HAMPSTEAD SCHOOL
Learning together Achieving together

Y12 – Y13
Summer Bridging Tasks
2023

A Level Biology

Name: ____

- You should spend some time during the summer holidays working on the activities in this booklet.
- You will be required to hand in this booklet in your first lesson at the start of Year 12 and the content will be used to form the basis of your first assessments.
- You should try your best and show commitment to your studies.

Transition Pack for A Level Biology

Get ready for A-level!

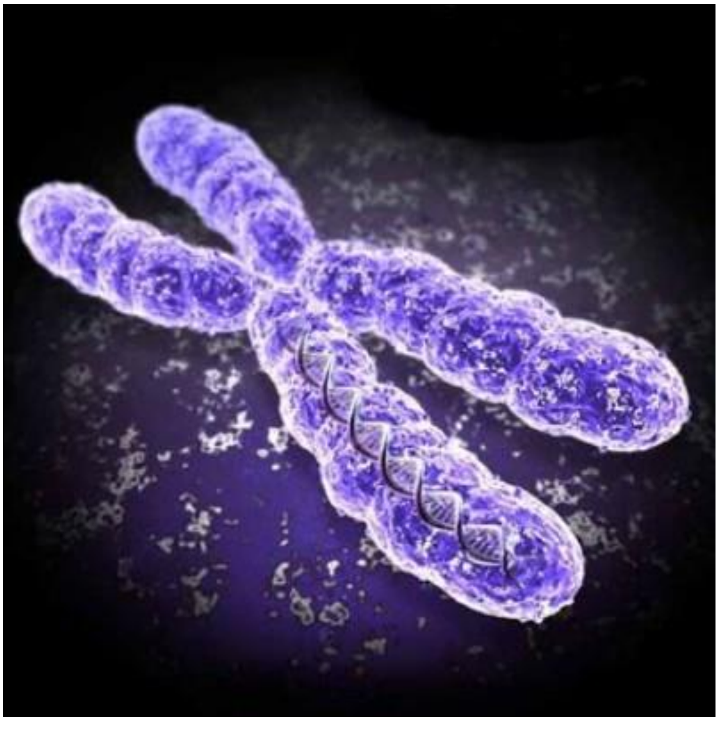
A guide to help you get ready for A-level Biology, including everything from topic guides to days out and online learning courses.

Commissioned by The PiXL Club Ltd. April 2016

Please note: these resources are non-board specific. Please direct your students to the specifics of where this knowledge and skills most apply.

So you are considering A level Biology?

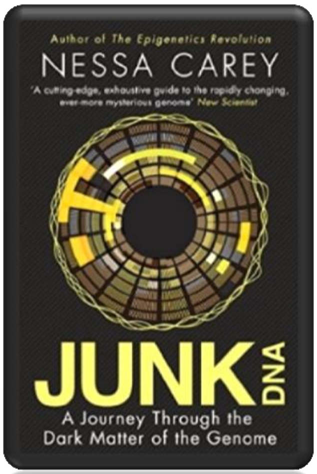
This pack contains a programme of activities and resources to prepare you to start A level in Biology in September. It is aimed to be used after you complete your GCSE throughout the remainder of the Summer term and over the Summer Holidays to ensure you are ready to start your course in September.



https://www.distance-education-academy.com/wp-content/uploads/2013/06/biology-a-level-course.jpg

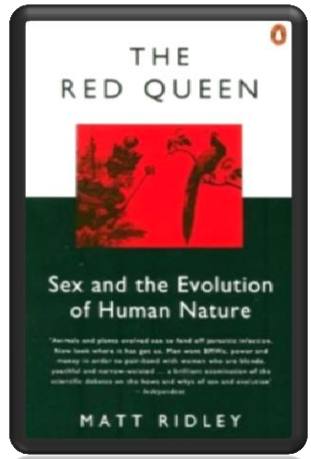
Book Recommendations

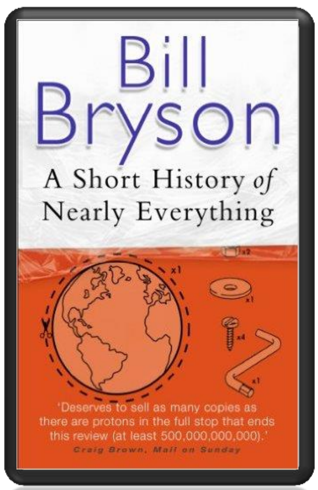
Kick back this summer with a good read. The books below are all popular science books and great for extending your understanding of Biology



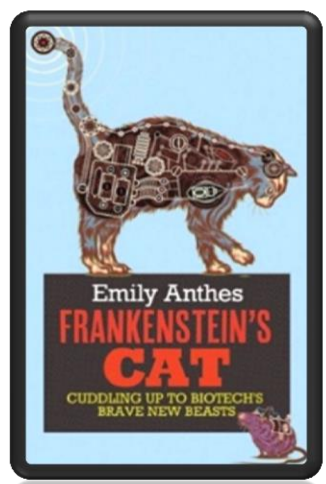
Junk DNA
Our DNA is so much more complex than you probably realize, this book will really deepen your understanding of all the work you will do on Genetics. Available at amazon.co.uk

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

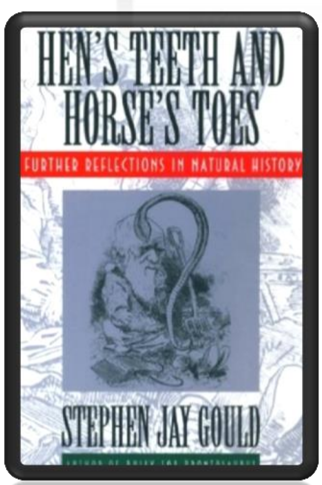




A Short History of Nearly Everything
A whistle-stop tour through many aspects of history from the Big Bang to now. This is a really accessible read that will re-familiarise you with common concepts and introduce you to some of the more colourful characters from the history of science! Available at amazon.co.uk



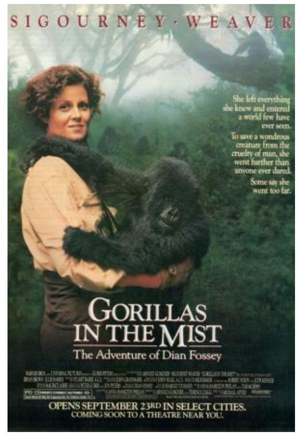
Studying Geography as well?
Hen's teeth and horses toes
Stephen Jay Gould is a great Evolution writer and this book discusses lots of fascinating stories about Geology and evolution. Available at amazon.co.uk



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

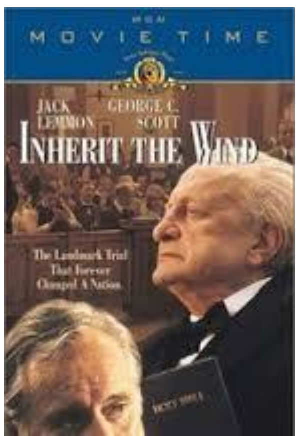
Movie Recommendations

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.



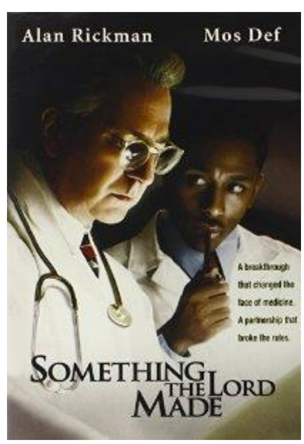
Gorillas in the Mist (1988)
An absolute classic that retells the true story of the life and work of Dian Fossey and her work studying and protecting mountain gorillas from poachers and habitat loss. A tear jerker.

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 (he of Jurassic Park fame). 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, The Ascent of Man, Catastrophe, Frozen Planet, Life Story, The Hunt and Monsoon.

Movie Recommendations

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. Use the link or scan the QR code to view:

A New Superweapon in the Fight Against Cancer
Available at :
http://www.ted.com/talks/paula_hammond_a_new_superweapon_in_the_fight_against_cancer?language=en
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 :
http://www.ted.com/talks/marla_spivak_why_bees_are_disappearing?language=en
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?

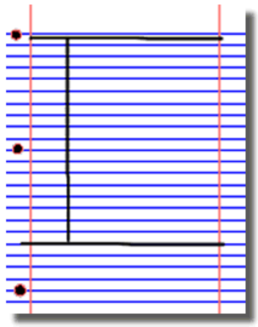
Why Doctors Don't Know About the Drugs They Prescribe
Available at :
http://www.ted.com/talks/ben_goldacre_what_doctors_don_t_know_about_the_drugs_they_prescribe?language=en
When a new drug gets tested, the results of the trials should be published for the rest of the medical world — except much of the time, negative or inconclusive findings go unreported, leaving doctors and researchers in the dark.

Growing New Organs
Available at :
http://www.ted.com/talks/anthony_atala_growing_organs_engineering_tissue?language=en
Anthony Atalla's state-of-the-art lab grows human organs — from muscles to blood vessels to bladders, and more.

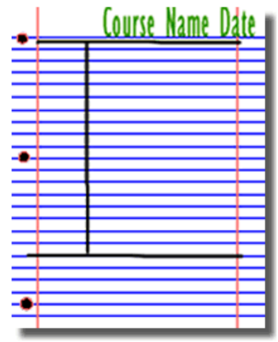
Research activities

Research, reading and note making are essential skills for A level Biology study. For the following task you are going to produce ‘Cornell Notes’ to summarise your reading.

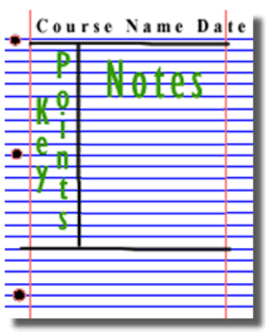
1. Divide your page into three sections like this



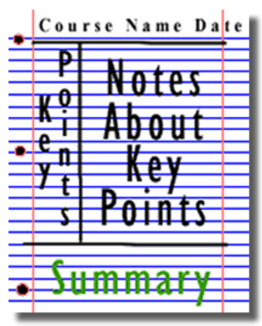
2. Write the name, date and topic at the top of the page



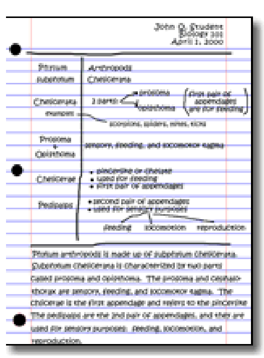
3. Use the large box to make notes. Leave a space between separate idea. Abbreviate where possible.



4. Review and identify the key points in the left hand box



5. Write a summary of the main ideas in the bottom space

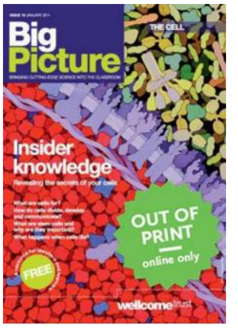


Images taken from http://coe.jmu.edu/learningtoolbox/cornellnotes.html

Research activities

The Big Picture is an excellent publication from the Wellcome Trust. Along with the magazine, the company produces posters, videos and other resources aimed at students studying for GCSEs and A level.
For each of the following topics, you are going to use the resources to produce one page of Cornell style notes.
Use the links of scan the QR code to take you to the resources.

Topic 1: The Cell
Available at: http://bigpictureeducation.com/cell
The cell is the building block of life. Each of us starts from a single cell, a zygote, and grows into a complex organism made of trillions of cells. In this issue, we explore what we know – and what we don't yet know – about the cells that are the basis of us all and how they reproduce, grow, move, communicate and die.



Topic 2: The Immune System
Available at:
http://bigpictureeducation.com/immune
The immune system is what keeps us healthy in spite of the many organisms and substances that can do us harm. In this issue, explore how our bodies are designed to prevent potentially harmful objects from getting inside, and what happens when bacteria, viruses, fungi or other foreign organisms or substances breach these barriers.

Topic 3: Exercise, Energy and Movement
Available at:
http://bigpictureeducation.com/exercise-energy-and-movement
All living things move. Whether it's a plant growing towards the sun, bacteria swimming away from a toxin or you walking home, anything alive must move to survive. For humans though, movement is more than just survival – we move for fun, to compete and to be healthy. In this issue we look at the biological systems that keep us moving and consider some of the psychological, social and ethical aspects of exercise and sport.

Topic 4: Populations
Available at:
http://bigpictureeducation.com/populations
What's the first thing that pops into your mind when you read the word population? Most likely it's the ever-increasing human population on earth. You're a member of that population, which is the term for all the members of a single species living together in the same location. The term population isn't just used to describe humans; it includes other animals, plants and microbes too. In this issue, we learn more about how populations grow, change and move, and why understanding them is so important.

Topic 4: Populations
Available at: http://bigpictureeducation.com/health-and-climate-change
The Earth's climate is changing. In fact, it has always been changing. What is different now is the speed of change and the main cause of change – human activities. This issue asks: What are the biggest threats to human health? Who will suffer as the climate changes? What can be done to minimise harm? And how do we cope with uncertainty?

Pre-Knowledge Topics

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A level Biology will use your knowledge from GCSE and build on this to help you understand new and more demanding ideas. Complete the following tasks to make sure your knowledge is up to date and you are ready to start studying:

DNA and the Genetic Code

In living organisms nucleic acids (DNA and RNA have important roles and functions related to their properties. The sequence of bases in the DNA molecule determines the structure of proteins, including enzymes.
The double helix and its four bases store the information that is passed from generation to generation. The sequence of the base pairs adenine, thymine, cytosine and guanine tell ribosomes in the cytoplasm how to construct amino acids into polypeptides and produce every characteristic we see. DNA can mutate leading to diseases including cancer and sometimes anomalies in the genetic code are passed from parents to babies in disease such as cystic fibrosis, or can be developed in unborn foetuses such as Downs Syndrome.
Read the information on these websites (you could make more Cornell notes if you wish):
http://www.bbc.co.uk/education/guides/z36mmp3/revision
http://www.s-cool.co.uk/a-level/biology/dna-and-genetic-code

And take a look at these videos:
http://ed.ted.com/lessons/the-twisting-tale-of-dna-judith-hauck
http://ed.ted.com/lessons/where-do-genes-come-from-carl-zimmer

Task:
Produce a wall display to put up in your classroom in September. You might make a poster or do this using PowerPoint or similar Your display should use images, keywords and simple explanations to:
Define gene, chromosome, DNA and base pair
Describe the structure and function of DNA and RNA
Explain how DNA is copied in the body
Outline some of the problems that occur with DNA replication and what the consequences of this might be.

