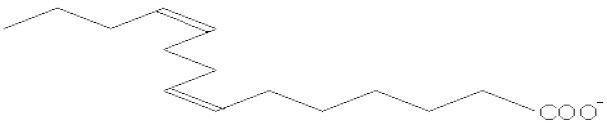
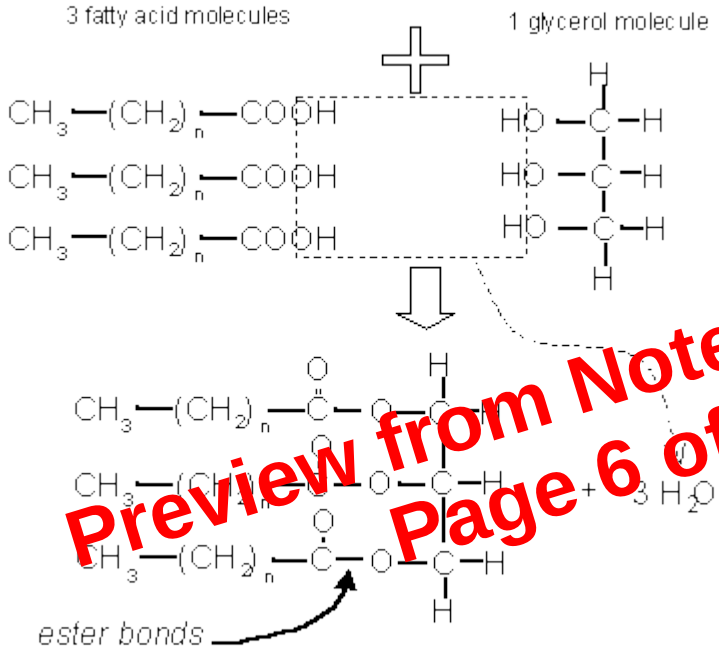
If there are C=C double bonds in the hydrocarbon chain, then it is an **unsaturated fatty acid** (i.e. unsaturated with hydrogen). These fatty acids form bent chains, and have a low melting point. Fatty acids with more than one double bond are called **poly-unsaturated fatty acids** (PUFAs).



- One molecule of glycerol joins together with three fatty acid molecules to form a **triglyceride** molecule, in another condensation polymerisation reaction:



Lipids (fats)

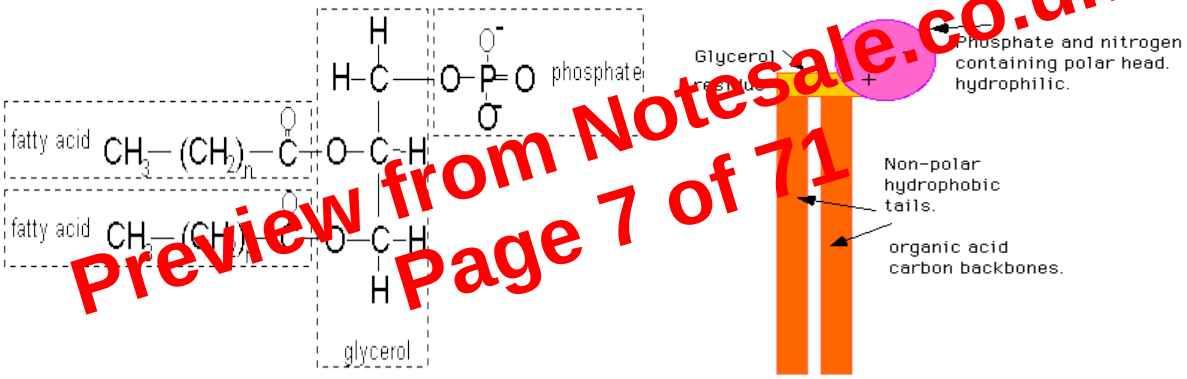
Animated tutorials - macromolecules

- Triglycerides are **insoluble** in water. They are used for **energy storage**, **insulation** and **protection** in fatty tissue (or **adipose tissue**) found under the skin (sub-cutaneous) or surrounding organs. They yield **more energy per unit mass** than other compounds so are good for energy storage. Carbohydrates can be mobilised more quickly, and glycogen is stored in muscles and liver for immediate energy requirements.
- Lipids can also be used to store **fat-soluble vitamins** (eg Vit D and A) within cell globules.
- Triglycerides containing **saturated** fatty acids have a high melting point and tend to be found in warm-blooded animals. At room temperature they are solids (fats), e.g. butter, lard.

