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Name:- .....

Year 1 Biology

Summer Transition Work

OCR Module 2

Welcome to Biology at St. Dominic's Sixth Form College! We look forward to you joining us in September.

A Level Biology is a much more detailed look at the concepts you studied at GCSE. It is a very rigorous and demanding course that involves learning content and applying it to unfamiliar contexts, in addition to analysing and evaluating data. The A level is much more strict and specific about the use of keywords.

Many students in the past have found the jump from GCSE to A level difficult and daunting. We hope the process of completing this booklet will be useful in preparing you for that transition, and give you a taste of the level of work to be successful.

Please bring this completed booklet with you (on paper) to your first Biology lesson in September.

The Biology summer work consists of the following tasks:
Task 1: Maths (this will be 10% of your A Level exam)
Task 2: Cell Structure
Task 3: Water
Task 4: Carbohydrates
Task 5: Nucleotides and practical skills
Task 6: University courses and careers

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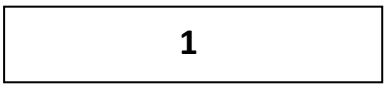
Task 1: Maths in Biology

Mathematical requirements at A level Biology are very high. The assessment will include least 10% Level 2 (GCSE) **or above** mathematical skills. These skills will be applied in the context of the relevant Biology.

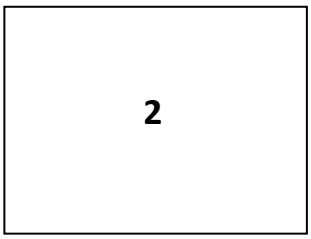
Unit	Symbol	Equivalent in metres	Fraction of a metre
Metre	m	1	One
Decimetre	dm	0.1	One tenth
Centimetre	cm	0.01	One hundredth
Millimetre	mm	0.001	One thousandth
Micrometre	µm	0.000 001	One millionth
Nanometre	nm	0.000 000 001	One thousand millionth

Unit Conversion

Measure these objects in mm then convert as necessary.



Length = ……mm



Length = …… µm

Length = …….. nm

What is the relationship between km, m, mm, µm and nm? (Why does cm not fit the pattern?)
……

Convert values from one unit to another unit

2km = …… m

5cm = …… mm

6µm = …… nm

7mm = …… µm

10nm = …… µm

2mm = …… nm

Here are some more questions to practice conversions.

a. How many micrometres are in a millimetre?	d. How many nanometres are in a micrometre?
b. How many nanometres are in a millimetre?	e Which is bigger? 35000 nm or 34 µm.
c. Which is bigger? 7.3 mm or 34µm.	f Which is bigger 250000nm or 25mm

Calculation of linear magnification

There is a relationship between the actual size, the magnification and the image size of a drawing or micrograph where:

$$\textbf{Actual size} = \frac{\textbf{Image size}}{\textbf{Magnification}}$$

Now have a go at the following calculations
Q1. Answer the following questions.

a) If the image of a specimen is 80mm long and it has been magnified 5000 times (x5000) what is the actual length of the specimen? Give your answer in micrometres.

b) If a specimen is 20μm long and it has been magnified 10,000 times (x10, 000) how long is the length of the specimen in the image? Give your answer in millimetres.

c) A 30nm specimen was photographed. In the text book the image of the specimen was 50mm long. How much has it been magnified?

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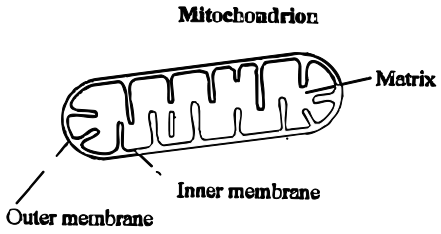
Q2. Use a ruler to find the size of the image of specimen A shown below. The actual size of specimen A is 15 micrometres long. What is the magnification?

Specimen A

Q3. Use a ruler to find the size of the image of specimen B shown below. The specimen has been magnified 30,000 times. What is the actual size of specimen B.?

Specimen B

Q4. Use a ruler to find the magnified size of the mitochondrion shown below. The actual size of the mitochondrion is 2.5 micrometres long. What is the magnification?



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Task 1: Cell Structure

This is a section of the OCR specification for 2.1.1 Cell Structure which shows what students will need to know.

d) the representation of cell structure as seen under the light microscope using drawings and annotated diagrams of whole cells or cells in sections of tissue
e) the use and manipulation of the magnification formula
g) the ultrastructure of eukaryotic cells and the functions of the different cellular components To include the following cellular components and an outline of their functions: nucleus, nucleolus, nuclear envelope, rough and smooth endoplasmic reticulum (ER), Golgi apparatus, ribosomes, mitochondria, lysosomes, chloroplasts, plasma membrane, centrioles, cell wall and cilia.
k) the similarities and differences in the structure and ultrastructure of prokaryotic and eukaryotic cells.

Use the provided CGP revision guide pages or pmt revision notes to fill in the missing words

Nucleus

The nucleus is composed of the nucleolus and the …… envelope.
mRNA and rRNA can enter and leave the nucleus moving through the …….. ……..
Sections of DNA that codes for a polypeptide is called a ……..

Rough endoplasmic reticulum (RER)

The rough endoplasmic reticulum membrane is continuous with the …… ……
The rough endoplasmic reticulum is made up of flattened sacs called ……..
The rough endoplasmic reticulum is studded with ……., which are responsible for …… ……

Smooth endoplasmic reticulum (SER)

The smooth endoplasmic reticulum is responsible for …… synthesis.

Golgi apparatus

The Golgi apparatus is responsible for …… and …… proteins

Ribosomes
Ribosomes are made up of …….. and ……
They are the site of the process of …….. …… They can be free in the cytoplasm or attached to ……..

Cytoskeleton
The cytoskeleton is composed of …… and ……..

Vacuole
The vacuole is surrounded by a membrane called the ……
Only plant cells have a …….. vacuole.

Lysosomes
Lysosomes are vesicles filled with …….. enzymes used to …… unwanted material.

Cilia
Cilia are found outside the cell and are made of ……..

Mitochondria
The mitochondria have a double …….
The inner mitochondrial membrane folds to make structures called ……., these increase the surface area for …….. respiration to occur.

Chloroplast
The chloroplast function is ……
It has a double membrane and a fluid filled interior called the ……

Centrioles
These are located next to the nucleus, they are made of …….. and move the …….. during cell division

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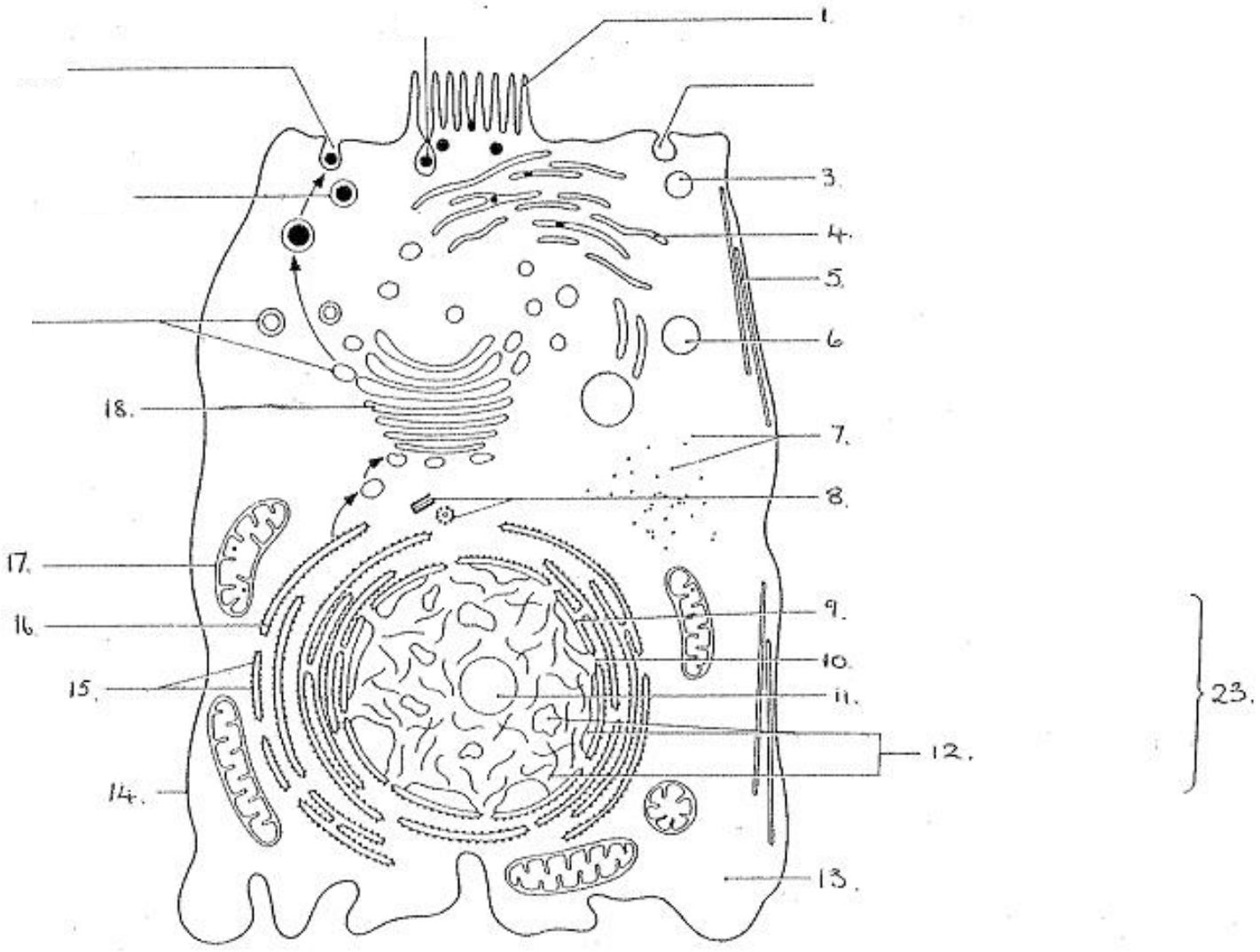
Label the numbered organelles in the animal cell below:-

