SAMPLE CHAPTER

INTERNATIONAL GCSE (9–1)

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Biology

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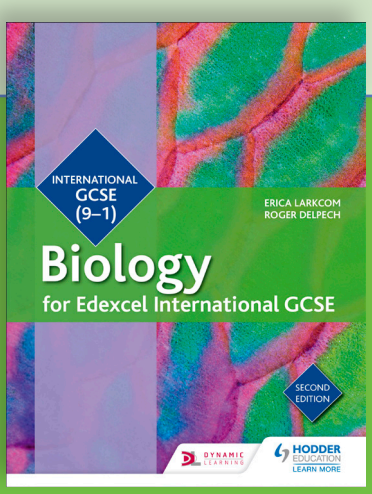

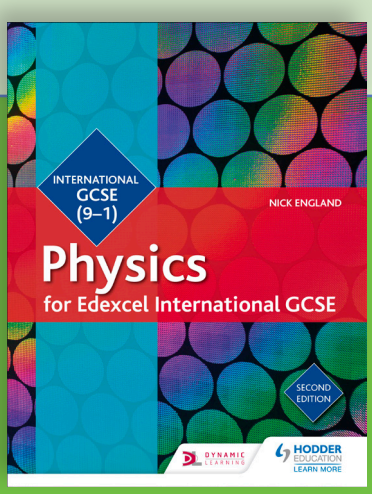

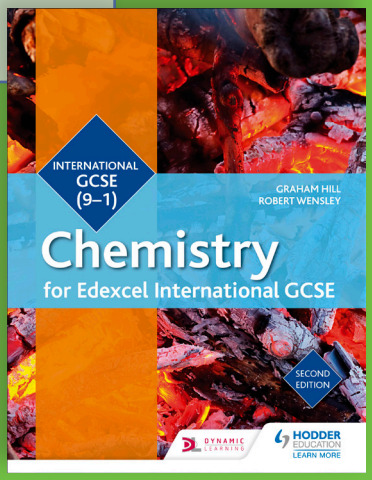

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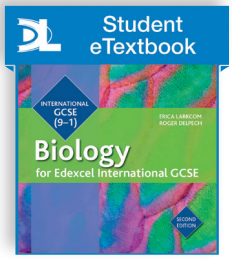

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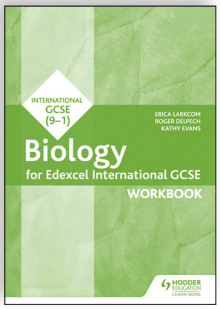
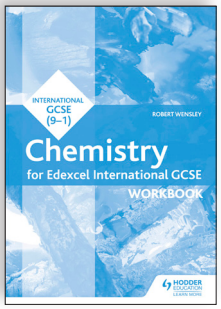
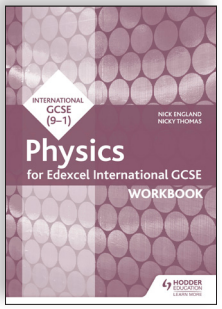






Contents

Section 4 Coordination and control

Section 5 Reproduction and inheritance

Section 6 Ecology and the environment

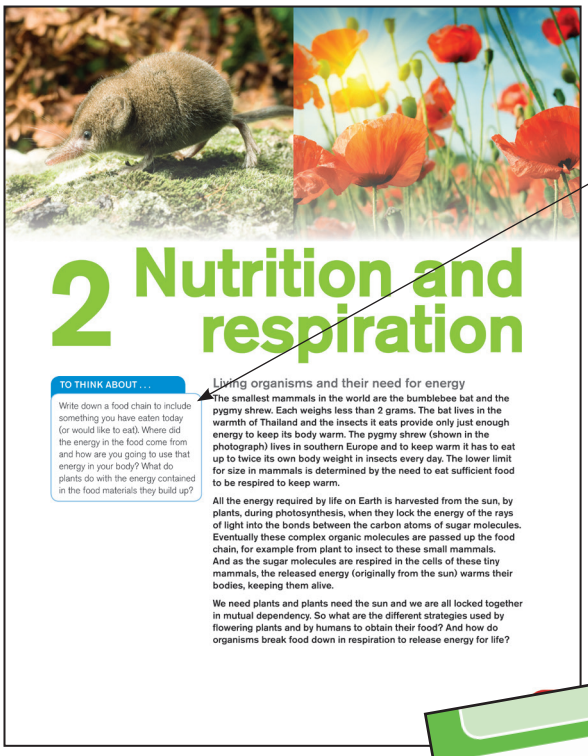
Section 7 Use of biological resources

Getting the most from this book

Welcome to the Edexcel International GCSE Biology Student Book. This book has been divided into seven Sections, following the structure and order of the Edexcel specification, which you can find on the Edexcel website for reference.

Each Section has been divided into a number of smaller Chapters to help you manage your learning.

The following features have been included to help you get the most from this book.

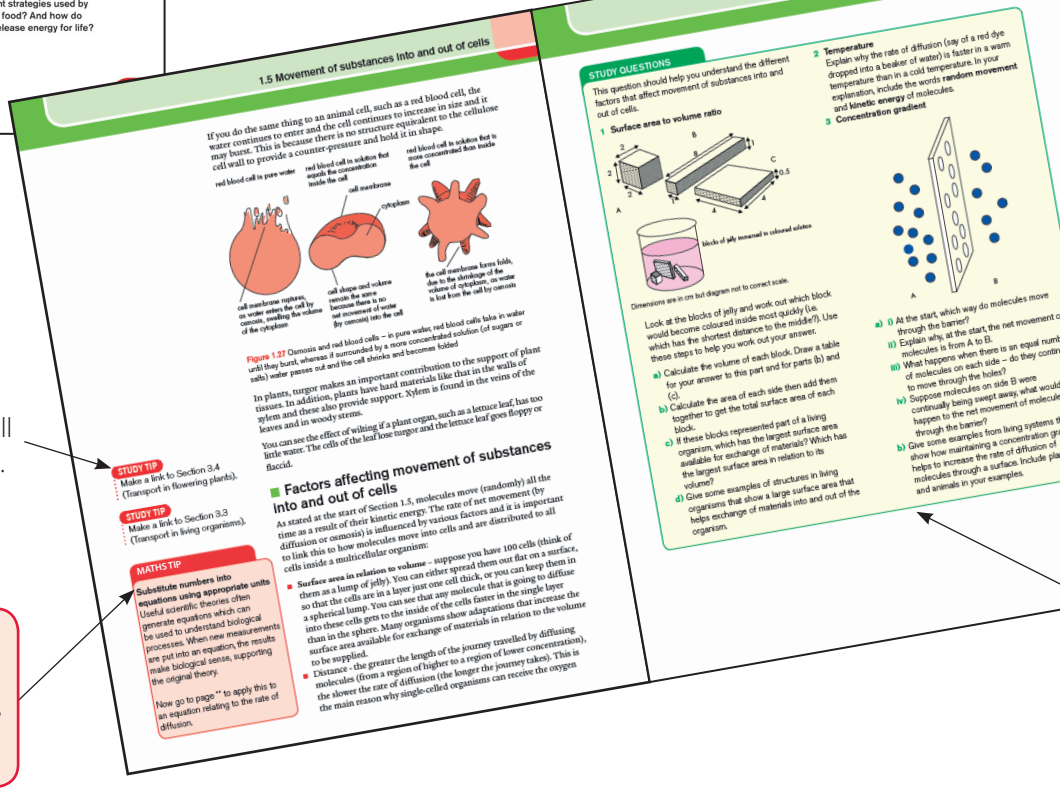


TO THINK ABOUT . . .

Try the activity before you start, and then have a look at it again once you have completed the Section, to see if your responses are different before and after learning more about the topics.

PRACTICAL

Practical boxes provide hints on key things to remember, or alternative practical work that you can do to help you learn more about that topic.



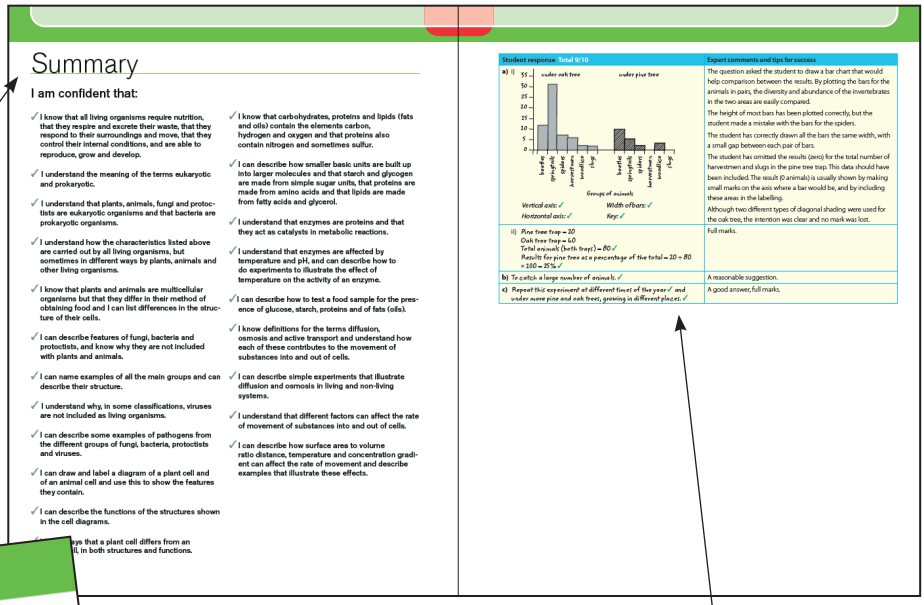
STUDY TIP

Study tips throughout the book will guide you in your learning process.

MATHS TIP

Maths skills give you additional help with the maths in the book so you can avoid losing valuable marks in the exam.

At the end of each Section, you will find a summary checklist, highlighting the key facts that you need to know and understand, and key skills that you learnt in the Section.



