St Bede's Catholic College

Year 11 into 12 Transition Work

Biology A Level

Course: - OCR A

If you have any questions or require any further guidance, please contact

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We look forward to welcoming you to A level Biology!

Contents

Link to the **specification** online https://www.ocr.org.uk/qualifications/as-and-a-level/biology-a-h020-h420-from-2015/

Biology A – Provides a flexible approach to teaching. The specification is divided into topics, each covering different key concepts of biology. Teaching of practical skills is integrated with the theoretical topics and they are assessed through the written papers. For A level only, the Practical Endorsement will also support the development of practical skills

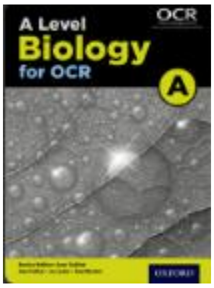
Exam structure

Content Overview	Assessment Overview	
Content is split into six teaching modules: • Module 1 – Development of practical skills in biology • Module 2 – Foundations in biology • Module 3 – Exchange and transport • Module 4 – Biodiversity, evolution and disease • Module 5 – Communication, homeostasis and energy • Module 6 – Genetics, evolution and ecosystems Component 01 assesses content from modules 1, 2, 3 and 5. Component 02 assesses content from modules 1, 2, 4 and 6. Component 03 assesses content from all modules (1 to 6).	Biological processes (01) 100 marks 2 hour 15 minutes written paper	**37%** of total A level
	Biological diversity (02) 100 marks 2 hour 15 minutes written paper	**37%** of total A level
	Unified biology (03) 70 marks 1 hour 30 minutes written paper	**26%** of total A level
	Practical Endorsement in biology (04) (non exam assessment)	**Reported separately** (see section 5f)

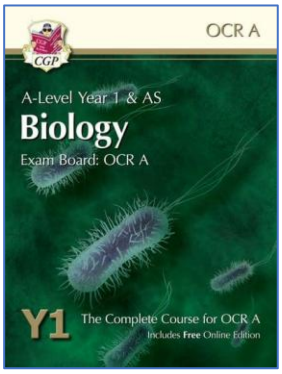
All components include synoptic assessment.

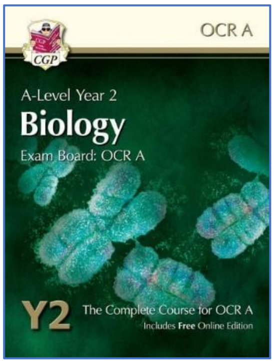
Link to sample/past papers: https://www.ocr.org.uk/qualifications/as-and-a-level/biology-a-h020-h420-from-2015/assessment/

We provide you with access to Kerboodle online textbooks

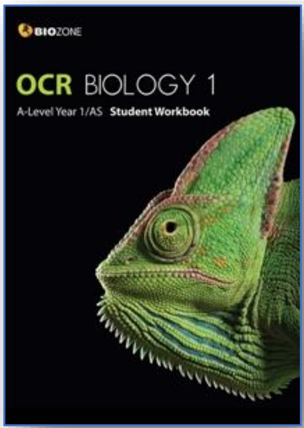


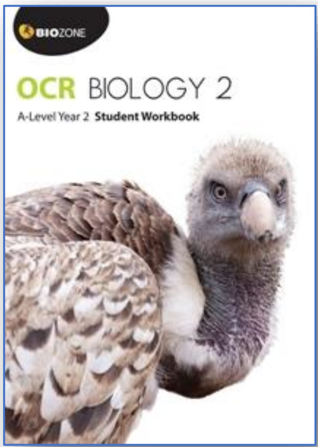
In addition, some students purchase these texts to support their learning:



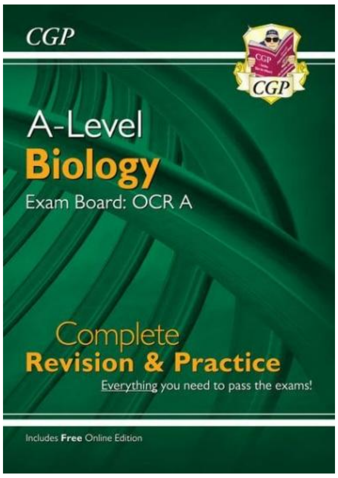


These are manuals that students can write in and answer Qs. They can be useful as HL resources and for extended detail.



