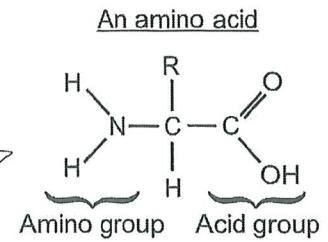


Proteins

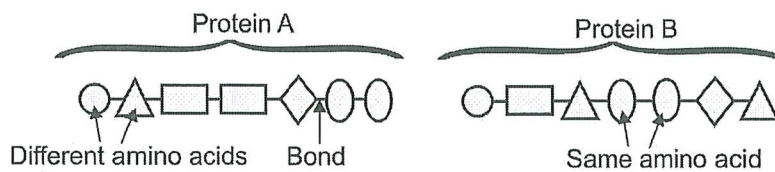
Proteins are Made of Amino Acids

Proteins are composed of long chains of **amino acids**. There are **twenty different** amino acids used in proteins. They all contain carbon, hydrogen, oxygen and nitrogen, and some contain sulfur. All have the **same structure** as the one in the diagram but **R** can be one of twenty different chemical groups.



Proteins are Held Together by Peptide Bonds

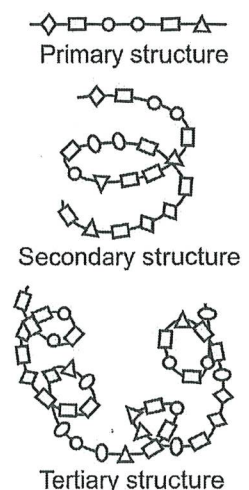
- 1) The chains of amino acids are attached to each other by **strong peptide bonds**.
- 2) The amino acids can be arranged in any sequence and proteins can be up to **several hundred** amino acids long.
- 3) The number of different proteins that are possible is almost unimaginable. Consider that there are several thousand ways of arranging a chain of just three amino acids, with each combination forming a different protein. Add one more amino acid to the chain and the number of possibilities leaps into the hundreds of thousands.
- 4) It's the **order** of the amino acids in a protein that determines its **structure** and it's the structure of a protein that determines **how it works**.



(N.B. Each different shape represents a different amino acid.)

Each Protein has its Own Special Shape

- 1) The order in which the amino acids are arranged in a protein chain is called the **primary structure**.
- 2) Some chains **coil up** or **fold** into pleats that are held together by weak forces of chemical attraction called **hydrogen bonds**. The coils and pleats are the **secondary structure** of a protein.
- 3) Some proteins (especially enzymes) have a **tertiary structure**. The coiled chain of amino acids is folded into a **ball** that's held together by a mixture of weak chemical bonds (e.g. hydrogen bonds) and stronger bonds (e.g. disulfide bonds).
- 4) If the protein has a roughly spherical shape it's called a **globular protein** (e.g. enzymes are classed as globular proteins).



The name's Bond. Peptide Bond...

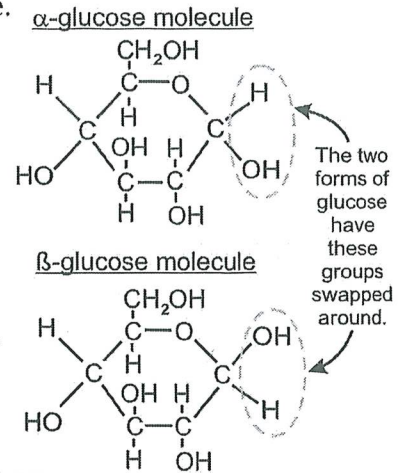
- 1) What is the primary structure of a protein?
- 2) What type of bond holds together the secondary structure of a protein?

Carbohydrates

Carbohydrates Contain Three Elements

Carbohydrates contain **carbon, hydrogen** and **oxygen**. There are several types of carbohydrate, e.g. sugars, starch and cellulose.

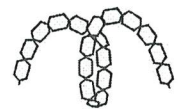
- 1) Sugars are **small, water-soluble** molecules that taste sweet.
- 2) They're divided into two groups: **monosaccharides** (pronounced: mono-sack-a-rides) and **disaccharides** (die-sack-a-rides).
- 3) Monosaccharides are the single units from which all the other carbohydrates are built. **Glucose** and **fructose** are both monosaccharides. Glucose has two forms — **alpha** (α) and **beta** (β).
- 4) Disaccharides are formed when **two monosaccharides** are joined together by a chemical reaction. A molecule of **water** is also formed (so it's called a **condensation reaction**).



