Applied Science (BTEC) Summer project

Useful website

https://qualifications.pearson.com/en/qualifications/btec-nationals/applied-science-aaq.html

This is the link to the specification that we will study.

Lots of useful information on the specification and website.

Useful email

Any questions or queries, please contact me on

callan.e@stowevalley.com

Remember to bring all the work you have done to the first lesson of Science – any work you have done electronically, please save with a sensible title and email (from school email if possible, please) to the address above.

Looking forward to seeing you all soon and good luck with your summer project.

Mrs Callan, Dr Brink and Mrs Thomas

There are two parts to the transition project……

1. Learning material for a test based on material covered at GCSE
2. Research some of the new practical techniques you will meet during the Applied Science course.

1. Learning material from GCSE

In your first Science lesson, you will be asked to complete a test based on topics that you will have met at GCSE. Use the photocopied pages in this booklet and make sure you can answer the questions on the next page.

- **Biology**

  Eukaryotic and Prokaryotic cells; Microscopes; Functions of Nucleus, Mitochondria and Cell Wall

- **Chemistry**

  Atomic Structure; Atomic number, Mass number and Isotopes; Relative Atomic Mass, The Periodic Table

- **Physics**

  Waves

Questions to practice (use the relevant pages below to support you)

Eukaryote and prokaryotic cells/Functions of the nucleus mitochondria and cell wall.

1. Name three parts of a plant cell NOT found in an animal cell.
2. What is the function of each part of the cell?
3. What is the difference between eukaryotic and prokaryotic cells? Give an example of each type.

Microscopes

4. Describe what each part of a microscope is for.

Atomic structure

5. What are the masses and charges of protons, neutrons and electrons?

Atomic number, mass number and Isotopes

6. What is an isotope?

Relative atomic mass

7. Try the calculations at the bottom of the “relative atomic mass” page of the photocopy.

Waves

8. What do the following terms mean – oscillations, longitudinal, transverse, amplitude, wavelength, frequency?
9. Sketch a wave that has a high amplitude and a low frequency, and a second wave with a low amplitude and a high frequency.

2. Researching new scientific techniques

There is lots of practical work throughout the Applied Science course, and the assignments you complete in year 12 are entirely practical based.

Please find out:

- why the following techniques are used in science
- what equipment they use
- how you carry out the practical.

Remember to use a numbered list for your method and diagrams to show the equipment.

The techniques are

1. Making a standard solution
2. Titration
3. Calibration of thermometers and balance
4. Chromatography (you will have met this at GCSE very briefly)
5. C**o**lorimetry (spell this carefully – there is a scientific technique with a very similar spelling (calorimetry))

Complete your research in a Word document or similar and remember to include the references for any web pages you use.

Email me if you have any queries or questions, and I look forward to seeing you again in September.

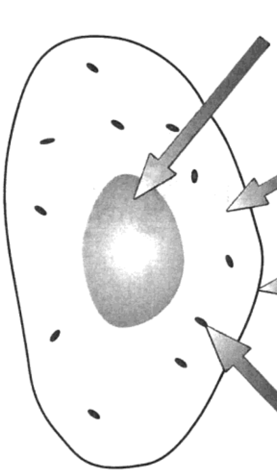
Eukaryotic and Prokaryotic Cells

Organisms can be *Prokaryotes* or *Eukaryotes*

1) **Prokaryotic** (pronounced like this: pro-carry-ot-ick) organisms are prokaryotic cells (i.e. they're **single-celled** organisms) and **eukaryotic** (you-carry-ot-ick) 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**.

Eukaryotic cells are **complex** and include all **animal** and **plant** cells.
Prokaryotic cells are **smaller** and **simpler**, e.g. **bacteria**.

4 organelles **animal** and **plant** cells have in **common**:



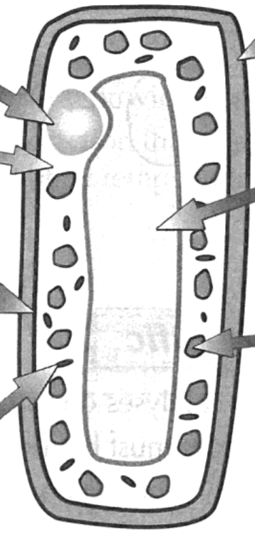
Nucleus contains genetic material (DNA) that controls what the cell **does**.

Cytoplasm contains enzymes that speed up biochemical reactions.

Cell-surface membrane holds the cell together and controls what goes **in** and **out**.