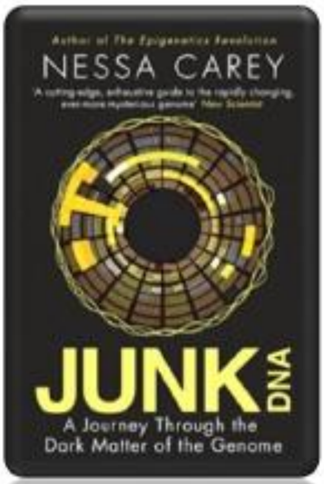


The CGP revision book is also popular with students.



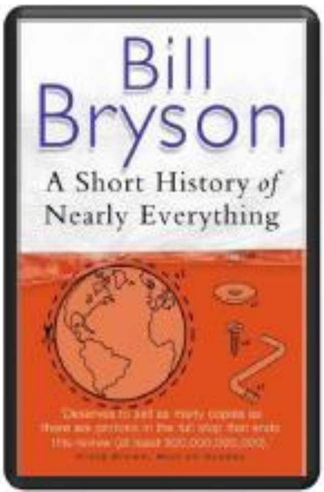
Book Recommendations

Kick back this summer with a good read. The books below are all popular science books and great for extending your understanding of Biology.



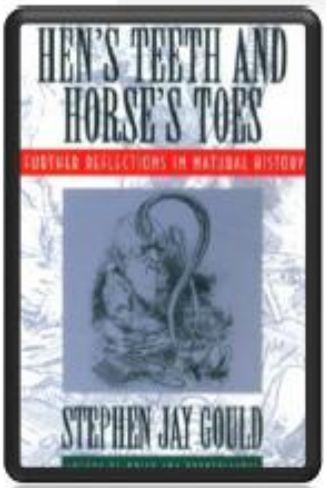
Junk DNA
Our DNA is so much more complex than you probably realize, this book will really deepen your understanding of all the work you will do on genetics. Available at amazon.co.uk

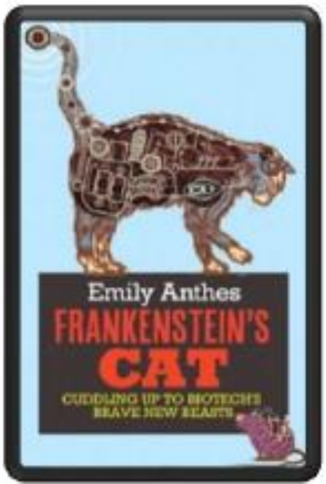
The Red Queen
Its all about sex. Or sexual selection at least. This book will really help your understanding of evolution and particularly the fascinating role of sex in evolution. Available at amazon.co.uk



A Short History of Nearly Everything
A whistle-stop tour through many aspects of history from the Big Bang to now. This is a really accessible read that will re-familiarise you with common concepts and introduce you to some of the more colourful characters from the history of science! Available at amazon.co.uk

Studying Geography as well?
Hen's Teeth and Horse's Toes
Stephen Jay Gould is a great evolution writer and this book discusses lots of fascinating stories about geology and evolution. Available at amazon.co.uk





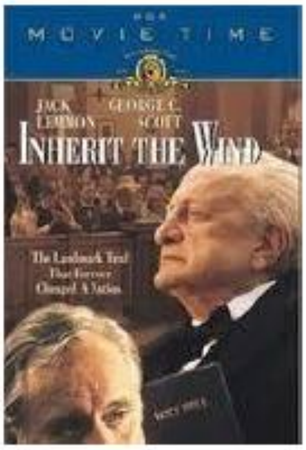
An easy read..
Frankenstein's Cat
Discover how glow in the dark fish are made and more great biotechnology breakthroughs. Available at amazon.co.uk

Movie Recommendations

Everyone loves a good story and everyone loves some great science. Here are some of the picks of the best films based on real life scientists and discoveries. You wont find Jurassic Park on this list, we've looked back over the last 50 years to give you our top 5 films you might not have seen before. Great watching for a rainy day.

Gorillas in the Mist (1988)
An absolute classic that retells the true story of the life and work of Dian Fossey and her work studying and protecting mountain gorillas from poachers and habitat loss. A tear jerker.

Inherit The Wind (1960)
Great if you can find it. Based on a real life trial of a teacher accused of the crime of teaching Darwinian evolution in school in America. Does the debate rumble on today?



Andromeda Strain (1971)
Science fiction by the great thriller writer Michael Cricthon (most famous for writing Jurassic Park). Humans begin dying when an alien microbe arrives on Earth.

