DDT is persistent (not biodegradable) in the environment; DDT enters the food chain through producers and is passed to higher trophic levels in the food chain; consumers cannot break down DDT which accumulates in fatty tissues; eagles are at the end of the food chain and have the highest concentration of DDT in their bodies; DDT is said to biomagnify (bioaccumulate)
- 11** Macroplastic waste such as fishing line can trap organisms such as turtles which cannot swim to the surface to breathe and drown.  
 Plastic may be mistaken for food by birds such as albatrosses and lead to stomach damage or starvation if the birds think they are full and stop eating.  
 Microplastics can enter the bodies of filter feeding molluscs and block their gills.  
 Microplastic waste may be ingested and release toxic chemicals inside the bodies of fish leading to metabolic upset or death.
- 12** Human population growth, which has caused loss of ecosystems hunting and other forms of over-exploitation; urbanisation; deforestation and clearance of land for agriculture has led to loss of natural habitat; pollution and spread of pests, diseases and invasive alien species spread to other locations by global transport.