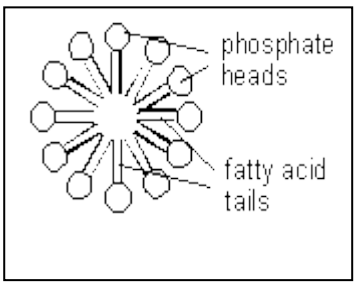
- Triglycerides containing **un**saturated fatty acids have a l**ow** melting point and tend to be found in cold-blooded animals and plants. At room temperature they are liquids (oils), e.g. fish oil, vegetable oils.
- **Cholesterol** is a steroid molecule and precursor in the manufacture of some lipids. High levels of cholesterol have been linked to heart disease. Cholesterol is non-polar and transported in association with proteins in the form of **LDL** or **low-density lipoprotein.**

(w) describe, with the aid of diagrams, the structure of a phospholipid molecule.

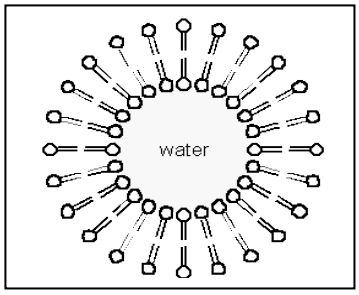
- **Phospholipids** have a similar structure to triglycerides, but with a phosphate group in place of one fatty acid chain. There may also be other groups attached to the phosphate. Phospholipids have a polar hydrophilic "head" (the negatively-charged phosphate group) and two non-polar hydrophobic "tails" (the fatty acid chains). This mixture of properties is fundamental to biology, for phospholipids are the main components of **cell membranes**.



- When mixed with water, phospholipids form droplet spheres with the hydrophilic heads facing the water and the hydrophobic tails facing each other. This is called a **micelle**.

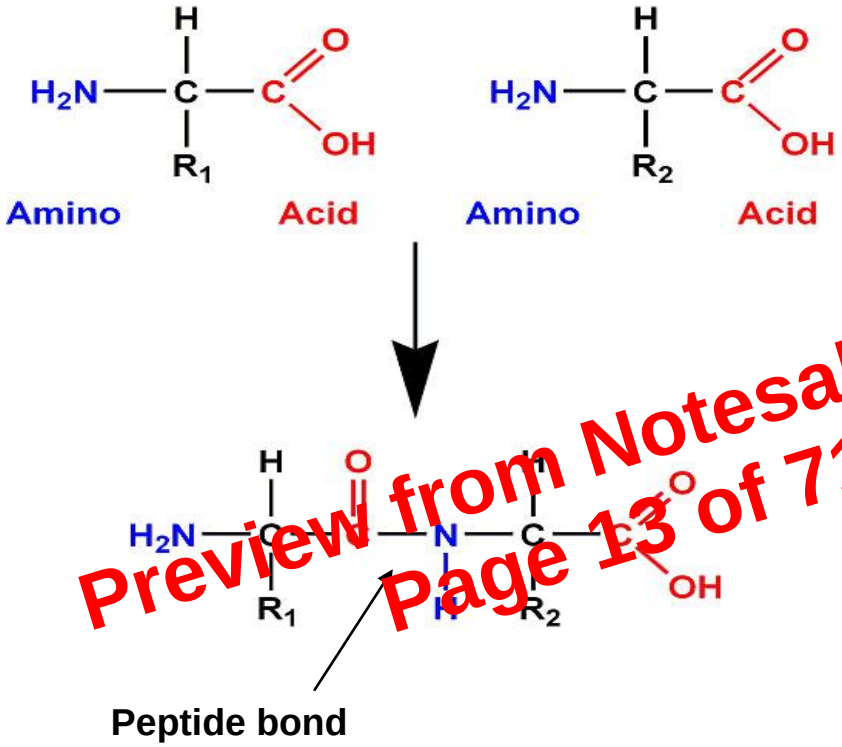


- Alternatively, they may form a double-layered **phospholipid bilayer**. This traps a compartment of water in the middle separated from the external water by the hydrophobic sphere. This naturally-occurring structure is called a **liposome**, and is similar to a membrane surrounding a cell.