This is a very detailed image of an animal cell, not all of the labels you need to know, please **only** label the numbered lines

Generalised animal cell as seen with an Electron Microscope (Ultra- Structure)



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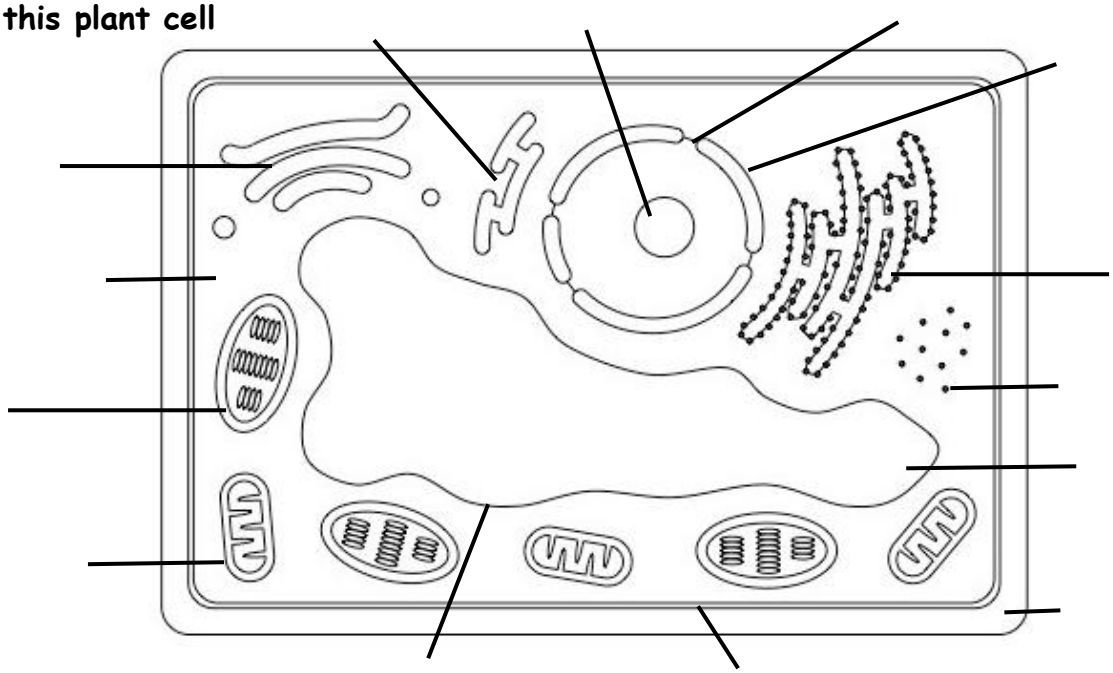
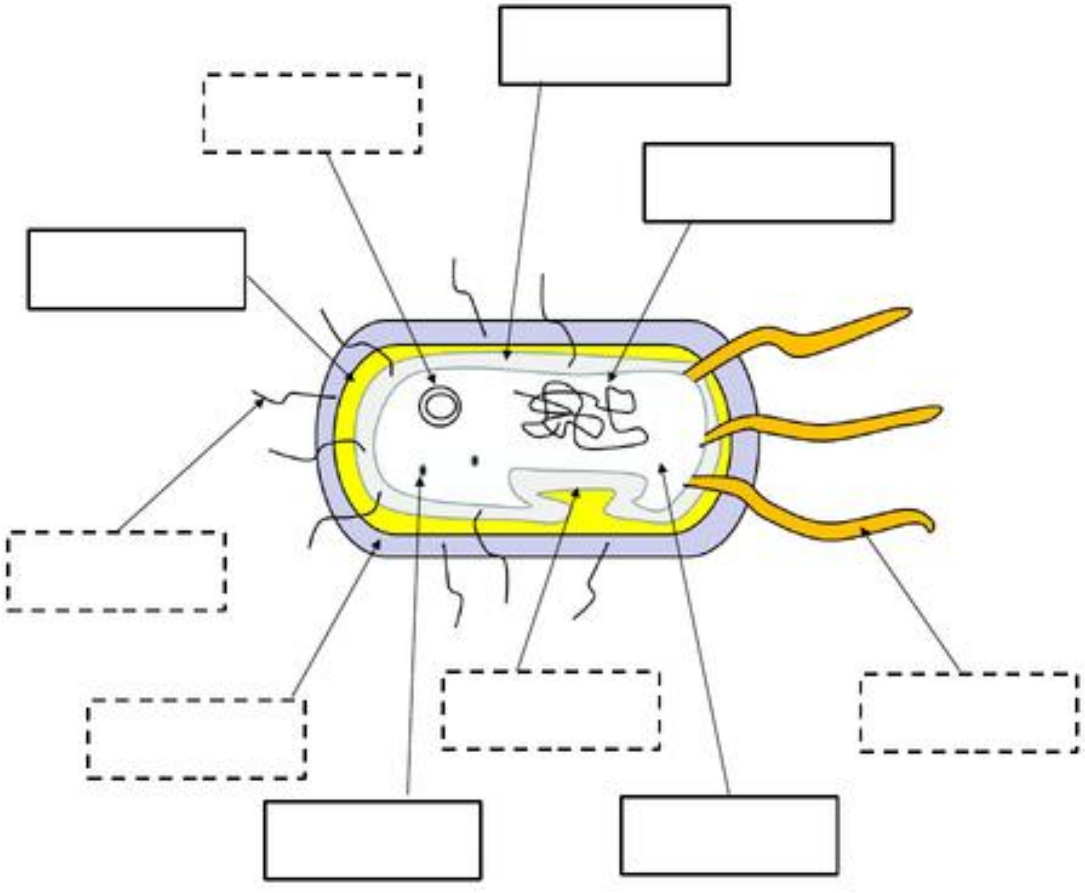
Label this plant cell



Label this bacteria cell & highlight the structures it has in common with eukaryotic cells



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Exam Question – Apply your knowledge

Fig. 1.1 is a diagram of an animal cell as seen using a transmission electron microscope.

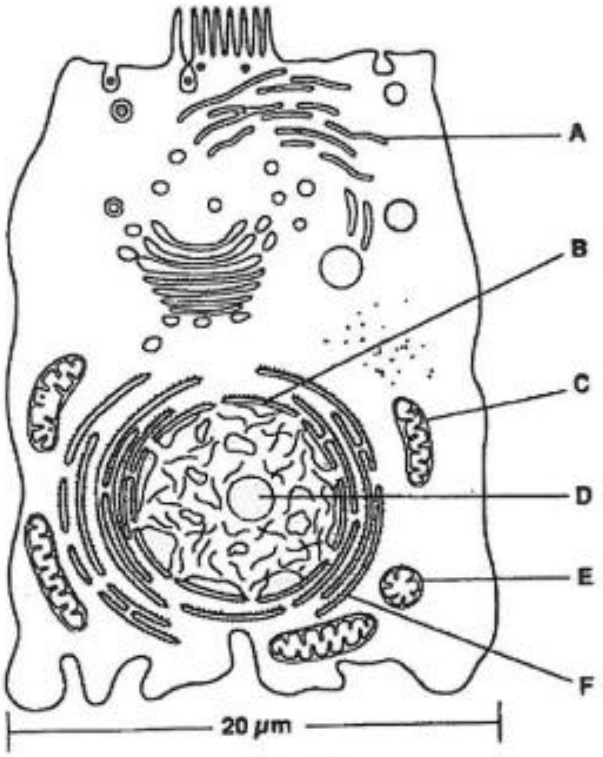

Fig. 1.1

(a) (i) Name the structures of the cell labelled **A**, **B**, **C** and **D**.

A .....

B .....

C .....

D ..... [4]

(ii) Structures **C** and **E** are examples of the same organelle.

Suggest why **E** looks so different to **C**.

.....

.....

.....

..... [2]

(iii) Calculate the actual length of structure **C**.

Show your working and give your answer in micrometres (µm).

Answer = ... µm [2]

In an investigation, cells were broken up (homogenised) and the component organelles were separated into tubes.

Each tube was then tested to determine the identity of the component organelle(s).

The observations are shown in Table 5.2.

Test for the...	Tube			
	1	2		
ability to make ATP	no ATP produced	ATP produced	no ATP produced	no ATP produced
presence of DNA	DNA present	trace amount	no DNA present	no DNA present
ability to produce proteins	no proteins made	no proteins made	no proteins made	proteins made
ability to digest bacteria	none	some ability	none	none

Table 5.2

(i) Identify the tube that contains the following organelles:

nuclei .....

ribosomes .....

mitochondria .....

lysosomes ..... **[4]**

(ii) Which of the organelles listed in **(i)** is the smallest in size?