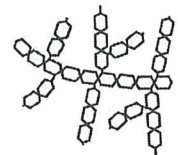
Starch is a Polysaccharide

Polysaccharides are **polymers** — large molecules made up of **monomers** (smaller units). The monomers of polysaccharides are **monosaccharides**. **Starch** molecules are made up of two different polysaccharides — **amylose** and **amylopectin**, which are polymers of glucose. The insoluble, compact starch molecules are an ideal way of **storing glucose**. Starch is **only** found in plant cells.

Amylose

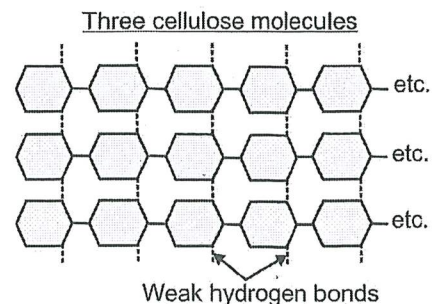


Amylopectin



Cellulose is Also a Polysaccharide

- 1) Like starch, cellulose is a polymer of glucose, but the **bonding** between the glucose units is different.
- 2) As a result, the cellulose molecules are **long and straight**.
- 3) Several cellulose molecules can lie side by side to form **microfibrils**.
- 4) The molecules are held together by many weak **hydrogen bonds**.
- 5) Cellulose is only found in plant cells.
- 6) The microfibrils **strengthen** the plant cell wall.



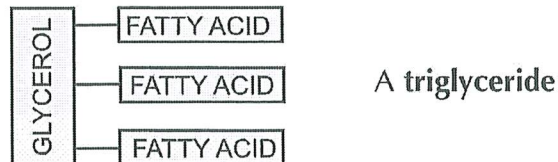
A poly-sack-a-ride — a bunch of kids on a helter skelter...

- 1) Name two monosaccharides.
- 2) Which disaccharide is composed of two molecules of glucose?
- 3) Name two polysaccharides.

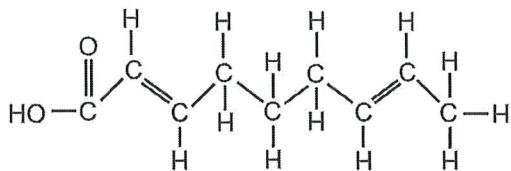
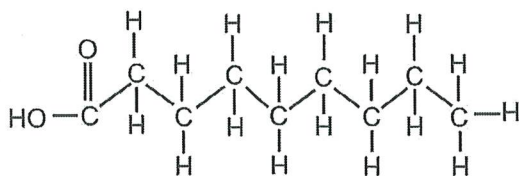
Lipids

Lipids Contain Carbon, Hydrogen and Oxygen

Lipids are **oils** and **fats**. Plant oils and animal fats are mostly made up of a group of lipids called **triglycerides**. A triglyceride consists of a molecule of **glycerol** with **three fatty acids** attached to it.



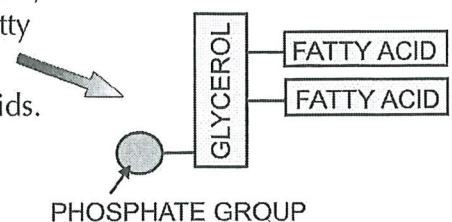
A fatty acid molecule is a long chain of **carbon atoms** with an **acid group** (-COOH) at one end. **Hydrogen atoms** are attached to the carbon atoms. If every carbon atom in the chain is joined by a **single bond**, we say that the fatty acid is **saturated**. If one or more of the bonds is a **double bond**, it's said to be **unsaturated**. A fatty acid with many double bonds is **polyunsaturated**.



Phospholipids are a Special Type of Lipid

Phospholipids (pronounced: foss-foe-lip-id) are like triglycerides, but instead of having three fatty acid chains, they have **two** fatty acid chains and a **phosphate** group.

Cell membranes are made from a **double layer** of phospholipids.



Acid chain and the phospholipids — sounds like a punk band...

- 1) Which elements are fatty acids composed of?
- 2) What's the difference between saturated fatty acids and unsaturated fatty acids?
- 3) What's the difference between triglycerides and phospholipids?