Mitochondria are where glucose and oxygen are used in **respiration** to provide a source of **energy** for the cell.

3 extras that **only plant cells** have:



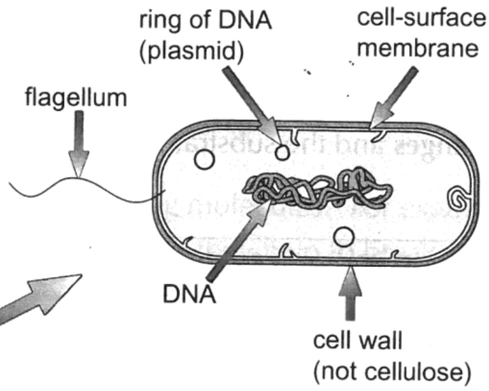
Rigid cell wall made of **cellulose**, gives the cell support.

Vacuole contains **cell sap**, a weak solution of sugar and salts.

Chloroplasts contain **chlorophyll** for **photosynthesis**. They're found in the **green** parts of plants, e.g. leaves and stem.

Bacterial Cells are *Prokaryotic*

1) Prokaryotes like bacteria are roughly a **tenth the size** of eukaryotic cells.
2) Prokaryotic cells **don't contain** a nucleus, mitochondria or chloroplasts.
3) As they **don't** have a nucleus, their **DNA floats freely** in the **cytoplasm**. Some prokaryotes also have **rings of DNA** called **plasmids**.
4) Some prokaryotes have a **flagellum** which **rotates** and allows the cell to **move**.
5) The diagram shows a bacterial cell as seen under an **electron microscope** (see next page).



Bacterial cheerleaders — they never stop swirling their flagella...

1) Give an example of a prokaryotic cell.
2) Name four organelles that plant and animals cells both have.
3) What is the function of mitochondria?

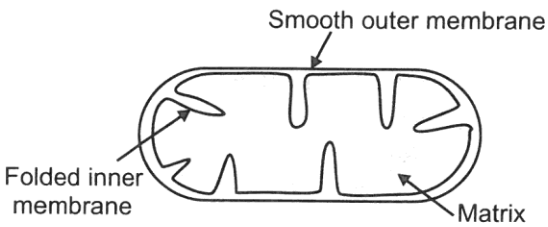
Functions of the Nucleus, Mitochondria and Cell Wall

Nucleus

1) The **nucleus** is the control centre of the cell.
2) It contains **DNA** (deoxyribonucleic acid): the coded information needed for **making proteins**.
3) During **cell division** the chromosomes carrying the long DNA molecules coil up, becoming shorter and thicker and visible with a light microscope.
4) Electron micrographs show that there's a **double membrane** around the nucleus.

Mitochondria

Mitochondria are about the size of bacteria, so they can be seen with a light microscope, but you need an electron microscope to see any of the detail.
Each mitochondrion has a **smooth outer membrane** and a **folded inner membrane**:



A **mitochondrion**

Their job is to capture the energy in glucose in a form that the cell can use.
To do this **aerobic respiration** takes place inside the mitochondria.

Word equation: GLUCOSE + OXYGEN → CARBON DIOXIDE + WATER + (ENERGY)

The energy released by respiration ends up in molecules of **ATP** (adenosine triphosphate). ATP is used in the cell to provide the energy for **muscle contraction**, **active transport** (called active uptake in some text books) and **building large molecules** from small ones, as well as many other processes.

Cell Wall — Plants

1) The plant cell wall is relatively rigid and provides **support** for the cell.
2) It mainly consists of bundles of long, straight **cellulose molecules**.
3) The cellulose molecules lay side by side to form **microfibrils**.

Doctor, doctor my DNA is getting shorter and thicker...*

1) Which organelle acts as the control centre of the cell?
2) In which organelle does aerobic respiration occur?
3) Describe the membranes of a mitochondrion.
4) What is the word equation for aerobic respiration?
5) Name the molecule used to provide energy for processes in the cell.
6) Name the molecule that is found in bundles in plant cell walls.