Evolution

Transfer of genetic information from one generation to the next can ensure continuity of species or lead to variation within a species and possible formation of new species. Reproductive isolation can lead to accumulation of different genetic information in populations potentially leading to formation of new species (speciation). Sequencing projects have read the genomes of organisms ranging from microbes and plants to humans. This allows the sequences of the proteins that derive from the genetic code to be predicted. Gene technologies allow study and alteration of gene function in order to better understand organism function and to design new industrial and medical processes.
Read the information on these websites (you could make more Cornell notes if you wish):
http://www.bbc.co.uk/education/guides/z237hyc/revision/4
http://www.s-cool.co.uk/a-level/biology/evolution

And take a look at these videos:
http://ed.ted.com/lessons/how-to-sequence-the-human-genome-mark-j-kiel
http://ed.ted.com/lessons/the-race-to-sequence-the-human-genome-tien-nguyen

Task:
Produce a one page revision guide for an AS Biology student that recaps the key words and concepts in this topic. Your revision guide should:
Describe speciation
Explain what a genome is
Give examples of how this information has already been used to develop new treatments and technologies.

Biodiversity

The variety of life, both past and present, is extensive, but the biochemical basis of life is similar for all living things. Biodiversity refers to the variety and complexity of life and may be considered at different levels. Biodiversity can be measured, for example within a habitat or at the genetic level. Classification is a means of organising the variety of life based on relationships between organisms and is built around the concept of species. Originally classification systems were based on observable features but more recent approaches draw on a wider range of evidence to clarify relationships between organisms. Adaptations of organisms to their environments can be behavioural, physiological and anatomical. Adaptation and selection are major factors in evolution and make a significant contribution to the diversity of living organisms.

Read the information on these websites (you could make more Cornell notes if you wish):
http://www.s-cool.co.uk/a-level/biology/ecological-concepts
http://www.s-cool.co.uk/a-level/biology/classification

And take a look at these videos:
http://ed.ted.com/lessons/why-is-biodiversity-so-important-kim-preshoff
http://ed.ted.com/lessons/can-wildlife-adapt-to-climate-change-erin-eastwood

Task:
Write a persuasive letter to an MP, organisation or pressure group promoting conservation to maintain biodiversity.
Your letter should:
Define what is meant by species and classification
Describe how species are classified
Explain one way scientists can collect data about a habitat, giving an example
Explain adaptation and how habitat change may pose a threat to niche species

Exchange and Transport

Organisms need to exchange substances selectively with their environment and this takes place at exchange surfaces. Factors such as size or metabolic rate affect the requirements of organisms and this gives rise to adaptations such as specialised exchange surfaces and mass transport systems. Substances are exchanged by passive or active transport across exchange surfaces. The structure of the plasma membrane enables control of the passage of substances into and out of cells

Read the information on these websites (you could make more Cornell notes if you wish):
http://www.s-cool.co.uk/a-level/biology/gas-exchange
http://www.s-cool.co.uk/a-level/biology/nutrition-and-digestion/revise-it/human-digestive-system

And take a look at these videos:
http://ed.ted.com/lessons/insights-into-cell-membranes-via-dish-detergent-ethan-perlstein
http://ed.ted.com/lessons/what-do-the-lungs-do-emma-bryce

Task:
Create a poster or display to go in your classroom in September. Your poster should either: compare exchange surfaces in mammals and fish or compare exchange surfaces in the lungs and the intestines. You could use a Venn diagram to do this. Your poster should:
Describe diffusion, osmosis and active transport
Explain why oxygen and glucose need to be absorbed and waste products removed
Compare and contrast your chosen focus.

Cells

The cell is a unifying concept in biology, you will come across it many times during your two years of A level study. Prokaryotic and eukaryotic cells can be distinguished on the basis of their structure and ultrastructure. In complex multicellular organisms cells are organised into tissues, tissues into organs and organs into systems. During the cell cycle genetic information is copied and passed to daughter cells. Daughter cells formed during mitosis have identical copies of genes while cells formed during meiosis are not genetically identical

Read the information on these websites (you could make more Cornell notes if you wish):
http://www.s-cool.co.uk/a-level/biology/cells-and-organelles
http://www.bbc.co.uk/education/guides/zvjycdm/revision

And take a look at these videos:
https://www.youtube.com/watch?v=gcTuQpuJyD8
https://www.youtube.com/watch?v=L0k-enzoeOM
https://www.youtube.com/watch?v=qCLmR9-YY7o

Task:
Produce a one page revision guide to share with your class in September summarising one of the following topics: Cells and Cell Ultrastructure, Prokaryotes and Eukaryotes, or Mitosis and Meiosis.
Whichever topic you choose, your revision guide should include:
Key words and definitions
Clearly labelled diagrams
Short explanations of key ideas or processes.

Biological Molecules

Biological molecules are often polymers and are based on a small number of chemical elements. In living organisms carbohydrates, proteins, lipids, inorganic ions and water all have important roles and functions related to their properties. DNA determines the structure of proteins, including enzymes. Enzymes catalyse the reactions that determine structures and functions from cellular to whole-organism level. Enzymes are proteins with a mechanism of action and other properties determined by their tertiary structure. ATP provides the immediate source of energy for biological processes.

Read the information on these websites (you could make more Cornell notes if you wish):
http://www.s-cool.co.uk/a-level/biology/biological-molecules-and-enzymes
http://www.bbc.co.uk/education/guides/zb739j6/revision

And take a look at these videos:
https://www.youtube.com/watch?v=H8WJ2KENlK0
http://ed.ted.com/lessons/activation-energy-kickstarting-chemical-reactions-vance-kite

Task:
Krabbe disease occurs when a person doesn't have a certain enzyme in their body. The disease effects the nervous system. Write a letter to a GP or a sufferer to explain what an enzyme is.
Your poster should:
Describe the structure of an enzyme
Explain what enzymes do inside the body

Ecosystems

Ecosystems range in size from the very large to the very small. Biomass transfers through ecosystems and the efficiency of transfer through different trophic levels can be measured. Microorganisms play a key role in recycling chemical elements. Ecosystems are dynamic systems, usually moving from colonisation to climax communities in a process known as succession. The dynamic equilibrium of populations is affected by a range of factors. Humans are part of the ecological balance and their activities affect it both directly and indirectly. Effective management of the conflict between human needs and conservation help to maintain sustainability of resources.

Read the information on these websites (you could make more Cornell notes if you wish):
http://www.bbc.co.uk/education/guides/z7vqtfr/revision
http://www.s-cool.co.uk/a-level/biology/ecological-concepts

And take a look at these videos:
https://www.youtube.com/watch?v=jZKIHe2LDP8
https://www.youtube.com/watch?v=E8dkWQVFAoA

Task:
Produce a newspaper or magazine article about one ecosystem (e.g. the arctic, the Sahara, the rainforest, or something closer to home like your local woodland, nature reserve or shore line).
Your article should include:
Key words and definitions
Pictures or diagrams of your chosen ecosystem.
A description of the changes that have occurred in this ecosystem
An explanation of the threats and future changes that may further alter this ecosystem.

Control Systems

Homeostasis is the maintenance of a constant internal environment. Negative feedback helps maintain an optimal internal state in the context of a dynamic equilibrium. Positive feedback also occurs. Stimuli, both internal and external, are detected leading to responses. The genome is regulated by a number of factors. Coordination may be chemical or electrical in nature

Read the information on these websites (you could make more Cornell notes if you wish):
http://www.s-cool.co.uk/a-level/biology/homeostasis
http://www.bbc.co.uk/education/topics/z8kxpv4

And take a look at these videos:
https://www.youtube.com/watch?v=x4PPZCLnVkA
https://www.youtube.com/watch?v=x4PPZCLnVkA

Task:
Produce a poster to display in your classroom in September summarising one of the following topics: Temperature Control, Water and the Kidneys, Glucose, or The Liver.
Whichever topic you choose, your poster or display should include:
Key words and definitions
Clearly labelled diagrams
Short explanations of key ideas or processes.

Energy for Biological Processes

In cellular respiration, glycolysis takes place in the cytoplasm and the remaining steps in the mitochondria. ATP synthesis is associated with the electron transfer chain in the membranes of mitochondria and chloroplasts in photosynthesis energy is transferred to ATP in the light- dependent stage and the ATP is utilised during synthesis in the light-independent stage.

Read the information on these websites (you could make more Cornell notes if you wish):
http://www.bbc.co.uk/education/guides/zcxrd2p/revision
http://www.s-cool.co.uk/a-level/biology/respiration

And take a look at these videos:
https://www.youtube.com/watch?v=00jbG_cfGuQ
https://www.youtube.com/watch?v=2f7YwCtHcgk

Task:

Produce an A3 annotated information poster that illustrates the process of cellular respiration and summarises the key points.

Your poster should include:
Both text and images
Be visually stimulating
Key words and definitions
Clearly labelled diagrams
Short explanations of key ideas or processes.

Scientific and Investigative Skills

As part of your A level you will complete a practical assessment. This will require you to carry out a series of practical activities as well as planning how to do them, analysing the results and evaluating the methods. This will require you to: use appropriate apparatus to record a range of quantitative measurements (to include mass, time, volume, temperature, length and pH), use appropriate instrumentation to record quantitative measurements, such as a colorimeter or photometer, use laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions, use of light microscope at high power and low power, including use of a graticule, produce scientific drawing from observation with annotations, use qualitative reagents to identify biological molecules, separate biological compounds using thin layer/paper chromatography or electrophoresis, safely and ethically use organisms, use microbiological aseptic techniques, including the use of agar plates and broth, safely use instruments for dissection of an animal organ, or plant organ, use sampling techniques in fieldwork.

Task:

Produce a glossary for the following key words:

accuracy, anomaly, calibration, causal link, chance, confounding variable, control experiment, control group, control variable, correlation, dependent variable, errors, evidence, fair test, hypothesis, independent, null hypothesis, precision, probability, protocol, random distribution, random error, raw data, reliability, systematic error, true value, validity, zero error,

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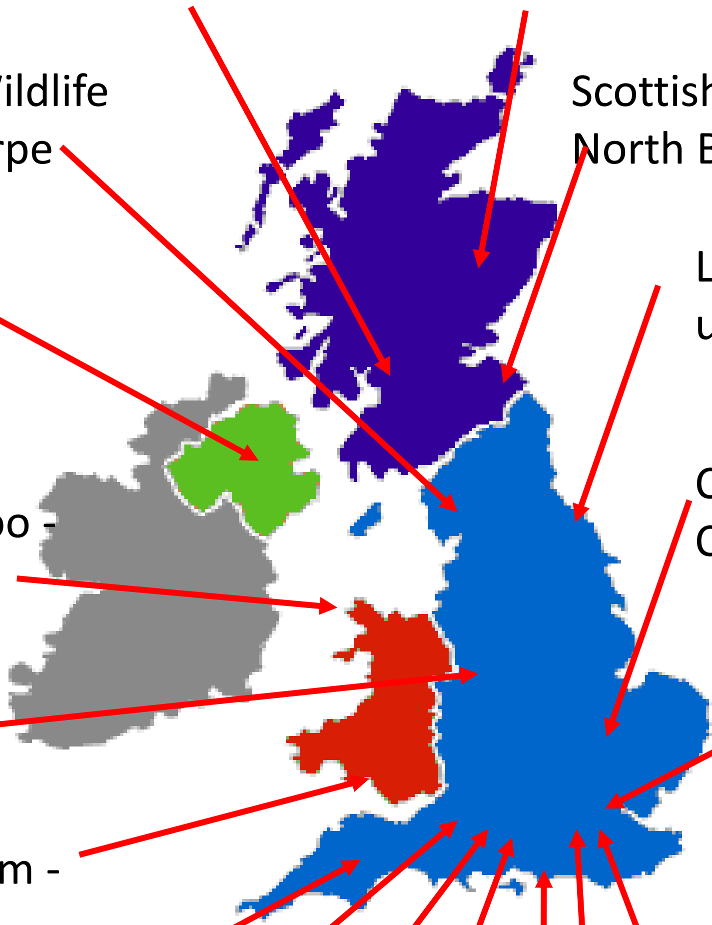
Ideas for Day Trips

If you are on holiday in the UK, or on a staycation at home, why not plan a day trip to one of these :



Ideas for Day Trips

If you are on holiday in the UK, or on a staycation at home, why not plan a day trip to one of these :

Remember there are also lots of zoos, wildlife and safari parks across the country, here are some you may not have heard of or considered:
Colchester Zoo, Cotswold Wildlife Park, Banham Zoo (Norfolk), Tropical Birdland (Leicestershire), Yorkshire Wildlife Park, Peak Wildlife Park, International Centre for Birds of Prey (York), Blackpool Zoo, Beale Park (Reading)

There are also hundreds of nature reserves (some of which are free) located all over the country including:
RSPB sites at Lochwinnoch, Saltholme, Fairburn Ings, Old Moor, Conwy, Minsmere, Rainham Marshes, Pulborough Brooks, Radipole Lake, Newport Wetlands.
Wildlife Trust Reserves and others at Rutland Water, Pensthorpe, Insh Marshes, Attenborough Centre, Inversnaid, Skomer, Loch Garten, Donna Nook, Chapmans Well, Woodwalton Fen, London Wetland Centre, Martin Down and Woolston Eyes Reserve.

