RIPLEY ST THOMAS

A-LEVEL BIOLOGY

BRIDGING BOOKLET

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CONTENTS:

THIS PACK CONTAINS A PROGRAMME OF ACTIVITIES AND RESOURCES TO PREPARE YOU FOR A-LEVEL BIOLOGY. THE COMPULSORY TRANSITION TASKS AT THE BEGINNING MUST BE DONE FOR SEPTEMBER, YOU WILL BE ASSESSED ON THESE.

KEY INFO:

We follow Pearson Edexcel Biology B. The specification can be found here: https://qualifications.pearson.com/en/qualifications/edexcel-a-levels/biology-b-2015.html

If you have any questions please contact montgomeryk@ripley.lancs.sch.uk

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BRAVO ON BEING A BRILLIANT BIOLOGIST!

science
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TRANSITION TASKS

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IMPORTANT:

These are the compulsory tasks 1,2&3 you will need to have complete by September.

Particularly focus on learning the structures of those biological molecules off by heart!

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Year 12 Biology Summer Work

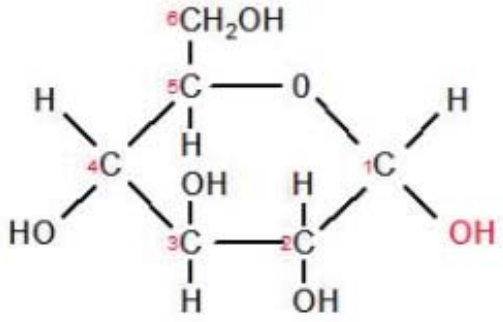
Task 1

Throughout your A Level Biology course there will be a huge amount of content that you will be required to learn. This summer work is designed to give you a taste of this.

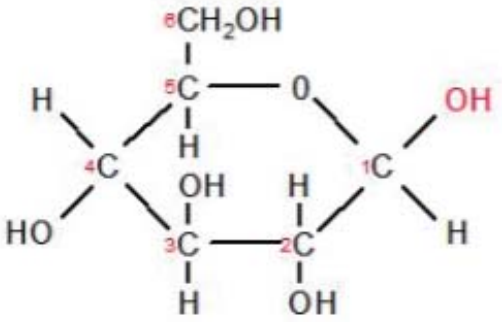
Over the summer, you must learn the following content off by heart for a mini assessment in September. You will be required to document how you have learnt this content and you will be asked to write a reflection on this too following the assessment.

In carbohydrates, the basic monomer is a sugar, otherwise known as a saccharide. A single monomer is therefore called monosaccharide. A pair of monosaccharides can be combined to form a disaccharide.

Learn the structures of the 2 monosaccharides: alpha and beta glucose.

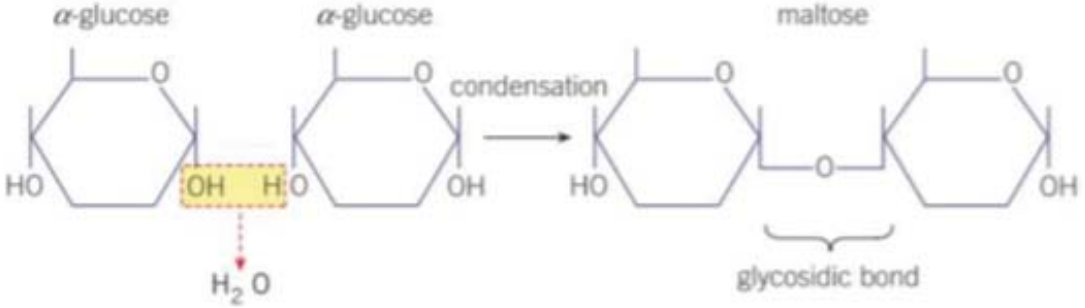


α-glucose

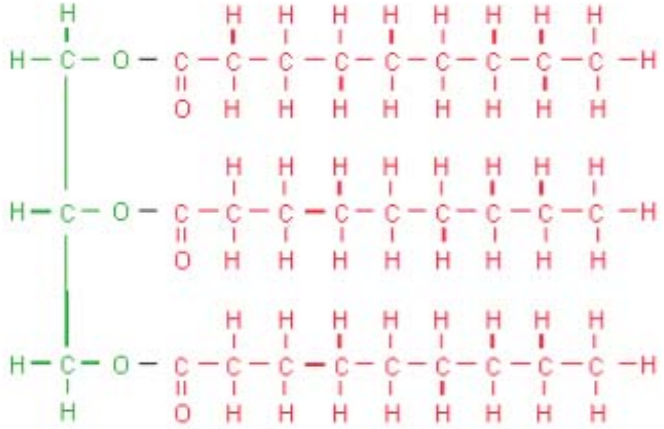


β-glucose

When two molecules of alpha-glucose join to form maltose a condensation reaction occurs and water is removed. The bond formed is called a glycosidic bond and a disaccharide is formed. Learn the diagram below to show the formation of maltose form its monomers:



Another type of biological molecule are lipids. The main group of lipids are the triglycerides. Triglycerides are so called because they have three (tri) fatty acids combined with glycerol. Each fatty acid forms an ester bond with glycerol.

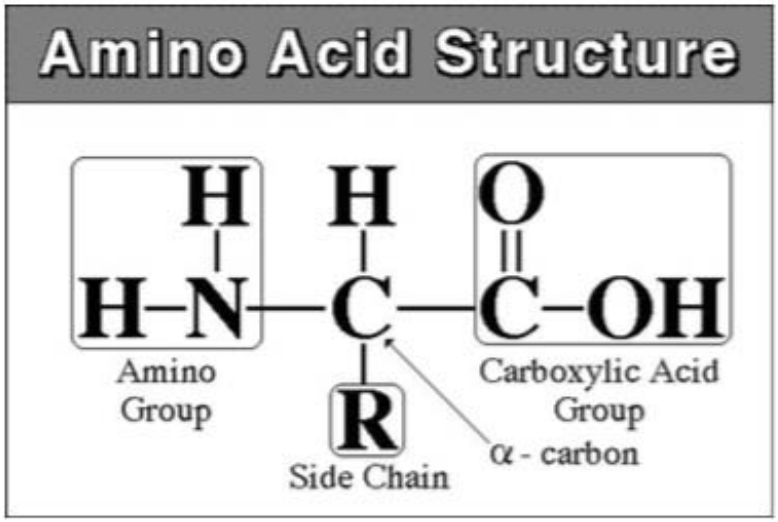


Learn the structure of the triglyceride above.

Finally, proteins are usually very large molecules.

Amino acids are the basic monomer units which combine to make up a polymer called a polypeptide. Polypeptides can be combined to form proteins.

Learn the general structure of an amino acid below.



When amino acid monomers join they form peptide bonds. The water is made by combining an –OH from the carboxyl group of one amino acid and an –H from the amino group of the other amino acid.

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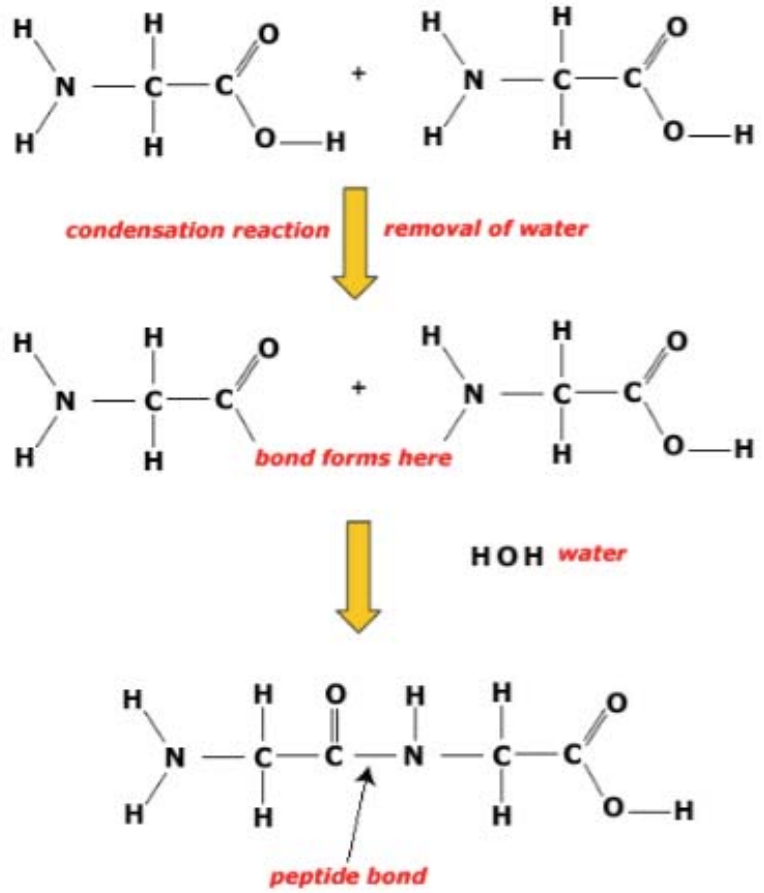
Learn the diagram below showing the formation of a peptide bond:

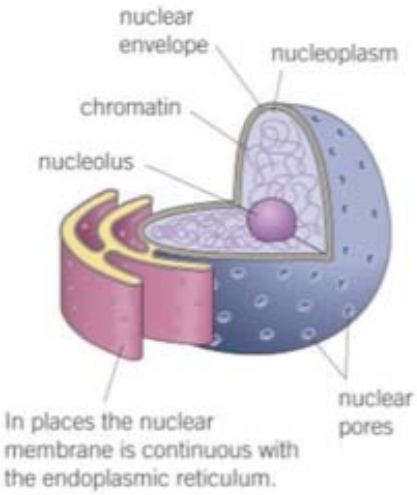
Dipeptide formation



Cells are the basic building blocks of life. In the A Level Biology course you will learn about cell structure in much more detail.

You are required to learn the structure and functions of the nucleus, mitochondria and ribosomes.

NUCLEUS



The nucleus

The nucleus is usually the largest organelle in the cell (1–20 μm) and it can be seen with the light microscope. Electron micrographs show that the nucleus, which is usually spherical in shape, is surrounded by a double nuclear membrane containing holes or pores, known as the nuclear envelope. Chemicals can pass in and out of the nucleus through these pores so that the nucleus can control events in the cytoplasm. Inside the nuclear envelope are two main substances, nucleic acids and proteins. The nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) (see **Chapter 1.3**).

When the cell is not actively dividing, the DNA is bonded to the protein to form **chromatin**, which looks like tiny granules. Also in the nucleus there is at least one **nucleolus** – an extra-dense area of almost pure DNA and protein. The nucleolus is involved in the production of ribosomes. Recent research also suggests that the nucleolus plays a part in the control of cell growth and division.

Mitochondria

Mitochondria

The name **mitochondrion** simply means 'thread granule' and describes the tiny rod-like structures that are 1 μm wide by up to 10 μm long, seen in the cytoplasm of almost all eukaryotic cells under the light microscope. In recent years, by using the electron microscope we have been able to understand not only their complex structure, but also their vital functions.

The mitochondria are the 'powerhouses' of the cell. Here, in a series of complicated biochemical reactions, simple molecules are oxidised in the process of cellular respiration, producing ATP (see **Chapter 1.3**) that can be used to drive the other functions of the cell and indeed the organism. The number of mitochondria present can give you useful information about the functions of a cell. Cells that require very little energy, for example white fat storage cells, have very few mitochondria. Any cell with an energy demanding function, for example muscle cells or cells that carry out a lot of active transport such as liver cells, will contain large numbers of mitochondria.

An outer and inner membrane surround the mitochondria. They also contain their own genetic material, so that when a cell divides, the mitochondria replicate themselves under the control of the nucleus. This mitochondrial DNA is part of the whole genome of the organism.

Mitochondria have an internal arrangement adapted for their function (see **fig B**). The inner membrane is folded to form **cristae**, which give a very large surface area, surrounded by a fluid matrix. This structure is closely integrated with the events in cellular respiration that take place in the mitochondrion (see **Book 2 Sections 5.1.3** and **5.1.4**). Backed by evidence that shows that mitochondria have their own DNA, scientists think that mitochondria and chloroplasts originated as symbiotic **eubacteria** living inside early cells. Over millions of years of evolution they have become an integral part of the cell (see **Section 3.1.5**). This is the **endosymbiotic theory** of the evolution of eukaryotic cells.

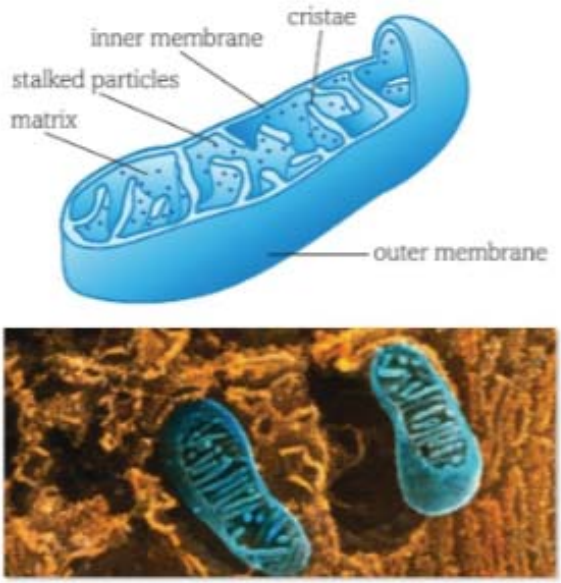


fig B The 3D structure of the mitochondria (blue) is closely related to their functions in cellular respiration.

Ribosomes

80S and 70S ribosomes

In **Section 1.3.5** you met ribosomes, the organelles on which protein synthesis takes place in the cytoplasm of the cell. Ribosomes are made from ribosomal RNA and protein, and consist of a large subunit and a small subunit. The main type of ribosomes in eukaryotic cells are **80S ribosomes**. The 'S' stands for Svedberg, a unit used to measure how quickly particles settle in a centrifuge. The rate of sedimentation depends on the size and shape of the particle. When 80S ribosomes are broken into their two units, they are made up of a 40S small subunit and a 60S large subunit. The ratio of RNA : protein in 80S ribosomes is 1 : 1.

However, eukaryotic cells also contain another type of ribosome. Scientists have discovered **70S ribosomes** in the mitochondria, and in the chloroplasts of plant cells. These ribosomes are usually found in prokaryotic cells (bacteria and cyanobacteria). They are made up of a small 30S subunit and a larger 50S subunit and the ratio of RNA : protein in 70S ribosomes is 2 : 1.