Enzymes

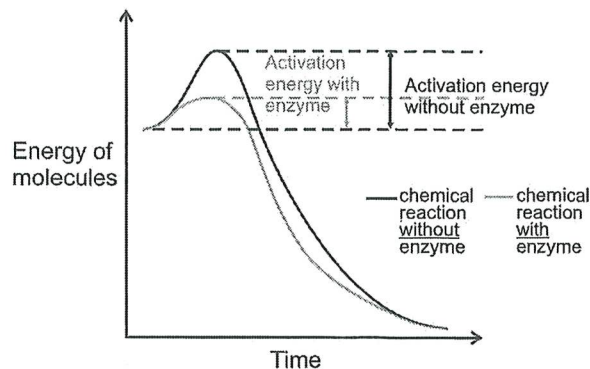
Enzymes Help to Speed up Biochemical Reactions

- 1) In a living cell, thousands of **biochemical reactions** take place every second. The sum of these reactions is called **metabolism**. A single chain of these reactions is called a **metabolic pathway**.
- 2) Without enzymes, these reactions would take place very **slowly** at normal body temperature.
 - 1) Enzymes are **biological catalysts**.
 - 2) They **increase** the **rate** (speed) of reactions.

How do Enzymes Act as Catalysts?

- 1) Even reactions that release energy require an **input of energy** to get them going, e.g. the gas from a Bunsen burner doesn't burn until you provide heat energy from a match.
- 2) This input energy is called the **activation energy**. A reaction that needs a high activation energy can't start at a low temperature of 37 °C (i.e. body temperature).
- 3) Enzymes **reduce** the activation energy.

This graph shows the activation energies of a reaction **with** and **without** an enzyme:



Enzymes are Proteins

- 1) All enzymes are **globular proteins** (because they're roughly spherical).
- 2) It's the order of amino acids in an enzyme that determines its **structure**, and so how it works.
- 3) Enzymes can be involved in **breaking down** molecules or **building** molecules. For example:
 - **Digestive enzymes** are important in the digestive system, where they help to break down food into smaller molecules, e.g. carbohydrases break down carbohydrates.
 - Enzymes involved in **DNA replication** help to build molecules, e.g. DNA polymerase.

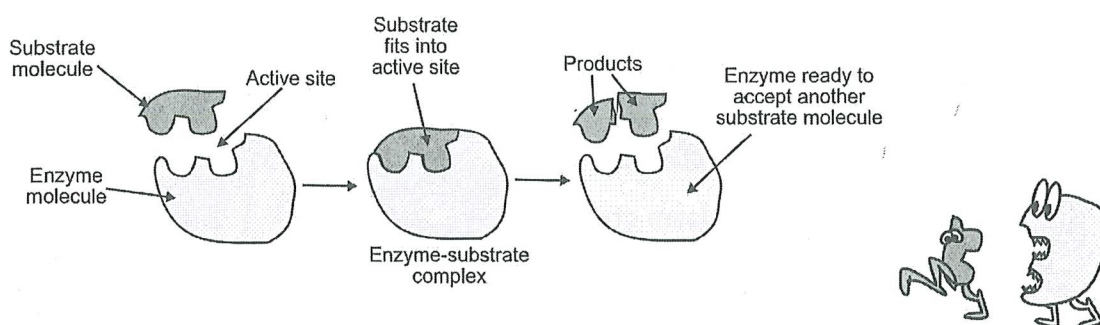
I could really use a catalyst to help me write this gag...

- 1) What is the function of enzymes?
- 2) What is activation energy?
- 3) What do digestive enzymes do?

Enzymes

Enzymes have an Active Site

- 1) A substance that's acted upon by an enzyme is called its **substrate**.
- 2) The **active site** is a region on the surface of the enzyme molecule where a substrate molecule can attach itself. It's where the catalysed reaction takes place.
- 3) The shape of the substrate molecule and the shape of the active site are **complementary**, i.e. they fit each other.
- 4) Almost as soon as the **enzyme-substrate complex** has formed, the products of the reaction are released and the enzyme is ready to accept another substrate molecule.



Enzymes are Specific

- 1) An enzyme usually catalyses one **specific** chemical reaction.
- 2) The substrate molecule must be the **correct shape** to fit into the active site.
- 3) **Only one substrate** will be the correct shape to fit, so each enzyme only catalyses one specific reaction.
- 4) Anything that **changes** the shape of the active site will **affect** how well the enzyme works.