Many organisations also have opportunities for people to volunteer over the summer months, this might include working in a shop/café/visitor centre, helping with site maintenance or taking part in biological surveys. Not only is this great experience, it looks great on a job or UCAS application.

For opportunities keep an eye out in your local press, on social media, or look at the websites of organisations like the RSPB, Wildlife Trust, National Trust or Wildlife & Wetland Trust.

There are also probably lots of smaller organisations near you who would also appreciate any support you can give!

Science on Social Media

Science communication is essential in the modern world and all the big scientific companies, researchers and institutions have their own social media accounts. Here are some of our top tips to keep up to date with developing news or interesting stories:

Follow on Twitter:
Commander Chris Hadfield – former resident aboard the International Space Station @cmdrhadfield

Tiktaalik roseae – a 375 million year old fossil fish with its own Twitter account!
@tiktaalikroseae

NASA's Voyager 2 – a satellite launched nearly 40 years ago that is now travelling beyond our Solar System
@NSFVoyager2

Neil dGrasse Tyson – Director of the Hayden Planetarium in New York
@neiltyson

Sci Curious – feed from writer and Bethany Brookshire tweeting about good, bad and weird neuroscience
@scicurious

The SETI Institute – The Search for Extra Terrestrial Intelligence, be the first to know what they find!
@setiinstitute

Carl Zimmer – Science writer Carl blogs about the life sciences
@carlzimmer

Phil Plait – tweets about astronomy and bad science
@badastronomer

Virginia Hughes – science journalist and blogger for National Geographic, keep up to date with neuroscience, genetics and behaviour
@virginiahughes

Maryn McKenna – science journalist who writes about antibiotic resistance
@marynmck

Find on Facebook:
Nature - the profile page for nature.com for news, features, research and events from Nature Publishing Group

Marin Conservation Institute – publishes the latest science to identify important marine ecosystems around the world.

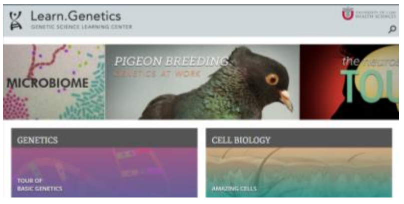
National Geographic - since 1888, National Geographic has travelled the Earth, sharing its amazing stories in pictures and words.

Science News Magazine - Science covers important and emerging research in all fields of science.

BBC Science News - The latest BBC Science and Environment News: breaking news, analysis and debate on science and nature around the world.

Science websites

These websites all offer an amazing collection of resources that you should use again and again through out your course.

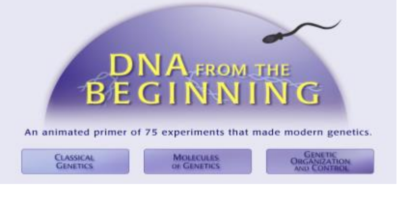


Probably the best website on Biology….
Learn Genetics from Utah University has so much that is pitched at an appropriate level for you and has lots of interactive resources to explore, everything from why some people can taste bitter berries to how we clone mice or make glow in the dark jelly fish.
http://learn.genetics.utah.edu/

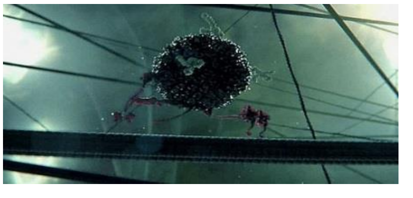
LIVING CONSERVATION

In the summer you will most likely start to learn about Biodiversity and Evolution. Many Zoos have great websites, especially London Zoo. Read about some of the case studies on conservation, such as the Giant Pangolin, the only mammal with scales.
https://www.zsl.org/conservation

At GCSE you learnt how genetic diseases are inherited. In this virtual fly lab you get to breed fruit flies to investigate how different features are passed on.
http://sciencecourseware.org/vcise/drosophila/



DNA from the beginning is full of interactive animations that tell the story of DNA from its discovery through to advanced year 13 concepts.
One to book mark!
http://www.dnaftb.org/



Ok, so not a website, but a video you definitely want to watch. One of the first topics you will learn about is the amazing structure of the cell. This BBC film shows the fascinating workings of a cell… a touch more detailed than the "fried egg" model you might have seen.
http://www.dailymotion.com/video/xzh0kb_the-hidden-life-of-the-cell_shortfilms
If this link expires – google "BBC hidden life of the cell"

Science: Things to do!

Day 4 of the holidays and boredom has set in?
There are loads of citizen science projects you can take part in either from the comfort of your bedroom, out and about, or when on holiday. Wikipedia does a comprehensive list of all the current projects taking place. Google ‘citizen science project’

Bumblebee Conservation Trust

AgeGuess

OPAL EXPLORE NATURE

big butterfly count 15th July - 7th August

eoceans www.eoceans.org

THE SHORE THING GET INVOLVED!

WildlifeLog SPOT IT - SHARE IT - SAVE IT

The Big Moss Map

MOOC

canvas NETWORK

OPEN 2 STUDY open2study.com

edX

coursera

UDACITY udacity.com

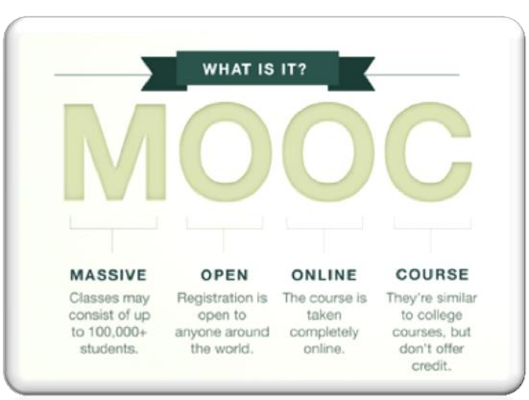
F/L FUTURELEARN

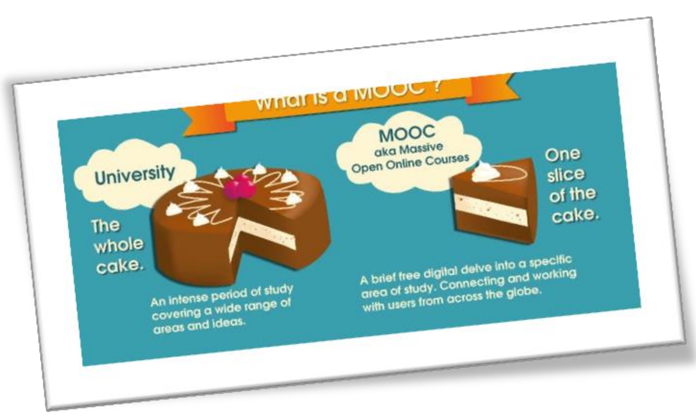
KHAN ACADEMY

ed2go

Want to stand above the rest when it comes to UCAS? Now is the time to act.
MOOCs are online courses run by nearly all Universities. They are short FREE courses that you take part in. They are usually quite specialist, but aimed at the public, not the genius!
There are lots of websites that help you find a course, such as edX and Future learn.
You can take part in any course, but there are usually start and finish dates. They mostly involve taking part in web chats, watching videos and interactives.

Completing a MOOC will look great on your Personal statement and they are dead easy to take part in!





A Level Biology Transition Baseline Assessment

The following 40 minute test is designed to test your recall, analysis and evaluative skills and knowledge.
Remember to use your exam technique: look at the command words and the number of marks each question is worth.
A suggested mark scheme is provided for you to check your answers.

1. a) What are the four base pairs found in DNA?

....
(2)

b) What does DNA code for?

....
(1)

c) Which organelle in a cell carries out this function?

....
(1)

2. a) What theory did Charles Darwin propose?

....
(1)

b) Why did many people not believe Darwin at the time?

....
(1)

c) Describe how fossils are formed.

....

....

....
(3)

d) The fossil record shows us that there have been some species that have formed and some that have become extinct.
i) What is meant by the term 'species'?

....
(2)

ii) Describe how a new species may arise:

....

....

....(3)

3. Ecologists regularly study habitats to measure the species present and the effect of any changes.
One team of ecologists investigated the habitat shown in the picture below:

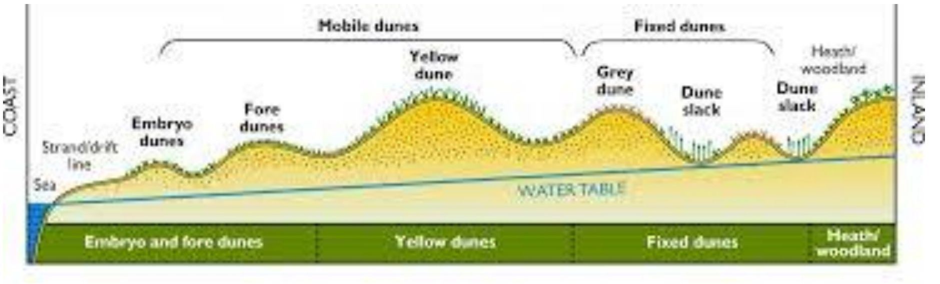


Image taken from http://www.macaulay.ac.uk/soilquality/Dune%20Succession.pdf

a) Define the following keywords:

i) Population

………

ii) Community

………

(2)

b) Give an example of one biotic factor and one abiotic factor that would be present in this habitat

Biotic: ……

Abiotic: ……

(2)

c) Describe how the ecologists would go about measuring the species present between the coast and the inland.

………

………

………

………

………

………

(6)

4. Every living organism is made of cells.

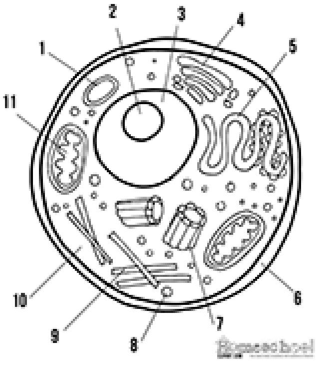


Image taken from http://prestigebux.com/worksheet/label-an-animal-cell-worksheet

a) Label the following parts of the animal cell:

2 ……

5 ……

8 ……

(3)

b) Describe how is the structure of the cell membrane related to its function?

……

……

……

(3)

5. A medical research team investigated how quickly the body deals with glucose after a meal. They studied the blood glucose concentration of people who exercised versus those who did not.
Here are their results:

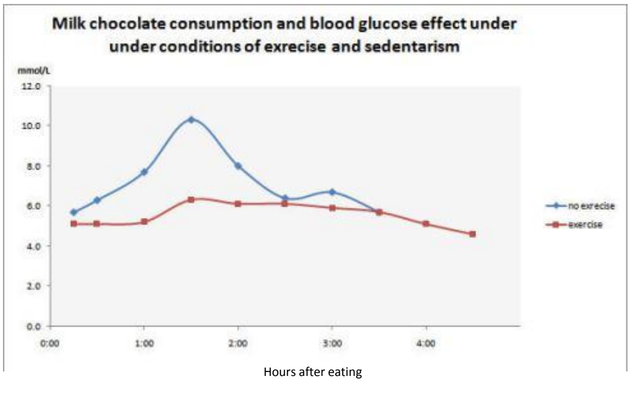


Image taken from https://memoirsofanamnesic.wordpress.com/category/blood-glucose/

a) What organ in the body regulates blood glucose concentration?

……

(1)

b) Explain how the stages that would bring about a return to normal blood glucose concentrations.

....

....

....

....

(4)

c) Name one variable the researchers will have controlled.

....

(1)

d) The researchers made the following conclusion:

"Blood glucose returns to normal values for all people after 4 hours"

To what extent do you agree with this conclusion.

....

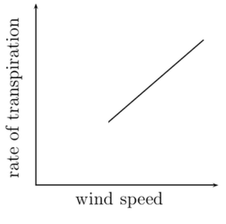
....

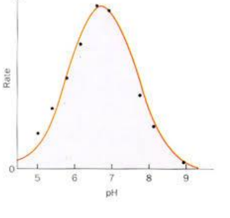
....

....

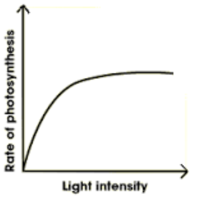
(3)

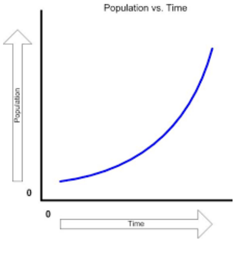
6. Scientists need to be able to interpret data in graphs to decide if there are trends in the results. For each graph bellow, describe the trend.





....