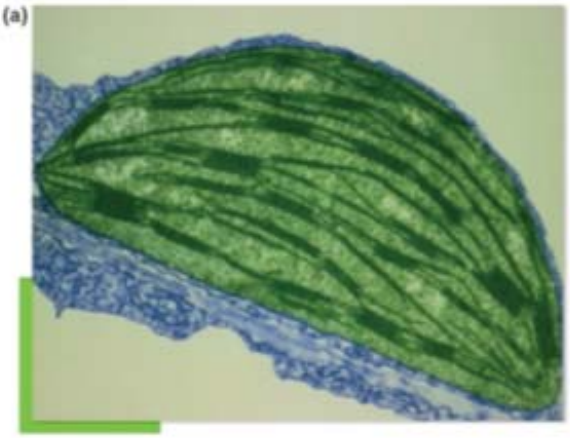
These 70S ribosomes are reproduced in the mitochondria and chloroplasts independently when a cell divides. This is seen as good evidence for the endosymbiotic theory that mitochondria and chloroplasts evolved from bacteria caught inside eukaryotic cells very early on in the process of evolution.

Chloroplasts

Chloroplasts

Of all the differences between plant and animal cells, the presence of **chloroplasts** in plant cells is probably the most important because they enable plants to make their own food. Not all plant cells contain chloroplasts – only those cells from the green parts of the plant. However, almost all plant cells contain the genetic information to make chloroplasts and so in some circumstances different areas of a plant will become green and start to photosynthesise. The exceptions are parasitic plants such as broomrape. Cells in flowers, seeds and roots contain no chloroplasts and neither do the internal cells of stems or the transport tissues. In fact the majority of plant cells do not have chloroplasts, but these organelles are very special and unique to plants.

(a)



(b)

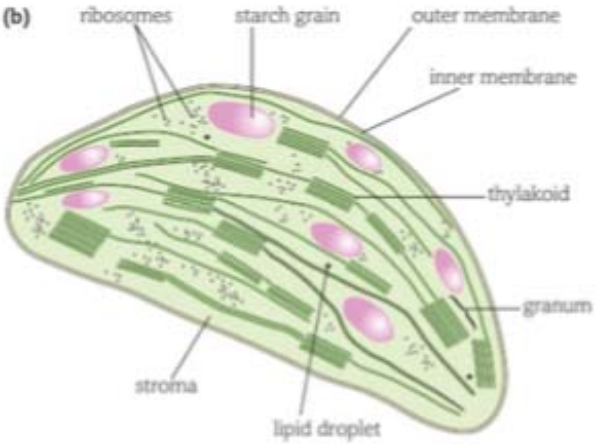


fig 8 (a) Micrograph of a chloroplast; and (b) Labelled diagram to show structures in a chloroplast.

There are some clear similarities between chloroplasts and mitochondria. Like mitochondria, chloroplasts:

- are large organelles: they have a biconvex shape with a diameter of 4–10 μm and are 2–3 μm thick
- contain their own DNA
- are surrounded by an outer membrane
- have an enormously folded inner membrane that gives a greatly increased surface area on which enzyme-controlled reactions take place
- are thought to have been free-living prokaryotic organisms that were engulfed by and became part of other cells at least 2000 million years ago.

However, there are also some clear differences. Chloroplasts:

- are the site of photosynthesis
- contain **chlorophyll**, the green pigment that is largely responsible for trapping the energy from light, making it available for the plant to use
- are formed from a type of relatively unspecialised plant organelle known as a leucoplast.

Amyloplasts

Amyloplasts are another specialised plant organelle and, like chloroplasts, they develop from leucoplasts. They are colourless and store starch (see **Section 1.2.2**). This can then be converted to glucose and used to provide energy when the cell needs it. Amyloplasts are found in large numbers in areas of a plant that store starch, for example potato tubers.

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Task 2

The second piece of summer work is a short introduction to some of the maths skills you will require for the course.

Use the information below to help you answer the following questions.

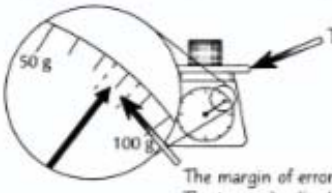
Uncertainties

The results you get from an experiment won't be completely perfect — this is due to ***uncertainties*** *in your readings.*

Accuracy Depends on your Equipment

When you take a reading, it's likely that the value you get is not the **true** value. The true value will lie **within a range** of values. This range is called the **margin of error**. It depends on the apparatus you're using. E.g.:

A reading is when you make a judgement about one value, e.g. when you read a value of mass off a balance. A measurement is when you judge two values and find the difference, e.g. when you measure length with a ruler.

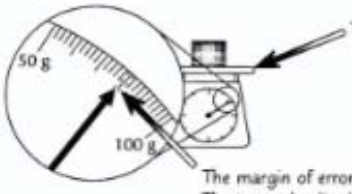


This balance has graduations for every 10 g.

The mass of the box is measured as 80 g, to the nearest 10 g — its true mass could be 5 g more or less.

You can write this as **80 ± 5 g**. ← The uncertainty is ± 5 g.

The margin of error is 10 g.
The true value lies between 75 and 85 g.



This balance has graduations for every 2 g.

The mass of the box is measured as 80 g, to the nearest 2 g — its true mass could be 1 g more or less.

So its mass is **80 ± 1 g**. ← The uncertainty is ± 1 g.

The margin of error is 2 g.
The true value lies between 79 and 81 g.

The **smaller** the margin of error given by your apparatus, the **closer** to the true value the reading should be.

Combining Readings ***Combines Uncertainties***

When you've got **two or more** readings that you're **adding together**, you need to **add** their uncertainties.

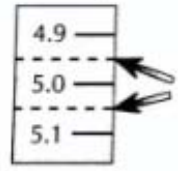
Worked example

5.0 cm^3 of glucose solution is measured using a pipette that has graduations for every 0.1 cm^3. The glucose solution is added to 10.0 cm^3 of distilled water that has been measured using a measuring cylinder that has graduations for every 0.5 cm^3.

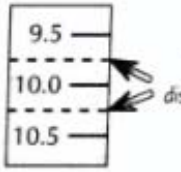
What is the total volume and uncertainty of the glucose solution and water?

1 ***Work out the margin of error of each reading.***

The margin of error is equal to the distance between the two smallest graduations:



The true volume of glucose solution is between these two values.



The true volume of distilled water is between these two values.

The margin of error of the pipette is: 0.1

The margin of error is half the amount of the distance between graduations in each direction, so in total it's the same value.

The margin of error of the measuring cylinder is: 0.5

2 ***Find the uncertainty of each reading.***

Divide the margin of error by 2. → $0.1 \div 2 = \pm$ **0.05 cm³**, $0.5 \div 2 = \pm$ **0.25 cm³**

3 ***Add together the measured volumes to get the combined measured volume.***

$5.0\ cm^3 + 10.0\ cm^3 =$ **15.0 cm³**

Make sure that all the volumes are in the same units.

4 ***Add together the uncertainties to get the combined uncertainty.***

$0.05\ cm^3 + 0.25\ cm^3 = \pm$ **0.3 cm³**

5 ***Combine your answers for steps 3 and 4 to get the total volume and uncertainty.***

The total volume and uncertainty is **15.0 ± 0.3 cm³**

You Can Calculate the Percentage Error

The **percentage error** does what it says on the tin really — it gives the error as a percentage of the reading. You can calculate it like this:

$$\text{percentage error} = \frac{\text{uncertainty}}{\text{reading}} \times 100$$

The smaller the reading is, the larger the percentage error will be.

Worked Example

5.0 cm³ of distilled water is measured with an uncertainty of ± 0.1 cm³.
What is the percentage error for this volume?

1 ***Divide the uncertainty by the reading.***

$0.1 \div 5.0 = 0.02$

2 ***Multiply the result by 100.***

$0.02 \times 100 =$ **2%**

The percentage error of double denim is arguably 100%.

Practice Questions

Q1 Calculate the uncertainty for:

a) A balance that measures mass to the nearest 0.02 g.

b) A thermometer that measures temperature to the nearest 0.5 °C.

Q2 A pH meter that gives readings to the nearest 0.05 reads the pH of a solution as 6.30.
Give the range of values that the true pH of the solution lies in.

Q3 A 10 cm³ pipette that has graduations to mark every 0.1 cm³ is used to measure 7.5 cm³ of glucose solution.

a) What is uncertainty of the pipette?

b) What is the percentage error for the volume of glucose solution measured?

Q4 Sayid measures 4.0 cm³ of starch solution in a pipette that has graduations for every 0.2 cm³.
He then measures 25.0 cm³ of water in a beaker that has graduations for every 1.0 cm³.

a) Which reading has the greater percentage error?

b) Sayid adds the two liquids together. What is the total volume and uncertainty?

Task 3

Further calculations

Read the notes and the worked examples in order to attempt the following questions.

2.7 Water potential

Understanding water potential

Water potential (Ψ) is a measure of the tendency for water molecules to diffuse into or out of solutions and cells by osmosis. The key variables affecting water potential are the contribution made to the solution by the solutes (solute potential Ψ_s) and the pressure of the plasma membrane or cell wall pushing on the contents of the cell (pressure potential Ψ_p). Knowing the water potential allows predictions to be made about the direction of water diffusion between cells and between cells and solutions.

Cells in solutions

Unlike animal cells, when water diffuses into plant cells they do not burst because they have a cellulose cell wall. Pressure potential (Ψ_p) builds up and prevents more water entering. When the water potential of the plant cell is equal to the water potential of the solution surrounding it, there will be no net movement of water molecules (i.e. equilibrium is reached).

WORKED EXAMPLE

Water potential, solute potential and pressure potential have the following relationship:

$$\Psi = \Psi_s + \Psi_p$$

Ψ has a maximum value of zero (distilled water) and becomes negative as solute is dissolved.

Ψ_s is always a negative value, which becomes more negative as more solute is dissolved.

Ψ_p is a positive pressure and is exerted by either the plasma membrane or the cell wall.

The units are kPa.

a The diagram shows two adjacent plant cells. Calculate the value of Ψ_{cell} for each one and determine the direction of any osmotic diffusion.

Cell A	Cell B
$\Psi_s = -700$ kPa	$\Psi_s = -500$ kPa
$\Psi_p = 200$ kPa	$\Psi_p = 100$ kPa

Cell A	Cell B
$\Psi_{cell} = \Psi_s + \Psi_p$	$\Psi_{cell} = \Psi_s + \Psi_p$
$\Psi_{cell} = -700 + 200$ kPa	$\Psi_{cell} = -500 + 100$ kPa
$\Psi_{cell} = -500$ kPa	$\Psi_{cell} = -400$ kPa

Cell B has a higher water potential (nearer to zero) so water diffuses from cell B to cell A by osmosis.

b Determine the water potential of the cells at equilibrium.

To answer this, remember that at equilibrium, Ψ of the two cells must be equal. So add the two values of Ψ then divide by two.

In this example $(-500 + -400) \div 2 = -450$ kPa

c If cell A was placed in a bathing solution of $\Psi = -200$ kPa, calculate the direction of osmotic diffusion and the value of Ψ_{cell} and Ψ_p at equilibrium.

The solution has a higher water potential so water diffuses from the solution into cell A by osmosis, raising the pressure potential. This causes the cell's water potential to increase until it is exactly equal to that of the solution and no further osmotic influx is possible.

REMEMBER: Ψ has a maximum value of zero. The more negative Ψ, the lower the water potential. Water diffuses from high to low water potential.

NOTE: This is a hypothetical situation: the volumes of water actually moving are so tiny that they have a negligible effect on Ψ_s, which is therefore assumed to remain unchanged.

At equilibrium the water potential of the cell will be equal to that of the solution, −200 kPa.
Therefore $\Psi_{cell} = \Psi_s + \Psi_p$ now gives $-200 = -700 + \Psi_p$
So Ψ_p must be 500 kPa.

NOTE: Incipient plasmolysis is the point at which a plant cell placed in a solution with a lower water potential is just at the point of achieving plasmolysis. At this point $\Psi_p = 0$ and any further reduction in the water potential bf the bathing solution will result in plasmolysis occurring, which will be visible with a microscope.

PRACTICE QUESTIONS

1 Determine the direction of osmotic flow in each of the following cell diagrams.

a

Cell A	Cell B
$\Psi_s = -800$ kPa	$\Psi_s = -500$ kPa
$\Psi_p = 400$ kPa	$\Psi_p = 300$ kPa

b

Cell A	Cell B
$\Psi_s = -350$ kPa	$\Psi_s = -500$ kPa
$\Psi_p = 300$ kPa	$\Psi_p = 0$ kPa

c

Cell A	Cell B
$\Psi_s = -1200$ kPa	$\Psi_s = -500$ kPa
$\Psi_p = 400$ kPa	$\Psi_p = 300$ kPa

Cell C
$\Psi_s = -700$ kPa
$\Psi_p = 400$ kPa

2 The table gives the initial values of Ψ_s and Ψ_p of some plant cells when placed into bathing solutions of given solute potential.
For each cell, calculate:

a the initial Ψ_{cell}

b the direction of osmotic flow

c the values of Ψ_{cell} and Ψ_p at equilibrium.

Cell	Initial value of Ψ_s/kPa	Initial value of Ψ_p/kPa	Ψ_s of the bathing solution/kPa
A	−1400	700	0
B	−800	0	0
C	−1100	400	−500
D	−900	600	−400

3 A plant cell with $\Psi_s = -600$ kPa and $\Psi_p = 200$ kPa is placed into a bathing solution with $\Psi_s = -700$ kPa. Calculate the initial value of Ψ_{cell}.
State the direction in which osmotic flow will occur.

4 A cell at incipient plasmolysis with a $\Psi_s = -2000$ kPa is placed into a bathing solution with a $\Psi = -800$ kPa. Determine the direction of osmotic flow. Calculate the values of Ψ_{cell} and Ψ_p for the cell when it reaches equilibrium.

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RECOMMENDATIONS

BRIDGING BOOKLET

Whether it be book, film, TV show or Ted talk, there a hundreds of productions you may not have thought had a link to Biology! Get your teeth stuck into some of these this Summer! Thanks to Pixl for these recommendations!