Summary

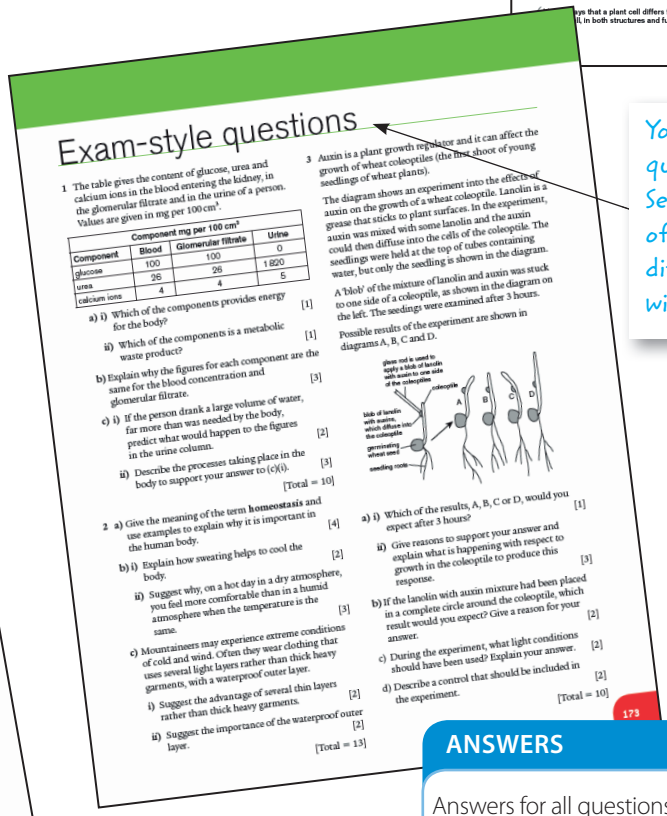
I am confident that:

- ✓ I know that all living organisms require nutrition, that they respire and excrete their waste, that they respond to their surroundings and move, that they control their internal conditions, and are able to reproduce, grow and develop.
- ✓ I understand the meaning of the terms eukaryotic and prokaryotic.
- ✓ I understand that plants, animals, fungi and protoctists are eukaryotic organisms and that bacteria are prokaryotic organisms.
- ✓ I understand how the characteristics listed above are carried out by all living organisms, but sometimes in different ways by plants, animals and other living organisms.
- ✓ I know that plants and animals are multicellular organisms but that they differ in their method of obtaining food and I can list differences in the structure of their cells.
- ✓ I can describe features of fungi, bacteria and protoctists, and know why they are not included with plants and animals.
- ✓ I can name examples of all the main groups and can describe their structure.
- ✓ I understand why, in some classifications, viruses are not included as living organisms.
- ✓ I can describe some examples of pathogens from the different groups of fungi, bacteria, protoctists and viruses.
- ✓ I can draw and label a diagram of a plant cell and of an animal cell and use this to show the features they contain.
- ✓ I can describe the functions of the structures shown in the cell diagrams.
- ✓ ...ys that a plant cell differs from an ...ll, in both structures and functions.
- ✓ I know that carbohydrates, proteins and lipids (fats and oils) contain the elements carbon, hydrogen and oxygen and that proteins also contain nitrogen and sometimes sulfur.
- ✓ I can describe how smaller basic units are built up into larger molecules and that starch and glycogen are made from simple sugar units, that proteins are made from amino acids and that lipids are made from fatty acids and glycerol.
- ✓ I understand that enzymes are proteins and that they act as catalysts in metabolic reactions.
- ✓ I understand that enzymes are affected by temperature and pH, and can describe how to do experiments to illustrate the effect of temperature on the activity of an enzyme.
- ✓ I can describe how to test a food sample for the presence of glucose, starch, proteins and of fats (oils).
- ✓ I know definitions for the terms diffusion, osmosis and active transport and understand how each of these contributes to the movement of substances into and out of cells.
- ✓ I can describe simple experiments that illustrate diffusion and osmosis in living and non-living systems.
- ✓ I understand that different factors can affect the rate of movement of substances into and out of cells.
- ✓ I can describe how surface area to volume ratio distance, temperature and concentration gradient can affect the rate of movement and describe examples that illustrate these effects.

Student response Total 9/10	Expert comments and tips for success
a) i) Groups of animals Vertical axis: ✓ Width of bars: ✓ Horizontal axis: ✓ Key: ✓	The question asked the student to draw a bar chart that would help comparison between the results. By plotting the bars for the animals in pairs, the diversity and abundance of the invertebrates in the two areas are easily compared. The height of most bars has been plotted correctly, but the student made a mistake with the bars for the spiders. The student has correctly drawn all the bars the same width, with a small gap between each pair of bars. The student has omitted the results (zero) for the total number of harvestmen and slugs in the pine tree trap. This data should have been included. The result (0 animals) is usually shown by making small marks on the axis where a bar would be, and by including these areas in the labelling. Although two different types of diagonal shading were used for the oak tree, the intention was clear and no mark was lost.
ii) Pine tree trap = 20 Oak tree trap = 40 Total animals (both traps) = 80 ✓ Results for pine tree as a percentage of the total = 20 ÷ 80 × 100 = 25% ✓	Full marks.
b) To catch a large number of animals: ✓	A reasonable suggestion.
c) Repeat this experiment at different times of the year ✓ and under some pine and oak trees, growing in different places. ✓	A good answer, full marks.

You will find Exam-style questions at the end of each Section covering the content of that Section and the different types of question you will find in an examination.

Before you try the Exam-style questions, look at the sample answers and expert comments to see how marks are awarded and common mistakes to avoid.



Exam-style questions

1 The table gives the content of glucose, urea and calcium ions in the blood entering the kidney, in the glomerular filtrate and in the urine of a person. Values are given in mg per 100 cm³.

Component	Component mg per 100 cm³		
	Blood	Glomerular filtrate	Urine
glucose	100	100	0
urea	26	26	1820
calcium ions	4	4	5

a) i) Which of the components provides energy for the body? [1]

ii) Which of the components is a metabolic waste product? [1]

b) Explain why the figures for each component are the same for the blood concentration and glomerular filtrate. [3]

c) i) If the person drank a large volume of water, far more than was needed by the body, predict what would happen to the figures in the urine column. [2]

ii) Describe the processes taking place in the body to support your answer to (c)(i). [3]

[Total = 10]

2 a) Give the meaning of the term **homeostasis** and use examples to explain why it is important in the human body. [4]

b) i) Explain how sweating helps to cool the body. [2]

ii) Suggest why, on a hot day in a dry atmosphere, you feel more comfortable than in a humid atmosphere when the temperature is the same. [3]

c) Mountaineers may experience extreme conditions of cold and wind. Often they wear clothing that uses several light layers rather than thick heavy garments, with a waterproof outer layer.

i) Suggest the advantage of several thin layers rather than thick heavy garments. [2]

ii) Suggest the importance of the waterproof outer layer. [2]

[Total = 13]

3 Auxin is a plant growth regulator and it can affect the growth of wheat coleoptiles (the first shoot of young seedlings of wheat plants).

The diagram shows an experiment into the effects of auxin on the growth of a wheat coleoptile. Lanolin is a grease that sticks to plant surfaces. In the experiment, auxin was mixed with some lanolin and the auxin could then diffuse into the cells of the coleoptile. The seedlings were held at the top of tubes containing water, but only the seedling is shown in the diagram.

A 'blob' of the mixture of lanolin and auxin was stuck to one side of a coleoptile, as shown in the diagram on the left. The seedings were examined after 3 hours.

Possible results of the experiment are shown in diagrams A, B, C and D.

a) i) Which of the results, A, B, C or D, would you expect after 3 hours? [1]

ii) Give reasons to support your answer and explain what is happening with respect to growth in the coleoptile to produce this response. [3]

b) If the lanolin with auxin mixture had been placed in a complete circle around the coleoptile, which result would you expect? Give a reason for your answer. [2]

c) During the experiment, what light conditions should have been used? Explain your answer. [2]

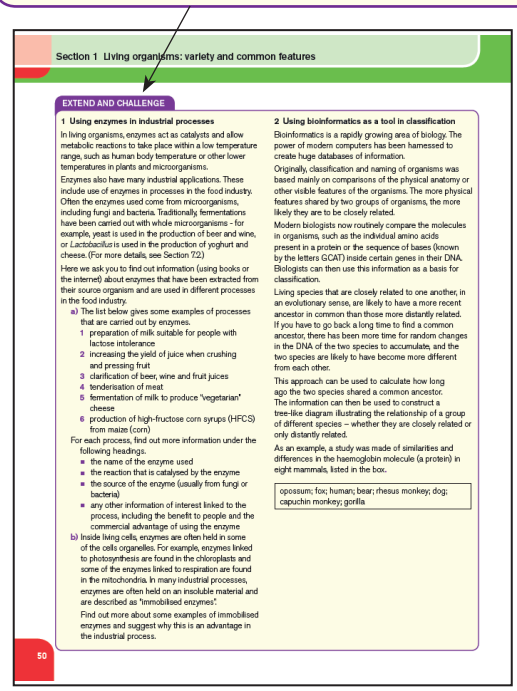
d) Describe a control that should be included in the experiment. [2]

[Total = 10]

173

EXTEND AND CHALLENGE

When you have completed all the Exam-style questions for the Section, try the Extend and Challenge questions.



Section 1 Living organisms: variety and common features

EXTEND AND CHALLENGE

1 Using enzymes in industrial processes

In living organisms, enzymes act as catalysts and allow metabolic reactions to take place within a low temperature range, such as human body temperature or other lower temperatures in plants and microorganisms.

Enzymes also have many industrial applications. These include use of enzymes in processes in the food industry. Often the enzymes used come from microorganisms, including fungi and bacteria. Traditionally fermentations have been carried out with whole microorganisms - for example, yeast is used in the production of beer and wine, or *Lactobacillus* is used in the production of yoghurt and cheese. (For more details, see Section 7.2)

Here we ask you to find out information (using books or the internet) about enzymes that have been extracted from their source organism and are used in different processes in the food industry.

a) The list below gives some examples of processes that are carried out by enzymes.
1 preparation of milk suitable for people with lactose intolerance
2 increasing the yield of juice when crushing and pressing fruit
3 clarification of beer, wine and fruit juices
4 tenderisation of meat
5 fermentation of milk to produce "vegetarian" cheese
6 production of high-fructose corn syrups (HFCS) from maize (corn)

For each process, find out more information under the following headings.
- the name of the enzyme used
- the reaction that is catalysed by the enzyme
- the source of the enzyme (usually from fungi or bacteria)
- any other information of interest linked to the process, including the benefit to people and the commercial advantage of using the enzyme

b) Inside living cells, enzymes are often held in some of the cells organelles. For example, enzymes linked to photosynthesis are found in the chloroplasts and some of the enzymes linked to respiration are found in the mitochondria. In many industrial processes, enzymes are often held on an insoluble material and are described as "immobilised enzymes".

Find out more about some examples of immobilised enzymes and suggest why this is an advantage in the industrial process.

2 Using bioinformatics as a tool in classification

Bioinformatics is a rapidly growing area of biology. The power of modern computers has been harnessed to create huge databases of information.

Originally, classification and naming of organisms was based mainly on comparisons of the physical anatomy or other visible features of the organisms. The more physical features shared by two groups of organisms, the more likely they are to be closely related.

Modern biologists now routinely compare the molecules in organisms, such as the individual amino acids present in a protein or the sequence of bases (known by the letters GCAT) inside certain genes in their DNA. Biologists can then use this information as a basis for classification.

Living species that are closely related to one another, in an evolutionary sense, are likely to have a more recent ancestor in common than those more distantly related. If you have to go back a long time to find a common ancestor, there has been more time for random changes in the DNA of the two species to accumulate, and the two species are likely to have become more different from each other.

This approach can be used to calculate how long ago the two species shared a common ancestor. The information can then be used to construct a tree-like diagram illustrating the relationship of a group of different species – whether they are closely related or only distantly related.