....(4)

Images taken from: http://www.everythingmaths.co.za/science/lifesciences/grade-10/05-support-and-transport-systems-in-plants/images/56aff2f9b6c5b041688f745ca928990c.png
http://www.bbc.co.uk/staticarchive/afa3f2b16b4d58d077943c96929c9a4020fea83a.gif
http://www.rpi.edu/dept/chem-eng/Biotech-Environ/Projects00/temph/enzyme.html
http://www.myearthwatchexperience.com/Essential%20Ecology.htm

Suggested Mark Scheme:

Question			Answer	Marks
1	a		Adenine-Thymine Cytosine-Guanine	1 1
	b		Protein/enzymes	1
	c		Ribosomes	1
2	a		Evolution (by natural selection)	1
	b		Not enough evidence	1
	c		(Plant/animal dies) and is quickly buried in sediment Not all conditions for decay are present Hard parts of the body are replaced by minerals	1 1 1
	d	i	Organisms that can reproduce to produce viable offspring/offspring that can also reproduce (fertile)	1
		ii	3 from Geographical isolation/named example Mutation of genes Natural Selection/selective advantage Species can no longer interbreed (not produce fertile offspring)	 1 1 1 1
3	a	i	A group of organisms, all of the same species, and all of whom live together in a particular habitat.	1
		ii	The total of all populations living together in a particular habitat.	1
	b		Biotic – one from: Predators, prey, plant, microbes Abiotic – one from: Availability of water, temperature, mineral concentration, reference to climate/weather	 1 1
	c		Measure out a transect Using a tape measure Use a quadrat At regular (named) intervals Identify species present Using a key/guide	1 1 1 1 1 1
4	A		2 Nucleolus 5 Smooth Endoplasmic Reticulum 8 Golgi body	1 1 1

Question			Answer	Marks
4	b		Any 3 from the following structure **and** function must be given. Lipid bilayer - has a hydrophobic inside and hydrophilic outside, allowing for selective permeability Proteins - allow for specific substances to come or some molecules to pass through, Cholesterol - allows for fluidity of the membrane, Glycoproteins - for cell identification they serve as markers	 1 1 1 1
5	a		Pancreas	1
	b		3 from Pancreas detects change Insulin secreted By alpha cells Respiration increased Uptake of glucose increased Liver increases storage of glucose as glycogen	 1 1 1 1 1 1
	c		Any one from: Amount of chocolate, time taken to eat, other food/drink consumed, age, gender, weight, fitness level/metabolic rate, health/pre existing conditions, use of medicines/drugs	 1
	d		Any three from Data suggests that blood glucose returns to normal Doesn't show how much exercise has been done Doesn't say age/gender/other named variable May only be true for chocolate/only one type of food investigated	 1 1 1 1
6			Top left: transpiration increases when wind speed increases/there is a positive correlation Top right: rate increases with pH until the optimum is reached, after the optimum, rate decreases Bottom left: Increasing light initially increases the rate of photosynthesis, but after a while remains constant Bottom right: Population increases slowly at first and then increases at a greater rate/increases exponentially	1 1 1 1

Finding rates of reaction in photosynthesis

Specification references

â€¢ 3.5.1
â€¢ MS 3.1, MS 3.2, MS 3.5, MS 4.1

Maths Skills for Biology references

â€¢ Oxygen release from photosynthesis

Learning outcomes

After completing this worksheet you should be able to:

â€¢ plot graphs to show two variables and draw best fit lines
â€¢ calculate the rate of change from graphs showing linear relationships
â€¢ recall the formula for calculating volume of a cylinder.

Introduction

You will have studied photosynthesis in Section 5, covered in Chapter 11 of your Student book. You will know that the rate of photosynthesis can be affected by key factors such as light intensity, temperature or carbon dioxide concentration. Experiments with photosynthesis commonly use these key factors as independent variables, e.g. light intensity or carbon dioxide availability, measuring the production of oxygen gas over time to follow the reaction. Plotting the volume of oxygen produced against time produces a graph from which a rate of reaction can be calculated and related to the factor being varied.

This task is set in the context of experiments in which a capillary tube is used to collect and measure the volume of oxygen produced during photosynthesis. It focuses on developing your graphing skills and also on a method for converting distances in capillary tubing into actual volumes.

Worked example

Question

In an experiment oxygen was collected for five minutes at a set light intensity. Find the rate of reaction from the graph in Figure 1, which shows the data collected.

Figure 1

Answer

Step 1

Once the straight best fit line has been drawn, select any two points along the line and use a ruler to draw construction lines to each axis, as shown on Figure 1.

Step 2

Divide the difference between these points on the y-axis by the difference between them along the x-axis.

In this example the calculation is 13 Ã· 2.7, giving a rate of 4.8 cm3 minuteâˆ’1.

Questions

1 Oxygen production was measured by using a capillary tube apparatus to collect the gas. This was repeated at five different temperatures. The results were as follows:

Temperature/Â°C

15

25

35

45

55

Time/s

Volume of oxygen collected/mm3

30

3

5

7

8

7

60

3

7

10

11

9

90

5

10

15

17

13

120

6

13

19

21

17

150

8

15

24

27

21

180

9

17

27

30

24

210

9

19

28

31

25

240

10

22

30

33

27

270

11

24

34

37

30

300

12

26

36

39

31

a Plot a neat graph to show the cumulative oxygen collected at each temperature.

(4 marks)

b Use the graph to determine the rate of oxygen production at each temperature.

(1 mark per temperature)

c Plot a graph to summarise the effect of temperature on the rate of oxygen production.

(4 marks)

d The oxygen was collected in capillary tubes, in which it formed bubbles. Describe how the length of the bubbles would have been converted to volumes.

(2 marks)

Maths skills links to other areas

This technique can be used in areas such as oxygen consumption rates in respirometers or water uptake in potometers, where a straight line relationship between volume and time might be expected.

When the graph shows a reaction that reaches an end point, such as an enzyme digestion over time, the technique you should use is tangents. An example of this is in the worksheet â€˜Finding rates of reaction using tangentsâ€™, which is also on Kerboodle.

Answers

1 a A neat line graph should be drawn, with the following criteria:

graph fills at least half the space available

axes correct way around and divided equidistantly

axes labelled with title and units

points plotted accurately

straight best fit lines drawn

a key to identify the line for each temperature. (Max 4 marks)

The rates will depend on the positioning of the best fit lines, but they will be in region of:

Temperature/oC

Rate/mm3 sâ€“
1

15

0.03

25

0.08

35

0.11

45

0.11

55

0.09

(1 mark per row)

(5 marks)

c The graph should also match the relevant criteria listed in part a and will look like this:

(4 marks)

d The length of the bubble and radius of capillary tube could be used (1 mark)

with the formula Ï€r2h (1 mark)

(2 marks)

Net primary production and carbon sinks

Specification references

â€¢ 3.5.3
â€¢ MS 0.1, MS 0.2, MS 0.3, MS 1.2

Maths Skills for Biology references

â€¢ Numbers and units
â€¢ Percentages

Learning outcomes

After completing this worksheet you should be able to:

â€¢ convert between units
â€¢ use standard form for very small or large numbers
â€¢ calculate percentages
â€¢ consider the relative importance of different ecosystems as carbon sinks.

Introduction

This worksheet links with the material from Section 5 that is described in Chapter 13 of your Student book. The focus is on practising the maths skills involved with converting units and using standard form. These skills are introduced in the context of productivity in different ecosystems. You will be converting units in different ways in the context of carbon fixation or net primary production.

A carbon sink is a reservoir within which carbon is stored in organic compounds. This can be for a brief period, e.g. a few years in temperate grassland, to millions of years in limestone rocks. Carbon dioxide fixed as organic compounds can be measured as net primary production. Photosynthetic organism biomass can, therefore, be regarded as a primary carbon sink.

Worked example

Questions

Convert the following:

a 18 g to kg

b 2.6 tonnes to kg

c 5 m2 to km2

d 2 km2 to m2

Answers

a

Step 1

There are 1000 g in one kg, so To convert g to kg divide by 1000.
11g.
1000kg=

Step 2

So 18 g = 18 Ã· 1000 kg

= 0.018 kg

b

Step 1

There are 1000 kg in one tonne, so To convert tonnes to kg
multiply by 1000.
11kg.
1000tonne=

Step 2

So 2.6 tonnes = 2.6 Ã— 1000 kg

= 2600 kg

c

Step 1

1 km2 (one square kilometre) is an area 1000 m Ã— 1000 m, so it is 1 000 000 m2. To convert m2 to km2 divide by 1 000 000.

Step 2

So 5 m2 = 5 Ã· 1 000 000 km2

= 0.000005 km2

= 5 Ã— 10âˆ’6 km2 expressed as standard form.

To convert to standard form, 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 5.0.

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

0.000005

until the end of the number is reached. This example requires 6 shifts backwards, so the standard form should be written as 5 Ã— 10âˆ’6.

d

Step 1

To convert km2 back to m2, multiply by 1 000 000.

Step 2

So 2 km2 = 2 Ã— 1 000 000 m2

= 2 000 000 m2

= 2 Ã— 106 expressed as standard form.

Questions

Ecosystem

Area/Ã— 106
km2

Mean net primary

production/g mâ€“2 yearâ€“1

Total annual net
primary
production/tonnes

Tropical rain forest

17

2200

3.74 Ã— 1010

Temperate deciduous
forest

7

1200

8.4 Ã— 109

Savannah grassland

15

900

1.35 Ã— 1010

Temperate grasslands

9

600

5.4 Ã— 10 9

Swamp and wetland

2

3000

Open ocean

332

125

Algal bed and reef

0.2

2500

Cultivated land

14

650

Table 1

(data quoted from R.H. Whittaker)

1 Table 1 contains data for estimated rates of net primary production and surface areas of some ecosystems.

a Calculate the area of the tropical rain forest in m2, expressed as standard form.

(2 marks)

b Calculate the total annual net primary production of the temperate grasslands in grams, expressed as standard form.

(2 marks)

c Calculate the total annual net primary production of the open ocean in kg, expressed as standard form.

(2 marks)

2 Complete the last column of the table by calculating the missing figures.

(8 marks)

3 Calculate the percentage of the total annual net primary production:

a in tropical rain forests

(2 marks)

b in cultivated land.

(2 marks)

4 Tropical forests and wetlands are both threatened ecosystems. Use the data in Table 1 to assess the possible impact on the carbon cycle if these ecosystems are not protected from human destruction.

(6 marks)

Maths skills links to other areas

Standard form is useful for dealing with very large and very small numbers, for example in magnification (measuring with the microscope). You could be asked about percentages in many areas, for example, percentage yields of crop or products from fermenter systems.

You will need to be able to convert between units in areas such as magnification and scale calculations measuring from diagrams and photomicrographs.

Answers

1 Allow one mark for correct sum shown but incorrect result in each case below:

a 1.7 Ã— 1013 m2 (2 marks)

b 5.4 Ã— 1015 g (2 marks)

c 4.15 Ã— 1013 kg (2 marks)

2 Swamp and wetland 6 Ã— 109 (2 marks)

Open ocean 4.15 Ã— 1010 (2 marks)

Algal bed and reef 5 Ã— 108 (2 marks)

Cultivated land 9.1 Ã— 109 (2 marks)

(8 marks)

3 a 31% (2 marks)

b 7% (2 marks)

4 Together they contribute 36% of the net primary production

but wetlands only 5%

If wetland is converted to cultivated land, net primary production reduces by
g/m2/year
30006502350â ̂’

which is a drop
2350100%
300078.3%
ï£«ï£¶Ã—
ï£¬ï£·
ï£ï£¸

This reduces net primary production to tonnes of carbon per year
990.783(610)
4.710Ã—Ã—Ã—

If TRF is converted, net primary production reduces by
22200650g/m/year1550â ̂’

which is a drop
1500100%
220070.5%
ï£«ï£¶Ã—
ï£¬ï£·
ï£ï£¸

This reduces net primary production to tonnes of carbon per
year
10100.705(3.7410)
by2.610Ã—Ã—Ã—

Together, this represents a 25.5% drop in total carbon fixation per year

Losing rainforests has a much larger impact. (6 marks)

Using the Hardyâ€“Weinberg equation to
estimate allele frequencies

Specification references

â€¢ 3.7.2
â€¢ MS 0.3, M. 2.3, MS 2.4

Maths Skills for Biology references

â€¢ The Hardy-Weinberg equation

Learning outcomes

After completing this worksheet you should be able to:

â€¢ use the Hardyâ€“Weinberg equation to estimate the frequency of alleles
â€¢ substitute values into algebraic equations and solve the equations
â€¢ convert decimals to percentages.

Introduction

In Section 7 you studied the inheritance of alleles. You will have learned that in a monohybrid cross there may be dominant and recessive alleles, so individuals expressing a dominant characteristic could be either homozygous or heterozygous but individuals expressing a recessive allele can only be homozygous. This is described in Chapters 17 and 18 of your Student book. A mathematical requirement is that you are able to apply an equation called the Hardyâ€“Weinberg equation in order to determine allele frequencies. This task is designed to allow you to practise with that equation.

The frequency of dominant and recessive alleles in a population will remain in equilibrium from generation to generation, provided that:

â€¢ the population is large
â€¢ mating is random
â€¢ no mutations occur
â€¢ there is no selection, that is, all alleles are equally likely to be passed to the next generation
â€¢ the population is isolated, that is, there is no flow of alleles into or out of the population.

Thus it is possible to apply a statistical analysis to the population in order to establish the gene frequencies of the dominant and recessive alleles and the frequency of carriers in a population. This is the Hardyâ€“Weinberg equation.

Worked example

Question

Phenylketonuria is a condition caused by an autosomal recessive allele that occurs at a rate of 0.1 per 1000 live births. What is the frequency of the carrier genotype?

Answer

In the equation p2 + 2pq + q2 = 1, p represents the frequency of the dominant allele and q the frequency of the recessive allele.

Consider the cross between two heterozygous parents, Aa:

Parent genotypes

Aa

Aa

Parent gametes

A

a

A

a

F1 genotypes

AA

Aa

Aa

aa

Substitute p and q

p Ã— p

p Ã— q

p Ã— q

q Ã— q

To give

p2

2pq

q2

so

p2 + 2pq + q2 = 1 (i.e. 100%)

1 Note the sum of all alleles is always 1, so p + q = 1

Step 1

First find the frequency of the sufferer (q2), which is the homozygous recessive.

Here it is = 0.0001
0.11000

Step 2

If q2 = 0.0001 then q =
0.0001

So q = 0.01

Step 3

Since p + q = 1 we can now find p, which is 1 âˆ’ 0.01 = 0.99

Step 4

Therefore 2pq = 2(0.99 Ã— 0.01) = 0.0198 (1.98%)

So 1.98% of people are carriers.

Questions

1 Around 1 in 5000 people in the UK have Alpha-1 Antitrypsin Deficiency, which is caused by an autosomal recessive allele.

a Calculate the frequency of the dominant allele.

(2 marks)

b Calculate the percentage of carriers in the population.

(2 marks)

c If the UK population is 65 million, calculate how many people will be carriers of Alpha-1 Antitrypsin Deficiency.