The more that you
READ
the more THINGS
you will know.
The more that you
LEARN,
the more PLACES
YOU'LL GO.
— Dr.Seuss

Book Recommendations

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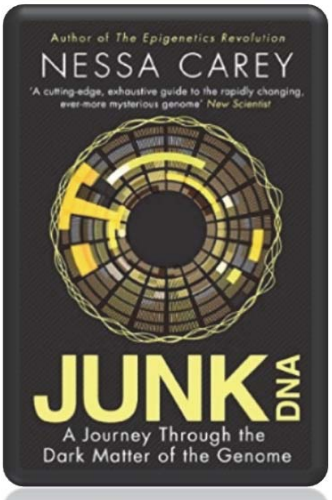
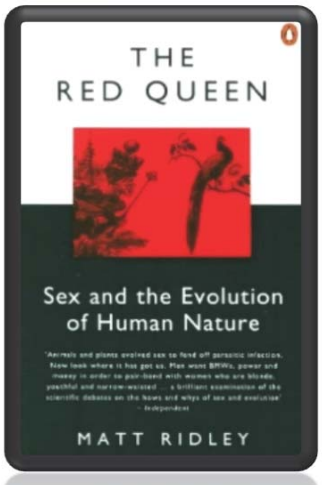
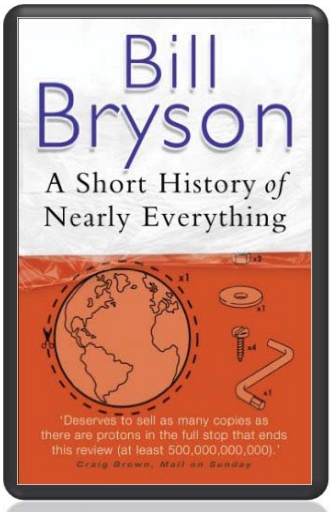
Kick back this summer with a good read. The books below are all popular science books and great for extending your understanding of Biology.



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

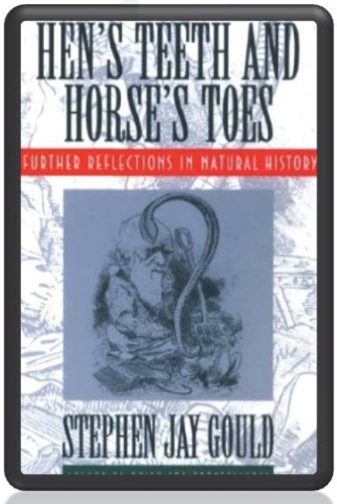
The Red Queen
Its all about sex. Or sexual selection at least. This book will really help your understanding of evolution and particularly the fascinating role of sex in evolution. Available at amazon.co.uk

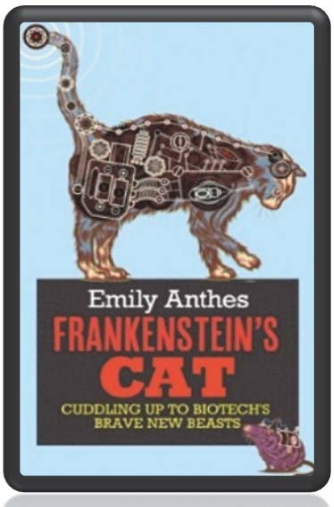




A Short History of Nearly Everything
A whistle-stop tour through many aspects of history from the Big Bang to now. This is a really accessible read that will re-familiarise you with common concepts and introduce you to some of the more colourful characters from the history of science! Available at amazon.co.uk

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

Film Recommendations

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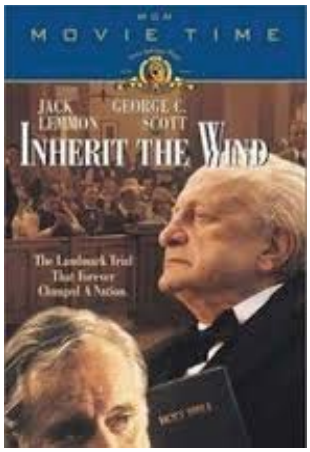
Everyone loves a good story and everyone loves some great science. Here are some of the picks of the best films based on real life scientists and discoveries. You wont find Jurassic Park on this list, we've looked back over the last 50 years to give you our top 5 films you might not have seen before.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

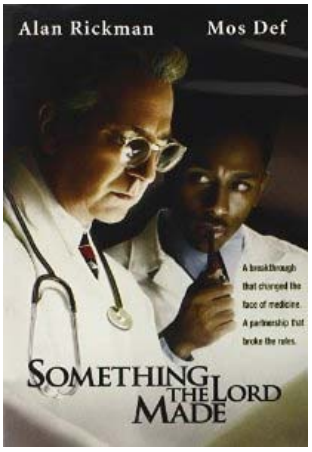
Gorillas in the Mist (1988)
An absolute classic that retells the true story of the life and work of Dian Fossey and her work studying and protecting mountain gorillas from poachers and habitat loss. A tear jerker.

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.

Presentation Recommendations

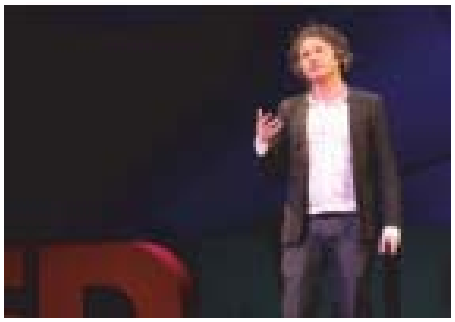
I BIOLOGY Ripley St Thomas

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:

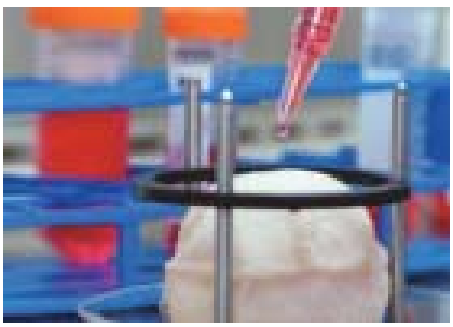
A New Superweapon in the Fight Against Cancer
Available at :
http://www.ted.com/talks/paula_hammond_a_new_superweapon_in_the_fight_against_cancer?language=en
Cancer is a very clever, adaptable disease. To defeat it, says medical researcher and educator Paula Hammond, we need a new and powerful mode of 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.



RIPLEY ST THOMAS

RESEARCH ACTIVITIES

BRIDGING BOOKLET

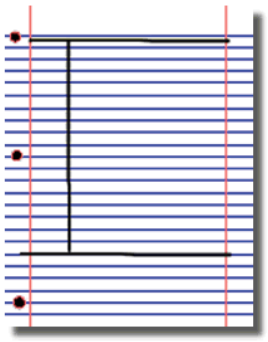
The Big Picture is an excellent publication from the Wellcome Trust. Along with the magazine, the company produces posters, videos and other resources aimed at students studying for GCSEs and A level.
For each of the following topics, you can use the resources to produce one page of Cornell style notes.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

BigPicture

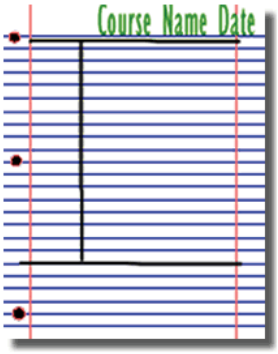
Research activities

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.

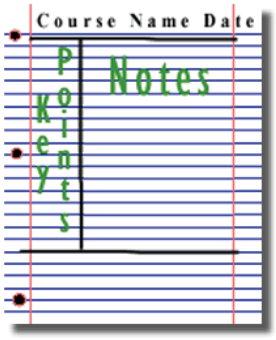
1. Divide your page into three sections like this



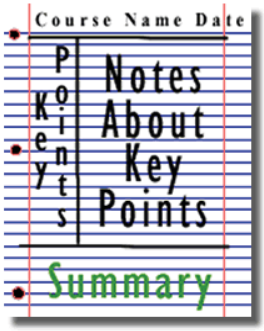
2. Write the name, date and topic at the top of the page



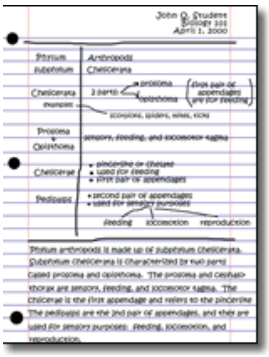
3. Use the large box to make notes. Leave a space between separate idea. Abbreviate where possible.



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

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.

I ♥ BIOLOGY
Ripley St Thomas

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

I BIOLOGY Ripley St Thomas

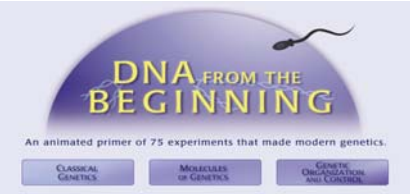
These websites all offer an amazing collection of resources that you should use again and again through out your course.

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/

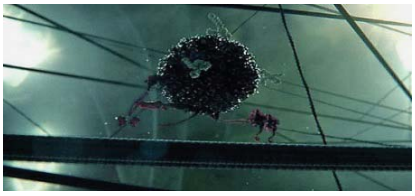
ZSL
LIVING CONSERVATION

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/



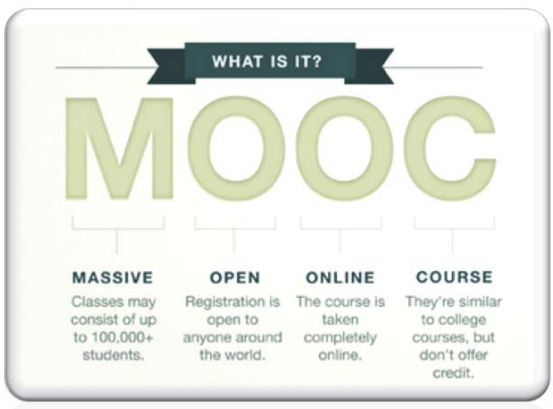
Ok, so not a website, but a video you definitely want to watch. One of the first topics you will learn about is the amazing structure of the cell. This BBC film shows the fascinating workings of a cell… a touch more detailed than the "fried egg" model you might have seen.
http://www.dailymotion.com/video/xzh0kb_the-hidden-life-of-the-cell_shortfilms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

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!



RIPLEY ST THOMAS

KNOWLEDGE BUILDERS

BRIDGING BOOKLET

INFO:

A-level Biology will use your knowledge from GCSE and build on this to help you understand new and more demanding ideas. While these are not compulsory, complete the following tasks to make sure your knowledge is up to date and you are ready to start studying.

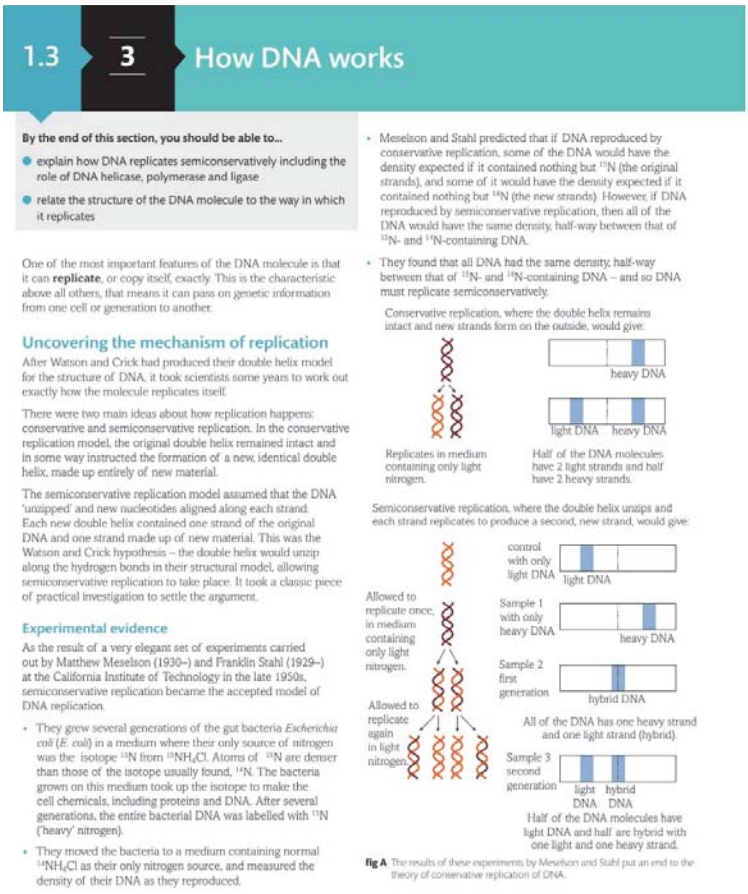
HARD WORK AND DETERMINATION WILL GET YOU WHERE YOU WANT TO GO.

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 & the textbook pages below (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. 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.



1.3 3 How DNA works

By the end of this section, you should be able to...
- explain how DNA replicates semiconservatively including the role of DNA helicase, polymerase and ligase
- relate the structure of the DNA molecule to the way in which it replicates

One of the most important features of the DNA molecule is that it can **replicate**, or copy itself, exactly. This is the characteristic above all others, that means it can pass on genetic information from one cell or generation to another.

Uncovering the mechanism of replication

After Watson and Crick had produced their double helix model for the structure of DNA, it took scientists some years to work out exactly how the molecule replicates itself.

There were two main ideas about how replication happens: conservative and semiconservative replication. In the conservative replication model, the original double helix remained intact and in some way instructed the formation of a new, identical double helix, made up entirely of new material.

The semiconservative replication model assumed that the DNA 'unzipped' and new nucleotides aligned along each strand. Each new double helix contained one strand of the original DNA and one strand made up of new material. This was the Watson and Crick hypothesis – the double helix would unzip along the hydrogen bonds in their structural model, allowing semiconservative replication to take place. It took a classic piece of practical investigation to settle the argument.

Experimental evidence

As the result of a very elegant set of experiments carried out by Matthew Meselson (1930–) and Franklin Stahl (1929–) at the California Institute of Technology in the late 1950s, semiconservative replication became the accepted model of DNA replication.

- They grew several generations of the gut bacteria *Escherichia coli* (*E. coli*) in a medium where their only source of nitrogen was the isotope ^{15}N from $^{15}NH_4Cl$. Atoms of ^{15}N are denser than those of the isotope usually found, ^{14}N. The bacteria grown on this medium took up the isotope to make the cell chemicals, including proteins and DNA. After several generations, the entire bacterial DNA was labelled with ^{15}N ('heavy' nitrogen).
- They moved the bacteria to a medium containing normal $^{14}NH_4Cl$ as their only nitrogen source, and measured the density of their DNA as they reproduced.
- Meselson and Stahl predicted that if DNA reproduced by conservative replication, some of the DNA would have the density expected if it contained nothing but ^{15}N (the original strands), and some of it would have the density expected if it contained nothing but ^{14}N (the new strands). However, if DNA reproduced by semiconservative replication, then all of the DNA would have the same density, half-way between that of ^{15}N- and ^{14}N-containing DNA.
- They found that all DNA had the same density, half-way between that of ^{15}N- and ^{14}N-containing DNA – and so DNA must replicate semiconservatively.