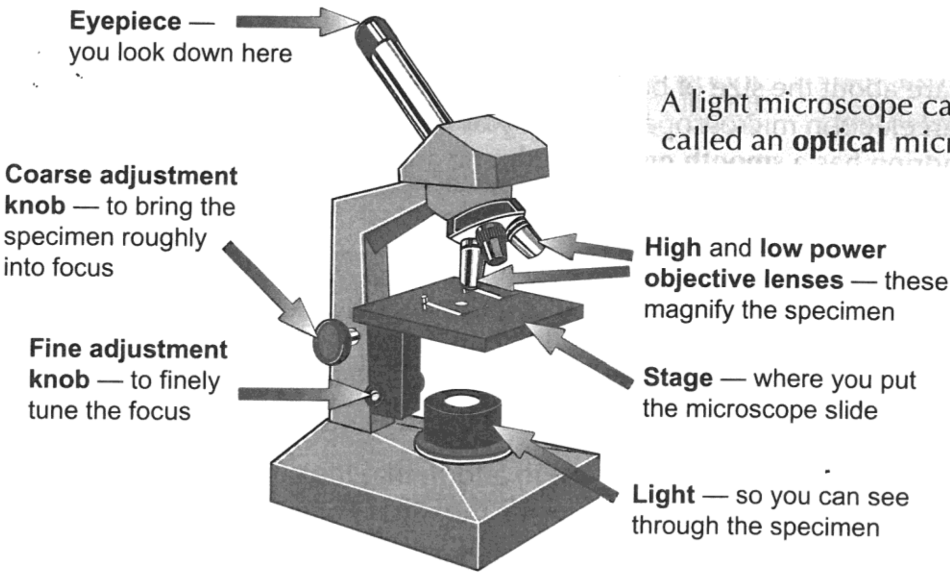
*...that's the least of your worries — you're going to divide soon.

Microscopes

You Can See Cell Structure with a Light Microscope

A **light microscope** can magnify up to 1500 times and allows you to see individual animal and plant cells along with the organelles inside them.

1) If the cells have been **stained** you can see the dark-coloured **nucleus** surrounded by lighter-coloured **cytoplasm**.
2) Tiny **mitochondria** and the black line of the **cell membrane** are also visible.
3) In plant cells, the **cell wall**, **chloroplasts** and the **vacuole** can be seen.



A light microscope can also be called an **optical** microscope.

Electron Microscopes have a Greater Magnification

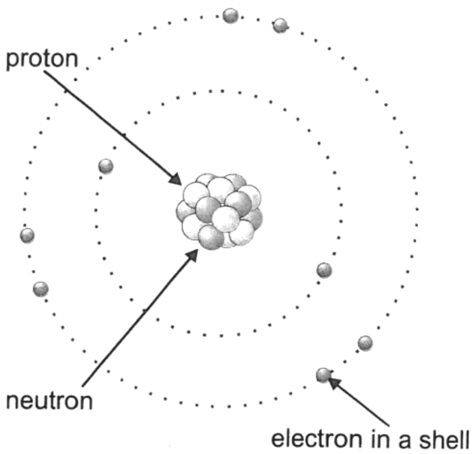
1) The detailed **ultrastructure** of cells was revealed in the 1950s when the **electron microscope** was invented.
2) An electron microscope can **magnify** objects more than 500 000 times and, more importantly, it allows **greater detail** to be seen than a light microscope. For example, it allows you to see the detailed **structures inside organelles** such as mitochondria and chloroplasts.
3) The image that's recorded is called an **electron micrograph**.

I put a slide on the stage and then slid straight off the edge...

1) Name three things visible with a light microscope in both animal and plant cells.
2) Which type of microscope must be used to show the detailed ultrastructure of a cell?
3) What is the image recorded by an electron microscope called?

Atomic Structure

What Are Atoms Like?



1) Atoms are made up of **three** types of **subatomic particle**: **protons**, **neutrons** and **electrons**.
2) In the **centre** of all atoms is a **nucleus** containing **neutrons** and **protons**.
3) Almost all of the **mass** of the atom is contained in the **nucleus** which has an overall **positive** charge. The positive charge arises because each of the **protons** in the nucleus have a **+1** charge.
4) The **neutrons** in the nucleus have a very similar **mass** to the protons but they are **uncharged**.
5) **Electrons** are much **smaller** and **lighter** than either the neutrons or protons. They have a **negative charge** (**–1**) and **orbit** the nucleus in **shells** (or energy levels).
6) There's an **attraction** between the **protons** in the nucleus and the **electrons** in the shells.
7) The nucleus is **tiny** compared with the total volume occupied by the whole atom.
8) The **volume** occupied by the **shells** of the electrons determines the **size** of the atom.

Here's a round up of the **properties** of the subatomic particles:

Particle	Relative Mass	Relative Charge
Proton	1	+1
Neutron	1	0
Electron	$\frac{1}{2000}$	–1

What is the Charge on an Atom?