(2 marks)

2 Sickle cell anaemia occurs in 1 in 500 African-American births but has an occurrence of 2% in West Africa. The alleles are H (normal) and Hs (sickle cell). The possible genotypes and phenotypes are HH normal blood, HHs carrier with partial anaemia and resistance to malaria, HsHs fully sickle cell anaemic (normally fatal).

a Calculate the frequency of carriers in both the USA and West Africa.

(4 marks)

b Suggest an explanation for the difference between the two populations.

(5 marks)

3 Beta-Thalassaemia is a rare disorder caused by an autosomal recessive allele. It has an incidence of approximately 0.05 out of every thousand births.

a Calculate the frequency of the carrier genotype.

(2 marks)

b Calculate the percentage of the population that do not have the recessive allele in their genotypes.

(2 marks)

4 Huntingtonâ€™s Chorea is a condition caused by an autosomal dominant allele. It has an incidence of around 7 per 100 000 of the population.

a Calculate the frequencies of the dominant and recessive alleles.

(4 marks)

b Calculate the percentage of the population that is likely to be heterozygous.

(2 marks)

Maths skills links to other areas

You will be given equations and expected to substitute in appropriate values and solve the equations in other areas of biology, for example calculating diversity index, calculating cardiac output, making statistical calculations.

Answers

1 a p = 0.986 (2 marks)
b 2.8% (2 marks)
c 1 820 000 or 1.82 million (2 marks)

2 a USA 8.6%, West Africa 24% (4 marks)
b Carrier is resistant to malaria

Homozygous recessive dies of SCA and homozygous dominant more likely to die from malaria

W. Africa carrier population is selected for resistance to malaria

so carrier genotype increases

US descendant carrier population no longer selected as malaria is absent

Homozygous dominant survives more

and increases the frequency of the dominant allele (Max 5 marks)

3 a 0.14 (2 marks)
b 98.6% (2 marks)

4 a Dominant p allele = 3.5 Ã— 10ï€5 (2 marks)

Recessive q allele = 0.999965 (2 marks)

(4 marks)

b 0.0069% of total population are heterozygous

Working for Question 4

p2 + 2pq (all sufferers = 7 in 100 000 = 7 Ã— 10ï€5)

so q2 = 1 âˆ' 7 Ã— 10ï€5 = 0.99993

so q = q = 0.999965
0.99993

p + q = 1 so p = 1 âˆ’ 0.999965 = 3.5 Ã— 10ï€5

2pq = 2(0.999965 Ã— 3.5 Ã— 10ï€5)

= 6.9998 Ã— 10ï€5

which is (6.9998 Ã— 10ï€5 ï‚¸ 100 000) Ã— 100%

=0.0069% (2 marks)

Using hydrogen ion concentration to
calculate pH

Specification reference

â€¢ 3.1.4.2
â€¢ Maths skill 0.5
â€¢ Maths skill 2.2
â€¢ Maths skill 2.3
â€¢ Maths skill 2.4

Learning outcomes

After completing the worksheet you should be able to:

â€¢ use calculators to find and use power, exponential, and logarithmic functions
â€¢ change the subject of a formula
â€¢ substitute numerical values into formulae and solve formulae.

Introduction

The maths skill in this worksheet focuses on the use of power and logarithmic functions. A function is simply a relationship between numbers, for example Ã— or +. A power, written using a superscript to the right of the number, tells you the number of times to use the number in a multiplication. For example, 23 means 2 Ã— 2 Ã— 2. To save space, numbers can be written using powers of 10, or â€˜standard formâ€™. For example, 5 Ã— 103 is a way of writing 5 000; 5 Ã— (10 Ã— 10 Ã— 10) = 5 000. Logarithms are based on powers of 10 and allow large numbers to be accommodated easily on a scale. For example, 1, 10, 100, 1000, 10 000 become logs 0, 1, 2, 3, 4.

You will also be rearranging equations (changing the subject of equations). This means moving the parts or terms in the formula.

For example, becomes a Ã— c = b.

Equations with logs work like this: to rearrange log10A = x so that A becomes the subject, move the base number (in this case 10) to the right and change the x to a power, so that you get A = 10x .

Worked examples

Question

A solution has a hydrogen ion concentration of 1.8 Ã— 10-5 M. What is the pH of the solution?

Answer

pH and hydrogen ion concentration are related so one may be calculated from the other using the formula

log10 is â€˜log to the base 10â€™ and [H+] = concentration of the hydrogen ions in moles per litre.

Step 1

Type the hydrogen ion concentration figure into the calculator. To do this type 1.8, then press the EXP (or Ã—10x) key, type 5 then press the change sign (+/â€“) key (see Figure 1).

Your display should now show 1.8-05

Step 2

Find log10 of this hydrogen ion concentration by pressing the log key.

Your display should now show â€“4.7447275

Step 3

Press the change sign key (+/â€“)

Your display should now show 4.744 727 5, which is the pH. Round this to an appropriate number of decimal places, for example to 4.74

Question

The pH of a solution is 8.6. What is the concentration of hydrogen ions present?

Answer

To solve this, the formula is rearranged so that [H+] becomes the subject of the equation (the thing you are trying to work out). Move the base number (10) to the right and make pH a power so that

â€“log10 [H+] = pH becomes [H+] = 10â€“pH

(As the log was negative, the power has to be negative also.)

Step 1

Type in the figure for pH so that the display shows 8.6.

Step 2

Press the change sign key (+/â€“) so that the display shows â€“8.6.

Step 3

Remember -8.6 would have been the log10 of the [H+], so you now have to work out the â€˜anti-logâ€™. Press the shift key on your calculator, then press the log10 key. Your display should now show 2.5118864-09 which is the value for [H+].

Round this to a sensible number of decimal places, e.g. 2.5-9 (2.5 10-9).

Questions

1 For each equation, rearrange to make A the subject.
a C = B â€“ A (1 mark)
b log10 A = B (1 mark)
c â€“log3 A = C (1 mark)

2 Work out the pH of solutions with the following hydrogen ion concentrations.
a 3.6 Ã— 10-3 moles per litre (1 mark)
b 1 Ã— 10-7 mol dm-3 (1 mark)
c 10-12 M (1 mark)
d 0.06 mmol per litre (1 mark)
e 10-4 mmol/L (1 mark)

3 Work out the hydrogen ion concentrations of solutions with the following pH values.
a 3.8 (1 mark)
b 9.6 (1 mark)
c 1.8 (1 mark)
d 11.34 (1 mark)
e 7.2 (1 mark)

Maths skills links to other areas

You may also use logarithms and power functions when doing calculations about population growth of microorganisms

Answers

4 a A = B â€“ C b A = 10B c A = 3-C (1 mark each)
5 a 2.44 b 7.0 c 11.0 d 4.2 e 6 (1 mark each)
6 a 1.58 Ã— 10-4 (1 mark)

b 2.51 Ã— 10-10 (1 mark)

c 0.016 (1 mark)

d 4.57 Ã— 10-12 (1 mark)

e 6.3 Ã— 10-8

Finding rates of reaction using tangents

Specification reference

â€¢ 3.1.4.2
â€¢ Maths skill M3.2
â€¢ Maths skill M3.6

Maths Skills for Biology reference

â€¢ Rates of reaction 1
â€¢ Rates of reaction 2

Learning objectives

After completing the worksheet you should be able to:

â€¢ plot two variables from experimental data
â€¢ draw and use the slope of a tangent to a curve as a measure of rate of change.

Introduction

When biological experiments give trends in which the rate of reaction changes, tangents can be used to allow calculation of the rate of reaction at any given point on the curve, for example, the fastest rate.

Worked example

Question

The graph in Figure 1 shows data collected during the reaction between catalase and hydrogen peroxide. The volume of gas collected is plotted against time. What is the maximum reaction rate?

Figure 1 Graph of volume of oxygen produced in the breakdown of hydrogen peroxide

Answer

Step 1

First construct a tangent line by drawing a line using a ruler as shown in Figure 1. The tangent line touches the curve at its steepest point. The exact position of a tangent is achieved by estimation, so the trend line curve is symmetrically diverging from the point at which the tangent line touches it.

Figure 2 Finding a tangent

Step 2

Next use construction lines to find the values of x and y at any two selected points on the tangent, as shown.

Find the change in y and the change in x between the two selected points. In the example, y goes from 12 to 48 cm3, a change of 36 cm3 oxygen while x changes from 128 to 220 s, a change of 92 s.

Step 3

Calculate the rate by dividing the change in y by the change in x (dy/dx). In the example:

= = 0.39 cm3 sâ€“1

Questions

1 The oxygen production by samples of Elodea pondweed was investigated at five different concentrations of bicarbonate. All other variables were controlled. The data collected is shown in the table below.

Concentration of
bicarbonate (%)

Time (s)

30

60

90

120

150

180

Cumulative volume of oxygen collected (mm3)

0

0.5

1.5

2.5

4.5

7.0

10.0

1

1.0

2.0

3.5

6.5

10.0

15.0

2

2.5

6.0

11.0

17.0

24.0

40.0

3

6.0

14.0

27.0

41.5

50.5

52.0

4

10.0

25.0

42.5

51.0

52.5

53.0

a Plot graphs to show the trends in oxygen production at each concentration of bicarbonate. (4 marks)
b Draw suitable tangents on each curve and use them to calculate maximum rates of reaction at each concentration. (5 marks)

2 The table below shows data collected from an experiment in which glucose was being produced by the digestion of starch.

Time (minutes)

Glucose produced
(mmol dm-3)

5

2

10

6

15

12

20

22

25

25

30

28

35

29

a Plot the data on a suitable graph. (4 marks)
b Use a tangent to calculate the maximum rate of reaction. (2 marks)
c Find the rates of reaction at 8 minutes and at 32 minutes. (2 marks)

Maths skills links to other areas

You may be asked to use this method of rate calculations when you study movement across cell membranes, water uptake with potometers, photosynthetic rate experiments, and respirometer measurements of oxygen uptake.

Answers

1 a Award marks for the following points:

axes correct orientation, scaled with equidistant divisions;

both axes labelled with title and units;

points correctly plotted;

neat ruler dot-to-dot line or sensible best fit trend line for each trend;

graphs fit at least half of the space on the paper used; (max 4 marks)

b rates are approximately:

0% = 0.13 mm3 s-1 (1 mark)

1% = 0.19 mm3 s-1 (1 mark)

2% = 0.47 mm3 s-1 (1 mark)
3% = 0.60 mm3 s-1 (1 mark)

4% = 0.63 mm3 s-1 (1 mark)

2 a Award marks for the following points:

axes correct orientation, scaled with equidistant divisions;

both axes labelled with title and units;

points correctly plotted;

neat ruler dot-to-dot line or sensible best fit trend line for each trend;

graphs fit at least half of the space on the paper used. (max 4 marks)

b (this will depend on the exact positioning of the tangent) Approx 2.3 mmol dm-3 min-1. (2 marks)

c (depends on the positioning of the tangent) Approx 0.9 mmol dm-3 min-1 and 0.3 mmol dm-3 min-1. (2 marks)

Calculations of DNA base frequencies

Specification references

â€¢ 3.1.5.1
â€¢ Maths skills 0.3

Maths Skills for Biology references

â€¢ Percentages

Learning outcomes

After completing the worksheet you should be able to:

â€¢ use ratios, fractions, and percentages.

Introduction

A ratio expresses the total contribution of parts, for example a 1 : 1 mixture means

equal parts of both quantities. A fraction is an expression of the specific contribution of one part. For example, in a mixture with a ratio of 1 part A : 3 parts B, A is one out of a total of four parts, or .
14

A percentage is simply expressing a fraction as a part of 100. For example, the fraction gives the decimal 0.25, which when multiplied by 100 gives 25%. The molecule DNA has a constant ratio of bases. This is due to the base pairing rule, adenine to thymine (Aâ€“T) and guanine to cytosine (Câ€“G). Consequently, for every adenine on one strand there will be a corresponding thymine on the complementary strand, so knowing the proportion of one base will allow the calculation of all the others quite easily.
14

Worked example

Question

Analysis of a sample of DNA revealed that it was made up of 32% adenine. Calculate the proportion of guanine in the sample.

Answer

Step 1: There will be the same percentage of thymine and adenine because they form pairs Aâ€“T. Find the total for A + T in the sample: 2 Ã— 32% = 64%

Step 2: Find the total for G + C, which is the remainder of the molecule by subtracting the value for A + T from the total:

Step 3: Guanine pairs with cytosine on a 1 : 1 ratio, so half the G + C proportion will be guanine. Find the proportion of guanine: 36% Ã· 2 = 18%

Questions

1 Convert these fractions to decimals. Give your answer to 2 significant figures.
a (1 mark)
b (1 mark)

2 What is the fraction of A in the following ratios?
a 5A : 10B (1 mark)
b 11B : 2A (1 mark)

3 What is the percentage of A in parts a and b of question 2? (2 marks)
4 In a sample of DNA, there was 17% thymine.

a Calculate the percentage of cytosine in the molecule. (1 mark)
b What is the percentage of purine bases in the sample? (1 mark)

5 A sample of DNA from the lambda bacteriophage virus was sequenced and was found to be made up from 48 502 base pairs. 12 336 base pairs were adenine and thymine.
a How many of the bases in the molecule will be cytosine? (1 mark)
b Calculate the percentage of the DNA molecule which is made up from guanine. (1 mark)

6 Cytosine makes up 29.50% of a DNA sample.
a Find the percentage of adenine. (1 mark)
b Predict the percentage of guanine that will be found in a molecule of mRNA that is made by transcribing this DNA sample. Assume that all the bases are equally distributed on each of the two strands in the DNA molecule. (1 mark)

7 A sample of messenger RNA was analysed and gave the following base sequence:

AAGCGGUUACGGAAUAG

a What is the percentage of pyrimidines in the original coding DNA strand? (1 mark)

b What proportion of bases in the original coding DNA molecule was contributed by guanine? (1 mark)

Maths skills links to other areas

You will find a very similar calculation in your second year of A Level when using the Hardyâ€“Weinberg ratio to find allele frequencies.