Lorenzo's Oil (1992)
Based on a true story. A young child suffers from an autoimmune disease. The parents research and challenge doctors to develop a new cure for his disease.

Something the Lord Made (2004)
Professor Snape (the late great Alan Rickman) in a very different role. The film tells the story of the scientists at the cutting edge of early heart surgery as well as issues surrounding racism at the time.

There are some great TV series and box sets available too, you might want to check out: Blue Planet, Planet Earth I and II,, Icarus, Blackfish, The Ascent of Man, Catastrophe, Frozen Planet, Life Story, The Hunt and Monsoon.

If you have 30 minutes to spare, here are some great presentations (and free!) from world leading scientists and researchers on a variety of topics. They provide some interesting answers and ask some thought-provoking questions. scan the QR code to view:

A New Superweapon in the Fight Against Cancer

Cancer is a very clever, adaptable disease. To defeat it, says medical researcher and educator Paula Hammond, we need a new and powerful mode of attack.

Why Bees are Disappearing
Available at :

Honeybees have thrived for 50 million years, each colony 40 to 50,000 individuals coordinated in amazing harmony. So why, seven years ago, did colonies start dying en-masse?

What Doctors Don't Know About the Drugs They Prescribe
Available at :

When a new drug gets tested, the results of the trials should be published for the rest of the medical world — except much of the time, negative or inconclusive findings go unreported, leaving doctors and researchers in the dark.

Growing New Organs
Available at :

Anthony Atalla's state-of-the-art lab grows human organs — from muscles to blood vessels to bladders, and more.

Useful websites

- http://www.ibiblio.org/virtualcell/index.htm
    - An interactive cell biology site
- http://www.accessexcellence.org/RC/VL/GG
    - A web site showing illustrations of many processes of biotechnology
- http://www.uq.oz.au/nanoworld
    - Visit the world of electron-microscopy
- http://www.dnai.org/a/index.htm
    - I – Explore the genetic code
- http://nobelprize.org
    - Details of the history of the best scientific discoveries
- http://nature.com
    - The site of the scientific journal
- https://www.nature.com/scitable
    - be inspired with resources on genetics and cell biology from Nature Publishing Group, home of Nature, the most cited scientific journal in the world.
- http://royalsociety.org
    - Podcasts, news and interviews with scientists about recent scientific developments
- http://www.nhm.ac.uk
    - The London Natural History Museum's website with lots of interesting educational material
- http://www.bmj.com
    - The website of the British Medical Journal
- http://www.bbc.co.uk/news/science_and_environment
        - The BBC news page for Science and the Environment

Transition work – there are 3 tasks to complete:

1. **Seneca Learning:** https://app.senecalearning.com/classroom/course/76917ca0-ac10-43c9-8742-e49b861417b2
    - They have set up GCSE refresher sessions covering five key areas of Biology. There are also four A Level taster learning sessions on the same link. Although it says for the AQA course the content covered is the same as for OCR module 2. Working through these tasks first will help you complete the transition booklet and prepare for studying A level Biology. For this task you can set up your own log in.

2. **Kerboodle A level Biology Transition worksheet**: (at the back of this booklet)
    - This covers key maths skills needed for A level Biology. There are answers to the maths questions at the end so you can practice the important skills needed for the course.

3. **Complete an introductory Open University Course**
    - As part of your 'bridging the gap' work **complete one of the <u>free courses available</u>** to you from The Open University. They offer an opportunity to understand the roles carried out by scientists and medical staff as well as finding out more about a subject of interest to you.
    - Please choose one of the introductory courses below.
    - Once completed **print out the certificate** and bring it along to our first lesson as evidence.
    - **Water for life**

    https://www.open.edu/openlearn/nature-environment/environmental-studies/water-life/content-section-0?active-tab=content-tab

    - **Introducing Mammals**

    https://www.open.edu/openlearn/nature-environment/introducing-mammals/content-section-0?active-tab=description-tab

    - **Infection and Immunity**

    https://www.open.edu/openlearn/health-sports-psychology/infection-and-immunity/content-section-overview?active-tab=description-tab

    - **Introduction to Ecosystems**

    https://www.open.edu/openlearn/science-maths-technology/introduction-ecosystems/content-section-overview?active-tab=description-tab

    - **Forensic Science and Fingerprints**

    https://www.open.edu/openlearn/health-sports-psychology/health/forensic-science-and-fingerprints/content-section-0?active-tab=description-tab

    - **What is the genome made of?**

    https://www.open.edu/openlearn/science-maths-technology/biology/what-the-genome-made-of/content-section-0?active-tab=description-tab

Transition from GCSE to A Level

Moving from GCSE Science to A Level can be a daunting leap. You'll be expected to remember a lot more facts, equations, and definitions, and you will need to learn new maths skills and develop confidence in applying what you already know to unfamiliar situations.