The overall charge on an atom is **zero**.

This is because each **+1** charge from a **proton** in the nucleus is **cancelled out** by a **–1** charge from an **electron**.

If an atom **loses** or **gains** electrons it becomes **charged**. These charged particles are called **ions**.

EXAMPLE: How many electrons has an Al^{3+} ion lost or gained?

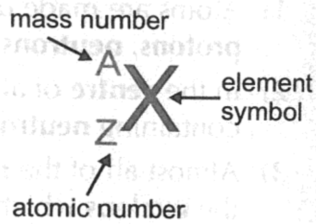
The Al^{3+} ion has a charge of **+3**, so there must be **3 more protons** than **electrons**. Ions are formed when **electrons** are lost or gained, so Al^{3+} must have **lost 3 electrons**.

Neutrons are the perfect criminals — they never get charged...

1) Which subatomic particles are found in the nucleus?
2) What is the charge on an ion formed when an atom loses two electrons?
3) What is the charge on an ion formed when an atom gains two electrons?

Atomic Number, Mass Number and Isotopes

Atomic and Mass Numbers



1) If you look at an element in the periodic table, you'll see it's given **two numbers**. These are the **atomic number** and the **mass number**.
2) The **atomic number** of an element is given the symbol **Z**. It's sometimes called the **proton number** as it represents the number of **protons** in the nucleus of the element.
3) For **neutral** atoms the number of **protons equals** the number of **electrons**, but you need to take care when considering ions as the number of electrons changes when an ion forms from an atom.
4) The **mass number** of an atom is given the symbol **A**. It represents the **total** number of **neutrons** and **protons** in the nucleus.
5) **Subtracting Z** from **A** allows you to calculate the number of **neutrons** in the nucleus.

EXAMPLE: Use the periodic table to complete the following information about sodium.

Element	Symbol	Z	A	No. Protons	No. Neutrons	No. Electrons
Sodium			23			

The periodic table tells you that the **symbol** for sodium is **Na** and **Z** is **11**.
The number of **protons** in sodium is the same as the **atomic number**, which is **11**.
You work out the number of **neutrons** by **subtracting** Z from A: 23 – 11 = **12**.
The number of **electrons** is the **same** as the number of protons, which is **11**.

Isotopes

1) Atoms of the same **element** always have the same number of **protons**, so they'll always have the same **atomic number**, but their **mass numbers** can **vary** slightly.
2) Atoms of the same **element** with different **mass numbers** are called **isotopes**.
3) Isotopes have the same number of **protons** but different numbers of **neutrons** in their nuclei.

EXAMPLE: Copper has an atomic number of 29. Its two main isotopes have mass numbers of 63 and 65. How many neutrons does each of the isotopes have?

The ^{63}Cu isotope has 63 – 29 = **34 neutrons**.
The ^{65}Cu isotope has 65 – 29 = **36 neutrons**.

Finding the number of neutrons — it's as easy as knowing your A – Z...

1) Use the periodic table to work out how many neutrons are in a neutral phosphorus atom.
2) In terms of the numbers of subatomic particles, state two similarities and one difference between two isotopes of the same element.
3) Three neutral isotopes of carbon have mass numbers 12, 13 and 14. State the numbers of protons, neutrons and electrons in each.

Relative Atomic Mass

Calculating the **Relative Atomic Mass**

1) The average mass of an element is called its **relative atomic mass**, or A_r.
2) When you look up the **relative atomic mass** of an element on a **detailed** copy of the periodic table, you'll see that it isn't always a **whole number**. This is because the value given is the **average** mass number of two or more **isotopes**.
3) The **value** of the relative atomic mass is further complicated by the fact that some isotopes are **more abundant** than others. It's a **weighted average** of all the element's different isotopes.
4) You can use the **relative abundances** and **relative isotopic masses** (the mass number of a single, specific isotope) of each isotope to work out the **relative atomic mass** of an element.
5) Relative abundances of isotopes are often given as **percentages**. To work out the **relative atomic mass** of an element, all you need to do is multiply **each isotopic mass** by its **relative abundance**, add all the values together and divide by **100**.

EXAMPLE: What is the relative atomic mass of chlorine given that 75% of atoms have an atomic mass of 35 and 25% of atoms have an atomic mass of 37?