..... **[1]**

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Task 3: Water

This is a section of the OCR specification for 2.1.2 Biological Molecules which shows what students will need to know.

a) how hydrogen bonding occurs between water molecules, and relate this, and other properties of water, to the roles of water for living organisms.
To include roles that relate to the properties of water; solvent, transport medium, coolant and as a habitat AND roles illustrated using examples of prokaryotes and eukaryotes.
Learners should be able to apply their knowledge and understanding in the context of prokaryotes and Eukaryotes

Part 1: Biochemistry and Water

***State** the **appropriate term** for the definitions below:*

1. A reaction that occurs when two molecules are joined together, with the removal of a water molecule **(1)**

……

2. A reaction that occurs when a molecule is split into two smaller molecules, with the addition of water **(1)**

……

3. A small molecule which binds to many other identical molecules to form a polymer **(1)**

……

4. A strong bond due to atoms sharing electrons **(1)**

……

5. A weak interaction which happens wherever molecules contain a slightly negatively charged atom bonded to a slightly positively charged hydrogen atom **(1)**

……

6. The net diffusion of water across a partially permeable membrane **(1)**

……

7. An example of a polar substance that dissolves in cells **(1)**

……

8. The correct biological term for the heat energy required to break water molecules away from each other so they become a gas **(1)**

……

9. The correct biological term for the heat energy required to raise 1 kg of water by $1^{o}C$ (it has a value of 4.2 KJ) **(1)**

……

10. The attraction of water molecules to each other due to hydrogen bonds between them **(1)**

……

11. Draw a diagram of two water molecules bonded by hydrogen bonds (include the polarity on the atoms) **(3)**

Marks: …… / 13

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Part 2: Properties of water

Below are some of the properties of water:

Liquid	***Solvent***	***Cohesion***	***Surface tension***
Density	***High specific heat capacity***	***High latent heat of vaporisation***	***Reactant***

From the above list, ***state*** *the most appropriate property and* ***explain*** *its ability to carry out the following functions. Each property can be used more than once.*

1. Dissolve and transport sodium chloride in animal circulation (two properties) (4)

Dissolve:

Property: ……

Explanation:

……

……

Transport:

Property: ……

Explanation:

……

……

2. Cool elephants when they spray themselves (2)

Property:……

Explanation:

……

……

3. Enable pond skaters to walk on water (2)

Property:……

Explanation:

……

……

……

4. Enable fish to survive in a freezing pond (2)

Property:……

Explanation:

……

……

……

5. Create a stable aquatic environment (2)

Property:……

Explanation:

……

……

……

6. To be involved in the process of photosynthesis (2)

Property:……

Explanation:

……

……

Marks: …… / 14

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Task 4: Carbohydrates

This is a section of the OCR specification for 2.1.2 Biological Molecules which shows what students will need to know.

d) the ring structure and properties of glucose as an example of a hexose monosaccharide and the structure of ribose as an example of a pentose monosaccharide To include the structural difference between an α- and a β-glucose molecule AND the difference between a hexose and a pentose monosaccharide.
e)the synthesis and breakdown of a disaccharide and polysaccharide by the formation and breakage of glycosidic bonds To include the disaccharides sucrose, lactose and maltose.
f)the structure of starch (amylose and amylopectin), glycogen and cellulose molecules
g)how the structures and properties of glucose, starch, glycogen and cellulose molecules relate to their functions in living organisms

1. Research and draw the structure of an alpha glucose and a beta glucose, highlighting the difference.

2. Research and draw the structure of a ribose sugar

3. Single sugars (called monosaccharides) can join to create a disaccharide (two sugars joined together). Research which sugars join with glucose to form the following 3 disaccharides.

monosaccharides	disaccharide
Glucose +	maltose
Glucose +	sucrose
Glucose +	lactose

4. When two monosaccharides join together this is a …… reaction because water is formed. The general name for the bond formed between the two sugars is a …… bond. To break this bond and reform the two original monosaccharides water is needed, this is a …… Reaction.

5. If a third sugar (or more) joins to the disaccharide it is now a polysaccharide. There are three polysaccharides that you must know. Complete the table below.

polysaccharide	structure	function
starch	Made of alpha glucose joined with 1-4 glycosidic bonds to form amylose and 1-6 glycosidic bonds to form amylopectin	
glycogen		Energy store in animals
cellulose		

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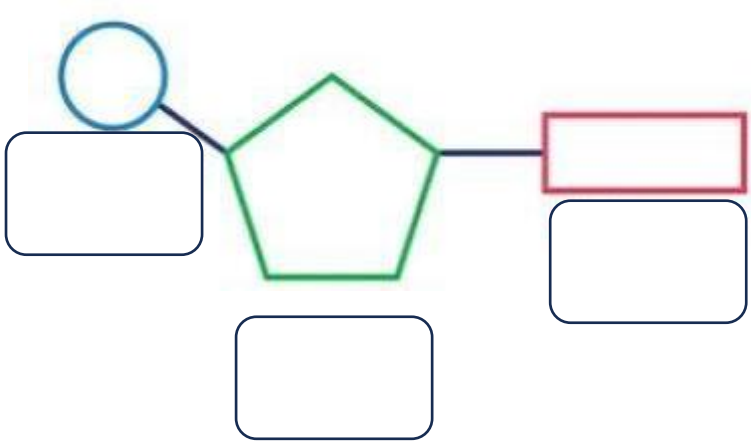
Task 5: Nulcleotides

This is a section of the OCR specification for 2.1.3 Nucleotides and nucleic acids which shows what students will need to know.

a) the structure of a nucleotide as the monomer from which nucleic acids are made. To include the differences between RNA and DNA nucleotides, the identification of the purines and pyrimidines and the type of pentose sugar.
b) the synthesis and breakdown of polynucleotides by the formation and breakage of phosphodiester bonds
c) the structure of ADP and ATP as phosphorylated nucleotides. Comprising a pentose sugar (ribose), a nitrogenous base (adenine) and inorganic phosphates.
d) the structure of DNA (deoxyribonucleic acid) To include how hydrogen bonding between complementary base pairs (A to T, G to C) on two antiparallel DNA polynucleotides leads to the formation of a DNA molecule, and how the twisting of DNA produces its 'double-helix' shape.
e) semi-conservative DNA replication To include the roles of the enzymes helicase and DNA polymerase, the importance of replication in conserving genetic information with accuracy and the occurrence of random, spontaneous mutations.

There are two types of nucleic acids – DNA and RNA. These are made of nucleotides. Label the components of a nucleotide below.



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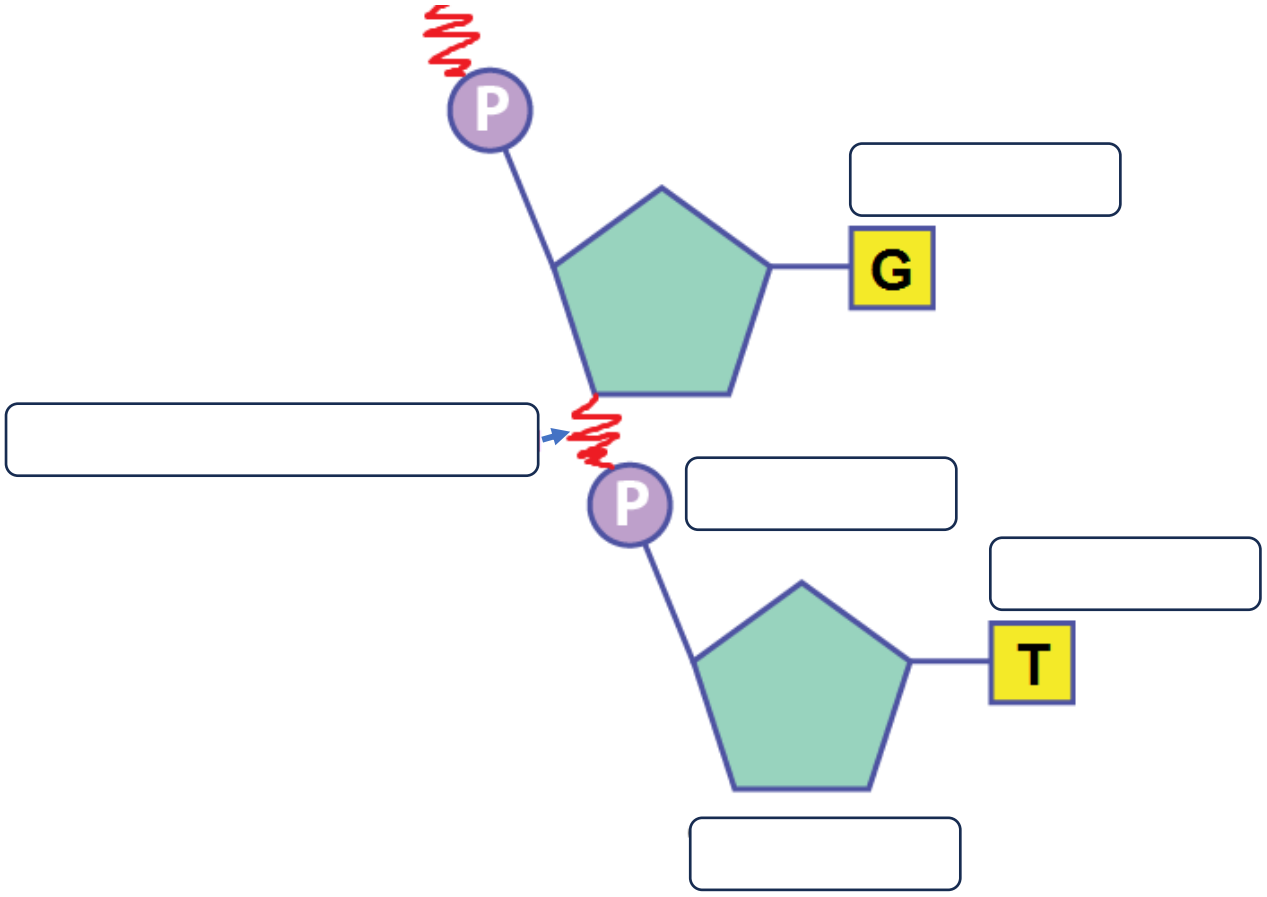
Compare the structure of DNA and RNA using the table below

Similarity 1	
Similarity 2	
Similarity 3	
Difference 1	
Difference 2	
Difference 3	

DNA nucleotides are joined together to form a polynucleotide as shown below. Label this image.