This worksheet aims to give you a head start by helping you:

- understand and practice of some of the maths skills you'll need.

Maths skills

1 Numbers and units

1.1 Units and prefixes

A key criterion for success in biological maths lies in the use of correct units and the management of numbers. The units scientists use are from the *Système Internationale* – the SI units. In biology, the most commonly used SI base units are metre (m), kilogram (kg), second (s), and mole (mol). Biologists also use SI derived units, such as square metre (m^2), cubic metre (m^3), degree Celsius (°C), and litre (l).

To accommodate the huge range of dimensions in our measurements they may be further modified using appropriate prefixes. For example, one thousandth of a second is a millisecond (ms). Some of these prefixes are illustrated in the table below.

Multiplication factor	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n

Practice questions

1 A burger contains 4 500 000 J of energy. Write this in:

a kilojoules **b** megajoules.

2 HIV is a virus with a diameter of between 9.0×10^{-8} m and 1.20×10^{-7} m.

Write this range in nanometres.

1.2 Powers and indices

Ten squared = 10 × 10 = 100 and can be written as 10^2. This is also called 'ten to the power of 2'.

Ten cubed is 'ten to the power of three' and can be written as 10^3 = 1000.

The power is also called the index.

Fractions have negative indices:

one tenth = 10^{-1} = 1/10 = 0.1

one hundredth = 10^{-2} = 1/100 = 0.01

Any number to the power of 0 is equal to 1, for example, $29^0 = 1$.

If the index is 1, the value is unchanged, for example, $17^1 = 17$.

When multiplying powers of ten, you must *add* the indices.

So 100 × 1000 = 100 000 is the same as $10^2 \times 10^3 = 10^{2+3} = 10^5$

When dividing powers of ten, you must *subtract* the indices.

So 100/1000 = 1/10 = 10^{-1} is the same as $10^2/10^3 = 10^{2-3} = 10^{-1}$

But you can only do this when the numbers with the indices are the same.

So $10^2 \times 2^3 = 100 \times 8 = 800$

And you can't do this when adding or subtracting.

$10^2 + 10^3 = 100 + 1000 = 1100$

$10^2 - 10^3 = 100 - 1000 = -900$

Remember: You can only add and subtract the indices when you are multiplying or dividing the numbers, not adding or subtracting them.

Practice questions

3 Calculate the following values. Give your answers using indices.

a $10^8 \times 10^3$ **b** $10^7 \times 10^2 \times 10^3$

c $10^3 + 10^3$ **d** $10^2 - 10^{-2}$

4 Calculate the following values. Give your answers with and without using indices.

a $10^5 \div 10^4$ **b** $10^3 \div 10^6$

c $10^2 \div 10^{-4}$ **d** $100^2 \div 10^2$

1.3 Converting units

When doing calculations, it is important to express your answer using sensible numbers. For example, an answer of 6230 μm would have been more meaningful expressed as 6.2 mm.

If you convert between units and round numbers properly, it allows quoted measurements to be understood within the scale of the observations.

To convert 488 889 m into km:

A kilo is 10^3 so you need to divide by this number, or move the decimal point three places to the left.

488 889 ÷ 10^3 = 488.889 km

However, suppose you are converting from mm to km: you need to go from 10^3 to 10^{-3}, or move the decimal point six places to the left.

333 mm is 0.000 333 km

Alternatively, if you want to convert from 333 mm to nm, you would have to go from 10^{-9} to 10^{-3}, or move the decimal point six places to the right.

333 mm is 333 000 000 nm

Practice question

5 Calculate the following conversions:

a 0.004 m into mm **b** 130 000 ms into s

c 31.3 ml into µl **d** 104 ng into mg

6 Give the following values in a different unit so they make more sense to the reader.

Choose the final units yourself. (Hint: make the final number as close in magnitude to zero as you can. For example, you would convert 1000 m into 1 km.)

a 0.000 057 m **b** 8 600 000 µl **c** 68 000 ms **d** 0.009 cm

2 Decimals, standard form, and significant figures

2.1 Decimal numbers

The number of decimal places is the number of figures *after* the decimal point. For example, the number 47.38 has 2 decimal places, and 47.380 is the same number to 3 decimal places. In science, you must write your answer to a sensible number of decimal places.