As an example, a study was made of similarities and differences in the haemoglobin molecule (a protein) in eight mammals, listed in the box.

opossum; fox; human; bear; rhesus monkey; dog; capuchin monkey; gorilla

50

ANSWERS

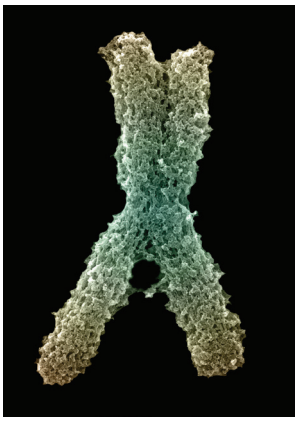
Answers for all questions and activities in this book can be found online at www.hoddereducation.co.uk/ igcsebiology

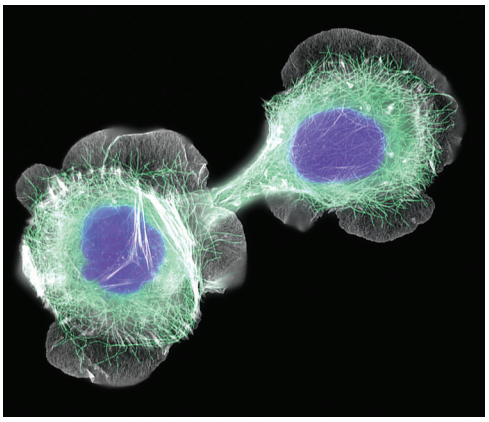
STUDY QUESTIONS

At the end of each Chapter you will find Study Questions. Work through these in class or on your own for homework. Answers are available online.

5.4 Genes and chromosomes

The nature versus nurture debate





Humans show common features that allow us to recognise that we belong to the same species. But every single human person differs in some way from everyone else.

How are the common features passed on from one generation to the next and what is the biological basis of the differences between people? Is it that each individual is exposed to a different personal environment? Does a suntan get passed on to the next generation, or is that something that just affects one individual and stops there? Or are there genetic reasons for some of the differences between us all?

Scientists now know that some of the differences are due almost entirely to environmental factors, some differences are due entirely to genetic differences, but most are the result of a combination of genes plus the effects of the environment and the interaction between them. Nature could be regarded as the pack of cards you are dealt and nurture as the way you employ the cards you have received. Discuss with other students which differences between yourselves might result from nature and which from nurture.

Two images show whole chromosomes and these hold the information that is the key to our inheritance. The third image shows a human cell dividing. We need to know how information is contained in the chromosome and how it is passed from one cell to another.

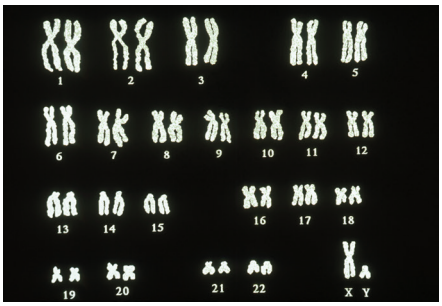


Figure 5.25 The human karyotype – the full set of human chromosomes, arranged to show their shapes and relative sizes. This one is a male (see the XY pair).

STUDY TIP

Make a link to the structure of cells in Section 1.3.

Chromosomes

Every one of the billions of cells that make up your body contains a library of genetic information called the genome. This information is stored inside the **nucleus** of each cell, in the **chromosomes**, as a code within molecules of **DNA** (**deoxyribonucleic acid**).

Chromosome number and homologous pairs

There are **46 chromosomes** inside the nucleus of each human body cell. Each chromosome is a molecule of DNA. Each chromosome has a partner, which looks very similar in its shape and structure, so our body cells contain **23 pairs** of chromosomes (Figure 5.25). The chromosomes in a pair are described as **homologous** chromosomes. One member of each pair came from each of your parents – so one set of 23 chromosomes came from one parent; the other set came from your other parent, giving you a total of 46. Gametes (in humans) each contain one set of 23 chromosomes.

The chromosome number has been worked out for many species. Here are just a few examples to let you see how this number varies: onion = 16 chromosomes; rice = 24; chimpanzee = 48; donkey = 62; chicken = 78.

The chromosome number for the extinct woolly mammoth has been worked out from a frozen carcass and this is found to be 58. Each of these examples gives the total number of chromosomes, so each of these species has half the number of homologous pairs. In the examples given, you can see that an onion has eight pairs of chromosomes and a donkey has 31 pairs.

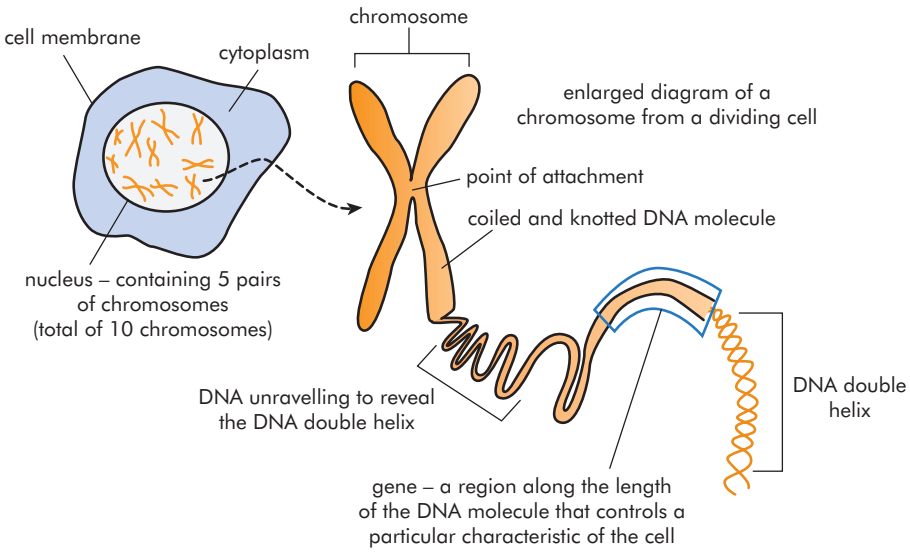


Figure 5.26 Looking more closely at chromosomes – from the cell nucleus to the DNA. Each stage in the sequence shows an enlarged view of the stage before.

A single set of chromosomes (one of each homologous pairs) is known as the **haploid** number. We use the symbol 'n' – often written as (n) – to show the haploid number. Two sets of chromosomes (including both members of the homologous pairs) are described as being **diploid** (2n).

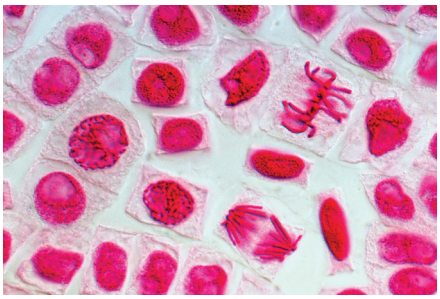


Figure 5.27 Cells near the root tip of a hyacinth, seen with a light microscope. In cells that are not dividing, chromosomes cannot be distinguished in the nucleus, but in cells that are dividing the dark strands of the chromosomes can be clearly seen. In one cell (lower part of photo), the chromosomes are separating and each group will go into one of the two daughter cells produced by mitosis.

Using a light microscope, chromosomes are visible only in **dividing cells** and you can see them more clearly when stained with a dye that sticks to DNA (Figure 5.27). The reason why chromosomes become visible in dividing cells is because the DNA becomes coiled forming shorter and fatter lengths of DNA. After cell division, the chromosomes uncoil again, becoming less obvious.

Genes and alleles

The genes are arranged along the length of each chromosome. Each of the 23 types of human chromosomes carry thousands of different genes. There are about 22 000 different genes that make up the complete genetic information for a human – or the human genome.

A gene is a length of DNA at a specific place on a chromosome, that codes for a particular protein. Each protein made in a cell gives a particular characteristic (or inheritable trait) to the individual carrying it.

As described above, chromosomes occur in homologous pairs. This means the position of genes along each member of a homologous pair is identical, and the cells always contains two copies of each gene – one copy on each member of the pair of chromosomes.

Genes often have more than one form, each of which instructs the cell to do slightly different things. These alternative forms of a gene are known as alleles. For example, in humans, the gene for eye colour may code for brown eyes or for blue eyes. In pea seeds, a gene for seed shape may code for round peas or for wrinkled peas. Different alleles are the result of subtle changes to the DNA code within a gene, as described below.

So, to look at these two examples again, in an individual, one chromosome (of the homologous pair) may carry the allele for brown eyes and the other chromosome of the pair may have the allele for blue eyes. Similarly, the allele for round seeds may occur on one chromosome and the allele for wrinkled on the other chromosome of the pair.

An individual may have two alleles that are the same (for a particular character), such as having the blue eye allele on both chromosomes, or the two alleles may be different. A single individual can only carry two alleles of a gene, but there may be other possible alleles of a gene in the population. For example, in the human population, the blood group gene has three alleles – called A, B and O, yet each individual human carries a maximum of two alleles.

Many of our genes are also shared with most other species of life on Earth – we share 98% of our genome with chimpanzees and 50% of our genes with bananas! Bacterial cells carry a thousand times fewer genes than animals and plants, and all their genes are fitted onto a single circular chromosome.

The structure of DNA

A DNA molecule is made of two strands of **polynucleotides** spiralling around one another to form a double helix shape. A nucleotide is made up of a sugar, phosphate and a base. If you imagine the DNA double helix as a twisted ladder, the sides of the ladder consist of an alternating series of sugars (deoxyribose) and phosphates. The rungs of the ladder are composed of pairs of bases. One base of each pair forms half a rung (Figure 5.28).

STUDY TIP
To help you remember the word, poly = many, hence polynucleotides.

STUDY TIP
Think of a simple way that you can remember the letters for these pairs of bases.

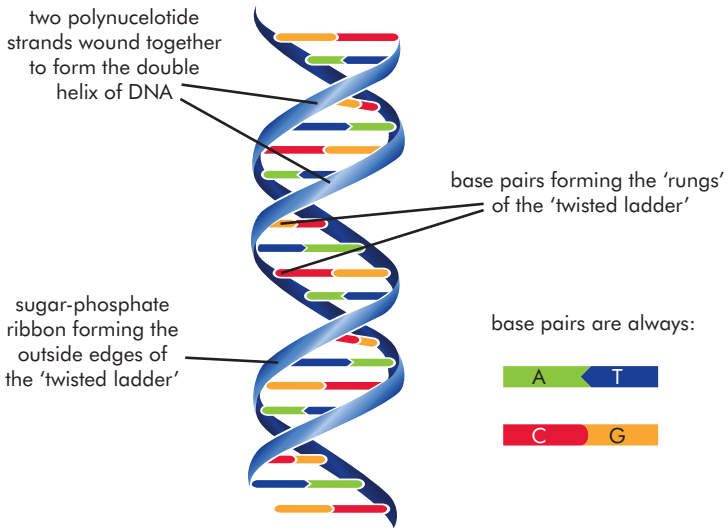


Figure 5.28 Structure of the DNA double helix – note the base pairs.

Each base projects from one side of the ladder, towards the middle of the double helix. Here it matches up with a complementary base, projecting from the opposite side of the ladder. There are four bases, usually known by their initial letters, as follows: adenine (A), thymine (T), guanine (G) and cytosine (C).

The bases can only pair up according to the following rules:
A can only form a pair with a T
G can only form a pair with a C.

STUDY TIP
You can find more details about gene technology and genetic modification (GM) in Section 7.5.

The double helix structure of DNA was proposed in Cambridge by James Watson and Francis Crick in 1953. Later they were awarded a Nobel Prize for this work. They had solved the riddle of the structure of this important molecule and they also realised how it could be accurately copied (replicated) as part of cell division. This discovery opened the way for enormous advances in understanding how DNA works and in the development of techniques of gene technology, which have become an important part of scientific work in the 21st century, with applications in many fields.

STUDY TIP
Look in Section 5.5 for details about cell division and mitosis. Make a link here between DNA and 'mistakes' that lead to mutations – see Section 5.6.