The Effect of Temperature on Enzyme Activity

As temperature **increases**, enzyme reactions become **faster**, because the molecules have more **energy**. However, at high temperatures the atoms of the enzyme molecule vibrate more rapidly and **break** the weak bonds that hold the **tertiary structure** together. The **shape** of the active site **changes** and the substrate can no longer fit in. The enzyme is said to be **denatured**.

The Effect of pH on Enzyme Activity

Acids and **alkalis** can denature enzymes. Hydrogen ions (H^+) in acids and hydroxyl ions (OH^-) in alkalis disrupt the **weak bonds** and change the shape of the active site.

Lonely enzyme seeking complementary substrate...

- 1) Why are enzymes described as 'specific'?
- 2) Explain why a denatured enzyme will not function.
- 3) Describe the effect of pH on enzyme activity.

Eukaryotic and Prokaryotic Cells

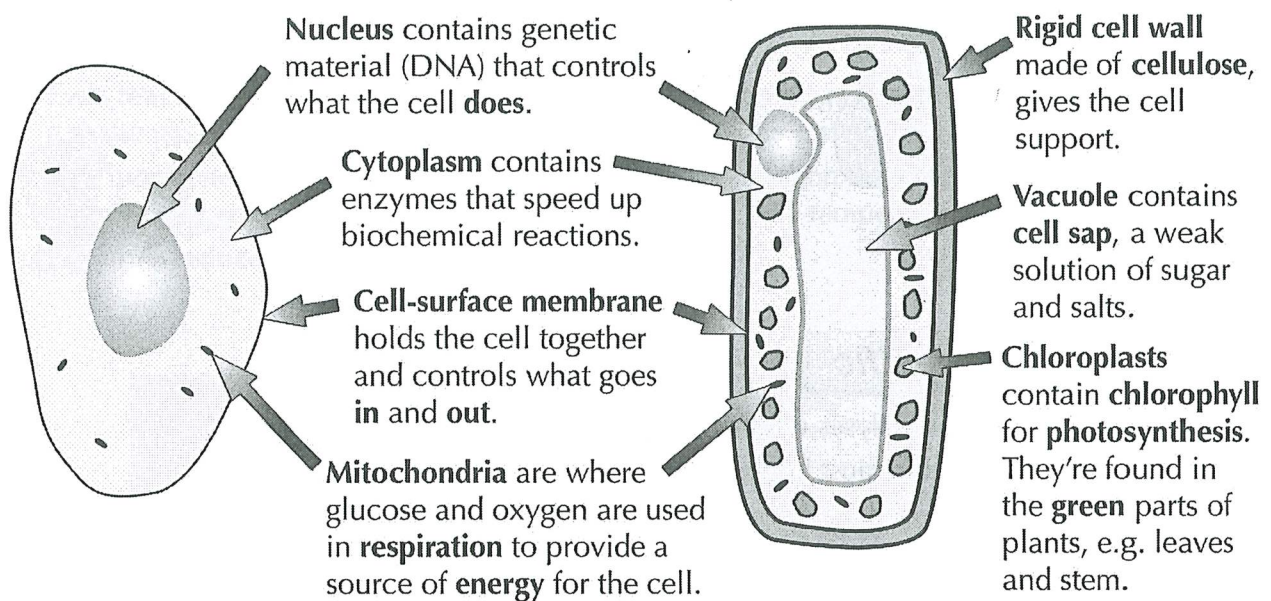
Organisms can be Prokaryotes or Eukaryotes

- 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**.

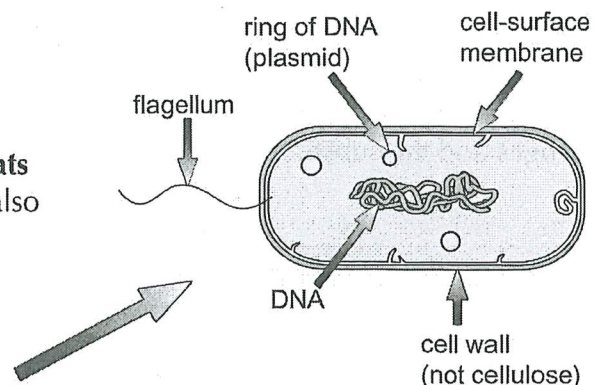
4 organelles **animal** and **plant** cells have in **common**:

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



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...