Practice questions

1 New antibiotics are being tested. A student calculates the area of clear zones in Petri dishes in which the antibiotics have been used. List these in order from smallest to largest.

0.0214 cm^2 0.03 cm^2 0.0218 cm^2 0.034 cm^2

2 A student measures the heights of a number of different plants. List these in order from smallest to largest.

22.003 cm 22.25 cm 12.901 cm 12.03 cm 22 cm

2.2 Standard form

Sometimes biologists need to work with numbers that are very small, such as dimensions of organelles, or very large, such as populations of bacteria. In such cases, the use of scientific notation or standard form is very useful, because it allows the numbers to be written easily.

Standard form is expressing numbers in powers of ten, for example, 1.5×10^{7} microorganisms.

Look at this worked example. The number of cells in the human body is approximately 37 200 000 000 000. To write this in standard form, follow these steps:

Step 1: Write down the smallest number between 1 and 10 that can be derived from the number to be converted. In this case it would be 3.72

Step 2: Write the number of times the decimal place will have to shift to expand this to the original number as powers of ten. On paper this can be done by hopping the decimal over each number like this:

6.3900000000

until the end of the number is reached.

In this example that requires 13 shifts, so the standard form should be written as 3.72×10^{13}.

For very small numbers the same rules apply, except that the decimal point has to hop backwards. For example, 0.000 000 45 would be written as 4.5×10^{-7}.

Practice questions

3 Change the following values to standard form.

a 3060 kJ **b** 140 000 kg **c** 0.000 18 m **d** 0.000 004 m

4 Give the following numbers in standard form.

a 100 **b** 10 000 **c** 0.01 **d** 21 000 000

5 Give the following as decimals.

a 10^6 **b** 4.7×10^9 **c** 1.2×10^{12} **d** 7.96×10^{-4}

2.3 Significant figures

When you use a calculator to work out a numerical answer, you know that this often results in a large number of decimal places and, in most cases, the final few digits are 'not significant'. It is important to record your data and your answers to calculations to a reasonable number of significant figures. Too many and your answer is claiming an accuracy that it does not have, too few and you are not showing the precision and care required in scientific analysis.

Numbers to 3 significant figures (3 s.f.):

7.88 25.4 741

Bigger and smaller numbers with 3 significant figures:

0.000 147 0.0147 0.245 39 400 96 200 000 (notice that the zeros before the figures and after the figures are *not* significant – they just show you how large the number is by the position of the decimal point).

Numbers to 3 significant figures where the zeros *are* significant:

207 4050 1.01 (any zeros between the other significant figures *are* significant).

Standard form numbers with 3 significant figures:

9.42×10^{-5} 1.56×10^8

If the value you wanted to write to 3.s.f. was 590, then to show the zero was significant you would have to write:

590 (to 3.s.f.) or 5.90×10^2

Remember: For calculations, use the same number of figures as the data in the question with the lowest number of significant figures. It is not possible for the answer to be more accurate than the data in the question.

Practice question

6 Write the following numbers to **i** 2 s.f. and **ii** 3 s.f.

a 7644 g

b 27.54 m

c 4.3333 g

d $5.995\times10^2\ cm^3$

7 The average mass of oxygen produced by an oak tree is 11800 g per year.

Give this mass in standard form and quote your answer to 2 significant figures.

3 Working with formulae

It is often necessary to use a mathematical formula to calculate quantities. You may be tested on your ability to substitute numbers into formulae or to rearrange formulae to find specific values.

3.1 Substituting into formulae

Think about the data you are given in the question. Write down the equation and then think about how to get the data to substitute into the equation. Look at this worked example.

A cheek cell has a 0.06 mm diameter. Under a microscope it has a diameter 12 mm. What is the magnification?

$$\text{magnification} = \text{image size (mm)} \div \text{object size (mm)} \quad \text{or} \quad M = \frac{I}{O}$$

Substitute the values and calculate the answer:

$$M = 12\text{ mm}/0.06\text{ mm} = 12/0.06 = 200$$

Answer: magnification = ×200 (magnification has no units)

Sometimes an equation is more complicated and the steps need to be carried out in a certain order to succeed. A general principle applies here, usually known by the mnemonic BIDMAS. This stands for **B**rackets, **I**ndices (functions such as squaring or powers), **D**ivision, **M**ultiplication, **A**ddition, **S**ubtraction.