Conservative replication, where the double helix remains intact and new strands form on the outside, would give:

heavy DNA

light DNA heavy DNA

Replicates in medium containing only light nitrogen.

Half of the DNA molecules have 2 light strands and half have 2 heavy strands.

Semiconservative replication, where the double helix unzips and each strand replicates to produce a second, new strand, would give:

control with only light DNA — light DNA

Allowed to replicate once in medium containing only light nitrogen.

Sample 1 with only heavy DNA — heavy DNA

Sample 2 first generation — hybrid DNA

All of the DNA has one heavy strand and one light strand (hybrid).

Allowed to replicate again in light nitrogen.

Sample 3 second generation — light DNA, hybrid DNA

Half of the DNA molecules have light DNA and half are hybrid with one light and one heavy strand.

fig A The results of these experiments by Meselson and Stahl put an end to the theory of conservative replication of DNA.

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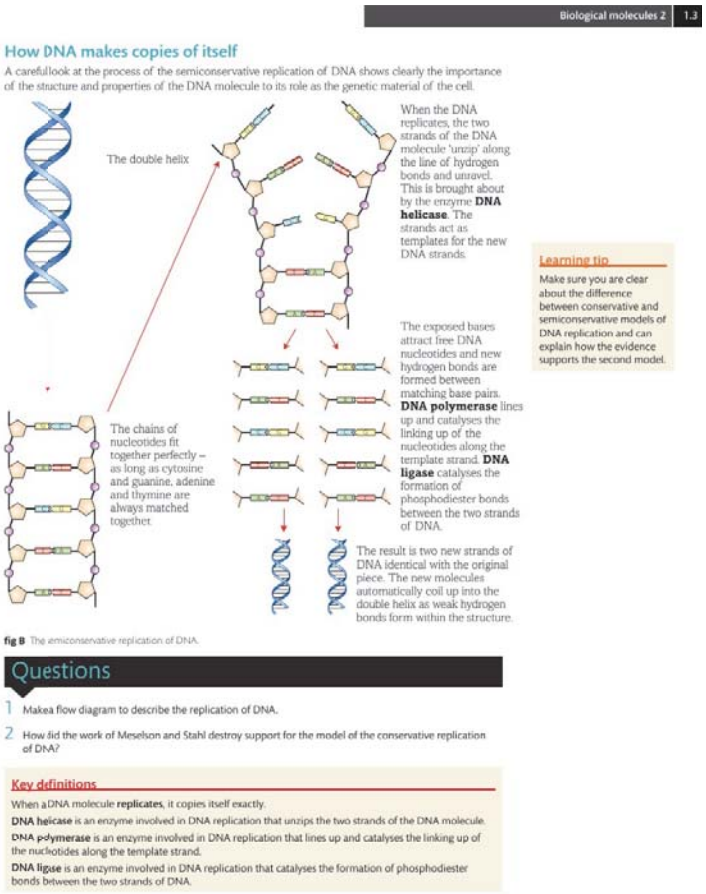

Biological molecules 2 1.3

How DNA makes copies of itself

A carefullook at the process of the semiconservative replication of DNA shows clearly the importance of the structure and properties of the DNA molecule to its role as the genetic material of the cell.

The double helix

When the DNA replicates, the two strands of the DNA molecule 'unzip' along the line of hydrogen bonds and unravel. This is brought about by the enzyme **DNA helicase**. The strands act as templates for the new DNA strands.

The exposed bases attract free DNA nucleotides and new hydrogen bonds are formed between matching base pairs. **DNA polymerase** lines up and catalyses the linking up of the nucleotides along the template strand. **DNA ligase** catalyses the formation of phosphodiester bonds between the two strands of DNA.

The chains of nucleotides fit together perfectly – as long as cytosine and guanine, adenine and thymine are always matched together.

The result is two new strands of DNA identical with the original piece. The new molecules automatically coil up into the double helix as weak hydrogen bonds form within the structure.

fig B The semiconservative replication of DNA.

Learning tip
Make sure you are clear about the difference between conservative and semiconservative models of DNA replication and can explain how the evidence supports the second model.

Questions

1 Makea flow diagram to describe the replication of DNA.

2 How did the work of Meselson and Stahl destroy support for the model of the conservative replication of DNA?

Key definitions
When a DNA molecule **replicates**, it copies itself exactly.
DNA helicase is an enzyme involved in DNA replication that unzips the two strands of the DNA molecule.
DNA polymerase is an enzyme involved in DNA replication that lines up and catalyses the linking up of the nucleotides along the template strand.
DNA ligase is an enzyme involved in DNA replication that catalyses the formation of phosphodiester bonds between the two strands of DNA.

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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 & textbook pages (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

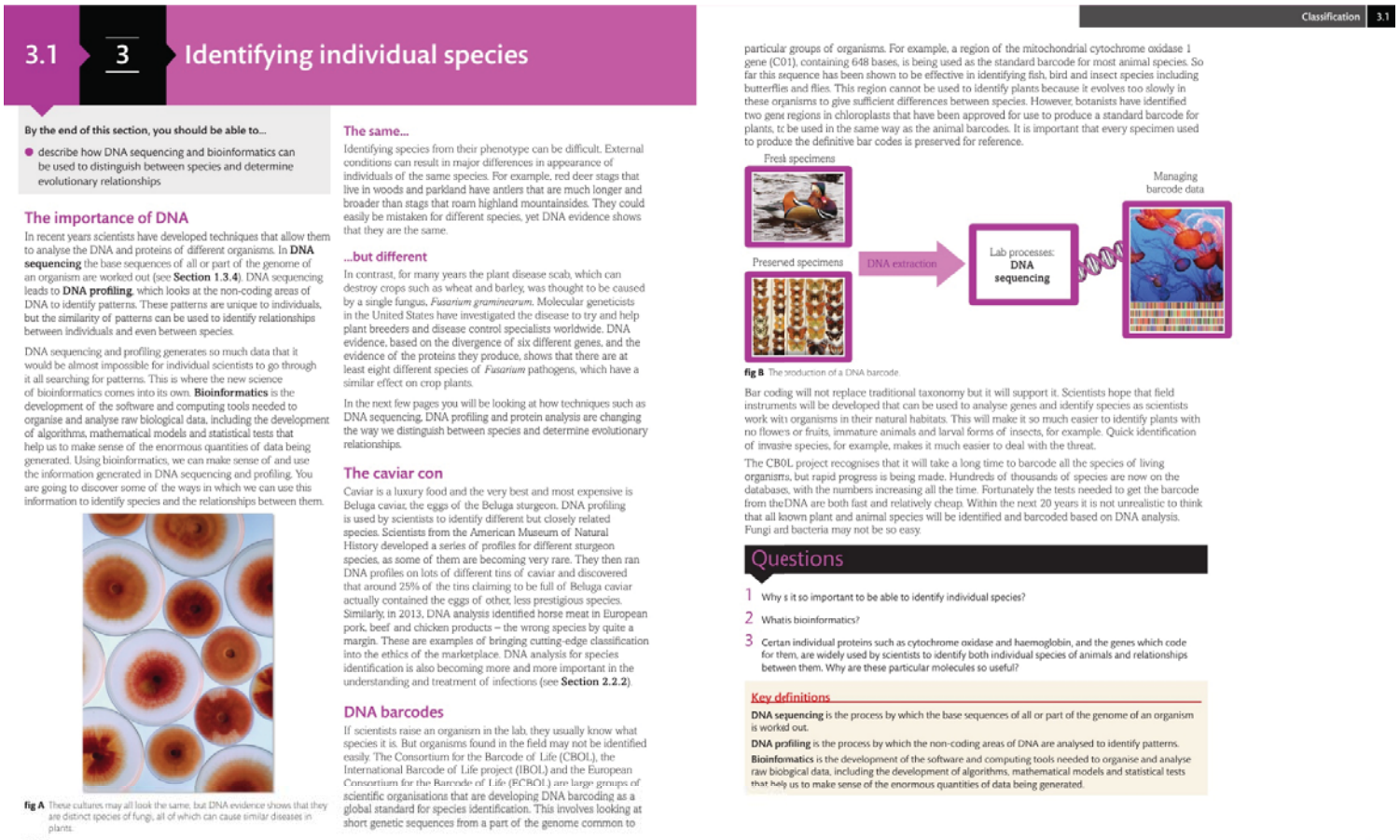
Task:

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.



3.1 3 Identifying individual species

By the end of this section, you should be able to...

- describe how DNA sequencing and bioinformatics can be used to distinguish between species and determine evolutionary relationships

The importance of DNA

In recent years scientists have developed techniques that allow them to analyse the DNA and proteins of different organisms. In **DNA sequencing** the base sequences of all or part of the genome of an organism are worked out (see **Section 1.3.4**). DNA sequencing leads to **DNA profiling**, which looks at the non-coding areas of DNA to identify patterns. These patterns are unique to individuals, but the similarity of patterns can be used to identify relationships between individuals and even between species.

DNA sequencing and profiling generates so much data that it would be almost impossible for individual scientists to go through it all searching for patterns. This is where the new science of bioinformatics comes into its own. **Bioinformatics** is the development of the software and computing tools needed to organise and analyse raw biological data, including the development of algorithms, mathematical models and statistical tests that help us to make sense of the enormous quantities of data being generated. Using bioinformatics, we can make sense of and use the information generated in DNA sequencing and profiling. You are going to discover some of the ways in which we can use this information to identify species and the relationships between them.

fig A These cultures may all look the same, but DNA evidence shows that they are distinct species of fungi, all of which can cause similar diseases in plants.

The same...

Identifying species from their phenotype can be difficult. External conditions can result in major differences in appearance of individuals of the same species. For example, red deer stags that live in woods and parkland have antlers that are much longer and broader than stags that roam highland mountainsides. They could easily be mistaken for different species, yet DNA evidence shows that they are the same.

...but different

In contrast, for many years the plant disease scab, which can destroy crops such as wheat and barley, was thought to be caused by a single fungus, *Fusarium graminearum*. Molecular geneticists in the United States have investigated the disease to try and help plant breeders and disease control specialists worldwide. DNA evidence, based on the divergence of six different genes, and the evidence of the proteins they produce, shows that there are at least eight different species of *Fusarium* pathogens, which have a similar effect on crop plants.

In the next few pages you will be looking at how techniques such as DNA sequencing, DNA profiling and protein analysis are changing the way we distinguish between species and determine evolutionary relationships.

The caviar con

Caviar is a luxury food and the very best and most expensive is Beluga caviar, the eggs of the Beluga sturgeon. DNA profiling is used by scientists to identify different but closely related species. Scientists from the American Museum of Natural History developed a series of profiles for different sturgeon species, as some of them are becoming very rare. They then ran DNA profiles on lots of different tins of caviar and discovered that around 25% of the tins claiming to be full of Beluga caviar actually contained the eggs of other, less prestigious species. Similarly, in 2013, DNA analysis identified horse meat in European pork, beef and chicken products – the wrong species by quite a margin. These are examples of bringing cutting-edge classification into the ethics of the marketplace. DNA analysis for species identification is also becoming more and more important in the understanding and treatment of infections (see **Section 2.2.2**).

DNA barcodes

If scientists raise an organism in the lab, they usually know what species it is. But organisms found in the field may not be identified easily. The Consortium for the Barcode of Life (CBOL), the International Barcode of Life project (IBOL) and the European Consortium for the Barcode of Life (ECBOL) are large groups of scientific organisations that are developing DNA barcoding as a global standard for species identification. This involves looking at short genetic sequences from a part of the genome common to

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Classification 3.1

particular groups of organisms. For example, a region of the mitochondrial cytochrome oxidase 1 gene (CO1), containing 648 bases, is being used as the standard barcode for most animal species. So far this sequence has been shown to be effective in identifying fish, bird and insect species including butterflies and flies. This region cannot be used to identify plants because it evolves too slowly in these organisms to give sufficient differences between species. However, botanists have identified two gene regions in chloroplasts that have been approved for use to produce a standard barcode for plants, tc be used in the same way as the animal barcodes. It is important that every specimen used to produce the definitive bar codes is preserved for reference.

fig B The production of a DNA barcode.

Bar coding will not replace traditional taxonomy but it will support it. Scientists hope that field instruments will be developed that can be used to analyse genes and identify species as scientists work with organisms in their natural habitats. This will make it so much easier to identify plants with no flowers or fruits, immature animals and larval forms of insects, for example. Quick identification of invasive species, for example, makes it much easier to deal with the threat.

The CBOL project recognises that it will take a long time to barcode all the species of living organisms, but rapid progress is being made. Hundreds of thousands of species are now on the databases, with the numbers increasing all the time. Fortunately the tests needed to get the barcode from theDNA are both fast and relatively cheap. Within the next 20 years it is not unrealistic to think that all known plant and animal species will be identified and barcoded based on DNA analysis. Fungi ard bacteria may not be so easy.

Questions

1 Why s it so important to be able to identify individual species?

2 Whatis bioinformatics?

3 Certan individual proteins such as cytochrome oxidase and haemoglobin, and the genes which code for them, are widely used by scientists to identify both individual species of animals and relationships between them. Why are these particular molecules so useful?

Key definitions

DNA sequencing is the process by which the base sequences of all or part of the genome of an organism is worked out.

DNA profiling is the process by which the non-coding areas of DNA are analysed to identify patterns.

Bioinformatics is the development of the software and computing tools needed to organise and analyse raw biological data, including the development of algorithms, mathematical models and statistical tests that help us to make sense of the enormous quantities of data being generated.

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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 and textbook pages (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

3.3 1 The importance of biodiversity

By the end of this section, you should be able to...

- describe what is meant by biodiversity
- recognise that biodiversity can be assessed within a habitat at the species level using a formula to calculate an index of diversity

Biological diversity is decreasing at an alarming rate. Most scientists are agreed that this is not a good thing, even if they disagree about the causes. But what is biodiversity? Why should we preserve it – and how can we do this?