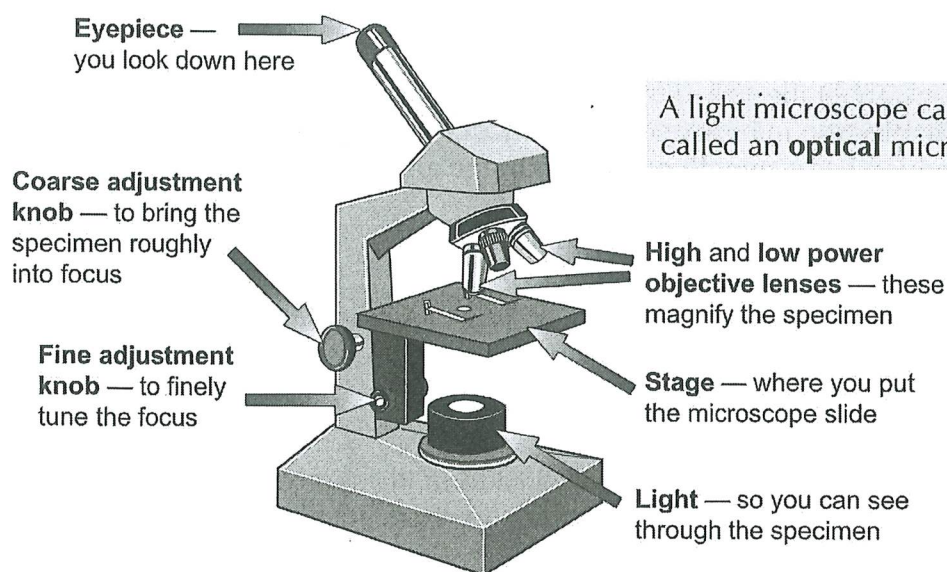
- 1) Give an example of a prokaryotic cell.
- 2) Name four organelles that plant and animals cells both have.
- 3) What is the function of mitochondria?

Microscopes

You Can See Cell Structure with a Light Microscope

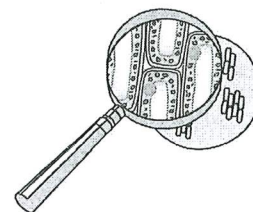
A **light microscope** can magnify up to 1500 times and allows you to see individual animal and plant cells along with the organelles inside them.

- 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.



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?

Functions of the Nucleus, Mitochondria and Cell Wall

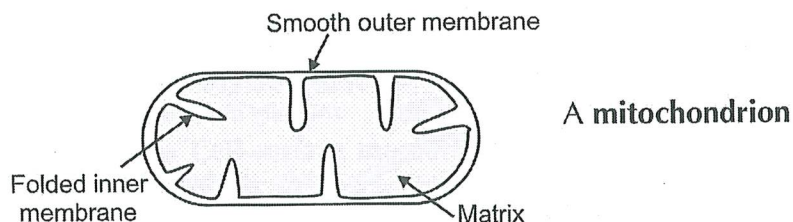
Nucleus

- 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**:



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: $\text{GLUCOSE} + \text{OXYGEN} \rightarrow \text{CARBON DIOXIDE} + \text{WATER} + (\text{ENERGY})$

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...*

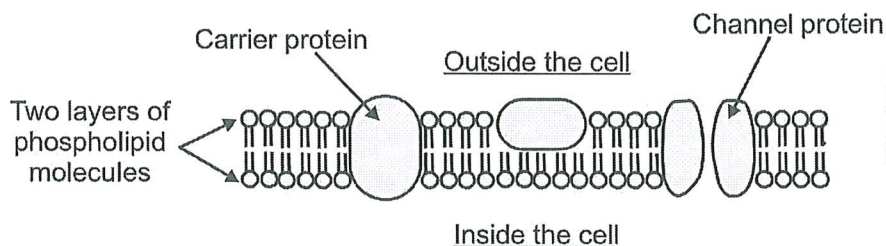
- 1) Which organelle acts as the control centre of the cell?
- 2) In which organelle does aerobic respiration occur?
- 3) Describe the membranes of a mitochondrion.
- 4) What is the word equation for aerobic respiration?
- 5) Name the molecule used to provide energy for processes in the cell.
- 6) Name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

Cell Membranes

Structure of the Cell-Surface Membrane

The **cell-surface membrane** is the very thin structure around an individual cell.