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Fill in the blanks using the following words (some may be used more than once, or not at all):

Word Bank:

Helicase ; Template ; Original ; DNA polymerase ; Complementary ; Guanine ; Cysteine Phosphodiester ; Thymine ; Semi-conservative ; Exposed ; Free ; Adenine ; DNA ligase; Unzip Coding ; DNA ; RNA; Newly synthesised

1. DNA replication is described as _____**(1)** because each new DNA molecule contains one original strand and one newly synthesised strand.

2. The process begins when the enzyme _____**(2)** breaks the hydrogen bonds between complementary base pairs, causing the DNA double helix to unwind and _____**(3)**.

3. Each original strand acts as a _____**(4)** for the formation of a new complementary strand.

4. Free _____**(5)** nucleotides in the nucleus pair with exposed bases according to the rules of _____**(6)** base pairing: adenine pairs with _____ **(7)** and cytosine pairs with _____ **(8)**.

5. The enzyme _____ **(9)** joins the nucleotides together by forming _____ **(10)** bonds between adjacent nucleotides, creating the sugar-phosphate backbone of the new strand.

6. As a result, two identical DNA molecules are produced. Each consists of one _____ **(11)** strand and one _____ **(12)** strand.

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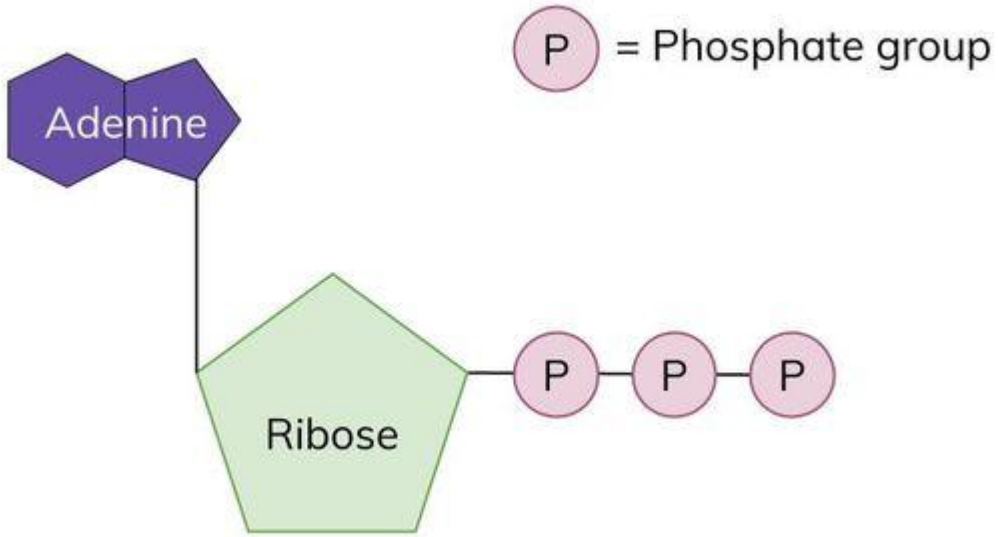
Below is a molecule of ATP, this is very similar to a DNA or RNA nucleotide so examiners often ask you to compare or label them.



Compare the structure of a DNA nucleotide and ATP using the table below

Similarity 1	
Similarity 2	
Similarity 3	
Difference 1	
Difference 2	
Difference 3	

Module 1 – Practical skills

Exam Question – Presenting data

Respiration is an important metabolic process that takes place in all living cells.

The black widow spider, Latrodectus hesperus, paralyses and kills its prey with venom. The venom contains a toxin known as latrotoxin. If a human is bitten, this toxin can cause serious harm by damaging heart tissue. Latrotoxin causes influx of Ca2+ ions, which disrupts normal cell function, including respiration.

An investigation was carried out into the effect of latrotoxin on aerobic respiration in humans. The rate of activity of malate dehydrogenase, a mitochondrial enzyme involved in aerobic respiration, was analysed at different substrate concentrations. The substrate concentrations used were within the normal range for a living cell.

The data is shown in Table 19.1.

Concentration of malate (mmol dm^{-3})	Rate of reaction of malate dehydrogenase (mmol dm^{-3} s^{-1})
0.0	0.0
1.0	37.7
2.0	55.2
3.0	66.0
4.0	74.8
6.0	83.1
8.0	88.9
10.0	92.3
14.0	96.9
18.0	99.0

Use the space provided to plot a suitable graph of these data.

Calculate the mean increase in malate dehydrogenase activity for every 1 mmol dm^{-3} increase in malate concentration between 1.0 and 10.0 mmol dm^{-3}. Give your answer to two significant figures. Show your working.

Answer = ... [3]

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Task 6: University Courses & Careers

1. Research one or more university courses that you are considering doing after you complete your A Levels at St Dominic's. If you are unsure, use this as an opportunity to begin looking into different courses.
   If you do not want to study at university, research the courses or apprenticeships you would like to do in order to support the career you want to pursue.

   You could use the UCAS website to look up courses (or look on each university website, or employers websites):
   https://www.ucas.com/
   https://www.ucas.com/explore/search/apprenticeships?query=

2. For each course list

a) the title of the course

b) the universities you could apply to in order to study this course

c) the entry requirements for this course at each university

d) if you will have to do any post graduate or further training to support your career when you complete your course

e) what work experience would support your application to study this course

3.Write a short paragraph on why you have chosen this course and career path. If you have chosen more than one possible path, write a paragraph for each one.

- Why does this course/apprenticeship interest you?
- What will the career entail and why do you want to pursue it?
- What skills will you have that will help you on this course?
- What skills would you like to develop further to help you on this course and how will you do this?

Eukaryotic Cells and Organelles

Ah, cells. Where would we be without them? There are two types of cell — prokaryotic and eukaryotic. This topic is about eukaryotic cells and their organelles (all the tiny bits and bobs that you can only see in detail with a fancy microscope)...

Organisms can be Prokaryotes or Eukaryotes

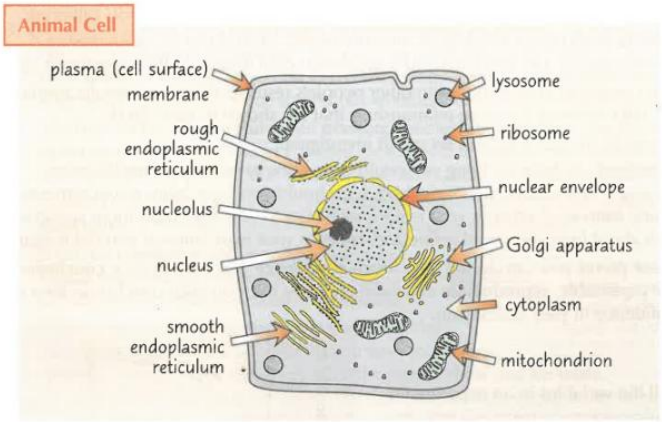
1) Prokaryotic organisms are **prokaryotic cells** (i.e. they're single-celled organisms) and eukaryotic organisms are made up of **eukaryotic cells**.
2) Both types of cells contain **organelles**. Organelles are **parts** of cells — each one has a **specific function**.

1) Eukaryotic cells are **complex** and include all **animal** and **plant cells**.
2) Prokaryotic cells are **smaller** and **simpler**, e.g. bacteria.
See page 15 for more.

Plant and Animal Cells are Both Eukaryotic

Eukaryotic cells are generally a **bit more complicated** than prokaryotic cells. You've probably been looking at **animal** and **plant cell** diagrams for years, so hopefully you'll be familiar with some of the bits and pieces...

Animal Cell

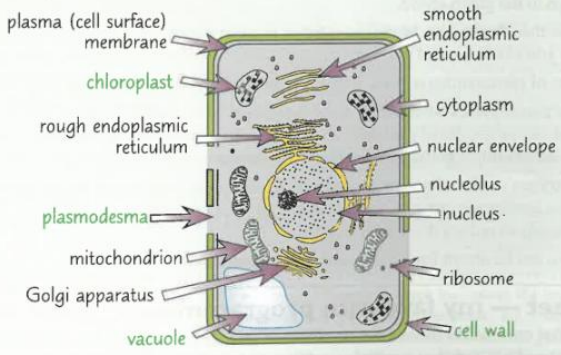


You're expected to be able to interpret photos of cells and their organelles, taken through different types of microscope — so make sure you learn to recognise all the structures on pages 11-13.

Plant Cell

Plant cells have all the **same organelles** as animal cells, but with a few **added extras**:

- a **cell wall** with **plasmodesmata** ('channels' for exchanging substances with adjacent cells),
- a **vacuole** (compartment that contains cell sap),
- and of course good old **chloroplasts**.