(a) describe, with the aid of diagrams, the basic structure of an amino acid;
(b) describe, with the aid of diagrams, the condensation reaction between two amino acids to form a peptide bond;

- **Amino acids** (building blocks of proteins) consist of a **central carbon** onto which are covalently bonded a **carboxylic** group (-COOH), an **amino** group ($-NH_2$), a **hydrogen** and one of twenty different possible **R groups**. It is the various sizes and chemistry if the R groups which greatly influence how the amino acids will affect the structure and function of the proteins they can build.



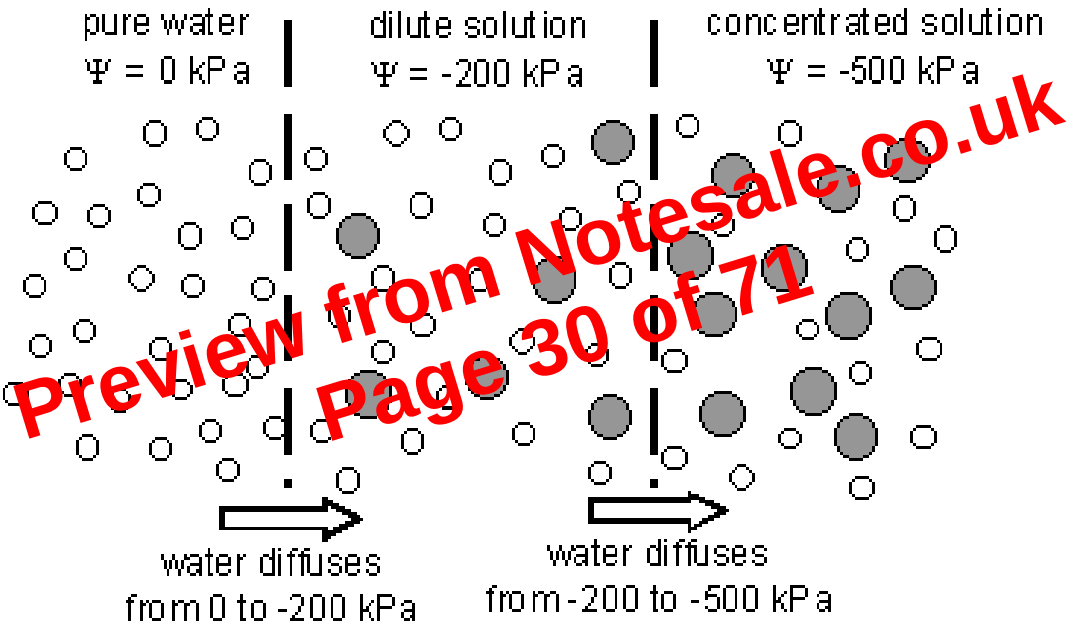
Biochemistry tests

- Amino acids can be chemically bonded together at one of a cell's ribosomes. A **peptide** bond forms during a **condensation** reaction (water released) between the carboxylic group of one amino acid and the amino group of an adjacent one.

(l) explain the meaning of the term *water potential*;

(m) explain, in terms of water potential, why the concentration of plasma proteins, glucose and electrolytes will affect the water potential of blood;

- **Water Potential** - osmosis can be quantified using **water potential**, so we can calculate which way water will move, and how fast. Water potential (Greek letter 'psi') is simply the effective **concentration of water**. It is measured in units of pressure (Pa, or usually kPa), and the rule is that water moves from an area of higher water potential to lower, down a **water potential gradient**. Pure water has is given the water potential value O kPa. Dissolving solute therefore reduces the concentration of water particles and therefore lowers the water potential of that solution.



- **Cells and Osmosis** - the concentration of the solution that surrounds a cell will affect the state of the cell, due to osmosis. There are three possible concentrations of solution to consider:

Isotonic solution - solution of equal water potential to a cell

Hypertonic solution - solution of lower water potential than a cell (high solute conc.)

Hypotonic solution - a solution of higher water potential than a cell (low solute conc.)

- Strenuous exercise can dehydrate the body due to sweating. However, sweat is made from blood plasma and therefore also contains dissolved salt ions (eg sodium, potassium, calcium etc.) These salts are called **electrolytes**. Excessive sweating can cause an **imbalance** of sodium and potassium ions leading to muscular cramping. **Isotonic** drinks not only replace water but also the inorganic salts lost during prolonged sweating. They have a **similar water potential** to that of the blood plasma itself. **Glucose** may also be present in "sport drinks" as this is the body's main **respiratory fuel**.