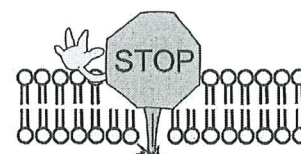
- 1) Electron micrographs show that the cell-surface membrane consists of a double layer of **phospholipid** molecules tightly packed together.
- 2) Bigger **protein molecules** are embedded in the phospholipid molecules.
- 3) Some proteins go **all the way through** the membrane and some only go **halfway**.
- 4) Membranes surrounding the **organelles** inside cells have the **same** structure.



Cell-surface membranes can also be called **plasma membranes**.

Do I Really have to Know this Much Detail?

- 1) The answer is "Yes". Once you're familiar with the molecular structure of the membrane you can explain how the membrane **controls** the passage of substances **in** and **out** of the cell.
- 2) Because the membrane only allows certain substances through it, it's described as being **partially permeable**.



Substances Pass Through Membranes by Four Methods

1 Diffusion

- 1) The particles of liquids and gases are constantly **moving about**. This movement causes the particles to spread from an area of **higher** concentration to an area of **lower** concentration.
- 2) Particles will **diffuse** through the cell membrane as long as they are small enough to pass through the very small gaps **between** the phospholipid molecules. Water, oxygen and **carbon dioxide** molecules can do this.
- 3) The cell **doesn't** need to provide any energy for this process.

The difference in concentration is sometimes called a **concentration gradient**, e.g. a big difference in concentration is a big concentration gradient.

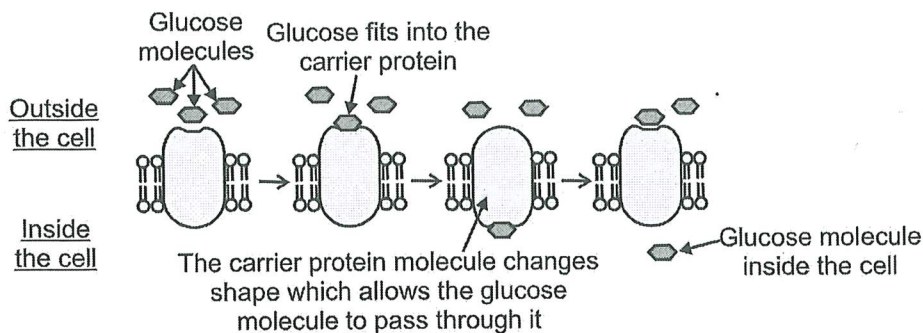
2 Osmosis

- 1) **Osmosis** is the diffusion of **water** molecules across a partially permeable membrane from a region of **higher concentration** of water molecules to a region of **lower concentration** of water molecules. The cell **doesn't** need to provide energy.
- 2) The concentration of water molecules is also referred to as the **water potential**. At AS and A-level, you tend to talk about water moving from a region of **higher water potential** to a region of **lower water potential**.

Cell Membranes

3 Facilitated Diffusion

- 1) Glucose and many other water soluble molecules are **too big** to diffuse across the membrane by themselves. They must be helped across by **carrier proteins**.
- 2) Each substance has its **own specific** carrier protein.
- 3) For example, a molecule of glucose fits onto the outside end of a **glucose carrier protein**.
- 4) This causes the protein to **change shape**, allowing the glucose molecule to diffuse through it into the cytoplasm of the cell. The cell **doesn't** need to provide any energy.



Mineral ions like sodium (Na^+) and potassium (K^+) have electrical charges on them, so they also need help to cross the membrane. Specific **channel proteins** in the membrane allow them to diffuse through.

4 Active Transport (or Active Uptake)

- 1) When a cell needs to move substances across the membrane from a region of **low** concentration to a region of **higher** concentration, it must provide **energy**.
- 2) The substance fits into a **specific carrier protein**, then molecules of **ATP** (see page 8) provide the energy to change the shape of the protein.
- 3) As it changes shape the protein **actively transports** the substance across the membrane.
- 4) These special **carrier proteins** are sometimes called "**pumps**" because they're moving substances **against** a concentration gradient.

Active transport — isn't that just riding a bike?

- 1) Name the two types of molecule that make up the cell membrane.
- 2) Give four ways substances can cross cell membranes.
- 3) What do you call the diffusion of water molecules through the cell membrane?
- 4) Give another term for the concentration of water molecules.
- 5) Name the two types of protein involved in facilitated diffusion.
- 6) Why does active transport require ATP?