When a DNA double helix is split lengthwise into two halves, the missing half of each ladder is rebuilt. Because A always pairs with T, and G always pairs with C, the sequence of bases in the two new complete molecules of DNA is identical. This is crucial when a cell divides by mitosis as it ensures that each new daughter cell gets a full set of chromosomes (and, therefore, the same genes) from the original parent cell.

PRACTICAL

This practical activity is a useful way for you to appreciate the presence of DNA in living cells, though scientists use more elaborate techniques to extract DNA for research – for example, when determining DNA sequences or doing forensic work.

Remember to wear eye protection.

Practical activity – extracting DNA from strawberries

1 Place one large strawberry (or two smaller ones), with stalk removed, into a small, strong plastic bag. Add two or three drops of detergent and a level teaspoon of table salt.
2 Knot the mouth of the bag and then massage the fruit, reducing it to a liquid mush with no lumps.
3 Cut the end of the bag to release the liquid into a funnel lined with muslin.
4 Pour ice cold ethanol gently onto the pink filtrate, forming a clear upper layer in the tube. (Ethanol is hazardous, so follow safety advice from your teacher.)
5 Strands of white DNA precipitate at the junction between the two layers and eventually float off into the upper layer.

Note that other material can be used, depending on the time of year and what is available.

STUDY TIP

To summarise at the end of Section 5.4, make sure you understand that gametes are haploid and that the diploid set of chromosomes is restored at fertilisation. This gives diploid body cells. You can check details of mitosis and meiosis in Section 5.5.

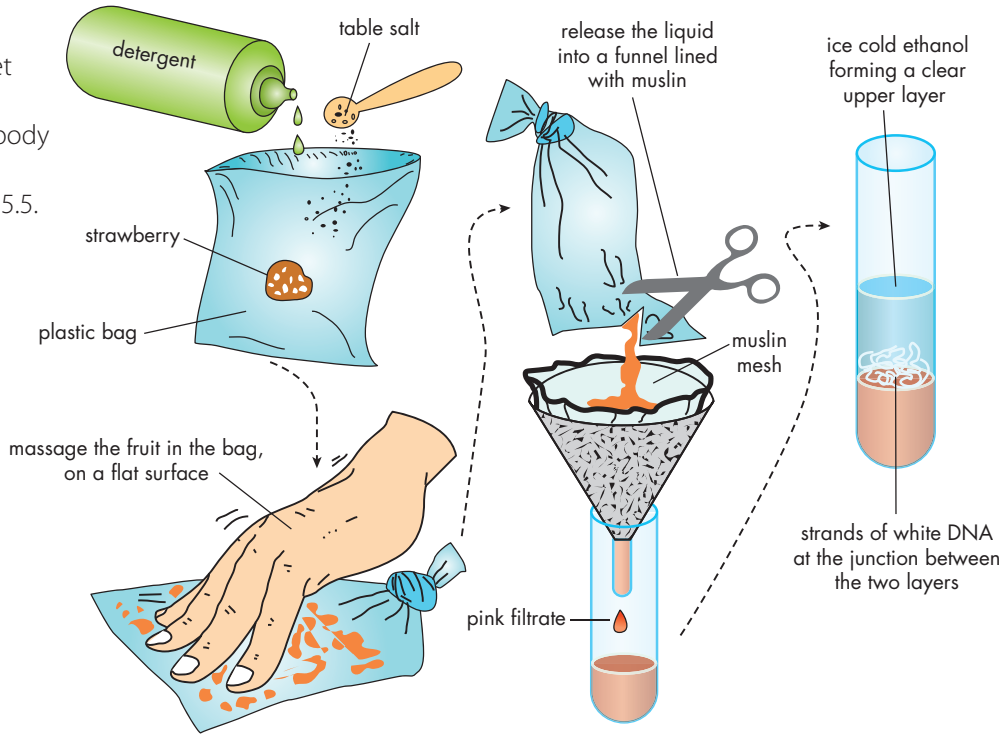


Figure 5.29 Extracting DNA from strawberries.

The genetic code and protein synthesis

A protein consists of a chain of a hundred or so amino acids. There are 20 different amino acids that can be used in a chain, and each type might be used once, repeatedly or not at all. A gene directing the synthesis of a protein ('coding' for a protein), must specify the exact type of amino acid used for each member of the chain. This information is encoded within the gene DNA as a sequence of chemical bases. The four DNA bases (the 'rungs' of the ladder, shown in Figure 5.28) are usually referred to by a single letter code: A (adenine), T (thymine), G (guanine), C (cytosine). The sequence of these

STUDY TIP

Alleles – look at Section 5.5 and Figure 5.31 for more details about alleles on homologous chromosomes and how they are inherited.

STUDY TIP

DNA and RNA – differences and similarities

DNA base pairs lie on the 'inside' of the DNA **double helix** and this protects them from random chemical changes, reducing the chance of mutations. Chromosomes last a lifetime and copies are passed on when a cell divides.

RNA molecules are **single stranded** and last for a few minutes in the cytoplasm of the cell, before being broken down. Also, remember that in RNA, **U** replaces **T** (found in DNA).

STUDY TIP

Transcription and translation

Transcribing means making a copy of something, which is what happens when the DNA of a gene is transcribed into mRNA (a nucleic acid copy of another nucleic acid).

Translating means converting something into another form. This is what happens when the mRNA 'message' is **translated** into a protein (a chain of amino acids).

MATHS TIP

Numbers in standard form and powers

Very large and very small numbers are best written in standard form, where the first part is a number between 1 and 10, and the second part is a whole-number power of ten (negative or positive).

For example, written in standard form, 0.00005 becomes 5.0×10^{-5}; and 750.34 becomes 7.5034×10^{2}.

Now go to page 9 to apply this to some calculations involving DNA.

bases along the DNA of a gene determines the exact order of the amino acids in the protein. Three adjacent bases (a **codon**) code for a particular amino acid. For example, AGA is a codon, and TGC is another. In the same way that different letters of the alphabet can be rearranged to make different words, the many different possible arrangements of the four DNA bases provide enough codons to allow the gene to specify all amino acids in the protein. For example, to code for a protein that is 100 amino acids long, 100 codons composed of a total of 300 bases are required.

Protein synthesis involves several steps (Figure 5.30). The protein is synthesised in the cytoplasm of the cell, but the gene directing its synthesis is held in the nucleus of the cell in a chromosome. When a gene is activated ('switched on'), a matching copy of the DNA base sequence within the gene is transcribed (re-written) into another kind of nucleic acid molecule called mRNA (messenger ribonucleic acid).

RNA is composed of single-stranded chain of RIBOnucleic acid (as opposed to the double chain of DEOXYRIBOnucleic acid in DNA) and contains the bases A, C, and G like DNA. However, in RNA the base uracil (U) occurs instead of the base T (found in DNA). The base sequence of the mRNA provides codons specifying the same amino acid sequence specified by the DNA of the gene.

The mRNA molecule is mobile and flexible. It moves out of the nucleus, into the cytoplasm, where it becomes attached to organelles called ribosomes. The ribosome carries out the synthesis of the protein (a step called translation). The ribosome moves steadily along the mRNA molecule like a train on the railway tracks, two codons at a time. Amino acids are delivered to the ribosome, attached to transfer RNA (tRNA) molecules.

Each tRNA molecule has a group of three bases called an anticodon. For example UCU is an anticodon, and AUC is another. Each different amino acid is attached to a specific tRNA. Each specific tRNA anticodon pairs up only with a specific mRNA codon. As a consequence, different amino acids are delivered to the ribosome by different tRNA molecules, in a precise order, because of the mRNA codon–tRNA anticodon pairing rules. For example, the mRNA codon UAU can only pair up with the tRNA anticodon AUA.

On the ribosome, the amino acids become chemically linked together with strong bonds. Thus the sequence of amino acids originally encoded in the DNA of the nucleus ends up being synthesised in the cytoplasm of the cell. This chain of amino acids can then fold into a protein. The series of steps described above shows how DNA directs the production of proteins and, in turn, the characteristics that you inherit. The exact pattern of different proteins made by an individual cell determines what the cell does and what it becomes.

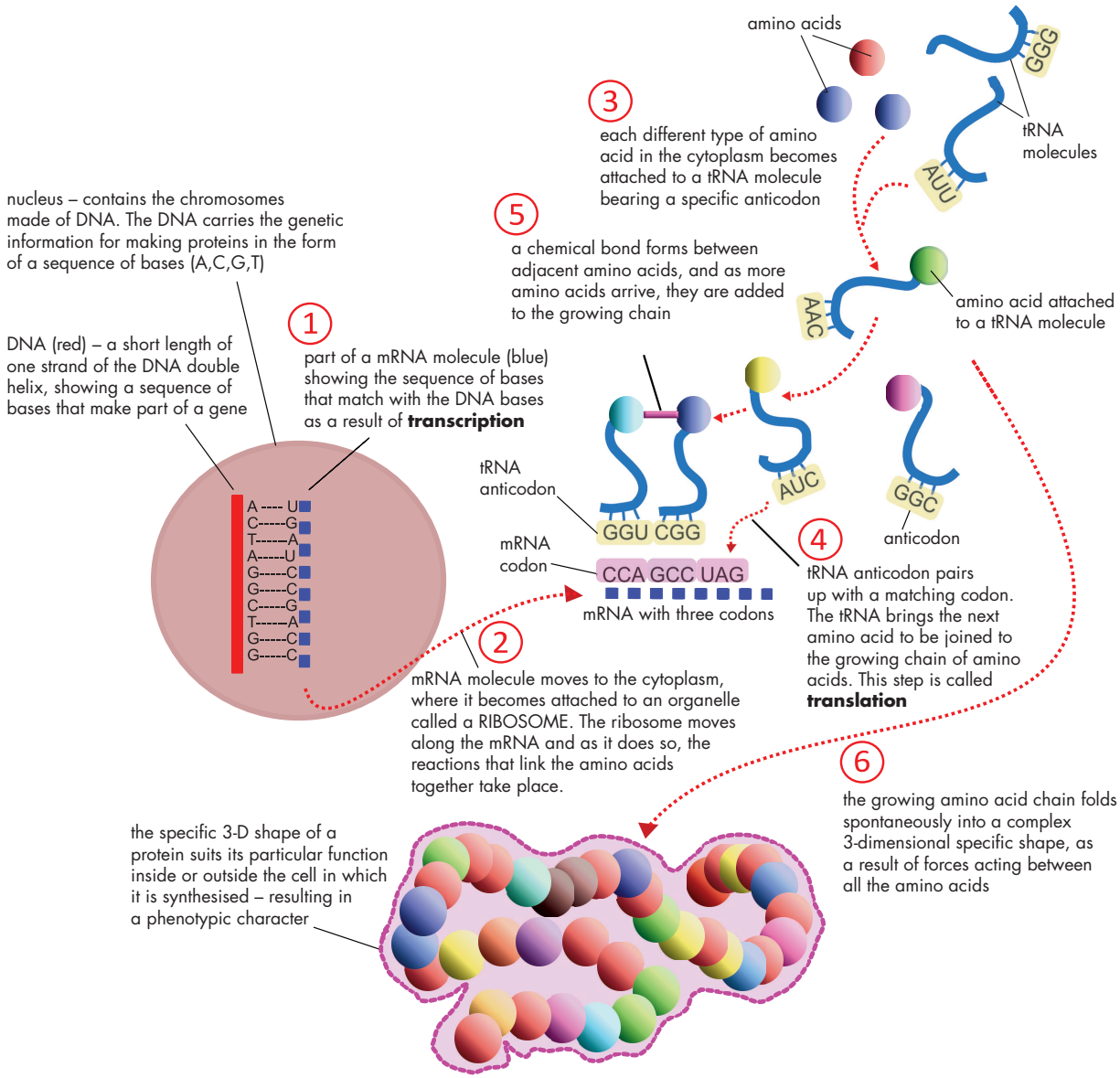


Figure 5.30 - A diagram to show the steps (numbered 1 to 6) involved in protein synthesis. Genetic information in the bases of a DNA molecule undergoes transcription to mRNA, followed by translation to form a chain of amino acids as part of a protein.