Answers

8 a 0.25 (1 mark)

b 0.29 (1 mark)

9 a 5/15 (1 mark)

b 2/13 (1 mark)

10 A is 33.3% and 15.4% (2 marks)
11 a 33% (1 mark)

b 50% (1 mark)

12 a 36,166 (1 mark)

b 37.3% (1 mark)

13 a 20.5% (keep same number of decimal places as in the question) (1 mark)

b 7.38% (1 mark)

14 a 70.6% (12 of the bases in the coding strand are C + T) (1 mark)

b 23.5% (8 of the 34 bases in the two strands of the DNA molecule were G) (1 mark)

Cardiac output

Specification reference

â€¢ 3.3.41
â€¢ Maths skill 2.2
â€¢ Maths skill 3.1

Maths Skills for Biology reference

â€¢ Electrocardiograms

Learning objectives

After completing the worksheet you should be able to:

â€¢ change the subject of an equation
â€¢ translate information between graphical, numerical, and algebraic forms.

Introduction

The individual parts or terms in equations are all related. Sometimes you might know all the values of the terms except one. The equation can be re-written so that the unknown term can be calculated. This is called rearranging or changing the subject of an equation. A very useful example of this arises during the study of cardiac output.

The different terms are cardiac output, stroke volume, and heart rate. The equation that relates them together is:

where cardiac output is the subject of the equation. Changing the subject of the equation means rearranging it so that heart rate can be calculated as:

Cardiac output is the volume of blood being pumped by the heart into the circulatory system in one minute. Usually this measurement relates specifically to the output from the left ventricle. It depends on the stroke volume (the volume of blood pumped out of the ventricle each contraction) and the heart rate.

Heart rate may be measured quickly using pulse counts in beats per minute or by measuring intervals on ECG peaks. Stroke volume is harder to measure precisely and several methods exist. Echocardiograms may be used to measure ventricle volume just before and after one beat and stroke volume measured as the difference between the two. A simpler method is to measure systolic and diastolic blood pressure using a blood pressure monitor and take the difference between the two (pulse pressure) to be equivalent to stroke volume in cm3.

Worked example

Question

Figure 1

The stroke volume of the ECG shown in Figure 1 is 69 cm3. Each small square represents 0.2 s. What is the cardiac output?

Answer

Step 1

Find the heart rate. Begin by measuring the distance between the high peaks. Here it is 13.5 small squares.

Step 2

Convert this to time in seconds using the scale.

13.5 Ã— 0.2 = 2.7 s

Step 3

Divide to find the number of beats in one minute (60 s).

60 Ã· 2.7 = 22.2 beats per minute

Step 4

Transfer the numbers into the formula to find the cardiac output (CO).

CO = 69 Ã— 22.2 cm3 per minute

CO = 1531.8 cm3 per minute

Step 5

Convert to dm-3 per minute by dividing by 1000.

1531.8 Ã· 1000 = 1.53 dm-3 per minute (1.53 dm-3 min-1)

Questions

1 For each equation, rearrange to make A the subject.
a C = B â€“ A (1 mark)
b P + Q = A Ã— B (1 mark)

2 An individual at rest had a stroke volume of 75 cm3 and a heart rate of 60 beats per minute.
a Calculate the cardiac output in dm-3 min-1. (1 mark)
b Calculate the cardiac output when the same individual exercises with a stroke volume of 98 cm3 and a heart rate of 103 beats per minute. (1 mark)
c What is the percentage increase in cardiac output? (2 marks)

3 Figure 2 shows the ECG of a healthy person at rest.

Figure 2

a What is the heart rate of the person? (1 mark)
b If the stroke volume of the person is 80 cm3, what is the cardiac output in litres per minute? (1 mark)

c What would the heart rate of the person be if their CO rose to 9.6 dm-3 min-1 and their stroke volume increased by 50%? (2 marks)

4 Figure 3 shows the ECG of a person at rest. The same person measured their blood pressure with a portable meter and found it to be 123 / 82 mmHg.
a Use the graph to find the person's heart rate. (1 mark)
b Use the following formula to estimate the person's stroke volume

systolic pressure â€“ diastolic pressure = pulse pressure

Assume that pulse pressure = stroke volume in cm3. (1 mark)

c Calculate the cardiac output for this person. (1 mark)
d When exercising, the person's heart rate rose to 105 beats per minute. What would be the percentage increase in stroke volume required to give them a cardiac output of 5.6 dm-3 min-1? (2 marks)

Figure 3

5 During a period of exercise the oxygen demand increased. It was necessary for the blood to deliver 10 cm3 of oxygen per minute per 100 g of respiring skeletal muscle.
â€¢ Oxygenated blood carries 20 cm3 of oxygen per 100 cm3.
â€¢ 80% of the CO is directed at skeletal muscles when exercising heavily.
â€¢ Skeletal muscle accounts for 50% of lean body mass.

a Calculate the volume of blood required to deliver sufficient oxygen to the muscles of a person weighing 108 kg during the exercise. (2 marks)

b What is the required cardiac output to supply oxygen at this rate? (1 mark)

c If the person had a heart rate of 193 bpm during the exercise, what would their stroke volume have been? (1 mark)

Maths skills links to other areas

You will find the ability to apply and rearrange the subject of equations like this in several places in the specification. For example, calculation of magnifications, working with rates of reaction, diversity indices.

Answers

6 a A = B â€“ C (1 mark)

b (1 mark)

7 a 4.5 dm-3 min-1 (1 mark)

b 10.1 dm-3 min-1 (1 mark)

c 124.4% (allow one for the correctly calculated increase but incorrect %, two for the correct %) (2 marks)

8 a 52.9 beats per minute (1 mark)

b 4.2 dm-3 min-1 (1 mark)

c 80 beats per minute (one mark for the new stroke volume = 120 cm3, one mark for the correct rate) (2 marks)

9 a 56.6 bpm (1 mark)

b 41 cm3 (1 mark)

c 2.3 dm-3 min-1 (1 mark)

d 30% (one mark for the change in stroke volume correctly found 12.3, one for the correct %) (2 marks)

10 a 27 dm3 / 27,000 cm3 (2 marks if correct, or one mark each correct step, e.g. muscle mass is 54 kg) (2 marks)

b 33 750 cm3 / 33.8 dm3 (1 mark)

c 174.9 cm3

Species diversity index

Specification reference

â€¢ 3.4.6
â€¢ Maths skill 1.1
â€¢ Maths skill 1.2

â€¢ Maths skill 1.5
â€¢ Maths skill 2.3

â€¢ Maths skill 2.4

Maths Skills for Biology reference

â€¢ Species diversity

Learning outcomes

After completing the worksheet you should be able to:

â€¢ find arithmetic means
â€¢ substitute numerical values into algebraic equations
â€¢ solve algebraic equations
â€¢ understand the principles of sampling as applied to scientific data.

Introduction

Species diversity is a calculated measure of the balance between the different species present in a community. High diversity suggests that the community is evenly balanced and likely to be stable, e.g. ancient woodland. Low diversity can be indicative of communities that have over-representation by some species and may be liable to change as the years pass. For example, early stages of succession, such as pioneer communities. Low values may also indicate dominant populations in specialised habitats, for example barnacles on rocks in the upper shore. Suitable data for the calculation depends on random sampling, such as frame quadrats placed using randomly generated grid coordinates.

Diversity is measured by calculating the value of Simpsonâ€™s index of diversity, D. This value does not have units but is a fraction of one. If all species had exactly the same populations, then the balance between them is equal and D will be 1. The more uneven the numbers of species, the smaller D becomes.

The formula required is
21nDN
ï£«ï£¶ï£«ï£¶=âˆ’ï£¬ï£·ï£¬ï£·ï£¬ï£·ï£ï£¸ï£ï£¸
Î£

Worked example

Question

Sampling a community gave the following data: species A 22 plants; species B 30 plants; species C 25 plants; species D 23 plants. Calculate the species diversity.

Answer

It helps to lay out the data in a table like the one below to make the calculation easy to follow through.

Plant species

Number of each
species of plant (n)

nN

2ï£«ï£¶
ï£¬ï£·
ï£ï£¸
nN

A

22

= 0.22
22100

0.05

B

30

= 0.30
30100

0.09

C

25

= 0.25
25100

0.06

D

23

= 0.23
23100

0.05

Totals

Total plants found (all species) N = 100

0.25
2
nN
ï£«ï£¶=ï£¬ï£·
ï£ï£¸Î£

Species richness

4

Step 1

Find the value of N, the total number of all plants present. Here, it is
22 + 30 + 25 + 23 = 100, shown in column 2.

Step 2

Calculate and fill in the values of n/N, where n is the number of plants of each individual species. The results are shown in the third column.

Step 3

Square the values of n/N to find for each plant species. These are shown in the fourth column.
2nN
ï£«ï£¶
ï£¬ï£·
ï£ï£¸

Step 4

Add up the values of to find the total, which is. In this example, the result is 0.25, shown at the bottom of column 4.
2nN
ï£«ï£¶
ï£¬ï£·
ï£ï£¸
2nN
ï£«ï£¶
ï£¬ï£·
ï£ï£¸Î£

Step 5

Finally, subtract the value of from 1 to give a value for D. Note: this will always be a fraction of 1. Here 1-0.25 = 0.75, which is a high diversity. In this
2nN
ï£«ï£¶
ï£¬ï£·
ï£ï£¸Î£

example, the reason is that all species are evenly represented and the community is consequently well balanced.

Note: this method will work just as well using % cover data from quadrats.

Questions

1 Three examples of data are shown in the table below.

Moorland

Rocky shore

Potato field

Species

Mean %
cover per
quadrat

Species

Mean
number per
quadrat

Species

Mean %
cover per
quadrat

Milkwort

5

Limpet

82

Potato

89

Carnation grass

16

Grey top shell

12

Dandelion

8

Purple moor
grass

29

Toothed top shell

36

Clover

13

Bell heather

6

Edible periwinkle

35

Nettle

7

Starry sedge

5

Chiton

4

Dock

14

Common heather

48

Beadlet anemone

23

Tormentil

13

Snakelocks
anemone

7

Sheep's fescue

82

Dog whelk

34

Sheep's sorrel

11

Barnacle

197

Mat grass

23

a Calculate the species diversity for each site. (6 marks)
b Comment on the diversity of the three sites. (3 marks)

2 Samples were taken from three randomly located positions in a freshwater pond.
The results are shown in the table below.

Number of specimens of each species found in freshwater pond samples

Species

Sample number

1

2

3

Water boatman

12

9

5

Great diving beetle

4

0

5

Water flea

56

78

36

Freshwater shrimp

35

12

24

Ramshorn pond snail

0

11

2

Dragonfly nymphs

9

10

7

a Calculate the mean number of each species present. (3 marks)
b Calculate the value of D for this pond by using the formula (2 marks)
21nDN
ï£«ï£¶ï£«ï£¶=âˆ'ï£¬ï£·ï£¬ï£·ï£¬ï£·ï£ï£¸ï£ï£¸
Î£
c Suggest how the random sampling positions might have been determined. (2 marks)
d Discuss how the data might have been different had the sampling not been random. (3 marks)
e Dragonfly nymphs were counted together and not as separate species. Suggest how this might have influenced the value of D that you have calculated. (3 marks)

Maths skills links to other areas

You will need to be confident with the calculation of arithmetic means in many areas of the specification where numerical data are used. Understanding the importance of adequate random sampling and how it affects the data you collect is very important, for example when trying to prove a trend, such as in enzyme reaction rate experiments, or when using data in statistical tests to try and prove significance of patterns.

Answers

1 2 marks per correct value. Allow one for a correct intermediate stage if not, e.g. N = 238 in the moorland.
a Moorland D = 0.81; Rocky shore D = 0.73; Potato field D = 0.51
b Any three of the following:

Moorland in the most diverse. Potato field is the least diverse;

balance of species is more even in the moorland and shore samples;

moorland and shore likely to be more stable communities/later in the succession;

potato field is least stable/most likely to change. (max 3 marks)

2 a water boatman 9, diving beetle 3, flea 57, shrimp 24, snail 4, dragonfly nymphs 9. Lose one mark per wrong answer.

b 0.64 (1 mark for correct workings; 1 mark for correct answer)

c Any two of the following:

A grid or system of tapes laid out; reference to some kind of laser range finder system

random coordinates generated;

samples taken at those coordinates. (max 2 marks)

d May have sampled only species from one part of the pond;

e.g. only the edge/only the deep water;

species from some parts of the pond would not be collected/ORA;

species richness may have been lower. (max 3 marks)

e D would be inaccurate/unrepresentative;

might have reduced the value of D;

because lumping would give a bigger (n/N)2 value;

would not allow comparison between this and other sites. (max 3 marks)

Standard deviation

Specification reference

â€¢ 3.4.7
â€¢ Maths skill M1.10

Specification reference

â€¢ Standard deviation

Learning objectives

After completing this worksheet you should be able to:

â€¢ calculate standard deviation using a formula
â€¢ relate the calculated values of standard deviation to error bars on graphs
â€¢ compare means of data.

Introduction

Standard deviation shows us how much variation there is between the data and the mean value. It is therefore a measure of spread in the data and gives an indication of the likely reliability of the mean value.

It is possible to calculate standard deviation automatically in a spreadsheet, but you may also be asked to calculate it using a given formula when analysing data.

The formula to use is
()2
1xxsnâˆ'
=
âˆ'
Î£

In the formula:

â€¢ s is standard deviation
â€¢ x refers to each measured value in the dataset
â€¢ refers to the arithmetic mean
x
â€¢ n is the number of values measured
â€¢ Î£ = â€˜the sum ofâ€™, meaning add together the values indicated to the right of this symbol.

Standard deviation becomes more meaningful as the number of measurements in the dataset increases. In general, having fewer than five repeats will not give a meaningful value for standard deviation.