Defining biodiversity

Most people have some idea what the term biodiversity means, but defining it clearly is not easy. The Convention on Biological Diversity, the largest international organisation working on the subject, uses biodiversity as a term to describe the variety of life on Earth, from the smallest microbes to the largest animals and plants. They suggest the concept of biodiversity includes genetic diversity both between individuals within a species and between different species, as well as the variety of different ecosystems.

The number of different species is a useful basic measure, but the concept of biodiversity is more complex than this. The differences between individuals in a species, between populations of the same species, between communities and between ecosystems are all examples of biodiversity. Biodiversity can be assessed on different scales, from species level in a habitat to the genetic level within a population.

fig A Biodiversity in the harsh environment of an Icelandic lava field, where mosses and lichens are the dominant species, is very different from the biodiversity of a tropical rainforest or a coral reef.

Why is biodiversity important?

Does it really matter if there are fewer species of snails or beetles in the world, if an unknown plant species ceases to exist or if the genetic variation between the members of a rare population gets less and less? All the evidence suggests that it does.

In your work at GCSE and earlier, you learned how all the organisms in an ecosystem are interdependent, and how they can affect the physical conditions around them. Rich biodiversity allows large scale ecosystems to function and self-regulate. These ecosystems are also interlinked on a larger scale across the Earth. If biodiversity is reduced in one area, the natural balance may be destroyed elsewhere. The air and water of the planet are purified by the action of a wide range of organisms. Waste is decomposed and rendered non-toxic by many organisms, including bacteria and fungi. For example, microorganisms in soil and water convert ammonia into nitrate ions, which are then taken up and used by plants.

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Biodiversity 3.3

Photosyrthesis by plants plays an important part in stabilising the atmosphere and the world climate. Plants absorb vast amounts of water from the soil, which then evaporates into the atmosphere through transpiration, producing clouds that in turn produce rain. Therefore plants help to determine where rain will fall. Plant roots, along with fungal mycelia, also hold the soil together, affecting how water runs off the soil surface and reducing the risk of flooding. Plant pollination, seed dispersal, soil fertility and nutrient recycling in systems such as the nitrogen and carbon cycles are vital for natural ecosystems and farming, and they all depend on a rich biodiversity.

Biodiversity also provides the genetic variation that has allowed us to develop the production of crops, livestock, fisheries and forests, and enables further improvement by cross-breeding and genetic engineering. This variation will help us to cope with problems arising from climate change and disease. Plant biodiversity also provides the potential of plants to produce chemicals that are important in many areas of human life, including new medicines.

The benefits of a biodiverse and healthy ecosystem are being increasingly assessed and valued as ecosystem services. You will consider this idea further in **Section 3.3.3**.

Assessing biodiversity at the species level

Biodiversity can be measured in a number of ways. There are two main factors which need to be considered when measuring biodiversity at the species level. One is the number of different species in an area – the **species richness**. The other is the evenness of distributions of the different species – the relative abundance of the different types of organism that make up the species richness.

Species richness

Biodiversity varies enormously around the world in terms of numbers of species. The wet tropics are generally the areas of highest biodiversity. For example, in 0.1 hectares (less than four tennis courts) of Amazon rainforest you would expect to find 150–280 tree species. Almost every tree is a different species. Imagine the numbers of other plants and animals associated with each type of tree and you can begin to appreciate the species richness of these areas.

As you move away from the wet tropics, the species diversity tends to fall. In temperate rainforests, tree species richness drops to 20–25 species in the same size of sample area. Further north again in the boreal forest in Scandinavia and Northern Canada, it falls to 1–3 species. To highlight this, scientists have identified a number of **biodiversity hotspots** (**fig B**) of unusual biodiversity and endemism. They occupy only 15.7% of the Earth's land surface, but are home to 77% of the Earth's terrestrial vertebrate species. Unfortunately, these areas often coincide with areas with resources that people want to use. For example, the Latin American rainforests have huge biodiversity, but are also a rich source of wood, gas, oil and minerals, and people are rapidly destroying the rainforests to access these resources.

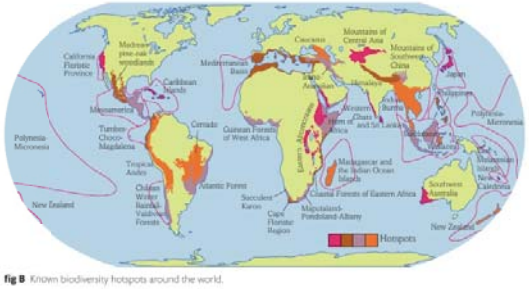

fig B Known biodiversity hotspots around the world.

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Exchange and Transport

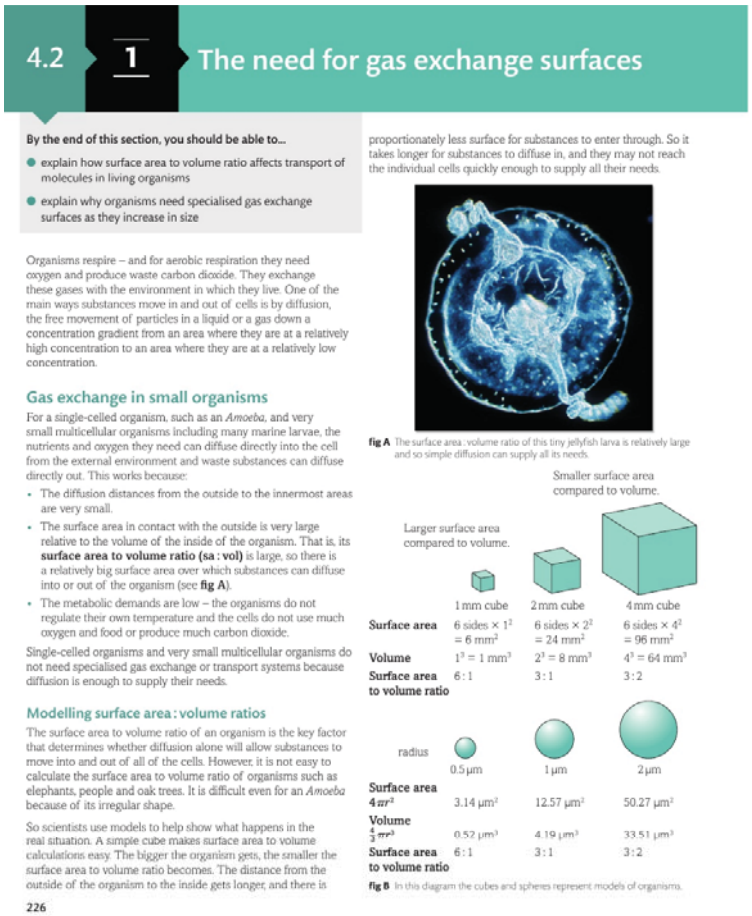
Organisms need to exchange substances selectively with their environment and this takes place at exchange surfaces. Factors such as size or metabolic rate affect the requirements of organisms and this gives rise to adaptations such as specialised exchange surfaces and mass transport systems. Substances 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 and textbook pages (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 an interactive poster. 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.
Have interactive parts: questions/hidden answers etc.



4.2 1 The need for gas exchange surfaces

By the end of this section, you should be able to...
- explain how surface area to volume ratio affects transport of molecules in living organisms
- explain why organisms need specialised gas exchange surfaces as they increase in size

Organisms respire – and for aerobic respiration they need oxygen and produce waste carbon dioxide. They exchange these gases with the environment in which they live. One of the main ways substances move in and out of cells is by diffusion, the free movement of particles in a liquid or a gas down a concentration gradient from an area where they are at a relatively high concentration to an area where they are at a relatively low concentration.

Gas exchange in small organisms

For a single-celled organism, such as an *Amoeba*, and very small multicellular organisms including many marine larvae, the nutrients and oxygen they need can diffuse directly into the cell from the external environment and waste substances can diffuse directly out. This works because:
- The diffusion distances from the outside to the innermost areas are very small.
- The surface area in contact with the outside is very large relative to the volume of the inside of the organism. That is, its **surface area to volume ratio (sa : vol)** is large, so there is a relatively big surface area over which substances can diffuse into or out of the organism (see **fig A**).
- The metabolic demands are low – the organisms do not regulate their own temperature and the cells do not use much oxygen and food or produce much carbon dioxide.

Single-celled organisms and very small multicellular organisms do not need specialised gas exchange or transport systems because diffusion is enough to supply their needs.

Modelling surface area : volume ratios

The surface area to volume ratio of an organism is the key factor that determines whether diffusion alone will allow substances to move into and out of all of the cells. However, it is not easy to calculate the surface area to volume ratio of organisms such as elephants, people and oak trees. It is difficult even for an *Amoeba* because of its irregular shape.

So scientists use models to help show what happens in the real situation. A simple cube makes surface area to volume calculations easy. The bigger the organism gets, the smaller the surface area to volume ratio becomes. The distance from the outside of the organism to the inside gets longer, and there is proportionately less surface for substances to enter through. So it takes longer for substances to diffuse in, and they may not reach the individual cells quickly enough to supply all their needs.

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Gas exchange 4.2

Gas exchange in large organisms

In contrast to unicellular organisms such as an *Amoeba*, larger organisms are made up of billions of cells, often organised into specialised tissues and organs. Substances need to travel long distances from the outside to reach the cytoplasm of all the cells. Nutrients and oxygen would eventually reach the inner cells of the body by simple diffusion, but not fast enough to sustain the processes of life.

The metabolic rate of larger organisms, especially larger animals, tends to be higher than that in smaller animals. Mammals and birds, which control their own body temperatures and are very active, have very high metabolic rates. The demands of each individual cell for oxygen and food, and the amount of carbon dioxide and other wastes produced, is much higher in each individual mammal cell than in, for example, an *Amoeba*.

Complex organisms have evolved specialised systems to exchange the gases they need, taking oxygen in and removing carbon dioxide. In humans, gas exchange takes place in the lungs, in fish it is the gills, in insects the tracheal system and in plants most gas exchange takes place in the leaves.

Factors affecting the rate of diffusion

Gas exchange systems are specialised for the exchange of oxygen and carbon dioxide between the body of the organism and the environment. These gases are exchanged by simple diffusion. The rate of diffusion across a membrane is controlled by a number of factors:
- the surface area – the bigger the surface area the more particles can be exchanged at the same time
- the concentration gradient of the particles diffusing – particles diffuse from an area where they are at a relatively high concentration to an area where they are at a relatively low concentration, so the more particles there are on one side of a membrane compared with the other, the faster they move across. Maintaining the gradient, e.g. by transporting substances away once they have diffused, makes diffusion faster
- the distance over which diffusion is taking place – the shorter the diffusion distance the faster diffusion can take place.

Learning tip
When you look at gas exchange systems in different organisms, take note of the adaptations that enable diffusion to take place as fast as possible and see which factors increase the rate of diffusion.

Questions

1 Explain why large animals cannot take in all the substances they need from outside the body through their skin.

2 Here are three facts about gas exchange in humans. Oxygen enters the body and carbon dioxide leaves it through the lungs. The lungs are made of thousands of tiny air sacs surrounded by blood vessels. The surface area of the lungs is approximately 50 m². Explain how this helps the two gases to diffuse quickly into and out of the blood.

Key definition
Surface area to volume ratio (sa : vol) is the relationship between the surface area of an organism and its volume.

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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 and textbook pages (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 3D model of either a eukaryotic or prokaryotic cell. Whichever you choose, your model should include:
Labelled structures with functions
Short explanations of key ideas or processes.

2.1 4 Eukaryotic cells 2 – protein transport

By the end of this section, you should be able to...

- describe the ultrastructure of eukaryotic cells and the functions of organelles including the rough and smooth endoplasmic reticulum, 80S ribosomes, Golgi apparatus and lysosomes

The cytoplasm of the cell contains the **endoplasmic reticulum (ER)**, a three-dimensional (3D) network of cavities bounded by membranes. The electron microscope reveals that some of the cavities are sac-like and some are tubular, and that the ER spreads extensively through the cytoplasm. The ER network links with the membrane around the nucleus, and makes up a large part of the transport system within a cell as well as being the site of synthesis of many important chemicals. It has been calculated that 1 cm^3 of liver tissue contains about 11 m^2 of endoplasmic reticulum. Electron microscopes also helped scientists to work out the functions of the endoplasmic reticulum, by showing up the different forms – the rough and the smooth endoplasmic reticulum.

Another useful technique is to provide cells with radioactively labelled chemicals that are building blocks for specific modules, for example labelled amino acids for the synthesis of proteins, and then find out where they appear in the cell. The labelled products can be tracked using microscopy. Another method of locating them is to break the cells open and then spin the contents in a centrifuge. The different parts of the cell can be separated out and the regions containing the radioactively labelled substances identified.

80S and 70S ribosomes

In **Section 1.3.5** you met ribosomes, the organelles on which protein synthesis takes place in the cytoplasm of the cell. Ribosomes are made from ribosomal RNA and protein, and consist of a large subunit and a small subunit. The main type of ribosomes in eukaryotic cells are **80S ribosomes**. The 'S' stands for Svedberg, a unit used to measure how quickly particles settle in a centrifuge. The rate of sedimentation depends on the size and shape of the particle. When 80S ribosomes are broken into their two units, they are made up of a 40S small subunit and a 60S large subunit. The ratio of RNA : protein in 80S ribosomes is 1 : 1.

However, eukaryotic cells also contain another type of ribosome. Scientists have discovered **70S ribosomes** in the mitochondria, and in the chloroplasts of plant cells. These ribosomes are usually found in prokaryotic cells (bacteria and cyanobacteria). They are made up of a small 30S subunit and a larger 50S subunit and the ratio of RNA : protein in 70S ribosomes is 2 : 1.

These 70S ribosomes are reproduced in the mitochondria and chloroplasts independently when a cell divides. This is seen as good evidence for the endosymbiotic theory that mitochondria and chloroplasts evolved from bacteria caught inside eukaryotic cells very early on in the process of evolution.

Rough and smooth endoplasmic reticulum

Electron micrographs show that much of the outside of the endoplasmic reticulum membrane is covered with granules, which are 80S ribosomes, so this is known as **rough endoplasmic reticulum (RER)** (see **fig A**). The function of the ribosomes is to make proteins and the RER isolates and transports these proteins once they have been made. Some proteins, such as digestive enzymes and hormones, are not used inside the cell that makes them, so they have to be secreted without interfering with the cell's activities. This is an example of **exocytosis**.