Practice questions

1 Calculate the magnification of a hair that has a width of 6.6 mm on a photograph. The hair is 165 µm wide.

2 Estimate the area of a leaf by treating it as a triangle with base 2 cm and height 9 cm.

3 Estimate the area of a cell by treating it as a circle with a diameter of 0.7 µm. Give your answer in μm^2.

4 An *Amoeba* population starts with 24 cells. Calculate how many *Amoeba* cells would be present in the culture after 7 days if each cell divides once every 20 hours. Use the equation $N_t = N_0 \times 2^n$ where N_t = number after time t, N_0 = initial population, n = number of divisions in the given time t.

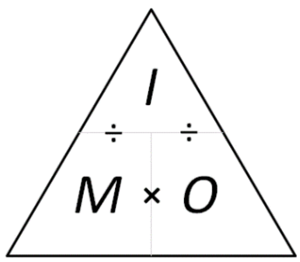
5 In a quadrat sample, an area was found to contain 96 aphids, 4 ladybirds, 22 grasshoppers, and 3 ground beetles. Calculate the diversity of the site using the equation $D = 1 - \Sigma\left(\frac{n}{N}\right)^2$ *where* n = number of each species, N = grand total of all species, and D = diversity.

Remember: In this equation there is a part that needs to be done several times then summed, shown by the symbol Σ.

3.2 Rearranging formulae

Sometimes you will need to rearrange an equation to calculate the answer to a question. For example, the relationship between magnification, image size, and actual size of specimens in micrographs usually uses the equation $M = \frac{I}{O}$, where M is magnification, I is size of the image, and O = actual size of the object.

You can use the algebra you have learnt in Maths to rearrange equations, or you can use a triangle like the one shown.



Cover the quantity you want to find. This leaves you with either a fraction or a multiplication:

$M = I \div O$ $\qquad$ $O = I \div M$ $\qquad$ $I = M \times O$

Practice questions

6 A fat cell is 0.1 mm in diameter. Calculate the size of the diameter seen through a microscope with a magnification of ×50.

7 A Petri dish shows a circular colony of bacteria with a cross-sectional area of 5.3 cm^2. Calculate the radius of this area.

8 In a photograph, a red blood cell is 14.5 mm in diameter. The magnification stated on the image is ×2000. Calculate the real diameter of the red blood cell.

9 Rearrange the equation 34 = 2*a*/135 × 100 and find the value of *a*.

10 The cardiac output of a patient was found to be 2.5 $dm^3\,min^{-1}$ and their heart rate was 77 bpm. Calculate the stroke volume of the patient.

Use the equation: cardiac output = stroke volume × heart rate.

11 In a food chain, efficiency = $\frac{\text{biomass transferred}}{\text{biomass taken in}} \times 100$

A farmer fed 25 kg of grain to his chicken. The chicken gained weight with an efficiency of 0.84. Calculate the weight gained by the chicken.

4 Magnification

To look at small biological specimens you use a microscope to magnify the image that is observed. The microscope was developed in the 17th century. Anton van Leeuwenhoek used a single lens and Robert Hooke used two lenses. The lenses focus light from the specimen onto your retina to produce a magnified virtual image. The magnification at which observations are made depends on the lenses used.

4.1 Calculating the magnifying power of lenses

Lenses each have a magnifying power, defined as the number of times the image is larger than the real object. The magnifying power is written on the lens.

To find the magnification of the virtual image that you are observing, multiply the magnification powers of each lens used. For example, if the eyepiece lens is ×10 and the objective lens is ×40 the total magnification of the virtual image is 10 × 40 = 400.

Practice questions

1 Calculate the magnification of the virtual image produced by the following combinations of lenses:

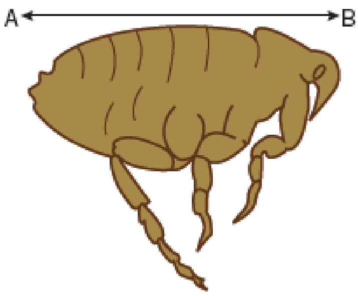
a objective ×10 and eyepiece ×12 **b** objective ×40 and eyepiece ×15

4.2 Calculating the magnification of images

Drawings and photographs of biological specimens should always have a magnification factor stated. This indicates how much larger or smaller the image is compared with the real specimen.