Worked example

Question

As part of an investigation into enzyme action, 10 measurements were made of the gas volume generated by an enzyme reaction at 20 Â°C. The volumes collected (cm3) were as follows:

45, 48, 12, 39, 52, 47, 45, 45, 36, 41

a Calculate the mean volume of gas.

b Calculate the standard deviation of this mean.

c Find the graph error bar values for the mean value.

Answer

a Find the mean by adding together all the values of x and dividing by the number of values.

45 + 48 + 12 + 39 + 52 + 47 + 45 + 45 + 36 + 41 = 410

410 Ã· 10 = 41

so = 41
x

It is easier to do the standard deviation calculation, if you use a table like the one below.

Values of x (volumes in cm3)

Values of x â€“
x

Values of (x â€“)2
x

45

4

16

48

7

49

12

-29

841

39

-2

4

52

11

121

47

6

36

45

4

16

45

4

16

36

-5

25

41

0

0

Number of values n =10

Total of this column
is Î£(x â€“)2
x

The mean, , is 41
x

Î£(x â€“)2 = 1124
x

b Find the values of . These are shown in the second column of the table.
xxâˆ’

Find the square of each of the values, e.g. for the first row: 4 Ã— 4 = 16.
xxâˆ’

The completed values are shown in the third column of the table.

Step 4

Find Î£(x â€“)2 by totalling the values of (x â€“)2, i.e. the sum of the values in the third column, which is 1124.
x
x

Step 5

Divide the total by n â€“1 (number of values â€“1, here it is 10 â€“ 1 = 9).

1124 Ã· 9 = 124.9

Step 6

Take the square root of this number (calculator button marked) to complete the calculation.

= 11.2
124.9

so SD = 11.2

Note: this is quite a high value because an anomalous outlier point has been included (i.e. the value 12, which is clearly out of line with the general pattern).

c When the mean value is plotted as a point on a graph the standard deviation can be used to mark on an error bar. This is simple to do.

Step 7

Find the value for the top of the error bar by adding the standard deviation to the mean:

41 + 11.2 = 52.2

Step 8

Find the value for the bottom of the error bar by subtracting standard deviation from the mean:

41 â€“ 11.2 = 29.8

Step 9

Plot the point on the graph (41). Mark the positions of the top and bottom of the error bar using small pencil dash marks directly above and below the plotted point, in this example at 52.2 and 29.8 as measured from the y-axis. Use a ruler and sharp pencil to draw a vertical line through your plotted point between these limits.

Note that an error bar is different from a range bar, which is drawn by simply using the highest and lowest values as top and bottom rather than the standard deviation. This is not as useful, because an outlying value will have a bigger effect and make the data appear more scattered. Try testing this visually by plotting this example on a sketch graph.

Questions

1 The table shows the results of an experiment with pondweed producing oxygen bubbles at different temperatures.

Temperature / Â°C

Rate of reaction / bubbles per minute

0

3.0

1.0

3.0

6.0

5.0

5

15.0

13.0

15.0

12.0

13.0

10

20.0

23.0

24.0

16.0

21.0

15

22.0

14.0

21.0

12.0

31.0

20

26.0

32.0

36.0

31.0

39.0

a Find the mean value for each row in the table. (5 marks)

b Calculate the standard deviation of each mean value. (5 marks)

c Comment on the reliability of the mean values. (2 marks)

d What are the upper and lower limits of the error bar you would plot for the mean value at 5 Â°C? (2 marks)

2 An identical experiment was carried out by five different students. Not all were as thorough as they should have been, so they were inconsistent in how many repeat measurements they took. Their results are shown in the table.

Student

Results of each repeat done

1

14.0

23.0

9.0

2

17.0

19.0

27.0

20.0

31.0

3

24.0

18.0

21.0

29.0

19.0

26.0

4

19.0

25.0

24.0

18.0

25.0

26.0

23.0

22.0

5

22.0

18.0

27.0

21.0

22.0

23.0

25.0

23.0

23.0

24.0

a Find the mean value for each student's data. (5 marks)

b Calculate the standard deviation of each student's data. (5 marks)

c Compare the mean values by describing and comment on the patterns in these calculations. (5 marks)

Maths skills links to other areas

Whenever you collect data you should consider using standard deviation to test the dispersion of the results and add error bars to your graphs as a normal part of your processing. To save time you can use spreadsheets to find standard deviation automatically.

Answers

1 a The mean values for five temperatures rows are 3.6, 13.6, 20.8, 20.0, and 32.8 (one mark deducted per error. Values must have same decimal places as the original data). (3 marks)

b One mark for each correct value:

The SD values are 1.9, 1.3, 3.1, 7.5, 5.0. (5 marks) c Any two from:

The mean, at 5 Â°C is the most reliable/at 15 Â°C is the least reliable. (1 mark)

Because SD is smallest at 5 Â°C/ largest at 15 Â°C. (1 mark)

Data at 5 Â°C are less spread/have less variation/are less dispersed from the mean/ORA. (1 mark)

2 The limits are 14.9 and 12.3 (one mark for each correct limit). (2 marks)
3 a One mark for each correct answer:

The means for the students from 1 to 5 are 15.3, 22.8, 22.8, 22.8, 22.8. (5 marks)

b One mark for each correct answer:

The SD for the students from 1 to 5 are 7.1, 5.9, 4.3, 2.9, 2.4. (5 marks)

c Any five from:

The true mean is (close to) 22.8;

All students with five or more repetitions succeed in getting an accurate mean

As the number of repeats increases the standard deviation becomes smaller

There is less, spread/dispersion, in the data/outliers have less effect;

Student 1 has insufficient data to calculate an accurate mean

Error bars become smaller as the number of repeats increase

Although the means for students 2â€“5 are the same, students 4 and 5 have the most certainty.

Students 4 and 5 will be able to plot the points with the greatest certainty.

There is no significant benefit in repeating this experiment more than eight times. (max 5 marks)

Using the chi-squared test to analyse genetic crosses

Specification references

â€¢ 3.7.1

â€¢ MS 1.4, MS 1.9, MS 2.3, MS 2.4

Maths Skills for Biology references

â€¢ Chi-squared goodness of fit test in genetics

Learning outcomes

After completing this worksheet you should be able to:

â€¢ apply the chi-squared test to compare observed and expected results
â€¢ understand the role of chance in genetic inheritance.

Introduction

The results of genetic crosses can be predicted using Punnett squares. In these diagrams there is an equal expectation that each combination will occur just by chance, because every gamete has an equal chance of being the one that is randomly combined at fertilisation.

Worked example

Question

In the Drosophila fly, the allele for long wing is dominant over that for vestigial wing. A cross between two heterozygous long winged flies gave 68 offspring in the ratio 55 long winged and 13 vestigial winged. Use the chi-squared test to determine the significance of the difference between observed and expected results.

Answer

The null hypothesis is that any difference between the observed and expected results is due to chance.

Step 1: Work out the possible results of the cross using a Punnett square.

Long wing = L; vestigial wing = l

Parental genotypes Ll Ã— Ll

Possible gametes L or l Ã— L or l

F1 combinations

gametes

gametes

L

l

L

LL

Ll

l

Ll

ll

Ratio expected 3 Long winged : 1 vestigial winged

Step 2: The formula for the chi-squared test is
()2Ï‡
22(OE)
Eâˆ’
Ï‡=Î£

It is easiest to lay out the calculation in a table like this:

Observed (O)

Expected (E)

(Oâˆ’E)

(Oâˆ’E)2

â^’2(OE)
E

Long winged
flies

55

51

4

16

0.314

Vestigial
winged flies

13

17

â€“4

16

0.941

Step 3: Total the values in the last column to find chi-squared, 0.314 + 0.941 = 1.255

Step 4: Find the degrees of freedom (df) in the data using

df = number of categories â^’ 1

Here two categories (long or vestigial wing) so 2 â^’ 1 = 1 df

Step 5:

Look up the value in the chi-squared distribution table, reading along the row corresponding with your df until you find the position of your calculated value. The p values at the tops of the columns indicate the probability that the results were just due to chance, i.e. there is no underlying causal factor skewing the outcome in some way. In this example the p values are between 50% and 10%, so chance alone did cause the outcome.

You can only decide that chance is not causing the outcome and that there is another causing factor where the p value is less than or equal to 5% (0.05). The values of chi-squared corresponding to the 5% probability level are often referred to as critical values.

Questions

1 A character for stem height in pea plants has a dominant allele giving tall stems and a recessive allele giving short stems. In a cross between two heterozygous individuals, 315 tall and 101 short plants were produced. Use the chi-squared test to determine the significance of the difference between observed and expected results.

(3 marks)

2 When two pink antirrhinum plants produced seed, the 96 F1 plants grew in the ratio 26 red : 51 pink : 19 white.

a Calculate the value of chi-squared.

(2 marks)

b The critical values of chi-squared at two degrees of freedom are 4.60 at the 10% level and 5.99 at the 5% level. Comment on your value of chi-squared in the light of these values.

(3 marks)

3 In a species of plant, leaf pigments are controlled by two alleles, G gives green leaves, g gives white leaves and the heterozygous Gg has variegated leaves (partially green and partially white). Two variegated plants were crossed and the seeds collected and grown. The resulting F1 plants were examined after two weeks and the leaf colours were 16 green leaved plants and 21 variegated plants.

a Determine the significance of the difference between the observed and expected results using the chi-squared test.

(3 marks)

b Explain the absence of white leaved plants in the F1.

(2 marks)

Maths skills links to other areas

The chi-squared test is used to test how well observed data fit with expectation. It is used in situations where the expected outcome can be clearly predicted, genetics being the example most often used. You will also need to apply statistical tests to compare the difference between sets of data (t test) and to test the correlation between variables (correlation coefficient). Worksheets on these two tests are also available on the Kerboodle site.

Answers

1 Chi-squared = 0.115 with one degree of freedom (1 mark)

p <0.9 and >0.5 / <90% and >50% mean that the difference between observed and expected values is due to chance (1 mark)

the difference is due to chance alone (1 mark)

(3 marks)

2 a Chi-squared = 1.396 (2 marks)

b The value is less than the critical values at both the 5% and the 10% levels of probability

(1 mark)

Therefore the p value is greater than 10% (1 mark)

The results are due only to chance (1 mark)

(3 marks)

3 a Chi-squared = 14.514 with two degrees of freedom (1 mark)

p <0.001 âˆ• <0.1% shows that the data are due to chance alone (1 mark)

The distribution is very unlikely to be due to chance (only 0.1%), so some factor
is causing the outcome to be skewed (1 mark)

(3 marks)

b White leaves contain no chlorophyll so they are unable to photosynthesise; they all die

(2 marks)

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:

- to pre-learn some useful knowledge from the first chapters of your A Level course
- understand and practise of some of the maths skills you'll need.

Learning objectives

After completing the worksheet you should be able to:

- define practical science key terms
- recall the answers to the retrieval questions
- perform maths skills including:
  - converting between units, standard form, and prefixes
  - using significant figures
  - rearranging formulae
  - magnification calculations
  - calculating percentages, errors, and uncertainties
  - drawing and interpreting line graphs.

Retrieval questions

You need to be confident about the definitions of terms that describe measurements and results in A Level Biology.

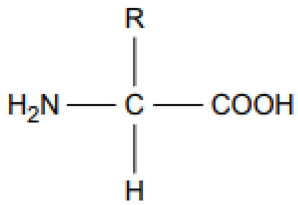
Learn the answers to the questions below then cover the answers column with a piece of paper and write as many answers as you can. Check and repeat.

Practical science key terms

When is a measurement valid?	when it measures what it is supposed to be measuring
When is a result accurate?	when it is close to the true value
What are precise results?	when repeat measurements are consistent/agree closely with each other
What is repeatability?	how precise repeated measurements are when they are taken by the *same* person, using the *same* equipment, under the *same* conditions
What is reproducibility?	how precise repeated measurements are when they are taken by *different* people, using *different* equipment
What is the uncertainty of a measurement?	the interval within which the true value is expected to lie
Define measurement error	the difference between a measured value and the true value
What type of error is caused by results varying around the true value in an unpredictable way?	random error
What is a systematic error?	a consistent difference between the measured values and true values
What does zero error mean?	a measuring instrument gives a false reading when the true value should be zero
Which variable is changed or selected by the investigator?	independent variable
What is a dependent variable?	a variable that is measured every time the independent variable is changed
Define a fair test	a test in which only the independent variable is allowed to affect the dependent variable
What are control variables?	variables that should be kept constant to avoid them affecting the dependent variable

Biological molecules

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many answers as you can. Check and repeat.

What are monomers?	smaller units from which larger molecules are made
What are polymers?	molecules made from a large number of monomers joined together
What is a condensation reaction?	a reaction that joins two molecules together to form a chemical bond whilst eliminating of a molecule of water
What is a hydrolysis reaction?	a reaction that breaks a chemical bond between two molecules and involves the use of a water molecule
What is a monosaccharide?	monomers from which larger carbohydrates are made
How is a glycosidic bond formed?	a condensation reaction between two monosaccharides
Name the three main examples of polysaccharides	glycogen, starch, cellulose
Describe Benedict's test for reducing sugars	gently heat a solution of a food sample with an equal volume of Benedict's solution for five minutes, the solution turns orange/brown if reducing sugar is present
Name the two main groups of lipids	phospholipids, triglycerides (fats and oils)
Give four roles of lipids	source of energy, waterproofing, insulation, protection
What is an ester bond?	a bond formed by a condensation reaction between glycerol and a fatty acid
Describe the emulsion test for lipids	mix the sample with ethanol in a clean test tube, shake the sample, add water, shake the sample again, a cloudy white colour indicates that lipid is present
What are the monomers that make up proteins?	amino acids
Draw the structure of an amino acid	
How is a peptide bond formed?	a condensation reaction between two amino acids
What is a polypeptide?	many amino acids joined together
Describe the biuret test for proteins	mix the sample with sodium hydroxide solution at room temperature, add very dilute copper(II) sulfate solution, mix gently, a purple colour indicates that peptide bonds are present
How does an enzyme affect a reaction?	it lowers the activation energy
Give five factors which can affect enzyme action	temperature, pH, enzyme concentration, substrate concentration, inhibitor concentration
What is a competitive inhibitor?	a molecule with a similar shape to the substrate, allowing it to occupy the active site of the enzyme
What is a non-competitive inhibitor?	a molecule that changes the shape of the enzyme by binding somewhere other than the active site.