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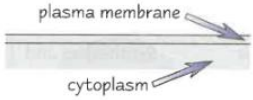
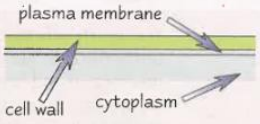
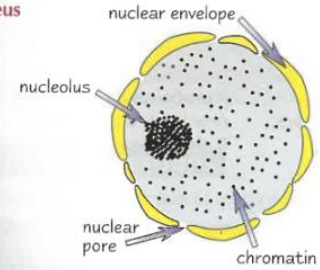
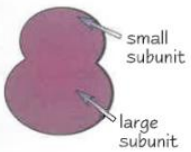
Eukaryotic Cells and Organelles

Different Organelles have Different Functions

This giant table contains a big list of organelles — you need to know the **structure** and **function** of them all. Sorry. Most organelles are surrounded by **membranes**, which sometimes causes confusion — don't make the mistake of thinking that a diagram of an organelle is a diagram of a whole cell. They're not cells — they're **parts of** cells.

ORGANELLE	DIAGRAM	DESCRIPTION	FUNCTION
Plasma (cell surface) membrane		The membrane found on the surface of animal cells and just inside the cell wall of plant cells and prokaryotic cells. It's made mainly of lipids and protein.	Regulates the movement of substances into and out of the cell. It also has receptor molecules on it, which allow it to respond to chemicals like hormones.
Cell wall		A rigid structure that surrounds plant cells. It's made mainly of the carbohydrate cellulose.	Supports plant cells.
Nucleus		A large organelle surrounded by a nuclear envelope (double membrane), which contains many pores. The nucleus contains chromatin (which is made from DNA and proteins) and a structure called the nucleolus.	The nucleus controls the cell's activities (by controlling the transcription of DNA — see page 40). DNA contains instructions to make proteins — see page 38. The pores allow substances (e.g. RNA) to move between the nucleus and the cytoplasm. The nucleolus makes ribosomes (see below).
Lysosome		A round organelle surrounded by a membrane, with no clear internal structure.	Contains digestive enzymes. These are kept separate from the cytoplasm by the surrounding membrane, and can be used to digest invading cells or to break down worn out components of the cell.
Ribosome		A very small organelle that either floats free in the cytoplasm or is attached to the rough endoplasmic reticulum. It's made up of proteins and RNA (see page 34). It's not surrounded by a membrane.	The site where proteins are made.

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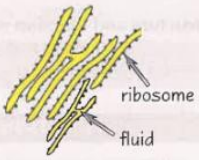
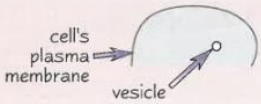
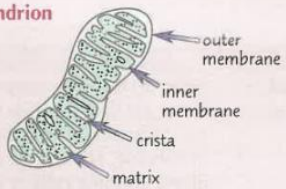
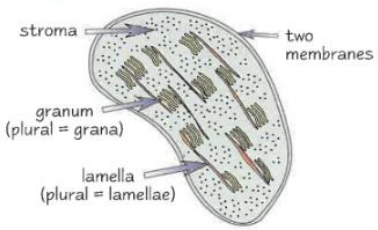
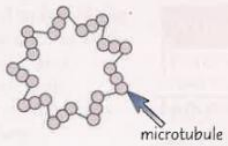
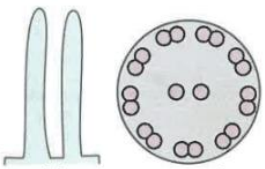
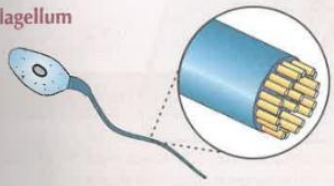
Eukaryotic Cells and Organelles

ORGANELLE	DIAGRAM	DESCRIPTION	FUNCTION
Rough Endoplasmic Reticulum (RER)		A system of membranes enclosing a fluid-filled space. The surface is **covered with ribosomes**.	**Folds** and **processes proteins** that have been made at the ribosomes.
Smooth Endoplasmic Reticulum (SER)		Similar to rough endoplasmic reticulum, but with no **ribosomes**.	**Synthesises** and **processes lipids**.
Vesicle		A small **fluid-filled sac** in the cytoplasm, surrounded by a membrane.	**Transports substances** in and out of the cell (via the plasma membrane) and between organelles. Some are formed by the Golgi apparatus or the endoplasmic reticulum, while others are formed at the cell surface.
Golgi Apparatus		A group of fluid-filled, membrane-bound, **flattened sacs**. Vesicles are often seen at the edges of the sacs.	It **processes** and **packages** new lipids and proteins. It also **makes lysosomes**.
Mitochondrion		They're usually oval-shaped. They have a **double membrane** — the inner one is folded to form structures called **cristae**. Inside is the **matrix**, which contains enzymes involved in respiration.	The **site of aerobic respiration**, where **ATP** is produced. They're found in large numbers in cells that are very **active** and require a lot of **energy**.
Chloroplast		A small, **flattened** structure found in **plant cells**. It's surrounded by a **double membrane**, and also has membranes inside called **thylakoid membranes**. These membranes are stacked up in some parts of the chloroplast to form **grana**. Grana are linked together by lamellae — thin, flat pieces of thylakoid membrane.	The **site** where **photosynthesis** takes place. Some parts of photosynthesis happen in the **grana**, and other parts happen in the **stroma** (a thick fluid found in chloroplasts).

Eukaryotic Cells and Organelles

ORGANELLE	DIAGRAM	DESCRIPTION	FUNCTION
Centriole		Small, **hollow cylinders**, made of **microtubules** (tiny protein cylinders). Found in animal cells, but only some plant cells.	Involved with the **separation of chromosomes** during cell division (see p. 60-62).
Cilia		Small, **hair-like structures** found on the surface membrane of some **animal cells**. In cross-section, they have an outer membrane and a ring of nine pairs of **protein microtubules** inside, with two microtubules in the middle.	The microtubules allow the cilia to **move**. This movement is used by the cell to **move substances along the cell surface**.
Flagellum		Flagella on eukaryotic cells are **like cilia** but longer. They **stick out** from the cell surface and are surrounded by the plasma membrane. Inside they're like cilia too — two **microtubules** in the centre and nine pairs around the edge.	The microtubules **contract** to make the flagellum **move**. Flagella are used like **outboard motors** to propel cells forward (e.g. when a **sperm cell** swims).

This is known as the '9 + 2' formation.

Warm-Up Questions

Q1 How does the structure of rough endoplasmic reticulum differ from that of smooth endoplasmic reticulum?
Q2 Describe the function of vesicles.
Q3 What is the function of chloroplasts?
Q4 What is the function of the centrioles?

PRACTICE QUESTIONS

Exam Questions

Q1 Which of the following describes a structure found in plant cells but not in animal cells?

A A system of membranes enclosing a fluid-filled space.
B A flattened structure surrounded by a double membrane. Internal membranes are stacked up in places to form grana.
C A small organelle consisting of two subunits. It is not surrounded by a membrane.
D A round, membrane-bound organelle containing digestive enzymes. [1 mark]

Q2 a) Identify these two organelles from their descriptions as seen in an electron micrograph.

i) An oval-shaped organelle surrounded by a double membrane. The inner membrane is folded and projects into the inner space, which is filled with a grainy material. [1 mark]

ii) A collection of flattened membrane 'sacs' arranged roughly parallel to one another. Small, circular structures are seen at the edges of these 'sacs'. [1 mark]

b) State the function of the two organelles that you have identified. [2 marks]

That's enough talk of fluid-filled sacs for my liking. Scientists eh...

'Organelle' is a very pretty-sounding name for all those blobs. Actually, under a microscope some of them are really quite fetching — well I think so anyway, but then my mate finds sheep fetching, so there's no accounting for taste. Anyway, you need to know the names and functions of all the organelles and also what they look like.

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Prokaryotic Cells

Prokaryotes are a Different Kind of Cell

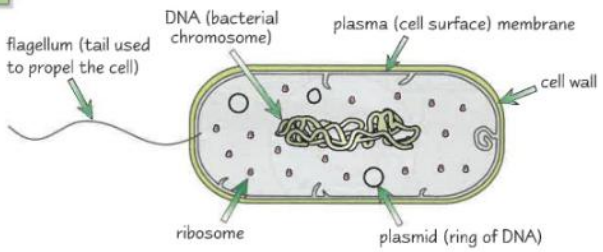
You need to be able to compare and contrast prokaryotic and eukaryotic cells. This big orange table should help...

A micrometre (μm) is one millionth of a metre, or 0.001 mm.

PROKARYOTES	EUKARYOTES
Extremely small cells (less than 2 μm diameter)	Larger cells (about 10-100 μm diameter)
DNA is circular	DNA is linear
No nucleus — DNA free in cytoplasm	Nucleus present — DNA is inside nucleus
Cell wall made of a polysaccharide, but not cellulose or chitin	No cell wall (in animals), cellulose cell wall (in plants) or chitin cell wall (in fungi)
Few organelles and no membrane-bound organelles, e.g. no mitochondria	Many organelles — mitochondria and other membrane-bound organelles present
Flagella (when present) made of the protein flagellin, arranged in a helix	Flagella (when present) made of microtubule proteins arranged in a '9 + 2' formation
Small ribosomes	Larger ribosomes
Example: *E. coli* bacterium	**Example:** Human liver cell

Bacterial Cells are Prokaryotic

1) Prokaryotes like bacteria are roughly a **tenth the size** of eukaryotic cells.
2) This means that normal microscopes aren't really powerful enough to look at their **internal structure**.
3) The diagram shows a bacterial cell as seen under an **electron microscope** (see page 17).