The magnification is calculated by comparing the sizes of the image and the real specimen. Look at this worked example.

The image shows a flea which is 1.3 mm long. To calculate the magnification of the image, measure the image (or the scale bar if given) on the paper (in this example, the body length as indicated by the line A–B).



For this image, the length of the image is 42 mm and the length of the real specimen is 1.3 mm.

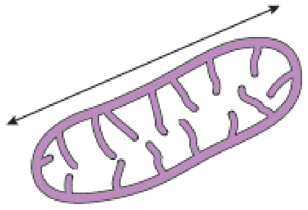
$$\text{magnification} = \frac{\text{length of image}}{\text{length of real specimen}} = 42/1.3 = 32.31$$

The magnification factor should therefore be written as ×32.31

Remember: Use the same units. A common error is to mix units when performing these calculations. Begin each time by converting measurements to the same units for both the real specimen and the image.

Practice question

2 Calculate the magnification factor of a mitochondrion that is 1.5 µm long.



4.3 Calculating real dimensions

Magnification factors on images can be used to calculate the actual size of features shown on drawings and photographs of biological specimens. For example, in a photomicrograph of a cell, individual features can be measured if the magnification is stated. Look at this worked example.

The magnification factor for the image of the open stoma is ×5000.

This can be used to find out the actual size of any part of the cell, for example, the length of one guard cell, measured from A to B.

Step 1: Measure the length of the guard cell as precisely as possible. In this example the image of the guard cell is 52 mm long.

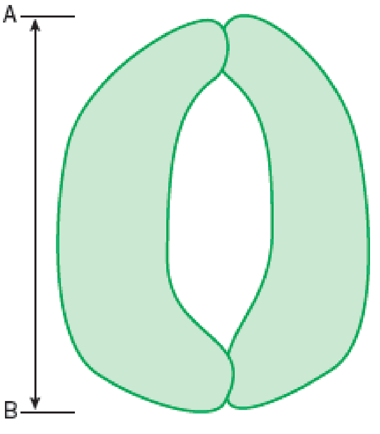
Step 2: Convert this measurement to units appropriate to the image. In this case you should use µm because it is a cell.

So the magnified image is 52 × 1000 = 52 000 µm

Step 3: Rearrange the magnification equation (see Topic 3.2) to get:

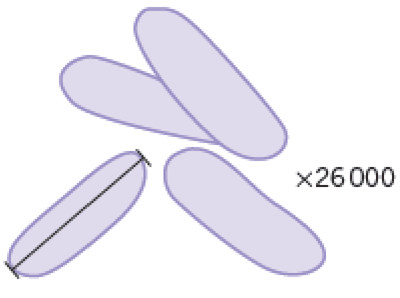
real size = size of image/magnification = 52 000/5000 = 10.4

So the real length of the guard cell is 10.4 µm.



Practice question

3 Use the magnification factor to determine the actual size of a bacterial cell.



GCSE → A Level Biology transition

Answers to maths skills practice questions

1 Numbers and units

1 **a** 1 kJ = 1000 J, so 4 500 000 J = 4 500 000/1000 kJ = 4500 kJ
b 1 MJ = 1000 kJ, so 4500 kJ = 4.5 MJ

2 1 m = 10^9 nm (there are a billion nanometre in a metre)

9.0×10^{-8} m = $9.0 \times 10^{-8} \times 10^9$ nm = $9.0 \times 10^{-8+9}$ nm = 9.0×10 nm = 90 nm

1.20×10^{-7} m = $1.20 \times 10^{-7} \times 10^9$ nm = $1.20 \times 10^{-7+9}$ nm = 1.20×100 nm = 120 nm
Range = 90 nm to 120 nm

3 **a** 10^{11} **b** 10^{12}
c 1000 + 1000 = 2000 **d** 100 − 0.01 = 99.99

4 **a** 10^1 or 10 **b** 10^{-3} or 0.001
c 10^6 or 1 000 00 **d** $100^2 \div 100 = 100$ or 10^2