STUDY QUESTIONS

1 It is important that you understand and remember the definitions for various terms that are used in Section 5.4. A list of terms is given in the box:

> allele; chromosome; diploid; DNA (deoxyribonucleic acid); gene; haploid; homologous chromosomes

a) First cover up the table (below) and write your own definitions for each of the terms in the list.
b) Then copy the table, look at the definitions or descriptions in it and match the correct term to each description.
c) Cover up the table again and write the definitions again, to check that you remember them correctly.
d) Write a sentence using each term or give an example for each term to show that you do understand them.

Definition or description	Term
Thread-like structures in the nucleus, made up of DNA, that carry the genetic information for the organism.	
A molecule with a double helix shape, consisting of two strands of nucleotides held together by pairs of bases. It carries the genetic information in coded form for all the characters in the organism.	
A pair of chromosomes that are the same shape and same size, and carry genes for the same characters in the individual. One of each pair came from each parent.	
A cell containing one set of chromosomes (n).	
A cell containing two sets of chromosomes (2n).	
A region along the length of the DNA of a chromosome that contains the information to control a certain characteristic.	
An alternative form of a gene – occurs at the same position (locus) on the chromosome and controls the same character but in different ways.	

2 a) List the four bases that occur in a DNA molecule. Use their names as well as the letters. Then draw a diagram to show which bases form pairs together.
b) DNA is described as a 'double helix'. Draw a simple diagram of a DNA molecule to show both strands and the helix shape. On the diagram, label the molecules that form the backbone and show where the pairs of bases fit into the structure.

3) Here are some questions to help you with the stages of protein synthesis and the different words used.
a) In a DNA molecule, how many bases code for one amino acid? Write down two examples. (Use letters for the bases rather than their names.)
b) Name the four bases found on an RNA molecule. Use their names as well as the letters.
c) For the two examples you gave in a) for DNA, write down the corresponding bases that would match them and form a codon on an mRNA molecule.

(continued)

d) Now write down the bases that would be found on a tRNA molecule, to correspond with the examples you wrote down in c) and form an anticodon.
e) Which stage above represents transcription? (Refer to the letters for the part of the question and give a description of the the term in words.)
f) Where, in the cytoplasm, does translation occur? Describe in words what happens.
g) Explain how a protein that is synthesised relates to the information contained in DNA molecules in the nucleus of a cell.

MATHS SKILLS

Standard form and powers

A adult human male can produce 20 million sperm per cm^3 of semen.
a) Write this figure out in standard form.
b) Of these 75% will be mobile. Calculate how many sperm this is. Write your answer in standard form.
c) A single ejaculation contains 369 million sperm. Calculate the volume of semen in cm^3 this involves.

a) 2 x 107 sperm per cm3
b) 1.5 x 10^7 sperm
c) 18.45 cm3

MATHS SKILLS

Probability

Probability is a measure of the likelihood that something will happen, ranging on a scale from impossible (= 0) to certain (= 1). On this scale, an even chance of something happening = 0.5.

This can also be expressed as a fraction or as a percentage (so 0.5 = 50% = 1/2). Remember it is still possible for unlikely things to happen!

a) If a single base is selected from a DNA molecule entirely at random, what is the probability of it being adenine (A)?
b) The chance of a mutation to a DNA base pair during cell division is estimated as 1×10^{-9} per base pair. With 6×10^9 bases in a single cell, how many mutations can be expected per cell division?

a) ¼ or 0.25 or 25%
b) 6 new mutations per cell division.

6.1 The organism in the environment

A focus on organisms in an ecosystem




Look carefully at the photographs. First you are likely to notice the coloured flowers – bluebells in a wood in Eastern England and primulas in high mountains in Western China. In each photo, the flower is a single species, surrounded by many others: plants, animals and microorganisms. The bluebells and primulas are each part of the much bigger grouping of many species that, together with their environment, make up the ecosystems we see in the photographs.

Now think about an area you know well, perhaps near your school or home, and make a list of any species you have seen there. Then think about how they might interact with each other. (At the end of the section, check back to your list and see whether your ideas about how they interact have changed.)

What makes up an ecosystem?

In Section 6.1 we tease apart the components of an ecosystem and see what contributes to this structure. We then put it all together into a whole. You also find out about methods you could use to look in more detail at the distribution of plants and animals within the ecosystem being studied.

Population

The term **population** describes a group of individuals of the same species, living in the same place at a certain time.

The bluebells (or primulas) in the photographs each represent a population. In another wood, perhaps 10 km away, there might be another population of bluebells (or primulas). In the background of each photograph, there is a population of certain tree species and on the ground, there are populations of beetles, ants and other small animals.

Community

The term **community** links together the populations of the different species living together in the same place.

Figure 6.1 A pond in Bradfield Woods (Eastern England).

The top-left photograph on page 10 shows a woodland community, with bluebells and other plants on the ground, shrubs and taller trees behind. There are likely to be beetles and other insects, on the ground or flying through the air, and many small invertebrate animals in the soil. In this woodland, there may be some mammals (such as dormice, squirrels or deer) with birds flying between the trees and shrubs. All these are part of the same community, even though you cannot see all the species in the picture.

Figure 6.1 shows a different community in the same woodland as the bluebells. The various species found in the water and on the edges of the pond are different from those in the bluebell picture.

Within each community, there are links or interactions between the species found there. The group of species existing together in a community have certain requirements that they all find in that particular place and the different species in a community are dependent on each other.

Habitat

The term **habitat** is used to describe the place where an organisms lives.

Habitat can be used as the place for just a single species, but often refers to a general area where many species are found. So the woodland in the first photograph on page 10 is the habitat for the various species already referred to (and many more). Similarly, the pond (Figure 6.1) is the habitat for many species (plants, animals and microorganisms) found in the water, but which would not be able to live in the open woodland.

Ecosystem

An **ecosystem** puts all the species, populations, habitats and communities together. The term **ecosystem** is used to describe the whole integrated mixture of biotic (living organisms) components, and abiotic (physical, non-living) components that exist in a particular habitat. The biotic components (living organisms) depend upon each other, and on getting the essential abiotic components in order to live and thrive. Abiotic components include things such as water, mineral ions and gases in the air, plus things such as warmth and light and shelter.

STUDY TIP

Check details about how energy is transferred through food chains and food webs, and how species are dependent on each other (see Section 6.2).

Referring again to the same photographs, we can recognise a woodland ecosystem (page 10) and a freshwater aquatic ecosystem (Figure 6.1). Within an ecosystem, there are interactions between the living organisms that are found there. In particular, species are dependent on each other through food chains, which provide a means for the transfer of energy and of various substances required for growth and other activities.

Figure 6.2 A person using a quadrat to sample an area of a field.

STUDY TIP

Remember that using a quadrat is a way of taking a **sample** in the area, rather than counting every plant (or animal).

Biodiversity

The term biodiversity is used to describe the range and variety of living organisms within an ecosystem. It can include all living organisms: plants, animals, fungi and bacteria, and is often used to indicate the richness or number of different species in an area. 'Biodiversity' also takes into account the distribution of each species within the area – whether or not they are spread evenly – as well as the population size of the different species (for example, of plants or animals) within the area.

Such an area can be defined at different levels: across the whole globe; a desert, a tropical rainforest or a mountain range; or the more limited areas shown in the photographs on pages 10 and 11.

Look again at the photographs on page 10 at the start of this section. At first glance, the two on the left have clear similarities: mainly flowers in the foreground (bluebells or primulas) against a background of trees. They come from different places (very far apart – England in Europe and China in Asia) but we may wish to compare the biodiversity in these two superficially similar communities. Their biodiversity may turn out to be quite different. The methods described below can be adapted to give a measure of biodiversity.

Distribution of organisms in their habitats

How quadrats can be used to estimate population size

Let's go back to the photograph of the primulas. Suppose you were asked how many primula plants there were in this field, and whether there were more in this field or in another field on the other side of the valley.

You could try to do this in one of two ways. Either you could count all the primula plants in the area, or you could estimate how much of the area was occupied (or covered) by the primula plants. Both these suggestions would be very tedious to do, take quite a long time and not be very accurate.

The best way to do this is to take a sample area and look at it in detail. To select your sample area you use a piece of equipment called a quadrat (Figure 6.2).

- A quadrat is usually square, but can be any shape.
- A quadrat can be made of any material, but often it is made of wire or string that is pegged into the ground at the corners.
- A quadrat can be different sizes, depending on the size of plant you are looking at. Often quadrats with sides of 0.5 m are used to sample small plants in an area.

A quadrat can also be used to find out about animals in the sample area, provided the animal does not move away quickly.

When you use a quadrat, you must not just put it down on the ground where all the best flowers are growing (or where they are not growing). You need to place the quadrats **randomly** so that you are not showing any bias when collecting your results. One way of getting random positions for a quadrat is to place two long measuring tapes on the ground at right angles, to give a grid. Each 'square' in this grid has a number. Numbers are then chosen randomly and used as the positions for the quadrats.

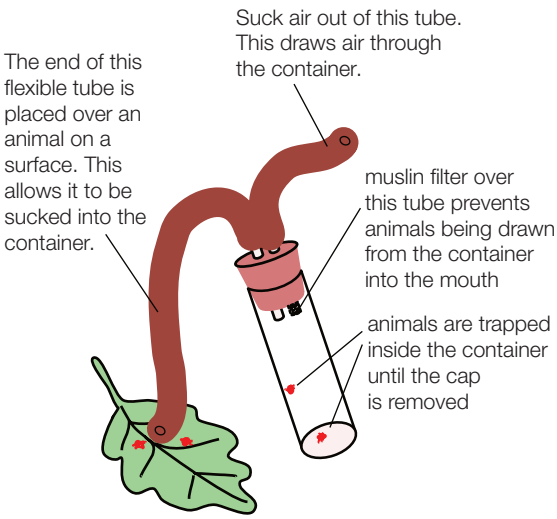


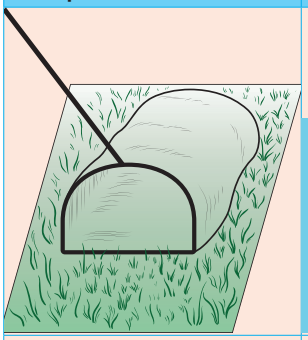
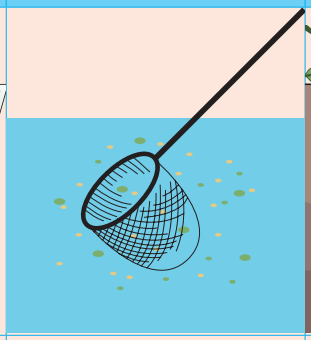
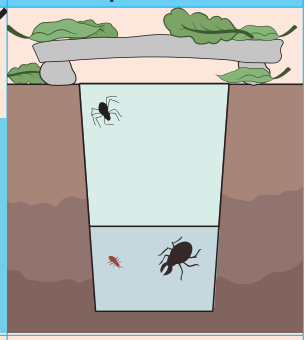
Figure 6.3 A Tullgren funnel used to sample small animals on a leaf.