Warm-Up Questions

Q1 An unidentified cell is found to contain mitochondria. Is it prokaryotic or eukaryotic?
Q2 How is a prokaryotic cell wall different to a eukaryotic cell wall?

PRACTICE QUESTIONS

Exam Questions

Q1 Some mucus-secreting cells were immersed in a solution of radioactive amino acids.
Every five seconds, some of the cells were removed and their organelles were separated and analysed.
The radioactivity in the different organelles was measured for each five second interval.

When answering the first two questions below, use organelles from this list —
Golgi apparatus, ribosomes, rough endoplasmic reticulum, vesicles.

a) In which of these organelles would you expect radioactivity to appear first? Explain your answer. [2 marks]
b) After 5 minutes, the Golgi apparatus had become radioactive.
Which other organelle(s) would be radioactive by this time? [2 marks]
c) The researchers were particularly interested in the cells' vesicles. What is the function of vesicles? [1 mark]

Q2 Give three functions of a cell's cytoskeleton. [3 marks]

A cell without a nucleus — it's like a Yorkshire pud without gravy...
Prokaryotes are way, way older than eukaryotes. In fact, most cellular biologists think that mitochondria and chloroplasts are remnants of ancient prokaryotes that lived inside the first eukaryotes and eventually just became part of them. Mad.

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Water

Your body needs all sorts of different molecules to stay alive, and this section covers all the major groups. Life can't exist without water — in fact, everyday water is one of the most important substances on the planet.

Water is Vital to Living Organisms

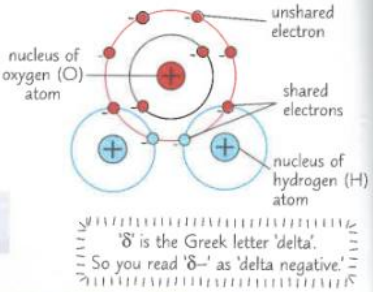
Water makes up about 80% of a cell's contents. It has loads of important **functions**, inside and outside cells:

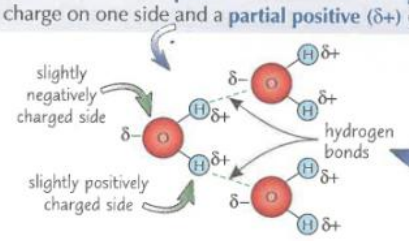
1) Water is a **reactant** in loads of important **chemical reactions**, including **hydrolysis reactions** (see page 22).
2) Water is a **solvent**, which means some substances **dissolve** in it. Most biological reactions take place **in solution** (e.g. in the **cytoplasm** of eukaryotic and prokaryotic cells) so water's pretty essential.
3) Water **transports** substances. The fact that it's a **liquid** and a **solvent** means it can easily transport all sorts of materials, like glucose and oxygen, around plants and animals.
4) Water helps with **temperature control** because it has a **high specific heat capacity** and a **high latent heat of evaporation** (see below).
5) Water is a **habitat**. The fact that it helps with **temperature control**, is a **solvent** and becomes **less dense** when it **freezes** (see next page) means many organisms can survive and reproduce in it.

Water Molecules have a Simple Structure

Examiners like asking you to relate **structure** to **properties** and **function**, so make sure you know the structure of water.

1) A molecule of **water** (H_2O) is **one atom** of **oxygen** (O) joined to **two atoms** of **hydrogen** (H_2) by **shared electrons**.
2) Because the **shared negative** hydrogen electrons are **pulled towards** the oxygen atom, the other side of each hydrogen atom is left with a **slight positive charge**.
3) The **unshared** negative electrons on the oxygen atom give it a **slight negative charge**.
4) This makes water a **polar** molecule — it has a **partial negative** (δ–) charge on one side and a **partial positive** (δ+) charge on the other.





5) The slightly negatively-charged **oxygen atoms attract** the slightly positively-charged **hydrogen atoms** of other water molecules.
6) This attraction is called **hydrogen bonding** and it gives water some of its useful properties.

Water's Structure is Related to its Properties and Functions

Hydrogen Bonds Give Water a High Specific Heat Capacity

1) Specific heat capacity is the **energy** needed to **raise the temperature** of 1 gram of a substance by 1 °C.
2) The **hydrogen bonds** between water molecules can **absorb** a **lot** of energy. So water has a **high** specific heat capacity — it takes a lot of energy to heat it up.
3) This means water **doesn't** experience **rapid temperature changes**, which is one of the properties that makes it a **good habitat** — the temperature under water is likely to be more stable than it is on land.

Hydrogen Bonds Also Give Water a High Latent Heat of Evaporation

1) It takes a lot of **energy** (**heat**) to **break** the hydrogen bonds between water molecules.
2) So water has a **high latent heat of evaporation** — a lot of energy is used up when water **evaporates**.
3) This is useful for living organisms because it means water's great for **cooling** things. This is why some **mammals**, like us, **sweat** when they're **too hot**. When sweat evaporates, it **cools** the **surface** of the **skin**.

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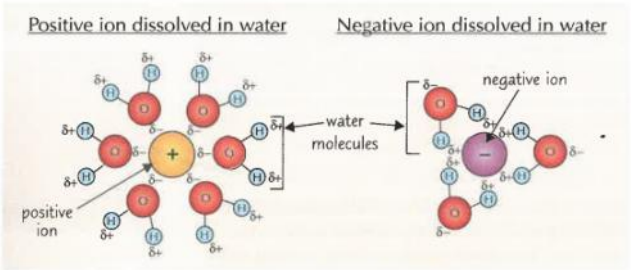
Water

Water's **Polarity** Makes it **Very Cohesive**

1) Cohesion is the **attraction** between molecules of the same type (e.g. two water molecules). Water molecules are **very cohesive** (they tend to stick together) because they're **polar**.
2) This helps water to **flow**, making it great for **transporting substances**. It also helps water to be transported up **plant stems** in the **transpiration stream** (see page 91).

Water's **Polarity** Also Makes it a **Good Solvent**

1) A lot of important substances in biological reactions are **ionic** (like **salt**, for example). This means they're made from **one positively-charged** atom or molecule and **one negatively-charged** atom or molecule (e.g. salt is made from a positive sodium ion and a negative chloride ion).
2) Because water is polar, the **slightly positive end** of a water molecule will be attracted to the **negative ion**, and the **slightly negative end** of a water molecule will be attracted to the **positive ion**.
3) This means the ions will get **totally surrounded** by water molecules — in other words, they'll **dissolve**.



The polar nature of bears sometimes results in unexpected hydrogen bonding.

4) Water's **polarity** makes it useful as a **solvent** in living organisms. E.g. in **humans**, important **ions** (see p. 29) can dissolve in the water in **blood** and then be transported around the body.

Water's **Less Dense When it's Solid**

1) At **low temperatures** water **freezes** — it turns from a liquid to a solid.
2) Water molecules are held **further apart** in **ice** than they are in liquid water because each water molecule forms **four hydrogen bonds** to other water molecules, making a **lattice** shape. This makes ice **less dense** than liquid water — which is why **ice floats**.
3) This is useful for living organisms because, in cold temperatures, ice forms an **insulating layer** on top of water — the water below **doesn't freeze**. So organisms that live in water, like **fish**, **don't freeze** and can still **move around**.

Warm-Up Questions

PRACTICE QUESTIONS

Q1 Briefly describe the structure of a water molecule.
Q2 Briefly describe what is meant by a polar molecule.
Q3 State five properties of water that make it useful for living organisms.
Q4 Why is water's high specific heat capacity useful for living organisms?

Exam Question

Q1 In hot temperatures, elephants commonly spray themselves with water. With reference to the structure of water, explain why this behaviour acts as a cooling mechanism for the elephant. [3 marks]

Psssssssssssssssssssssssssssssssssssssssss — need the loo yet?
Water is pretty darn useful really. It looks so, well, dull — but in fact it's scientifically amazing. It's essential for all kinds of jobs — keeping cool, transporting things, enabling reactions, etc. You need to learn all of its properties and functions, and be able to say how they relate to its structure. Right, I'm off — when you gotta go, you gotta go.

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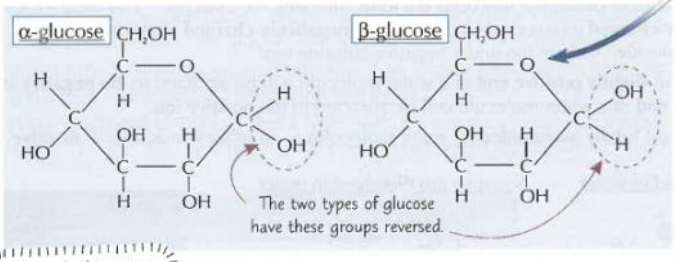
Carbohydrates

Carbohydrates are important biological molecules — for a start they're the main energy supply in living organisms.

Carbohydrates are Made from Monosaccharides

1) Most carbohydrates are **polymers**. A polymer is a molecule made up of **many similar, smaller molecules** (called **monomers**) bonded together.
2) The monomers that make up carbohydrates are called **monosaccharides**.
3) **Glucose** is a monosaccharide with **six carbon** atoms — this means it's a **hexose** monosaccharide.
4) There are **two forms** of glucose — **alpha** (α) and **beta** (β). They both have a **ring structure**:

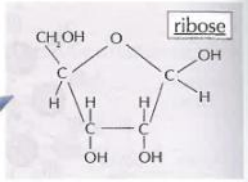
Although most carbohydrates are polymers, single monosaccharides are also called carbohydrates.