5 **a** 4 mm **b** 130 s
c 31 300 µl **d** 0.000 104 mg

6 **a** 57 µm **b** 8.6 L or 8.6 dm^3
c 68 s **d** 0.09 mm

2 Decimals, standard form, and significant figures

3 0.0214 cm^2 0.0218 cm^2 0.03 cm^2 0.034 cm^2

4 12.03 cm 12.901 cm 22 cm 22.003 cm 22.25 cm

5 **a** 3.06×10^3 kJ **b** 1.4×10^5 kg
c 1.8×10^{-4} m **d** 4×10^{-6} m

4 **a** 1×10^2 **b** 1×10^4
c 1×10^{-2} **d** 2.1×10^7

5 Give the following as decimals.
a 1 000 000 **b** 4 700 000 000
c 1 200 000 000 000 **d** 0.000 796

6 **a** 7600 g / 7640 g **b** 28 m / 27.5 m
c 4.3 g / 4.33 g **d** 6.0×10^2 m / 5.00×10^2 m

7 1.2×10^4 g

3 Working with formulae

1 *M*? *I* = 6.6 mm *O* = 165 µm

Change to same units: either both mm or both µm or both m: 165 µm = 0.165 mm

M = *I*/*O* = 6.6/0.165 = × 40

2 Area = 0.5 × 2 cm × 9 cm = 9 cm^2

3 Area = $\pi r^2 = \pi \times (0.7\ \mu m)^2 = \pi \times (0.7 \times 10^{-6}\ m) \times (0.7 \times 10^{-6}\ m) = 1.5\ \mu m^2$

4 $N_0 = 24$

7 days = 7 × 24 hours = 168 hours

so n = 168 ÷ 20 = 8.4

Nt = 24 x 28.4 = 8107 cells

5 N = 96 + 4 + 22 + 3 = 125 animals found

so $D = 1 - \sum\left(\frac{n}{N}\right)^2$

inner brackets: $D = 1 - \left(\left(\frac{96}{125}\right)^2 + \left(\frac{4}{125}\right)^2 + \left(\frac{22}{125}\right)^2 + \left(\frac{3}{125}\right)^2\right)$

indices: $D = 1 - \left(0.768^2 + 0.032^2 + 0.176^2 + 0.024^2\right)$

addition: D = 1 – 0.6224 = 0.3776 = 0.38 (2.d.p)

8 O = 0.1 mm I = ? M = 50 $I = M \times O$ = 50 × 0.1 mm = 5 mm

9 Area = 5.3 cm^2 radius? $A = \pi r^2$

$5.3 = \pi r^2$ $r^2 = \frac{5.3}{\pi} = 1.687$ $r = \sqrt{1.687} = 1.3$ cm

Or $A = \pi r^2$ $r^2 = \frac{A}{\pi}$ $r = \sqrt{\frac{A}{\pi}}$ $r = \sqrt{\frac{5.3}{\pi}} = 1.3$ cm

8 7.25×10^{-6} m (7.25 μm)

9 $a = \frac{\left(\frac{34}{100}\right) \times 135}{2} = 22.95$

10 cardiac output = stroke volume x heart rate

stroke volume = $\frac{2.7}{77}$ = 0.035 dm^3

11 Substitute in the known values: $0.84 = \frac{\text{biomass transfer}}{25} \times 100$

Rearrange the equation to give: $\text{biomass transfer} = \frac{0.84}{100} \times 25$ = 0.21 kg

4 Magnification

2 **a** ×120 **b** ×600

2 ×26 000

3 0.88 μm

5 Percentages and uncertainty

1 **a** $\frac{2240}{3600000} \times 100 = 0.06\%$ **b** $\frac{480}{3600000} \times 100 = 0.013\%$

2 5.88%

3

Sucrose conc. / mol dm^{-3}	Initial mass / g	Final mass / g	Mass change / g	Percentage change in mass
0.9	1.79	1.06	−0.73	−40.8%
0.7	1.86	1.30	−0.56	−30.1%
0.5	1.95	1.70	−0.25	−12.8%
0.3	1.63	1.76	+0.13	+8.0%
0.1	1.82	2.55	+0.73	+40.1%

4 **a** 1 cm^3 **b** 0.005 s **c** 0.05 °C

5

Measurement made	Equipment used	Absolute error	Relative error
Length of a fluid column in a respirometer is 6 mm	mm scale	0.5 mm	$\frac{0.5}{6} \times 100 = 8.3\%$
Volume of a syringe is 12 cm^3 of liquid	0.5 cm^3 divisions	0.25 cm^3	$\frac{0.25}{12} \times 100 = 2.1\%$
Change in mass of 1.6 g	balance with 2 d.p.	0.005 g	$\frac{0.005 \times 2}{1.6} \times 100 = 0.6\%$