Many other proteins are needed within the cell. The RER has a large surface area for the synthesis of all these proteins, and it stores and transports them both within the cell and from the inside to the outside. Cells that secrete materials, such as those producing the digestive enzymes in the lining of the gut, have a large amount of RER.

Not all endoplasmic reticulum is covered in ribosomes (see **fig A**). **Smooth endoplasmic reticulum (SER)** is also involved in synthesisand transport, but in this case of steroids and lipids. For example, lots of SER is found in the testes, which make the steroid hormone testosterone, and in the liver, which metabolises cholesterol amongst other lipids. The amount and type of endoplasmic reticulum in a cell give an idea of the type of job the cell does.

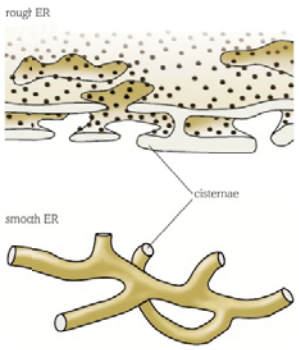


fig A Rough and smooth endoplasmic reticulum. Smooth ER is more tubular than rough ER and also lacks ribosomes on the surface.

The Golgi apparatus

Under the light microscope the **Golgi apparatus** looks like a rather dense area of cytoplasm. An electron microscope reveals that it is made up of stacks of parallel, flattened membrane pockets called cisternae, formed by vesicles from the endoplasmic reticulum fusing together (see **Section 2.1.2, fig A**).

The Golgi apparatus has a close link with, but is not joined to, the RER. It has taken scientists a long time to discover exactly what the Golgi apparatus does. Materials have been radioactively labelled and tracked through the cell to try and find out exactly what goes on inside it. Proteins are brought to the Golgi apparatus in vesicles that have pinched off from the RER where they were made. The vesicles fuse with the membrane sacs of the Golgi apparatus and the protein enters the Golgi stacks. As the proteins travel through the Golgi apparatus they are modified in various ways.

Carbohydrate is added to some proteins to form glycoproteins such as mucus. The Golgi apparatus also seems to be involved in producing materials for plant and fungal cell walls and insect cuticles. Some proteins in the Golgi apparatus are digestive enzymes. These may be enclosed in vesicles to form an organelle known as a **lysosome**. Alternatively, enzymes may be transported through the Golgi apparatus and then in vesicles to the cell surface membrane where the vesicles fuse with the membrane to release extracellular digestive enzymes. The Golgi apparatus was first reported over 100 years ago, in April 1898. The flattened stack of membranes was observed by the Italian scientist Camillo Golgi (1843–1926) through a light microscope. For more than 50 years scientists argued over its function. Some thought it was an artefact from the process of fixing and staining during tissue preparation. The arrival of the electron microscope in the 1950s allowed the detailed structure of the Golgi apparatus to be seen.

The electron microscope has been central in showing details of the internal structure of the Golgi apparatus. In addition, a number of techniques have been developed that have allowed more detailed understanding. The most important of these has been the process of labelling specific enzymes so they can be seen using the electron microscope. The inner areas of the Golgi apparatus, nearer to the RER, have been shown to be very rich in enzymes that modify proteins in various ways. This is where most enzymes or membrane proteins are converted into the finished product. In contrast, in the outer regions of the Golgi apparatus you find lots of finished protein products, but not many of the enzymes that make them. The movement of cell membrane proteins through the Golgi apparatus is very complex. Areas of the protein that need to be on the outside of the cell membrane, such as receptor binding sites, are orientated by the Golgi apparatus so that when they arrive at the membrane they are inserted facing in the right direction.

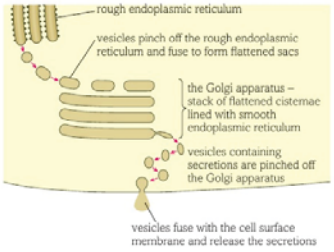


fig B The Golgi apparatus takes proteins from the RER, assembles and packages them and then transports them to where they are needed. This may be the surface of the cell or different regions inside it.

Lysosomes

Food taken into the cell of single-celled protoctists such as *Amoeba* must be broken down into simple chemicals that can then be used. Organelles in the cells of your body that are worn out need to be destroyed. These jobs are the function of the lysosomes. The word lysis, from which they get their name, means 'breaking down'. Lysosomes appear as dark, spherical bodies in the cytoplasm of most cells and they contain a powerful mix of digestive enzymes. They frequently fuse with each other and with a membrane-bound

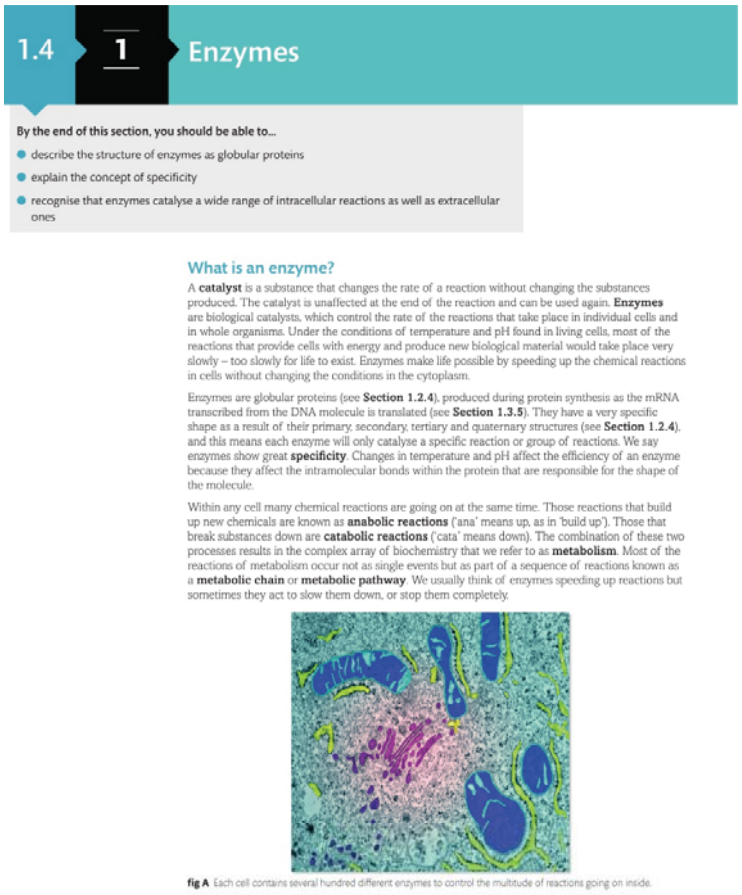
Biological Molecules

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 and textbook pages (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 affects the nervous system. Write a letter to a GP or a sufferer to explain what an enzyme is.
Your letter should:
Describe the structure of an enzyme
Explain what enzymes do inside the body



1.4 1 Enzymes

By the end of this section, you should be able to...
- describe the structure of enzymes as globular proteins
- explain the concept of specificity
- recognise that enzymes catalyse a wide range of intracellular reactions as well as extracellular ones

What is an enzyme?

A **catalyst** is a substance that changes the rate of a reaction without changing the substances produced. The catalyst is unaffected at the end of the reaction and can be used again. **Enzymes** are biological catalysts, which control the rate of the reactions that take place in individual cells and in whole organisms. Under the conditions of temperature and pH found in living cells, most of the reactions that provide cells with energy and produce new biological material would take place very slowly – too slowly for life to exist. Enzymes make life possible by speeding up the chemical reactions in cells without changing the conditions in the cytoplasm.

Enzymes are globular proteins (see **Section 1.2.4**), produced during protein synthesis as the mRNA transcribed from the DNA molecule is translated (see **Section 1.3.5**). They have a very specific shape as a result of their primary, secondary, tertiary and quaternary structures (see **Section 1.2.4**), and this means each enzyme will only catalyse a specific reaction or group of reactions. We say enzymes show great **specificity**. Changes in temperature and pH affect the efficiency of an enzyme because they affect the intramolecular bonds within the protein that are responsible for the shape of the molecule.

Within any cell many chemical reactions are going on at the same time. Those reactions that build up new chemicals are known as **anabolic reactions** ('ana' means up, as in 'build up'). Those that break substances down are **catabolic reactions** ('cata' means down). The combination of these two processes results in the complex array of biochemistry that we refer to as **metabolism**. Most of the reactions of metabolism occur not as single events but as part of a sequence of reactions known as a **metabolic chain** or **metabolic pathway**. We usually think of enzymes speeding up reactions but sometimes they act to slow them down, or stop them completely.

fig A Each cell contains several hundred different enzymes to control the multitude of reactions going on inside.

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Naming enzymes

In the study of biology, in medicine, in cellular and genetic research and in industries that use biotechnology, it is important to be able to refer to the action of specific enzymes. To do this we need to understand how enzymes are named.

Many of the enzymes found in animals and plants work inside the cells. These are known as **intracellular enzymes**, for example DNA polymerase and DNA ligase. Cells secrete other enzymes that have an effect beyond the boundaries of the cell membrane. These are **extracellular enzymes**. The digestive enzymes and lysozyme, the enzyme in your tears, are well-known examples of these.

Most enzymes – both intracellular and extracellular – have several names including:
- a relatively short recommended name, which is often the name of the molecule that the enzyme works on (the substrate) with '-ase' on the end, or the substrate with an indication of what it does, e.g. creatine kinase
- a longer systematic name describing the type of reaction being catalysed, e.g. ATP:creatine phosphotransferase
- a classification number, e.g. EC 2.7.3.2.

Some enzymes, such as urease, ribonuclease and lipase, are known by their recommended names. But there are still some enzymes that are known by common but uninformative names – trypsin and pepsin for example. However, the names of most enzymes give you useful information about the role of the enzyme in the cell or the body.

Did you know?

The discovery of enzymes

In 1835 people noticed that starch is broken down to sugars more effectively by malt (sprouting barley) than by sulfuric acid.

People also suspected there were 'ferments' in yeast (a single-celled fungus) that turned sugar to alcohol and in 1877 the name enzyme (literally 'in yeast') was introduced. In 1897 Eduard Buchner (1860–1917) extracted a 'juice' from yeast cells that would breakdown various sugars outside a living cell.

In 1926 James B. Sumner (1887–1955) extracted the first pure, crystalline enzyme from jack beans. It was urease, the enzyme that catalyses the breakdown of urea. Sumner found the crystals were protein and concluded that enzymes must therefore be proteins. Unfortunately no-one believed the young researcher at the time, because many established scientists had been trying and failing to isolate enzymes for years. However, 20 years later Sumner received a Nobel Prize for his ground-breaking work.

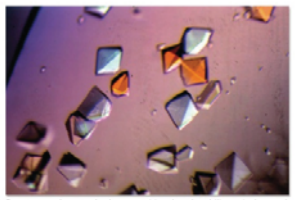

fig B Pure urease does not look very exciting, but the ability to isolate and extract enzymes has revolutionised our understanding of biology and the way we can use enzymes in industry.

Questions

1 From which organisms were the first enzymes isolated?
2 What is the difference between an intracellular enzyme and an extracellular enzyme?
3 Investigate Sumner's work and discover which scientists were particularly against his ideas and why.

Key definitions

A **catalyst** is a substance that speeds up a reaction without changing the substances produced or being changed itself.

Enzymes are proteins that have a very specific shape as a result of their primary, secondary, tertiary and quaternary structures. They act as biological catalysts and each enzyme will only catalyse a specific reaction or group of reactions.

Specificity is the characteristic of enzymes that means that, as a result of the very specific shapes resulting from their tertiary and quaternary structures, each enzyme will only catalyse a specific reaction or group of reactions.

An **anabolic reaction** is the reaction that builds up (synthesises) new molecules in a cell.

A **catabolic reaction** is a reaction which breaks down substances within a cell.

Metabolism is the sum of the anabolic and catabolic processes in a cell.

A **metabolic chain (metabolic pathway)** is a series of linked reactions in the metabolism of a cell.

Intracellular enzymes are enzymes that catalyse reactions within the cell.

Extracellular enzymes are enzymes that catalyse reactions outside of the cell in which they were made.

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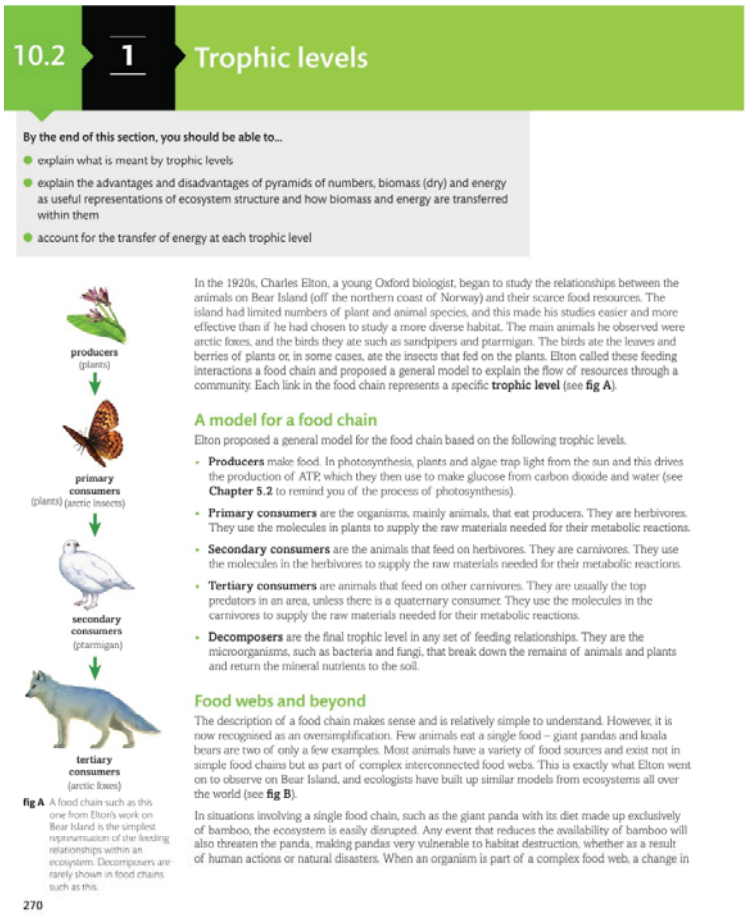
Ecosystems

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 and textbook pages (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.



10.2 1 Trophic levels

By the end of this section, you should be able to...