Average mass = (abundance of $^{35}Cl \times 35$ + abundance of $^{37}Cl \times 37) \div 100$
= $[(75 \times 35) + (25 \times 37)] \div 100$
= $(2625 + 925) \div 100$
= $3550 \div 100$
= **35.5** (You can check your answer against a periodic table to see if it's right.)

Calculating the **Relative Formula Mass**

If you **add up** the relative atomic masses of all the atoms in a chemical formula, you get the **relative formula mass**, or M_r, of that compound.

(If the compound is molecular, you might hear the term relative molecular mass used instead, but it means pretty much the same.)

EXAMPLE: Calculate the relative formula mass of $CaCl_2$.

Ca has an atomic mass of 40.1 and Cl has an atomic mass of 35.5.
$M_r = (1 \times 40.1) + (2 \times 35.5)$
= **111**

Together, my brother and I weigh 143 kg — it's our relative mass...

1) Find the relative atomic mass of lithium if its composition is 8% ^{6}Li and 92% ^{7}Li.
2) Find the relative atomic mass of carbon if its composition is 99% ^{12}C and 1% ^{13}C.
3) Find the relative atomic mass of silver if its composition is 52% ^{107}Ag and 48% ^{109}Ag.
4) Find the relative formula mass of sodium fluoride, NaF.
5) Find the relative formula mass of chloromethane, CH_3Cl.

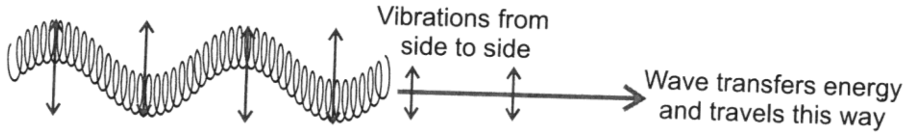
Waves

Waves Transfer Energy Without Transferring Matter

1) Waves are **oscillations** that transfer energy — like water waves or electromagnetic waves.
2) Waves carry **energy** from one place to another **without** transferring **matter**.

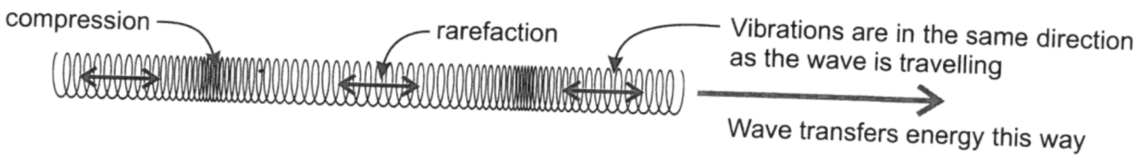
Transverse Waves Vibrate at 90° to the Direction of Travel

Transverse waves have **vibrations** at **90°** to the direction of **energy transfer** and **travel**. E.g. **electromagnetic** waves (like light) or shaking a Slinky® spring from side to side.



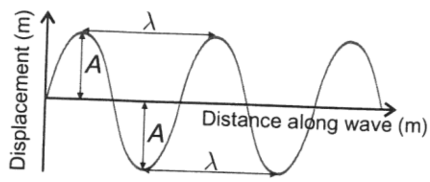
Longitudinal Waves Vibrate Along the Direction of Travel

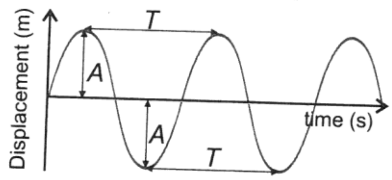
Longitudinal waves vibrate in the **same direction** as the direction of **energy transfer** and **travel**. They are made of alternate **compressions** and **rarefactions** of the medium. E.g. sound waves or pushing on the end of a Slinky® spring.



You Can Show Wave Motion on a Graph

A **displacement-distance** graph shows **how far** each part of the wave is **displaced** from its **equilibrium position** for different distances along the wave.





You can also consider **just one point** on a wave and plot how its **displacement** changes with **time**. This is a **displacement-time** graph.

Displacement = how far a point on the wave has moved from its equilibrium position
Amplitude (*A*) = the largest possible displacement from the equilibrium position
Wavelength (λ) = the length of one wave cycle, from crest to crest or trough to trough
Period (*T*) = the time taken for a whole cycle (vibration) to complete, or to pass a given point

Transverse waves are terrible singers — they always skip the chorus...

1) Sketch a graph of displacement against distance for five full wavelengths of a wave with amplitude 0.01 metres and wavelength 0.02 metres.
2) Sketch a graph of displacement against time for three complete oscillations of one part of a wave of amplitude 0.05 metres and time period 0.8 seconds.