Basic components of living systems

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many answers as you can. Check and repeat.

What is the formula to calculate magnification?	$\text{magnification} = \dfrac{\text{size of image}}{\text{actual size of object}}$
Why are cells stained before being viewed with a light microscope?	staining increases contrast between different cell components, makes them visible, and allows them to be identified
What is an eyepiece graticule?	a glass disc that fits on top of the eyepiece lens that is marked with a fine scale from 1 to 100
What is a stage micrometer?	a microscope slide with a very accurate scale in micrometers (μ) engraved on it
What is a scientific drawing?	a labelled line drawing that is used to highlight particular features and does not include unnecessary detail or shading, it should always have a title and state the magnification
What is magnification?	how many times larger an image is than the actual size of the object being viewed
What is resolution?	the ability to see individual objects as separate entities
What is the function of the nucleus?	controls the metabolic activities of the cell as it contains genetic information in the form of DNA
What is the nucleolus?	area within the nucleus that is responsible for producing ribosomes
What is the function of mitochondria?	site of production of ATP in the final stages of cellular respiration
What are vesicles?	membranous sacs that are used to transport materials in the cell
What are lysosomes?	specialised forms of vesicles with hydrolytic enzymes that break down waste material in cells
What is the role of the cytoskeleton?	controls cell movement, movement of organelles within the cell, and provides mechanical strength to the cell
Name the three types of cytoskeletal filaments	microfilaments, microtubules, and intermediate fibres
Give two types of extension that protrude from some cells	flagella (whip-like protrusions) and cilia (tail-like protrusions)
What is the endoplasmic reticulum (ER)?	a network of membranes enclosing flattened sacs called cisternae
What are the functions of the two types of ER?	smooth ER – lipid and carbohydrate synthesis, and storage rough ER – synthesis and transport of proteins
What is the function of the Golgi apparatus?	plays a part in modifying proteins and packaging them into vesicles

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.

$488\,889 \div 10^3 = 488.889$ 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 questions

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

A decimal number has a decimal point. Each figure *before* the point is a whole number, and the figures *after* the point represent fractions.

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:

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 questions

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 5.995×10^2 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.

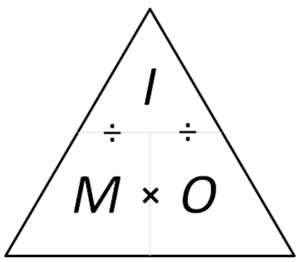
5 In a quadrat sample, an area was found to contain 96 aphids, 4 ladybirds, 22 grasshoppers, and 3 ground beetles. Calculate the diversity of the site using the equation $D = 1 - \Sigma\left(\frac{n}{N}\right)^2$ *where* n = number of each species, N = grand total of all species, and D = diversity.

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:

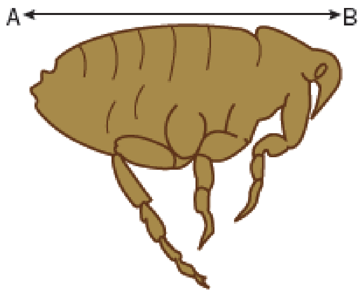
a objective ×10 and eyepiece ×12 **b** objective ×40 and eyepiece ×15

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.

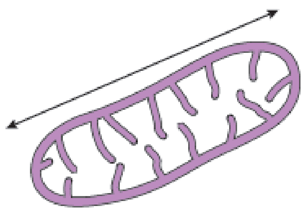
$$\text{magnification} = \frac{\text{length of image}}{\text{length of real specimen}} = 42/1.3 = 32.31$$

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 questions

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.

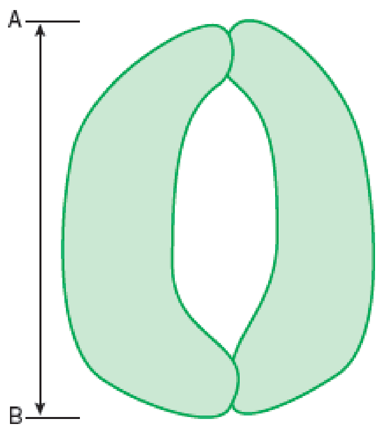
Step 2: Convert this measurement to units appropriate to the image. In this case you should use μm because it is a cell.

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

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

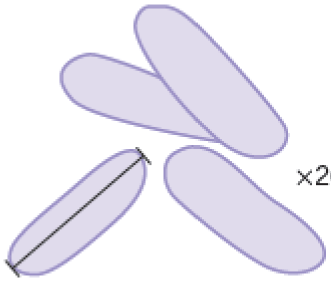
real size = size of image/magnification = 52 000/5000 = 10.4

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



Practice questions

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



5 Percentages and uncertainty

A percentage is simply a fraction expressed as a decimal. It is important to be able to calculate routinely, but is often incorrectly calculated in exams. These pages should allow you to practise this skill.

5.1 Calculating percentages as proportions

To work out a percentage, you must identify or calculate the total number using the equation:

$$\text{percentage} = \frac{\text{number you want as a percentage of total number}}{\text{total number}} \times 100\%$$

For example, in a population, the number of people who have brown hair was counted.

The results showed that in the total population of 4600 people, 1800 people had brown hair.

The percentage of people with brown hair is found by calculating:

$$\frac{\text{number of people with brown hair}}{\text{total number of people}} \times 100$$

$$= \frac{1800}{4600} \times 100 = 39.1\%$$

Practice questions

1 The table below shows some data about energy absorbed by a tree in a year and how some of it is transferred.

Energy absorbed by the tree in a year	3 600 000 kJ/m^2
Energy transferred to primary consumers	2240 kJ/m^2
Energy transferred to secondary consumers	480 kJ/m^2

Calculate the percentage of energy absorbed by the tree that is transferred to

a primary consumers **b** secondary consumers.

2 One in 17 people in the UK has diabetes.

Calculate the percentage of the UK population that have diabetes.

5.2 Calculating the percentage change

When you work out an increase or a decrease as a percentage change, you must identify, or calculate, the total original amount:

$$\% \text{ increase} = \frac{\text{increase}}{\text{original amount}} \times 100$$

$$\% \text{ decrease} = \frac{\text{decrease}}{\text{original amount}} \times 100$$

Remember: When you calculate a percentage change, use the total *before* the increase or decrease, not the final total.

Practice questions

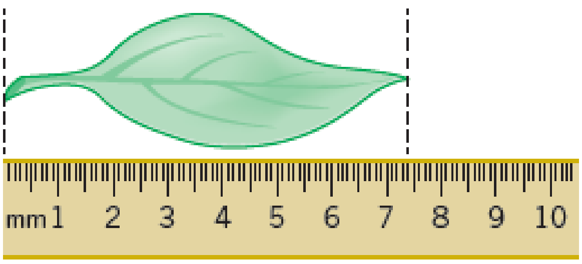
3 Convert the following mass changes as percentage changes.

Sucrose conc. / mol dm^{-3}	Initial mass / g	Final mass / g	Mass change / g	Percentage change in mass
0.9	1.79	1.06		
0.7	1.86	1.30		
0.5	1.95	1.70		
0.3	1.63	1.76		
0.1	1.82	2.55		

5.3 Measurement uncertainties

When you measure something, there will always be a small difference between the measured value and the true value. This may be because of the size of the scale divisions on your measuring equipment, or the difficulty of taking the measurement. This is called an uncertainty.

To estimate the uncertainty of a measurement with an instrument with a marked scale such as a ruler, a good rule of thumb is to let the uncertainty be equal to half the smallest division on the scale being used.



Using a ruler with a mm scale, the length of the leaf seems to be 74 mm. The smallest division is 1 mm, so the uncertainty is 0.5 mm.

The true length is therefore 74 mm +/− 0.5 mm.

Practice questions

4 Give the uncertainty for the following pieces of equipment:

a large measuring cylinder with 2 cm^3 divisions

b digital stopwatch timer measuring to the nearest hundredth of a second

c thermometer with 0.1 °C divisions.

5.4 Calculating percentage uncertainties

The uncertainty is the range of possible error either side of the true value due to the scale being used, so the value recorded for the measurement = closest estimate +/− uncertainty.

The difference between the true value and the maximum or minimum value is called the **absolute error**.

Once the absolute error has been established for a particular measurement, it is possible to express this as a percentage uncertainty or **relative error**. The calculation to use is:

$$\text{relative error} = \frac{\text{absolute error}}{\text{measured value}} \times 100\%$$

In the leaf example above, the absolute error is +/−0.5 mm.

The relative error is therefore:

0.5/74 × 100% = 0.7%

Practice questions

5 Complete the table to show the missing values in the last two columns.

Measurement made	Equipment used	Absolute error	Relative error
Length of a fluid column in a respirometer is 6 mm	mm scale	0.5 mm	
Volume of a syringe is 12 cm^3 of liquid	0.5 cm^3 divisions		
Change in mass of 1.6 g	balance with 2 d.p.		

6 Scatter graphs and lines of best fit

The purpose of a scatter graph with a line of best fit is to allow visualisation of a trend in a set of data. The graph can be used to make calculations, such as rates, and also to judge the correlation between variables. It is easy to draw such a graph but also quite easy to make simple mistakes.

6.1 Plotting scatter graphs

The rules when plotting graphs are:

- Ensure that the graph occupies the majority of the space available:
  - In exams, this means more than half the space
  - Look for the largest number to help you decide the best scale
  - The scale should be based on 1, 2, or 5, or multiples of those numbers

- Ensure that the dependent variable that you measured is on the *y*-axis and the independent variable that you varied is on the *x*-axis
- Mark axes using a ruler and divide them clearly and equidistantly (i.e. 10, 20, 30, 40 not 10, 15, 20, 30, 45)
- Ensure that both axes have full titles and units are clearly labelled
- Plot the points accurately using sharp pencil 'x' marks so the exact position of the point is obvious
- Draw a neat best fit line, either a smooth curve or a ruled line. It does not have to pass through all the points. Move the ruler around aiming for:
    - as many points as possible on the line
    - the same number of points above and below the line
- If the line starts linear and then curves, be careful not to have a sharp corner where the two lines join. Your curve should be smooth
- Confine your line to the range of the points. Never extrapolate the line beyond the range within which you measured
- Add a clear, concise title.

Remember: Take care, use only pencil and check the positions of your points.

Practice questions

1 Use your calculated data in Topic 5.2 question 3 to plot a graph of % mass change against sucrose concentration.

2 For each of the tables of data:

a Plot a scatter graph

b Draw a line of best fit

c Describe the correlation

Turbidity of casein samples at different pH	
pH	**% transmission (blue light)**
9.00	99
8.00	99
6.00	87
5.00	67
4.75	26
4.50	30
4.00	24
3.75	43
3.50	64

Sodium bicarbonate concentration / %	Rate of oxygen production by pondweed / $mm^3\ s^{-1}$
6.5	1.6
5.0	2.1
3.5	1.2
2.0	0.8
1.0	0.5
0.5	0.2

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

1 10.0214 cm^2 0.0218 cm^2 0.03 cm^2 0.034 cm^2

2 12.03 cm 12.901 cm 22 cm 22.003 cm 22.25 cm

3 **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)

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

7 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: biomass transfer $= \frac{0.84}{100} \times 25$ = 0.21 kg

4 Magnification

1 **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

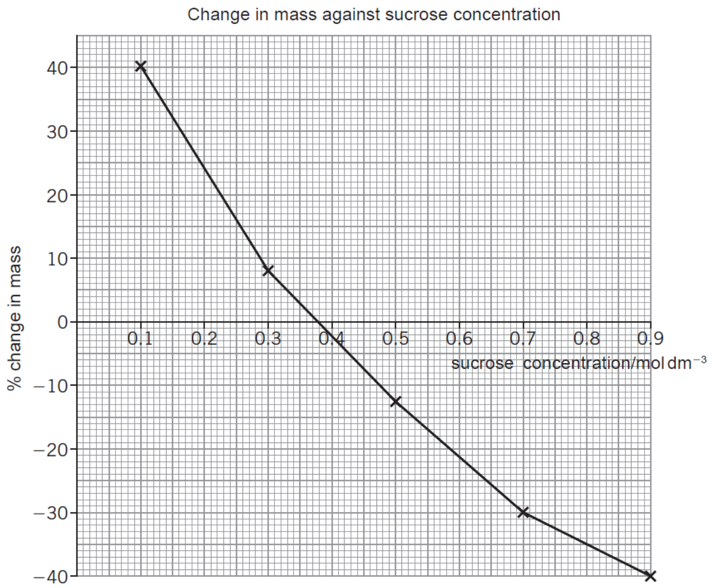
Sucrose conc. / mol dm^{-3}	Initial mass / g	Final mass / g	Mass change / g	Percentage change in mass
0.9	1.79	1.06	−0.73	−40.8%
0.7	1.86	1.30	−0.56	−30.1%
0.5	1.95	1.70	−0.25	−12.8%
0.3	1.63	1.76	+0.13	+8.0%
0.1	1.82	2.55	+0.73	+40.1%

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	$\frac{0.005 \times 2}{1.6} \times 100 = 0.6\%$

6 Scatter graphs and lines of best fit



1 .

2 Table 1: Strong correlation. Positive at the start. As light intensity increases, the increase in the rate of photosynthesis decreases (so the graph levels off).

Table 2: Strong correlation. Negative at the start. As time increases, the rate of the decrease of the concentration decreases (so the graph levels off).