5) Glucose's **structure** is related to its **function** as the main **energy source** in animals and plants. Its structure makes it **soluble** so it can be **easily transported**. Its chemical bonds contain **lots of energy**.

Ribose is the sugar component of RNA nucleotides (see p. 34).

6) **Ribose** is a monosaccharide with **five carbon** atoms — this means it's a **pentose** monosaccharide.
7) You need to know its **structure**:



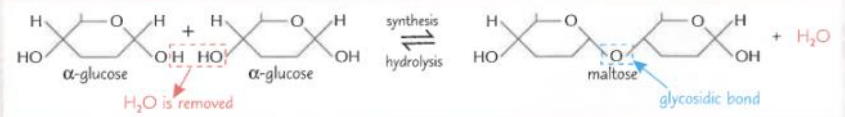
8) All carbohydrates are made up of the same **three chemical elements** — **carbon** (**C**), **hydrogen** (**H**) and **oxygen** (**O**). For every **carbon atom** in the carbohydrate there are usually **two hydrogen atoms** and **one oxygen atom**.

Monosaccharides Join Together to Form Disaccharides and Polysaccharides

1) Monosaccharides are **joined together** by **glycosidic bonds**.
2) During **synthesis**, a **hydrogen** atom on one monosaccharide bonds to a **hydroxyl** (OH) group on the other, **releasing** a molecule of **water**. This is called a **condensation** reaction.
3) The **reverse** of this synthesis reaction is **hydrolysis**. A molecule of water reacts with the glycosidic bond, **breaking it apart**.
4) A **disaccharide** is formed when **two monosaccharides** join together:

Sugar is a general term for monosaccharides and disaccharides.

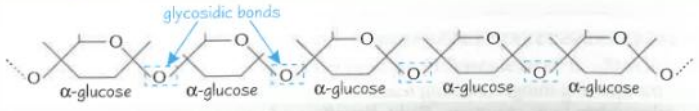
For example, two α-glucose molecules are joined together by a glycosidic bond to form maltose:



Other disaccharides are formed in a similar way. Sucrose is a disaccharide formed when α–glucose and fructose join together. Lactose is a disaccharide formed by the joining together of either α–glucose or β–glucose and galactose.

5) A **polysaccharide** is formed when **more than two monosaccharides** join together:

Lots of α-glucose molecules are joined together by glycosidic bonds to form amylose.



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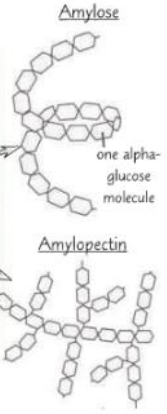
Carbohydrates

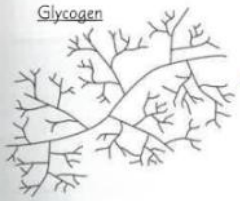
You Need to Learn About Three Polysaccharides

You need to know about the relationship between the **structure** and **function** of three polysaccharides:

1 Starch — the main energy storage material in plants

1) Cells get energy from glucose. Plants store excess glucose as starch (when a plant needs more glucose for energy it breaks down starch to release the glucose).
2) Starch is a mixture of two polysaccharides of alpha-glucose — amylose and amylopectin:
   - Amylose — a long, unbranched chain of α–glucose. The angles of the glycosidic bonds give it a coiled structure, almost like a cylinder. This makes it compact, so it's really good for storage because you can fit more in to a small space.
   - Amylopectin — a long, branched chain of α–glucose. Its side branches allow the enzymes that break down the molecule to get at the glycosidic bonds easily. This means that the glucose can be released quickly.
3) Starch is insoluble in water, so it doesn't cause water to enter cells by osmosis (see p. 58) which would make them swell. This makes it good for storage.



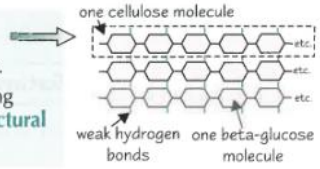


2 Glycogen — the main energy storage material in animals

1) Animal cells get energy from glucose too. But animals store excess glucose as glycogen — another polysaccharide of alpha-glucose.
2) Its structure is very similar to amylopectin, except that it has loads more side branches coming off it. Loads of branches means that stored glucose can be released quickly, which is important for energy release in animals.
3) It's also a very compact molecule, so it's good for storage.

3 Cellulose — the major component of cell walls in plants

1) Cellulose is made of long, unbranched chains of beta-glucose.
2) When beta-glucose molecules bond, they form straight cellulose chains.
3) The cellulose chains are linked together by hydrogen bonds to form strong fibres called microfibrils. The strong fibres mean cellulose provides structural support for cells (e.g. in plant cell walls).



Warm-Up Questions

Q1 What is the structural difference between an alpha-glucose molecule and a beta-glucose molecule?
Q2 Describe how glycosidic bonds are formed and broken in living organisms.
Q3 Briefly describe the structure of starch.
Q4 What is the function of cellulose?

PRACTICE QUESTIONS

Exam Questions

Q1 Mannose is a hexose monosaccharide.
Which of the following is most likely to give the chemical formula of a mannose molecule?
A $C_5H_{10}O_5$ B $C_6H_{12}O_6$ C $C_6H_{12}N_6$ D $C_5H_5O_{10}$ [1 mark]

Q2 State the function of glycogen and explain how the structure of glycogen is linked to its function. [3 marks]

Mmmm, starch... Tasty, tasty chips and beans... *dribble*. Ahem, sorry.
Remember that condensation and hydrolysis reactions are the reverse of each other. You need to learn how maltose, sucrose and lactose are formed and broken down by these reactions. And don't forget that starch is composed of two different polysaccharides... and that glucose exists in two forms... so many reminders, so little space...

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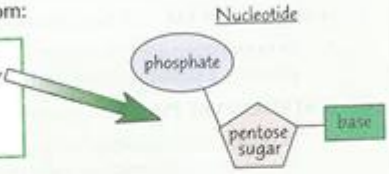
Nucleotides

You might not have heard of them, but nucleotides are pretty vital for life. These two pages will tell you more.

Nucleotides are Used to Make Nucleic Acids

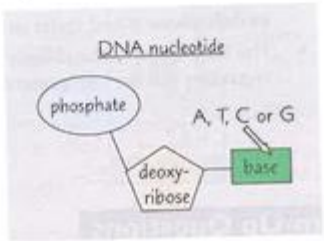
1) A **nucleotide** is a type of biological molecule. It's made from:
   - a **pentose sugar** (that's a sugar with 5 carbon atoms),
   - a **nitrogenous** (nitrogen-containing) **base**,
   - a **phosphate** group.



   All nucleotides contain the elements **C**, **H**, **O**, **N** and **P**.
2) Nucleotides are really **important**. For a start, they're the **monomers** (see p. 22) that make up **DNA** and **RNA**. DNA and RNA are both types of **nucleic acid**. DNA is used to **store genetic information** — the instructions an organism needs to grow and develop. RNA is used to make **proteins** from the instructions in DNA.
3) **ADP** and **ATP** are **special types** of nucleotide (see next page). They're used to **store** and **transport energy** in **cells**.

The Sugar in DNA is Called Deoxyribose

1) The **pentose sugar** in a **DNA nucleotide** is called **deoxyribose**. (DNA stands for **d**eoxyribo**n**ucleic **a**cid.)
2) Each DNA nucleotide has the **same sugar** and a **phosphate group**. The **base** on each nucleotide can **vary** though.
3) There are **four** possible bases — adenine (**A**), thymine (**T**), cytosine (**C**) and guanine (**G**).
4) **A**denine and **g**uanine are a type of base called a **purine**. **C**ytosine and **t**hymine are a type of base called a **pyrimidine**.



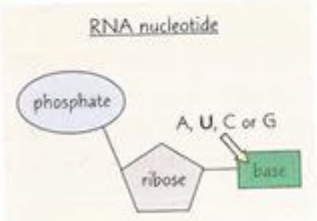
   - A **purine** base contains **two carbon-nitrogen rings** joined together.
   - A **pyrimidine** base only has **one carbon-nitrogen ring**. So a pyrimidine base is **smaller** than a purine base.

5) A **molecule** of DNA contains two **polynucleotide** chains — each chain is made up of lots of **nucleotides** joined together. There's more on how polynucleotides form on page 36.

Remember: the pyrimidines in DNA are cytosine and thymine.

The Sugar in RNA is Called Ribose

1) **RNA** (**r**ibo**n**ucleic **a**cid) contains nucleotides with a **ribose sugar** (not deoxyribose).
2) Like DNA, an RNA nucleotide also has a **phosphate group** and one of **four** different **bases**.
3) In RNA though, **uracil** (a **pyrimidine**) replaces **thymine** as a base.



4) An RNA molecule is made up of a **single polynucleotide chain**.

Hana didn't care if it was ribose or deoxyribose, she was just enjoying her cuppa.