To make your estimate, you look in detail inside the relatively small area of the quadrat. You must decide whether you are going to count the number of plants (for example, primulas) or estimate the proportion of ground covered by these plants. Often this is done as 'percentage cover'.

You then repeat the measurements in a number of quadrats. From that you can multiply up the results from all the quadrats you have recorded to give a reasonably accurate estimate of the number of plants in this population in the whole area.

In some habitats, particularly with animal species, equipment other than a quadrat may be used to capture a 'sample' of the animals. These include sweep nets (through vegetation), pond nets (in water) and pitfall traps (for small animals on the ground). Often you can devise something that is appropriate for a particular habitat but you need to remember you are taking a sample that is used to represent the distribution pattern in a larger area.

Table 6.1 Three sampling techniques for invertebrate animals.

Sweep net	Pond net	Pitfall trap
		
collects small animals from soft vegetation	collects small animals from rivers, ponds and lakes	collects small animals crawling around soil surface
the flat part of the net entrance is dragged across the vegetation trapping animals inside the net	the mesh net is submerged in the water and then used to scoop up the animals swimming in the water, allowing the water to drain away	the container is buried up to its rim, with a flat stone used to provide a lid, with space around the edge to allow small animals in, but not large predators
cannot be used with stiff woody vegetation like tree branches, and some animals flee before capture!	lets animals smaller than a certain size pass through mesh, and others swim away before capture!	requires animals to be killed to avoid them crawling out of the trap, or eating each other! Dilute detergent is usually used.
surprised animals are collected directly from the inside of the net using a pooter	animals tipped into a tray of water for further study	animals tipped into a tray for further study

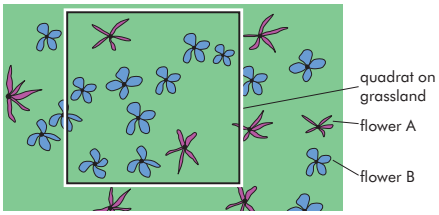


Figure 6.4 How to use a quadrat to estimate the density of two species of flowers on grassland.

Using quadrats to estimate the density of two species of flowers in grassland

Figure 6.4 shows two species of flowers (A and B) growing in grassland.

1. Use a quadrat. This can be a square of wire or a loop of string with a stake at each corner. Choose a size of quadrat that is for the size of the plants you are observing.
2. Place the quadrat in the study area, using a random method. This is usually done by using two measuring tapes running at right angles to each other at the border of the area. Random numbers are then used to get a distance along each tape. The intersection of the two distances gives the precise location for the quadrat in the study area.
3. Count the number of flower A and the number of flower B in the quadrat.
4. Then a new quadrat position is randomly chosen. Count the numbers of A and B in this quadrat.
5. Repeat this in several quadrat positions.
6. To calculate the density of each flower, add up the total number of flowers counted in each of the quadrats. Divide this by the total area sampled to obtain the plant density.

MATHS TIP

Percentages

One quantity (n) can be expressed as a percentage of another (N), by setting up the first quantity as a fraction of the second and multiplying by 100:

(n/N) × 100 = the percentage of N represented by n.

If n is the magnitude of an increase, or decrease, from the original value N, then the formula above will give the percentage increase/decrease.

Worked example: A sample of fresh soil weighs 50 g. After drying to remove all water present, the sample weighs 25 g. The percentage of fresh soil mass composed of water =

$$\frac{50 - 25}{50} \times 100 = 50\%$$

Now go to page 25 to apply this to a calculation involving a percentage.

Practical activity – investigating the biodiversity of two areas of grassland

One measure of biodiversity is to assess how many different animal and plant species are found in a study area. Quadrats, sweep nets and pooters can be used to assess this in grassland. You might like to think about what other abiotic differences there could be between the two areas, and how they could be measured.

(a) (b)

Figure 6.5 Two different areas of grassland.

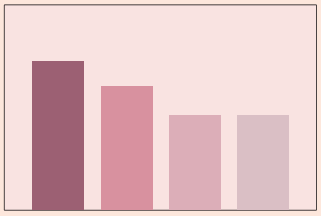
Figure 6.5 shows the appearance of two areas of grassland around a school playing field. Area (a) is located near the middle of a football pitch, and area (b) is found at the edge of the field, near the fence. Area (a) is mown frequently but area (b) is mown only three or four times a year.

MATHS TIP

Bar charts

Bar charts consist of a series of bars of equal thickness, drawn vertically from the *x*-axis of the chart. They are used to represent the **frequency** of items in a series of discrete **categories.**

If each category has no logical connection to the others (for example, different eye colours), the individual bars are often arranged in ascending or descending order of magnitude and separated by small gaps.



Now go to page 25 to apply this to the presentation of results of some investigations.

PRACTICAL

This practical activity emphasises the use of a sampling technique to make a reasonable estimate of living plants (or animals) in different areas. It is important to choose a size of quadrat that is appropriate to the size of the organism being sampled. You may be asked to describe use of quadrats in the examination.

Assessing the presence of different plant species using a quadrat

1. Use a random method to take several quadrat samples in both areas. This is usually done by using two tape measures running at right angles to each other at the border of a study area. Random numbers are then used to get a distance along each tape. The intersection of the two distances gives the precise location for a particular quadrat.
2. For each quadrat sample, note the presence or absence of all the different broad-leaf plants (weeds) within the quadrat. *Even if you cannot find the precise name of the plant, you can recognise different ones by their leaf shapes.*
3. Repeat the quadrat sampling in several randomly chosen positions in each study area.
4. Note the total number of different plant species in each area. The area with the larger figure has the greater plant biodiversity.

Assessing the presence of small invertebrate animals using a sweep net and a pooter

1. Collect small invertebrates from both study areas. For each area, drag a sweep net along the grass for a fixed distance (several metres).
2. Grip the entrance to the bag, to ensure the animals are trapped, and then reveal each of them slowly by gradually peeling the bag open. Collect each animal in a pooter, before they fly or crawl away.
3. Once the bag has been emptied, repeat the procedure in the other study area, and use an empty pooter to collect the second batch of animals.
4. Empty each pooter into a shallow tray containing a layer of dilute detergent. This traps and kills the captured animals.
5. Use a small brush to gather the different animals into groups of the same species (that look the same).
6. Note the total number of different species collected from each area. The area with the larger figure has the greater animal biodiversity.

Estimating the population densities of plants and animals in an area

Note the total number of plants of a particular species within each quadrat sample. Then divide this figure by the total area sampled to obtain the plant density in number per unit area.

Note the number of animals of a particular species captured in a pooter and placed on a tray.
Then divide this figure by the total area of grassland swept by the trap:

(total area swept = width of net × distance the net was dragged along the grass)

This gives the density in number per unit area.

Factors that affect distribution of organisms in an ecosystem

The organisms that are present in an ecosystem and their distribution within it are influenced by both **biotic** and **abiotic** factors.

The **biotic** factors include all the other living organisms in the ecosystem, how they interact with each other and how they affect each other. These interactions may, for example, be in terms of competition (for example, for food resources or for water), predator–prey relationships, food chains and

food webs or perhaps shading by trees. At any time, such interactions are not fixed, but part of a dynamic and changing system.

The **abiotic** factors are the physical and chemical (non-living components) that contribute to the growth of living organisms in their habitats, within the ecosystem. Some abiotic factors are summarised in Table 6.2 with an indication of how they may vary and examples of effects they may have on living organisms in an ecosystem.

Table 6.2 Some examples of abiotic factors – how they may vary and a few examples that illustrate their effects.

Abiotic factor	How it may vary	Example(s) of effect(s)
temperature	hot (40 °C or higher) to below freezing (0 °C)	▶ hot dry desert, plants have adaptations that reduce water loss; animals seek shade or shelter in heat of day
light	▶ bright sunlight to deep shade ▶ different depths in water	▶ different range of plants found in sunny and shady areas of a woodland
pH	acid to neutral to alkaline	▶ lakes with low pH often lack fish populations ▶ plants tolerate different levels of acidity or alkalinity (for example, different plants found in peat bogs and chalky soil)
water	rainfall, available water, moisture in soil, humidity in air	▶ water needed for all ecosystems, but varies from swamps to desert conditions
mineral ions	full range of nutrients available to deficiencies in some	▶ eutrophication (high nutrient) to low levels of nutrient ▶ pollution from very high levels sewage or waste in fish farm
salinity (saltiness)	salty (as in seawater) through estuarine conditions to freshwater river	▶ marine fish cannot live in freshwater (and vice versa
gases (oxygen, carbon dioxide)	▶ normal oxygen level to low levels (anaerobic) ▶ normal carbon dioxide to enriched levels	▶ low levels of oxygen in polluted rivers and in muddy soil – organisms have adaptations that allow them to survive there
soil	sandy (large particles) to clay (small particles)	▶ sandy soil loose, low in nutrients and does not hold water ▶ clay soil firm but may become waterlogged and lacks air spaces

Summary

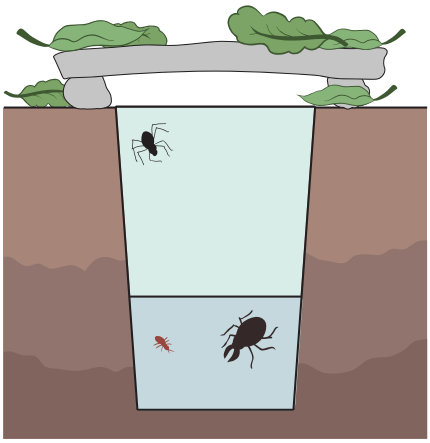
I am confident that:

- ✓ I know the meaning of the terms population, community, habitat and ecosystem.
- ✓ I understand the term biodiversity, within an ecosystem and across the whole globe.
- ✓ I can describe how to use different sampling techniques to find out about distribution of organisms (including plants and animals) in an area.
- ✓ I understand how to use different practical techniques, including quadrats, to investigate the distribution of organisms in their habitats and to compare the biodiversity of different areas.
- ✓ I appreciate that biotic and abiotic factors affect population size and distribution of organisms and understand some of the effects of abiotic factors on living organisms in an ecosystem.
- ✓ I know the meaning of the terms producer and consumer and understand the relationships between organisms at different trophic levels in a food web.
- ✓ I understand how solar energy is captured by the producers (green plants) and transferred to consumers in a food web, and how energy is lost at each trophic level of a food web.
- ✓ I understand the importance of decomposers and their role in a food web.
- ✓ I appreciate the reasons for representing numbers of organisms as pyramids of numbers of organisms, as pyramids of biomass and as pyramids of energy, and understand the limitations of each method.
- ✓ I can describe the stages of the carbon cycle and understand how living organisms are involved through the processes of respiration, photosynthesis and decomposition.
- ✓ I can describe the nitrogen cycle, including the roles of bacteria in the soil and the activities of plants and animals that contribute to it.
- ✓ I know that sulfur dioxide can contribute to acid rain and understand ways that this can be harmful to plants and animals.
- ✓ I understand the significance of the greenhouse effect for life on Earth.
- ✓ I appreciate that some human activities increase greenhouse gases and that this may contribute to global warming with various consequences for living organisms.
- ✓ I know about eutrophication and how this can lead to lack of oxygen in the water and the possible effects on plants and animals living in the water.
- ✓ I understand how deforestation can have harmful effects on the local ecosystems as well as in the wider environment.