- explain what is meant by trophic levels
- explain the advantages and disadvantages of pyramids of numbers, biomass (dry) and energy as useful representations of ecosystem structure and how biomass and energy are transferred within them
- account for the transfer of energy at each trophic level

producers (plants)
primary consumers (plants) (arctic insects)
secondary consumers (ptarmigan)
tertiary consumers (arctic foxes)

fig A A food chain such as this one from Elton's work on Bear Island is the simplest representation of the feeding relationships within an ecosystem. Decomposers are rarely shown in food chains such as this.

In the 1920s, Charles Elton, a young Oxford biologist, began to study the relationships between the animals on Bear Island (off the northern coast of Norway) and their scarce food resources. The island had limited numbers of plant and animal species, and this made his studies easier and more effective than if he had chosen to study a more diverse habitat. The main animals he observed were arctic foxes, and the birds they ate such as sandpipers and ptarmigan. The birds ate the leaves and berries of plants or, in some cases, ate the insects that fed on the plants. Elton called these feeding interactions a food chain and proposed a general model to explain the flow of resources through a community. Each link in the food chain represents a specific **trophic level** (see **fig A**).

A model for a food chain

Elton proposed a general model for the food chain based on the following trophic levels.

- **Producers** make food. In photosynthesis, plants and algae trap light from the sun and this drives the production of ATP, which they then use to make glucose from carbon dioxide and water (see **Chapter 5.2** to remind you of the process of photosynthesis).
- **Primary consumers** are the organisms, mainly animals, that eat producers. They are herbivores. They use the molecules in plants to supply the raw materials needed for their metabolic reactions.
- **Secondary consumers** are the animals that feed on herbivores. They are carnivores. They use the molecules in the herbivores to supply the raw materials needed for their metabolic reactions.
- **Tertiary consumers** are animals that feed on other carnivores. They are usually the top predators in an area, unless there is a quaternary consumer. They use the molecules in the carnivores to supply the raw materials needed for their metabolic reactions.
- **Decomposers** are the final trophic level in any set of feeding relationships. They are the microorganisms, such as bacteria and fungi, that break down the remains of animals and plants and return the mineral nutrients to the soil.

Food webs and beyond

The description of a food chain makes sense and is relatively simple to understand. However, it is now recognised as an oversimplification. Few animals eat a single food – giant pandas and koala bears are two of only a few examples. Most animals have a variety of food sources and exist not in simple food chains but as part of complex interconnected food webs. This is exactly what Elton went on to observe on Bear Island, and ecologists have built up similar models from ecosystems all over the world (see **fig B**).

In situations involving a single food chain, such as the giant panda with its diet made up exclusively of bamboo, the ecosystem is easily disrupted. Any event that reduces the availability of bamboo will also threaten the panda, making pandas very vulnerable to habitat destruction, whether as a result of human actions or natural disasters. When an organism is part of a complex food web, a change in any one component, whilst potentially affecting the balance of the ecosystem, is far less likely to have catastrophic effects and so the system will be more stable (see **fig B**).

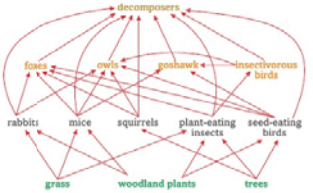


fig B The English deciduous woodland in this simplified food web represents a relatively stable system. When rabbits almost died out from myxomatosis, owls survived by eating more of their other prey species. Although mice and squirrels were more heavily predated, there was reduced competition for the plant food resources, so they could reproduce more successfully. The rest of the community was relatively unaffected by the loss of the rabbits.

Ecological pyramids

Although a food chain is a highly simplified model of the trophic levels within an ecosystem, it has helped us to develop an understanding of the energy economy of ecosystems. We can also use pyramids to illustrate what is happening in an ecosystem.

Pyramids of numbers

In many food chains, the number of organisms decreases at each trophic level. There are more producers than primary consumers, more primary consumers than secondary consumers, and so on. These observations are represented at their simplest by a **pyramid of numbers** (see **fig C**).

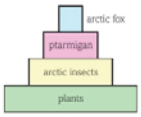


fig C A pyramid of numbers for the simple Bear Island food chain shown in **fig A** The number of individuals decreases as you move up the chain.

Pyramids of biomass

In many situations a pyramid of numbers does not accurately reflect what is happening in an ecosystem. For example, a single rosebush will support a very large population of aphids, which will be eaten by a smaller population of ladybirds and hoverfly larvae, that are themselves the prey of relatively few birds. This gives a very distorted pyramid of numbers. You get a much more realistic model by using a **pyramid of biomass**. This shows the combined mass of all the organisms in a particular habitat.

Counting the plants and animals for pyramids of numbers can be difficult and measuring biomass is even harder. Either wet or dry biomass may be used; however, wet biomass is very inaccurate. It is affected by water uptake in the soil, transpiration in plants, and drinking, urinating, defaecating and in some cases sweating in animals. Using dry mass eliminates the inaccuracy of variable water content in organisms, but involves destroying the material. To avoid the destruction of the habitat, a small sample of all the organisms involved is taken and the dry mass obtained. The total biomass of the population is then calculated from this sample. It is much more time consuming to produce a pyramid of biomass than a pyramid of numbers, but it gives much more accurate information about what is happening in an ecosystem (see **fig D**).

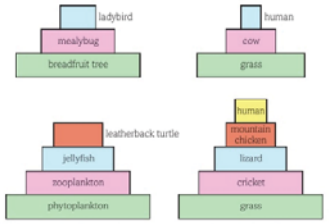


fig D Pyramids of biomass give a more accurate picture of what is happening in a food chain than pyramids of numbers do.

Pyramids of energy

Even pyramids of biomass have their limitations. For example, if the biomass of the organisms in a sample of water from the English Channel is analysed, there appears to be a greater biomass of zooplankton than of the photosynthetic phytoplankton on which it feeds. The sample is only a snapshot of the ecosystem. What it fails to show is that the phytoplankton reproduces much more rapidly than the zooplankton. Although the biomass of the total phytoplankton population at any one time (the standing crop) is smaller than that of the zooplankton, the turnover of the phytoplankton is much higher and so the biomass over a period of time is much greater. A pyramid made up of observations over time gives the most accurate model of what is happening in an ecosystem. This is what we try to do with **pyramids of energy**.

The energy in an ecosystem remains the same at every level, and it is the size of the different type of energy stores that changes. As you move along a food chain, less energy is stored in the organisms and more is stored in the surrounding atmosphere.

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

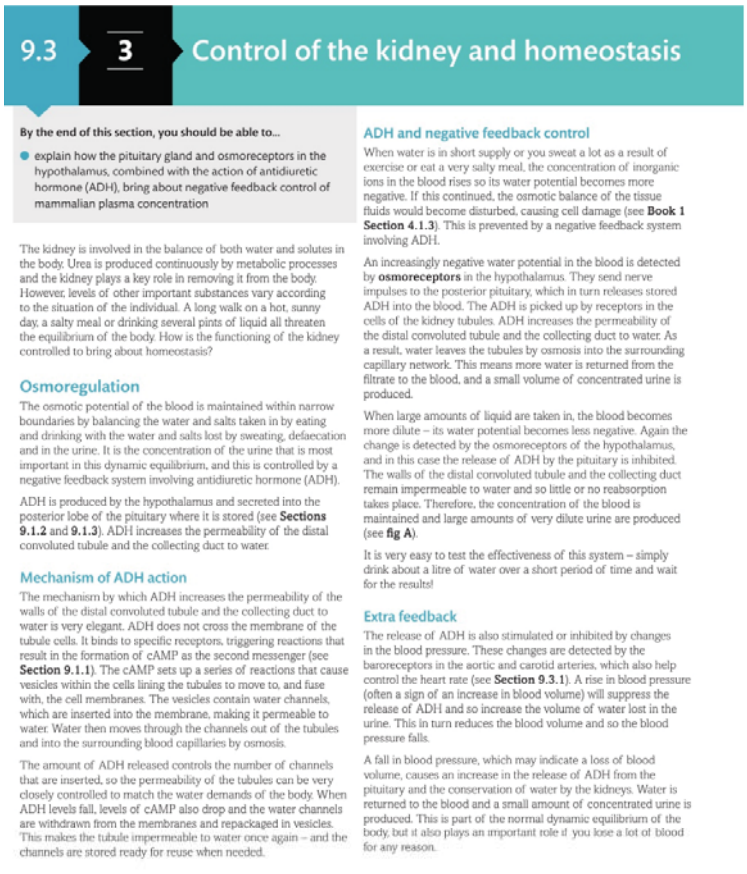
Read the information on these websites and textbook pages (you could make more Cornell notes if you wish):
http://www.s-cool.co.uk/a-level/biology/homeostasis
http://www.bbc.co.uk/education/topics/z8kxpv4

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.



9.3 3 Control of the kidney and homeostasis

By the end of this section, you should be able to...

- explain how the pituitary gland and osmoreceptors in the hypothalamus, combined with the action of antidiuretic hormone (ADH), bring about negative feedback control of mammalian plasma concentration

The kidney is involved in the balance of both water and solutes in the body. Urea is produced continuously by metabolic processes and the kidney plays a key role in removing it from the body. However, levels of other important substances vary according to the situation of the individual. A long walk on a hot, sunny day, a salty meal or drinking several pints of liquid all threaten the equilibrium of the body. How is the functioning of the kidney controlled to bring about homeostasis?

Osmoregulation

The osmotic potential of the blood is maintained within narrow boundaries by balancing the water and salts taken in by eating and drinking with the water and salts lost by sweating, defaecation and in the urine. It is the concentration of the urine that is most important in this dynamic equilibrium, and this is controlled by a negative feedback system involving antidiuretic hormone (ADH).

ADH is produced by the hypothalamus and secreted into the posterior lobe of the pituitary where it is stored (see **Sections 9.1.2** and **9.1.3**). ADH increases the permeability of the distal convoluted tubule and the collecting duct to water.

Mechanism of ADH action

The mechanism by which ADH increases the permeability of the walls of the distal convoluted tubule and the collecting duct to water is very elegant. ADH does not cross the membrane of the tubule cells. It binds to specific receptors, triggering reactions that result in the formation of cAMP as the second messenger (see **Section 9.1.1**). The cAMP sets up a series of reactions that cause vesicles within the cells lining the tubules to move to, and fuse with, the cell membranes. The vesicles contain water channels, which are inserted into the membrane, making it permeable to water. Water then moves through the channels out of the tubules and into the surrounding blood capillaries by osmosis.

The amount of ADH released controls the number of channels that are inserted, so the permeability of the tubules can be very closely controlled to match the water demands of the body. When ADH levels fall, levels of cAMP also drop and the water channels are withdrawn from the membranes and repackaged in vesicles. This makes the tubule impermeable to water once again – and the channels are stored ready for reuse when needed.

ADH and negative feedback control

When water is in short supply or you sweat a lot as a result of exercise or eat a very salty meal, the concentration of inorganic ions in the blood rises so its water potential becomes more negative. If this continued, the osmotic balance of the tissue fluids would become disturbed, causing cell damage (see **Book 1 Section 4.1.3**). This is prevented by a negative feedback system involving ADH.

An increasingly negative water potential in the blood is detected by **osmoreceptors** in the hypothalamus. They send nerve impulses to the posterior pituitary, which in turn releases stored ADH into the blood. The ADH is picked up by receptors in the cells of the kidney tubules. ADH increases the permeability of the distal convoluted tubule and the collecting duct to water. As a result, water leaves the tubules by osmosis into the surrounding capillary network. This means more water is returned from the filtrate to the blood, and a small volume of concentrated urine is produced.

When large amounts of liquid are taken in, the blood becomes more dilute – its water potential becomes less negative. Again the change is detected by the osmoreceptors of the hypothalamus, and in this case the release of ADH by the pituitary is inhibited. The walls of the distal convoluted tubule and the collecting duct remain impermeable to water and so little or no reabsorption takes place. Therefore, the concentration of the blood is maintained and large amounts of very dilute urine are produced (see **fig A**).

It is very easy to test the effectiveness of this system – simply drink about a litre of water over a short period of time and wait for the results!

Extra feedback

The release of ADH is also stimulated or inhibited by changes in the blood pressure. These changes are detected by the baroreceptors in the aortic and carotid arteries, which also help control the heart rate (see **Section 9.3.1**). A rise in blood pressure (often a sign of an increase in blood volume) will suppress the release of ADH and so increase the volume of water lost in the urine. This in turn reduces the blood volume and so the blood pressure falls.

A fall in blood pressure, which may indicate a loss of blood volume, causes an increase in the release of ADH from the pituitary and the conservation of water by the kidneys. Water is returned to the blood and a small amount of concentrated urine is produced. This is part of the normal dynamic equilibrium of the body, but it also plays an important role if you lose a lot of blood for any reason.

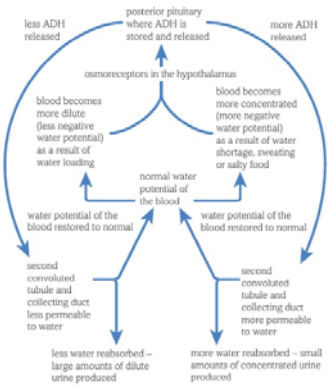


fig A A negative feedback system involving ADH maintains the osmotic potential of the blood within very narrow limits.

Diabetes insipidus

The most common form of diabetes, diabetes mellitus, is the result of insufficient insulin being produced. The name literally means 'sweet fountain', because large volumes of urine containing sugar are produced.

There is, however, another form of diabetes – a relatively rare condition known as **diabetes insipidus**. The name means 'dilute fountain' and affected individuals continuously produce large volumes of very dilute urine. It is caused when an individual does not produce any ADH, or their kidneys do not respond to ADH. Without ADH, the distal convoluted tubules and collecting ducts are permanently impermeable to water. The patient feels extremely thirsty and has to drink large quantities of liquid to avoid severe dehydration. Diabetes insipidus is treated in different ways, depending on the severity of the condition and the cause, either with drugs that replace the ADH or with drugs that enable the kidneys to produce a more concentrated urine.

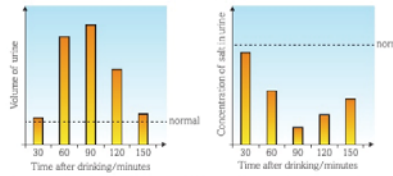


fig B These graphs show the effect of drinking a given volume of distilled water on both the volume and salt concentration of the urine. Urine was collected at 30 minute intervals from the time that the water was drunk. This shows the sensitivity of the response to an imposed change – the water load is removed, but without an unwanted loss of salt.

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 and textbook pages (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.

5.1 1 Respiration in cells

By the end of this section, you should be able to...