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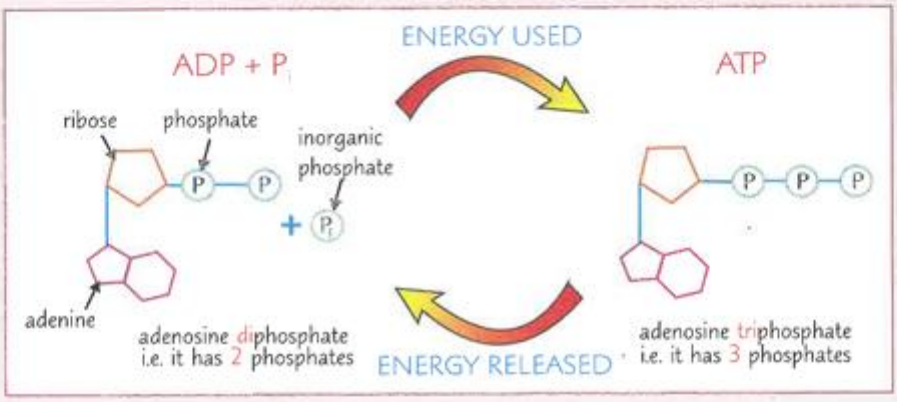
Nucleotides

ADP and ATP are Phosphorylated Nucleotides

1) To **phosphorylate** a nucleotide, you **add** one or more **phosphate** groups to it.
2) **ADP** (adenosine **di**phosphate) contains the base **adenine**, the sugar **ribose** and **two phosphate groups**.
3) **ATP** (adenosine **tri**phosphate) contains the base adenine, the sugar ribose and **three** phosphate groups.

- ATP provides energy for chemical reactions in the cell.
- ATP is synthesised from ADP and inorganic phosphate (P_i) using the energy from an energy-releasing reaction, e.g. the breakdown of glucose in respiration. The ADP is phosphorylated to form ATP and a phosphate bond is formed.
- Energy is stored in the phosphate bond. When this energy is needed by a cell, ATP is broken back down into ADP and inorganic phosphate (P_i). Energy is released from the phosphate bond and used by the cell.



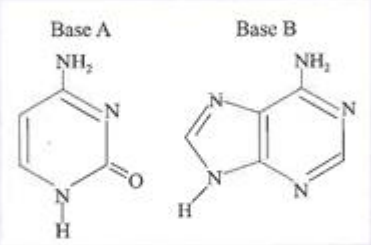
Warm-Up Questions

PRACTICE QUESTIONS

Q1 What are the three main components of nucleotides?
Q2 What sugar is found in DNA nucleotides?
Q3 Which sugar do RNA nucleotides contain?
Q4 What is the name of the base in ATP?

Exam Questions

Q1 The structures of two nitrogen-containing bases are shown on the right.



a) Which base, **A** or **B**, is adenine and which is cytosine? Explain your answer. [3 marks]
b) Apart from nitrogen, name a chemical element present in base **A**. [1 mark]

Q2 ADP is made up of the molecule AMP and an inorganic phosphate.
a) Suggest the chemical composition of AMP. [3 marks]
b) Name the process by which one or more phosphate groups are added to a molecule. [1 mark]

Q3 After a heart attack ATP levels in the heart are low. Studies have been carried out to find whether ribose supplements could help the heart to replenish ATP supplies after a heart attack. Suggest why scientists think ribose supplements have the potential to be used in this way. [2 marks]

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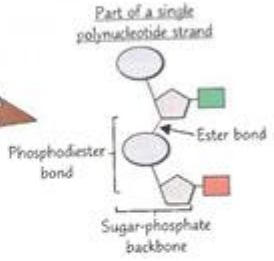
Polynucleotides and DNA

Right, by now you should know what a nucleotide is (see the previous two pages if not).
Well now you need to learn how they come together to form polynucleotides — like DNA.

Nucleotides Join Together to Form Polynucleotides

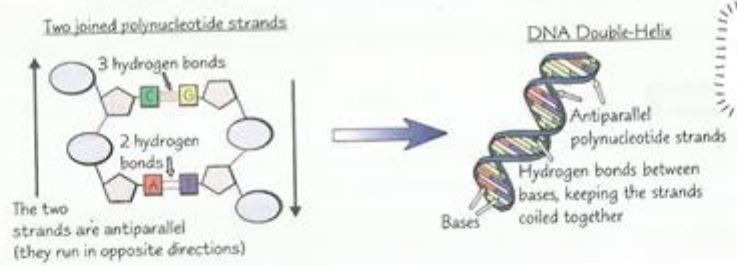
1) The nucleotides join up between the **phosphate** group of one nucleotide and the **sugar** of another via a **condensation reaction**. This forms a **phosphodiester bond** (consisting of the phosphate group and two ester bonds).
2) The chain of sugars and phosphates is known as the **sugar-phosphate backbone**.
3) **Polynucleotides** can be **broken down** into nucleotides again by breaking the phosphodiester bonds (using **hydrolysis reactions**).

There's more on condensation and hydrolysis reactions involving ester bonds on p.24.



Two Polynucleotide Strands Join Together to Form a Double-Helix

1) **Two DNA** polynucleotide strands join together by **hydrogen bonding** between the bases.
2) Each base can only join with one particular partner — this is called **complementary base pairing**.
3) **Adenine** always pairs with **thymine** (**A - T**) and **cytosine** always pairs with **guanine** (**C - G**).
   A **purine** (A or G) always pairs with a **pyrimidine** (T or C).
4) **Two** hydrogen bonds form between **A and T**, and **three** hydrogen bonds form between **C and G**.
5) Two **antiparallel** (running in opposite directions) polynucleotide strands **twist** to form the **DNA double-helix**.



You can use computer modelling to investigate the structure of DNA and other nucleic acids.

You Can Purify DNA Using a Precipitation Reaction

PRACTICAL SKILLS

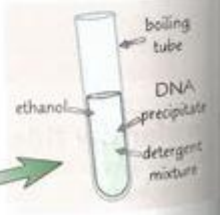
I really like this investigation. It's **proper science**, with **green bubbly stuff** (detergent) and everything...

1) **Break up the cells** in your sample (probably a bit of **onion** or something). You can do this using a **blender**.
2) Make up a solution of **detergent** (a dilute washing-up liquid will do), **salt** (sodium chloride) and **distilled water**.
3) Add the broken-up cells to a beaker containing the detergent solution. Incubate the beaker in a **water bath** at **60 °C** for **15 minutes**.

The detergent in the mixture breaks down the cell membranes. The salt binds to the DNA and causes it to clump together. The temperature of the water bath should stop enzymes in the cells from working properly and breaking down the DNA.

4) Once incubated, put your beaker in an **ice bath** to **cool** the mixture down. When it's cooled, **filter** the mixture. Transfer a sample of your mixture to a clean boiling tube.
5) Add **protease enzymes** to the filtered mixture. These will **break down** some **proteins** in the mixture, e.g. proteins bound to the DNA. Adding **RNase enzymes** will break down any **RNA** in the mixture.
6) Slowly dribble some **cold ethanol** down the side of the tube, so that it forms a **layer** on top of the DNA-detergent mixture.
7) If you leave the tube for a few minutes, the DNA will form a **white precipitate** (solid), which you can remove from the tube using a glass rod.

There's more on enzymes on pages 42 - 49.



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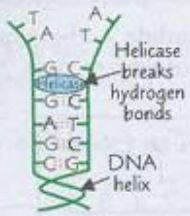
Polynucleotides and DNA

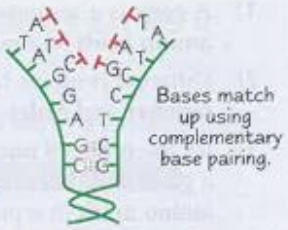
DNA can Copy Itself — Self-Replication

DNA copies itself before **cell division** (see page 60) so that each new cell has the full amount of DNA.

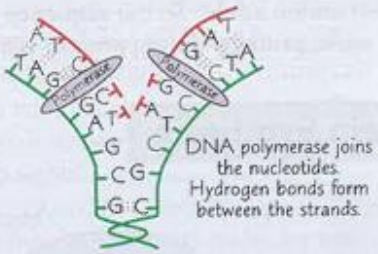
1) **DNA helicase** (an enzyme) **breaks** the **hydrogen bonds** between the two **polynucleotide** DNA strands. The helix **unzips** to form two single strands.



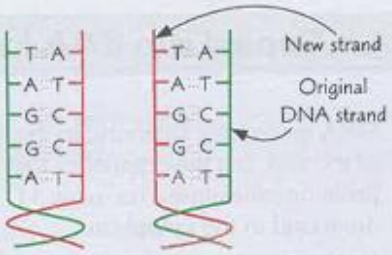
2) Each **original** single strand acts as a **template** for a new strand. Free-floating DNA nucleotides join to the **exposed bases** on each original template strand by **complementary base pairing** — A with T and C with G.



3) The nucleotides of the new strand are **joined together** by the enzyme **DNA polymerase**. This forms the **sugar-phosphate backbone**. **Hydrogen bonds** form between the bases on the original and new strand. The strands twist to form a **double-helix**.



4) Each new DNA molecule contains **one strand** from the **original** DNA molecule and **one new strand**.



1) This type of copying is called **semi-conservative replication** because **half** of the strands in each new DNA molecule are from the **original** piece of DNA (i.e. the new molecule contains one **old** strand and one **new** strand).
2) DNA replication is really **accurate** — it has to be, to make sure **genetic information** is **conserved** (stays the same) **each time** the DNA in a cell is replicated.
3) Every so often though, a **random, spontaneous mutation** occurs. A mutation is any **change** to the **DNA base sequence**. Mutations don't always have an effect, but they can **alter** the **sequence of amino acids** in a **protein** (see next page). This can cause an **abnormal protein** to be produced. The abnormal protein might function **better** than the normal protein — or it might **not work at all**.