Practical activities

Example

1 The diagram shows a pitfall trap. The container is buried in a hole dug into the soil, with the opening level with the surface of the soil. The large stone over the top stops large animals getting in and the small stones round the edge make sure there are gaps that allow small animals to enter.



A pitfall trap can be used to find out about small animals in the layer of leaves on the ground. Animals that fall into the trap cannot climb out of the container.

Some students suggested that there might be differences in the invertebrate animals under an oak tree and under a pine tree. They used one pitfall trap under each type of tree and examined the contents of the container after 24 hours. They sorted the animals into groups and counted the number in each group. Their results are given in the table.

Group of animals	Total number of animals caught in 24 hours	
	Under oak tree	Under pine tree
beetles	12	10
springtails	31	5
spiders	7	2
harvestmen	6	0
woodlice	2	3
slugs	2	0

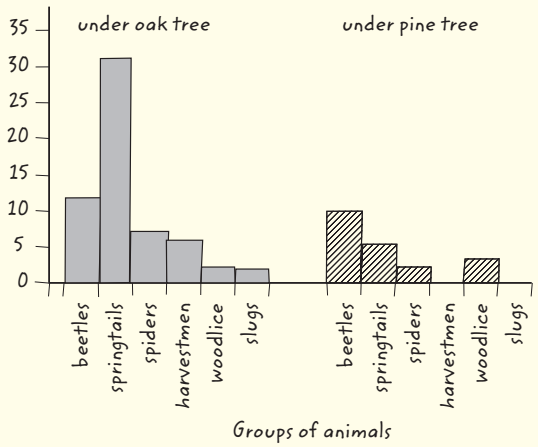
a) i) Plot these results in a bar chart so that you can compare them. [5]

ii) Calculate the percentage of the total animals caught that were in the trap under the pine tree. Show your working. [2]

b) Suggest why they left the traps for 24 hours before examining the contents. [1]

c) One student said that the results show that there is a greater abundance and a greater diversity of animals under the oak tree compared with the pine tree. Describe **two** ways that you could modify or extend the investigation to support this suggestion. [2]

[Total = 10 marks]

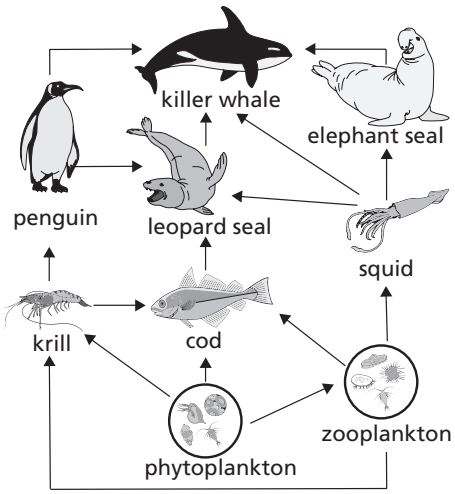
Student response Total 9/10	Expert comments and tips for success
a) i)  *Vertical axis:* ✓ *Width of bars:* ✓ *Horizontal axis:* ✓ *Key:* ✓	The question asked the student to draw a bar chart that would help comparison between the results. By plotting the bars for the animals in pairs, the diversity and abundance of the invertebrates in the two areas are easily compared. The height of most bars has been plotted correctly, but the student made a mistake with the bars for the spiders. The student has correctly drawn all the bars the same width, with a small gap between each pair of bars. The student has omitted the results (zero) for the total number of harvestmen and slugs in the pine tree trap. This data should have been included. The result (0 animals) is usually shown by making small marks on the axis where a bar would be, and by including these areas in the labelling. Although two different types of diagonal shading were used for the oak tree, the intention was clear and no mark was lost.
ii) *Pine tree trap = 20* *Oak tree trap = 60* *Total animals (both traps) = 80* ✓ *Results for pine tree as a percentage of the total = 20 ÷ 80 × 100 = 25%* ✓	Full marks.
b) *To catch a large number of animals.* ✓	A reasonable suggestion.
c) *Repeat this experiment at different times of the year* ✓ *and under more pine and oak trees, growing in different places.* ✓	A good answer, full marks.

Applying principles

Example

1 The food web shows some feeding relationships for marine organisms living in polar seas. Phytoplankton is made up of microscopic organisms that can carry out photosynthesis, including many algae.

a) Copy and complete the table, using organisms shown in the food web. Organisms may be used once, more than once or not at all. [3]



Description	Name of organism
one group of organisms that are producers	
two organisms that are both primary and secondary consumers	
two organisms that are tertiary consumers	

b) i) Explain what is meant by **biomass**. [1]

ii) Which group of organisms has the greatest biomass in this food web during the whole year? [1]

c) A region of the polar seas, with organisms in this food web, suffers from pesticide pollution. The pesticide is not biodegradable (does not break down quickly). An analysis of samples of tissues from organisms in this food web showed the highest concentration in the killer whale. Suggest an explanation for this. [2]

d) Fishing of cod increased in the region until it became 'unsustainable'. This means that the fish (cod) were removed at a faster rate than they could be replaced by natural breeding.
If cod became extinct as a result of over-fishing, predict and explain **two** ways that this might affect the food web. [2]

e) Polar regions have a good supply of mineral ions, carried in sea currents, such as the Gulf Stream.

i) Which group of organisms benefits directly from this supply of mineral ions? [1]

ii) Suggest **two** mineral ions that are important for this group. [2]

[Total = 12 marks]

Student 1 response Total 9/12	Expert comments and tips for success
a) zooplankton ○ cod and squid ○ killer whale and leopard seal ✓	Zooplankton are animals (the 'zoo' in the name might help you) so are not the producers. You should be able to interpret food webs based on unfamiliar ecosystems. In the question you are told that phytoplankton carry out photosynthesis so this gives you the clue that they are producers. To help identify the producers, look for an organism with no arrow pointing towards it (so does not feed on other organisms). Cod is correct, but not squid.
b) i) The mass of all living organisms at a stage of a food chain. ✓	Correct response.
ii) The killer whale. ○	Although each killer whale is a large animal, the biomass of the tertiary (and quaternary) consumers at the top of the pyramid of biomass is very small compared with the biomass of the producers at the bottom.

(continue)

Student 1 response Total 9/12	Expert comments and tips for success
c) The killer whale is at the top of the food chain. The pesticide is taken into the bodies of the small animals at the bottom of the food chain and when they are eaten by the food of the killer whale, ✓ the whale gets a high dose of pesticide. It has accumulated through the food chain. ✓	The student gains a mark for describing the way that the pesticide is passed up through the food chain to the whale. The second mark is for describing the accumulation of the pesticide, plus the description 'high dose of pesticide' for the whale.
d) There would be less food for the leopard seals, which at present eat cod, squid and penguins, so their numbers would go down. ✓ The krill would no longer be eaten by the cod, so their population would probably go up. ✓	The disappearance of cod from the food web would affect many of the organisms. Student 1 has given a good description of two possible outcomes.
e) i) The plants in the sea, such as plankton, ✓ need minerals.	Student 1 applied knowledge learned during the course to the unfamiliar marine food web — i.e. that algae, like green plants, carry out photosynthesis and also need a supply of mineral ions. Strictly speaking, algae are not plants, but the student's answer is accepted for the mark.
ii) Nitrate ✓ for growth and magnesium ✓ for making chlorophyll.	Answer is correct. Note that some students mistakenly refer to 'nitrogen' rather than nitrate. The only times it is correct to refer to 'nitrogen' is in the context of nitrogen gas, or as a molecule (for example, describing the nitrogen cycle or amino acid structure).

Student 2 response Total 12/12	Expert comments and tips for success
a) phytoplankton ✓ cod and krill ✓ penguin and leopard seal ✓	To find organisms that were both primary and secondary consumers, the student looked for organisms that were the first consumers in one food chain and the second consumers in another. e.g. phytoplankton ⟶ krill phytoplankton ⟶ zooplankton ⟶ krill
b) i) Biomass is the total mass of living organisms in e.g. a wood. ✓	A clear answer.
ii) The producers. ✓	Correct answer.
c) The pesticide is taken in from the water by the producers and passes to the primary and secondary consumers, going up the food chain to the killer whale. ✓ The pesticide doesn't break down ✓ (it is not biodegradable) so it stays poisonous and builds up to dangerous levels (✓).	The student applied understanding of food chains to the information about the pesticide (not biodegradable) in the question. She could have gained a third mark for saying the pesticide builds up in the killer whale, but the maximum for the question had been reached.
d) There would be more zooplankton because they would not be eaten by cod. ✓ There would be more squid, as more food (zooplankton) for them. ✓	Full marks for a good description of two possible outcomes if cod became extinct.
e) i) The phytoplankton. ✓ They are the producers in the food web and like all green plants they need mineral salts e.g. magnesium.	Do not waste time by writing more than is necessary. Always check the mark allocation to judge how much information is expected. As advised for student 1, strictly speaking algae are not plants, but the student has already answered the question and this part of the answer is not needed.
ii) Magnesium ✓ and phosphates ✓	In this question, any correct answer is given credit, even if it is based on knowledge beyond that required by the specification (e.g. phosphate).

Extended writing - Example

1 Explain how deforestation can cause flooding and affect the fertility of the soil in the deforested area. [6]

Student 1 response
Forests are cut down so that people can build houses and roads. The bulldozers disturb the soil when they take the trees away. The soil can get washed down the hill into the rivers. If the river gets blocked there might be some flooding somewhere else. When there are fewer trees there is less photosynthesis so less carbon dioxide is removed. This helps global warming.
Student 2 response
When trees are cut down the soil is easily eroded. Nutrients are also washed out of the soil so it is less fertile. If there aren't any trees the leaves don't fall to the ground and so the bacteria in the soil don't break them down and release the nutrients. Sometimes there is flooding because the trees don't take up the water and it stays in the ground.
Mark scheme
The mark scheme shows how marks are awarded. (1) vegetation / soil on ground exposed / no longer protected by trees / equivalent (2) less water taken up by trees from soil / equivalent (3) water can run off more easily (if on slope) / equivalent (4) (vegetation) does not bind / hold soil / equivalent (5) soil eroded / washed away / equivalent (6) (washed away soil) accumulates in rivers / blocks waterways in valleys (leading to flooding) / equivalent (7) soil can become saturated (because trees do not take up the water), leading to flooding / equivalent (8) mineral ion content (of soil) washed away / removed / leaching / equivalent (9) microorganisms (in soil) washed away / equivalent (10) (therefore) disturbance to soil recycling / equivalent (11) less vegetation on surface / eq that would break down / decompose / equivalent (12) mineral ions / eq not released from decaying vegetation / equivalent (13) soil less fertile / equivalent Total: 6

Student 1 response Total 2/6	**Expert comments and tips for success**
Forests are cut down so that people can build houses and roads.	No marks. This was not asked for in the question.
The bulldozers disturb the soil when they take the trees away. The soil can get washed down the hill into the rivers. ✓	No marks for the first sentence but 'washed down the hill' is enough for mark (5).
If the river gets blocked there might be some flooding somewhere else. ✓	This links flooding with rivers getting blocked and gains mark (6).
When there are fewer trees there is less photosynthesis so less carbon dioxide is removed. This helps global warming.	The statements are correct but do not answer the question set. Always read the question carefully and select relevant information for your response.