- show that cellular respiration yields ATP which is used as a source of energy for metabolic reactions, and the process also generates a rise in temperature
- explain that aerobic respiration involves different stages, including glycolysis, the link reaction, the Krebs cycle and oxidative phosphorylation
- describe how you can investigate factors affecting the rate of respiration using a respirometer

fig A Even when you are asleep your body uses lots of energy for breathing, blood circulation, excretion, growth, repair and maintaining your body temperature.

The cells of all organisms need energy to break and make bonds during the chemical reactions that bring about growth, reproduction and the maintenance of life. Autotrophic organisms make their own food, usually by photosynthesis, while heterotrophic organisms eat and digest other organisms. The energy in the chemical bonds of the food is transferred to the bonds in ATP (adenosine triphosphate) during cellular respiration, providing the energy for all other metabolic reactions.

What is cellular respiration?

Cellular respiration is the process by which the energy from food molecules is transferred to ATP (see **Book 1 Section 1.3.1**). The substance that is broken down is referred to as the **respiratory substrate**. The main respiratory substrate used by cells is glucose. Oxygen from the air is used in the process, and carbon dioxide and water are formed as waste products. The volume of oxygen used and the volume of carbon dioxide produced change depending on the level of activity of the organism, the type of food being respired and other external factors such as temperature.

Aerobic respiration is the form of cellular respiration that takes place in presence of oxygen. Aerobic respiration of glucose is usually summarised as follows:

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ (+ ATP) $\Delta H \approx -2880$ kJ

glucose + oxygen → carbon dioxide + water (+ ATP) $\Delta H \approx -2880$ kJ

which provides readily transferable energy for all cellular reactions. When energy is needed, the third phosphate bond can be broken by a hydrolysis reaction, catalysed by the enzyme ATPase (see **fig B**). The result is adenosine diphosphate (ADP) and a free inorganic phosphate group (P_i). About 30.5 kJ of energy is released for every mole of ATP hydrolysed. Some of this energy is transferred to the environment, warming it up, but the rest is available for any energy-requiring biological activity. The breakdown of ATP into ADP and P_i is reversible. The phosphorylation of ADP to ATP is also catalysed by ATPase and requires 30.5 kJ of energy.

ATP cannot be stored in the body in large amounts. The raw materials to make ATP are almost always available, so the compound is made as and when it is needed. However, once the raw materials are used up, cellular respiration cannot continue and no more ATP is made. This is seen in the onset of rigor mortis after death. Once cellular respiration stops and ATP production ends, the contracting proteins of the muscles cannot work and the muscles lock solid.

fig B When ATP is hydrolysed to ADP + P_i (left → right), energy is made available for cellular reactions. The reverse reaction, where ATP is synthesised from ADP and P_i, takes in the same amount of energy – this energy is derived from respiration.

An outline of aerobic respiration

fig C A simplified model of the main stages of aerobic respiration.

The simple equation given for aerobic respiration hides the fact that the complete process is a complex series of reactions.

Aerobic respiration takes place in two distinct phases. This first stage is known as glycolysis and does not require oxygen. A little ATP is produced here, but more importantly the splitting of the respiratory substrate begins and the molecules are prepared for entry into the second stage of the process.

The second set of reactions is known as the Krebs cycle (see **Section 5.1.3**) and needs oxygen to proceed. The link reaction is needed to move the products of glycolysis into the Krebs cycle and the electron transport chain (see **Section 5.1.4**).

As in all biochemical pathways, the reactions are controlled by enzymes. Because each enzyme is specific to a particular reaction, many different enzymes are involved. The rate of the reaction is controlled by inhibition of the various enzymes, usually by other chemicals in the reaction chain (see **Section 5.1.2**).

Most organisms depend on aerobic respiration, which means that they rely on the presence of oxygen to allow both parts of the respiratory process to occur and provide them with sufficient energy to survive. They may be able to cope with a temporary lack of oxygen, but only in the very short term. Some organisms can survive without oxygen, such as facultative anaerobes, which can rely on anaerobic respiration if necessary. There are a few groups that cannot use oxygen at all and may even be killed by it (see **fig D(b)**).

fig D (a) If this hummingbird (an aerobic organism) is deprived of oxygen, it will only survive for a very short time as the cells cannot obtain enough ATP. (b) However, supply actively dividing *Clostridium perfringens* (the bacterium responsible for gas gangrene in wounds) with oxygen and it will die.

Where does cellular respiration take place?

Glycolysis, the first part of the respiratory pathway, is not associated with any particular cell organelle. The enzymes controlling glycolysis are found in the cytoplasm. However, the other stages in aerobic respiration, including the link reaction, Krebs cycle and the electron transport chain involved in producing ATP, take place inside the mitochondria.

Mitochondria are relatively large organelles with a complex internal structure. They have a double membrane and the inner one is formed in many folds called cristae (see **fig E**). The matrix of the mitochondrion contains the enzymes of the Krebs cycle, while the cristae carry the **stalked particles** associated with ATP synthesis. Cells with very low energy requirements, such as fat storage cells, generally contain very few mitochondria, while cells that are very active, such as those of the muscles and the liver, have very large numbers of mitochondria packed into the cytoplasm.

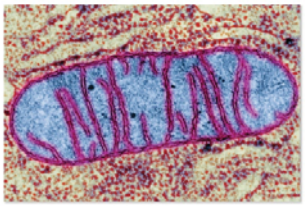


fig E A mitochondrion – the powerhouse of the cell.

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.

RIPLEY ST THOMAS

MINI ASSESSMENT

BRIDGING BOOKLET

INFO:

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.

A Level Biology Transition Mini Assessment

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:

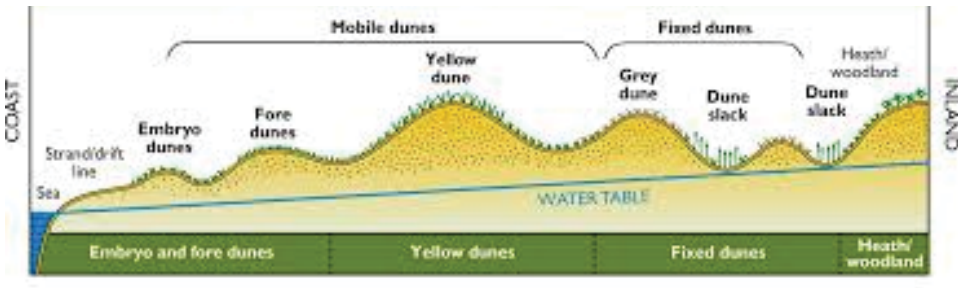


Image taken from http://www.macaulay.ac.uk/soilquality/Dune%20Succession.pdf

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:

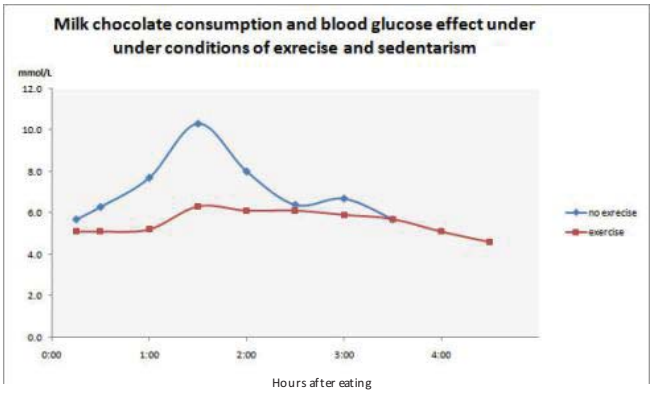


Image taken from https://memoirsofanamnesic.wordpress.com/category/blood-glucose/

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.

……

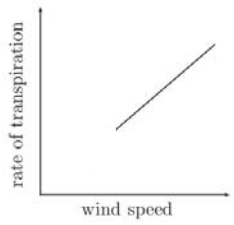
……

……

……

(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.



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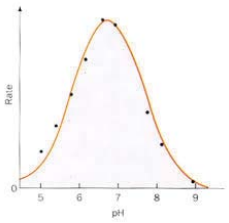

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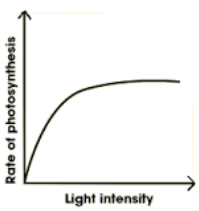


……

……(4)

Images taken from: http://www.everythingmaths.co.za/science/life sciences/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

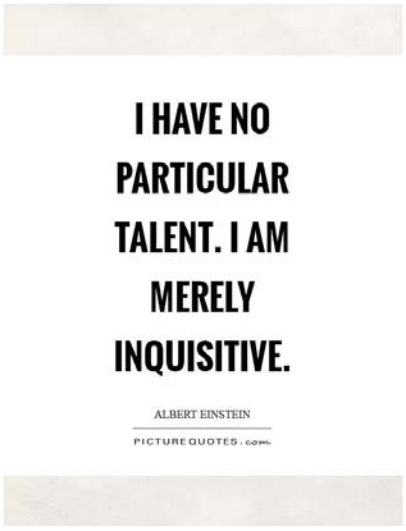
Question			Answer	Marks
4	b		Any 3 from the following structure **and** function must be given. Lipid bilayer - has a hydrophobic inside and hydrophilic outside, allowing for selective permeability Proteins - allow for specific substances to come or some molecules to pass through, Cholesterol - allows 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

RIPLEY ST THOMAS

FURTHER LINKS

BRIDGING BOOKLET

If you have a particular interest in one of these biological areas, follow the links to find out more. Thanks to Shelley Parry for this document!



Virology & Global Health	• Explained: The Next Global Pandemic (20 mins) https://www.netflix.com/watch/81062202?trackId=13752289&tctx=0%2C3%2C0d03e68c-6321-41f2-9dfa-11f336ddc8ca-52560540%2C%2C • FutureLearn course on Coronavirus: https://www.futurelearn.com/courses/covid19-novel-coronavirus • The Life Scientific - viruses: https://www.bbc.co.uk/programmes/m0009b2t
Key Biological Concepts	• Short video - *electron microscopy images* https://www.youtube.com/watch?v=yutNM8AIkkk • Podcast - *'In Our Time - Microscopes'* https://www.bbc.co.uk/programmes/b03jdy3p • Podcast - *'In Our Time - Enzymes'* https://www.bbc.co.uk/programmes/b08rp369
Cells and Control	• TEDx - *Animations of unseeable biology* *https://www.ted.com/talks/drew_berry_animations_of_unseeable_biology?language=en* • *TEDx - A look inside the brain in real time* *https://www.ted.com/talks/christopher_decharms_a_look_inside_the_brain_in_real_time#t-179742* • In Our Time - Free Radicals https://www.bbc.co.uk/programmes/m0000xqd • Reading on microbes: https://www.sciencenews.org/topic/microbes • In Our Time - The Brain https://www.bbc.co.uk/programmes/b00b54yx
Genetics	• Article - Virus mutations - https://www.historyofvaccines.org/content/articles/viruses-and-evolution • Movie - Gattaca. IntoFilm have a worksheet of Science questions you can consider while watching the movie - let me know if you'd like me to send it to you • In Our Time: Genetic Mutation https://www.bbc.co.uk/programmes/b008drvm
Natural Selection & Genetic Modification	Can Science Make Me Perfect? https://www.bbc.co.uk/iplayer/episode/b0b6q3qy/can-science-make-me-perfect-with-alice-roberts Explained: Designer DNA (20 mins) https://www.netflix.com/search?q=science&jbv=80216752&jbp=2&jbr=1 Unnatural Selection (short series) https://www.netflix.com/watch/80208833?trackId=13752289&tctx=0%2C0%2C8bd41505-055d-4d08-a8c9-e71150318bb2-44683054%2C%2C • In Our Time: Neanderthals https://www.bbc.co.uk/programmes/b00sq1nv • The Life Scientific: evolution of cancer https://www.bbc.co.uk/programmes/m0003ks6
Health & Disease	CrowdScience: How did humans discover medicine? https://www.bbc.co.uk/sounds/play/w3csz1v9 CrowdScience: Is vaping bad for your health? https://www.bbc.co.uk/sounds/play/w3cswvx3 • In Our Time: Penicillin https://www.bbc.co.uk/programmes/b07dnnkm • In Our Time: The Origins of Infectious Disease https://www.bbc.co.uk/programmes/b011pldm
Plants	• TEDx - *How can we make crops survive without water?* *https://www.ted.com/talks/jill_farrant_how_we_can_make_crops_survive_without_water#t-16976* • Podcast: Plants, from roots to riches https://www.bbc.co.uk/programmes/b048s3my/episodes/downloads • Plenty of articles to read: https://www.sciencenews.org/topic/plants
Homeostasis & Hormones	Interviews with researchers working on hormones: https://endocrinepod.com/episodes/ OpenUniversity course on diabetes: https://www.open.edu/openlearn/science-maths-technology/biology/living-diabetes/content-section-3.1
Exchange & Transport	• Research Lance Armstrong. For a long time his success was attributed to the fact that his heart is a third larger than the average male's… But what else did he make use of? • In Our Time: Discovery of Oxygen https://www.bbc.co.uk/programmes/b0088nql • In Our Time: The Heart https://www.bbc.co.uk/programmes/p003c1bh • The Big Picture - respiration https://www.stem.org.uk/resources/elibrary/resource/460338/cellular-respiration#&gid=undefined&pid=1
Ecosystems	Read about the work of the World Food Programme https://www.wfp.org/ Your teacher can send you the resources to the Encounter Edu programmes on Frozen Oceans, Coral Oceans and Plastic, Plankton & Poo https://encounteredu.com/teacher-resources/frozen-oceans-science-ages-14-16 https://encounteredu.com/teacher-resources/coral-oceans-science-ages-14-16 https://encounteredu.com/teacher-resources/plankton-plastics-and-poo-science-ages-14-16 Open University free courses: Water cycle: https://www.open.edu/openlearn/science-maths-technology/science/environmental-science/water-use-and-the-water-cycle/content-section-0?active-tab=description-tab Carbon cycle: https://www.open.edu/openlearn/science-maths-technology/across-the-sciences/ecosystems-the-carbon-cycle The Life Scientific: carbon cycle https://www.bbc.co.uk/programmes/m0003cy9 For those with Disney+ - check out all of the National Geographic films and share your recommendations! The same for episodes of Blue Planet/Planet Earth etc The Wonder of Animals (BBC) https://www.bbc.co.uk/iplayer/episode/b04dq5tb/the-wonder-of-animals-1-penguins Articles on ecosystems: https://www.sciencenews.org/topic/ecosystems