Student 2 response Total 6/6	**Expert comments and tips for success**
When trees are cut down the soil is easily eroded. ✓	Student 2 gains mark (5) with correct use of the term 'eroded'.
Nutrients are also washed out ✓ *of the soil so it is less fertile.* ✓	The first sentence gains marks (8) and (13). 'Nutrients' is an acceptable alternative (as it is equivalent) to 'mineral ions'.
If there aren't any trees the leaves don't fall to the ground and so the bacteria in the soil don't break them down and release the nutrients. ✓	Several points contribute to mark (11) but no mark for mention of bacteria (9), as this is awarded only in the context of being washed away. Student 2 correctly links less vegetation on the soil with being broken down (or decomposed).
Sometimes there is flooding because the trees don't take up the water ✓ *and it stays in the ground.* ✓	'Trees don't take up the water' earns mark (2). No mark for mention of 'flooding' as this is in the question but it is correctly linked to water in the ground, equivalent to mark (7).

Exam-style questions

1 The diagram shows a sweep net.

A sweep net can be used to capture insects and other small animals in soft vegetation such as long grass. The net is dragged through the grass with the flat part of the entrance ring pressed close to the ground. As it is swept forward, small animals are caught in the cotton bag. The trapped animals can then be collected from the bag, identified and counted.

Some students made a study of invertebrate animals in an area of grassland. They wanted to draw up a food web that represented feeding relationships of the community in the area.

The net was swept through the vegetation for a total of 4 m. The table shows information about the animals captured.

Organism	Description	Numbers caught in one sweep
aphids	feed on sap of plants	240
plant bugs	feed on sap of plants	12
snails	feed on algae on surfaces and on plant leaves	4
spiders	eat insects	2
harvestmen	eat insects	1
flies	feed on decaying matter	10

a) i) Explain why the net catch may not accurately represent the actual community of animals present in the grassland. [2]

ii) What additional steps could the students take to ensure greater reliability for the results? [2]

b) Draw a simple grassland food web, using the species caught. [4]

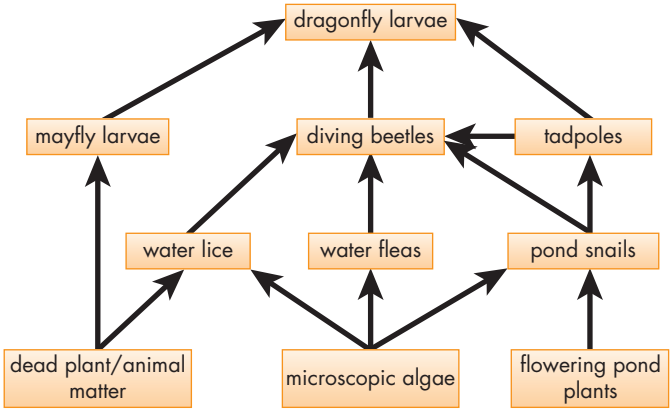
c) i) Name **one** herbivore and **one** carnivore in the catch. [2]

ii) Suggest why the catch shows fewer carnivores than herbivores. [2]

d) Suggest possible effects on the grassland web community if a pesticide led to the death of the aphids. [2]

[Total = 14]

2 The diagram shows a food web in a pond.



Use information in this food web to answer the questions that follow.

a) Name **two** producers in this pond ecosystem. [2]

b) i) How many organisms are there in the longest food chain in this web? [1]

ii) List the organisms for **one** food chain with this number of organisms and state the trophic level of each organism in the chain. [4]

c) If all the tadpoles in the pond died from the effects of a new fungal disease, predict what might happen to the populations of the other pond species. [3]

d) A pair of predatory (carnivorous) fish is introduced to the pond. (The predatory fish are secondary consumers.) Describe and explain the possible consequences to the balance of the whole ecosystem. [3]

[Total = 13]

3 a) i) The following pathways represent different parts within the nitrogen cycle.

Which pathway is not dependent on the activities of microorganisms?

A nitrates in the soil ➔ plant proteins ➔ animal proteins

B nitrogen in the air ➔ plant proteins ➔ animal proteins

C ammonia in the soil ➔ nitrites in the soil ➔ nitrates in the soil

D nitrogen in the air ➔ fertiliser synthesis ➔ nitrates in the soil

. [1]

b) Explain why leguminous plants (such as beans, clover and lentils) are often grown by farmers and gardeners to help maintain the fertility of the soil.

[3]

c) Human activities may affect the nitrogen and carbon cycle. Explain how the use of fossil fuels may link into the carbon cycle. [2]

[Total = 6]

4 Describe and explain the shortest route by which nitrogen atoms present in the proteins of an animal's body might become part of the proteins in a wheat plant.

[Total = 6]

5 Some scientists were looking at the effects of pollution. They did a study of about 1500 lakes in Norway. They measured the pH of the water and made estimates of the numbers of fish in each of the lakes.

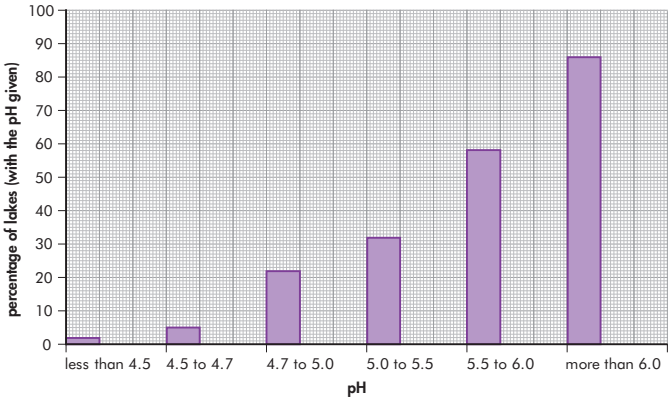
They found that some lakes had very few or no fish in them, while others had quite good numbers of fish. Some lakes had very good populations of fish. They divided their results into categories, according to the estimated number of fish in the lake.

Their results for two groups of fish population numbers are given below.

pH	Percentage of lakes (with the pH given)	
	No fish	Good populations of fish
less than 4.5	73	2
4.5 to 4.7	54	5
4.7 to 5.0	38	22
5.0 to 5.5	24	32
5.5 to 6.0	8	58
more than 6.0	2	86

a) The bar chart below shows the results for the lakes with good populations of fish.

i) Make a copy of the graph on a graph grid. On the same grid, plot the results for percentage of lakes with no fish. [4]



ii) Describe the effect of pH on the numbers of fish in the lakes for no fish in the lake and a good population of fish in the lake. [2]

b) The scientists noticed that fish in the lakes with the lowest pH (very acid) appeared to have a lot of mucus around their gills. Suggest how this might affect the numbers of fish in the lake. [2]

c) The scientists linked the pH of the lake to the presence of sulfur dioxide in the air.

i) Explain how sulfur dioxide could affect the pH of the water in the lake. [2]

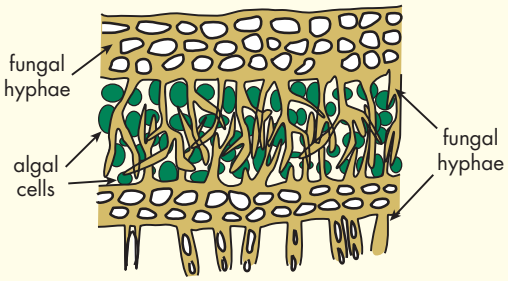
ii) Suggest **one** possible source of the sulfur dioxide in the air. [1]

d) Suggest why the scientists included 1500 lakes in their study. [2]

[Total = 13]

EXTEND AND CHALLENGE

1



These brightly coloured crusts are lichens, growing on the bitterly cold rocks found on the Antarctic peninsular. They are an example of one of the toughest organisms found on Earth. They survive the intense cold, dryness and long winter nights in this region.

Lichens are living organisms, composed of a mixture of fungal and algal cells. The fungus forms a tough mat on the rocks, which forms a space inside for the resident algal cells. The algae make food by photosynthesis and they share some of this with the fungus. Together the two organisms in the lichen are able to survive and grow in this inhospitable place, where nothing else can survive. The growth rate of a lichen is very slow compared with that of green plants – a colony may grow only a few millimetres in a year.

a) Two ecological terms used for a mutually supportive relationship between two species are 'mutualistic' and 'symbiotic'.
- **i)** Explain the roles of each of the two partners in the lichen.
- **ii)** Find out about **three** other examples of mutualism (symbiosis). For each example, suggest what the benefits are to each organism in the relationship. (You can find out about at least one example in this book.)

b) List environmental factors that would affect growth in Antarctic regions. Explain why the growth rate of lichens here is so slow, compared with green plants growing in other regions of the world.

c) Herds of caribou (reindeer) are found in northern tundra, for example in regions of Canada, Greenland and Norway. Lichens growing in the tundra form a substantial part of the diet for caribou herds. The caribou dig through the snow and scrape the lichen off the rocks underneath. The people who herd the caribou are nomadic, moving with the seasons rather than living in one place. Why do they have to move in this way?

2 In the 21st century, a lot of publicity is given to the effects of deforestation, particularly the loss of tropical forests. But global change is not new. Some of the effects of deforestation were recognised by Plato, who wrote this passage 2500 years ago. He was writing about Attica, in Greece.

'There are mountains in Attica which can now keep nothing but bees, but which were clothed not very long ago, with fine trees producing timber suitable for roofing the largest buildings . . . There were also many lofty trees, while the country produced boundless pastures for cattle. The annual supply of rainfall was not lost as it is at present, through being allowed to flow over the denuded surface to the sea, but was received by the country . . . where she stored it . . . and so was able to discharge the drainage of the heights into the hollows in the form of springs and rivers with an abundant volume and a wide territorial distribution.'

Look at the information in the passage and discuss how far Plato's words are relevant today. Use the following questions to guide you. You may need to refer to other sections in the book and use other sources of information.

a) List some uses of timber that is harvested from forests.

b) List reasons why forests are cut down and how the land is used after deforestation.

c) What were Plato's concerns about the rainfall and what happens to it? Describe the events that occur with respect to rainfall when forests are cut down in the 21st century and the problems that may result. How far are these similar to Plato's view of the situation?

d) Describe how deforestation can lead to poor quality soil.

e) In this passage, Plato makes no mention of changes in the balance of gases in the atmosphere. Explain, to a non-scientist, how deforestation may contribute to global warming and climate change.

f) Suggest how deforestation might affect biodiversity. Find out information about tropical rainforests, but also consider forests in temperate regions.

g) Draw up a list of recommendations that could help reverse the effects of deforestation. In your discussion, include measures that can be carried out by individuals as well as by governments and on a wider international scale.

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