(n) outline how the concentration of glucose is measured in human blood;

- Suffers from **diabetes mellitus** must monitor their blood glucose levels carefully. This disease results from a failure to produce enough **insulin**, the hormone responsible for removing glucose from the blood stream after a **carbohydrate** meal and lowering its plasma concentration to a safe level. This is usually done using an electronic device which contains a **biosensor**. A test strip impregnated with the enzyme **glucose dehydrogenase** is inserted into the sensor after a drop of blood has been placed in contact with the strip. The enzyme converts the blood glucose present into gluconolactone. The reaction produces a small **electric current** which is converted into a measurement for **blood glucose concentration** after 30 seconds (mmol dm-3).

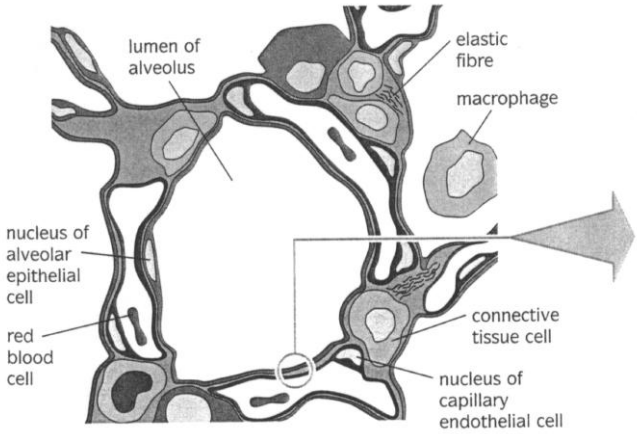
Advice on insulin injection

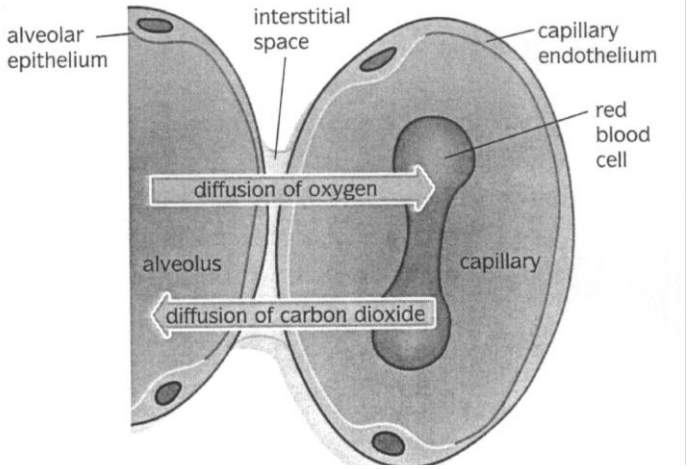
- Due to the small surface area to volume ratio of large organisms, diffusion alone would be too slow to get to cells of the inner regions of that organism, it is said the diffusion path is too long.
- Large organisms therefore need a specialised transport system to decrease diffusion pathways to allow all cells to exchange materials by diffusion in a quick manner
- Other factors to consider
    - The activity level of an organism – if the organism is highly active, they will need to rely on a transport system to get O_2 to all respiring cells quickly. But if the organism is not active, then the need for O_2 to get to all respiring cells is not great, so they can rely on diffusion alone although slow.

(a) explain the meaning of the terms *tissue* and *organ*; (b) explain the relationships between cells, tissues and organs, with reference to squamous epithelial cells in the alveoli of the lung;

- Understand that cells can be organised into tissues. A tissue is defined as *a group of cells and any intercellular material produced by them. The cells are specialised for a particular function.* The tissue can contain the same type of cell (e.g. squamous epithelium in alveolus) or a mixture of cells.
- Epithelial tissue is arranged in single or multilayered sheets and covers the internal and external surfaces of the body. The cells are held together by special junctions and a carbohydrate based cementing substance between the cells.
- Epithelium rests on a **basement membrane** which is a connective tissue matrix containing collagen fibrils. This helps to stabilise and hold the epithelium to underlying tissues.
- Different tissues can be organised into larger structures called **organs**. An organ is defined as a structure composed of 2 or more tissues working together as a functional and structural unit.
    - *In animals an example would be the stomach which contains muscular tissue to mix the food, secretory tissue to produce enzymes, acid and mucus and nervous and hormonal tissue to control the churning & secretions.* Other examples include the heart, brain and liver.

- Know that the alveoli are in close contact (**short diffusion pathway**) with the blood transport system allowing oxygen to diffuse across the thin alveolar membrane into the blood where it can combine with the respiratory pigment haemoglobin present in red blood cells.





- Know that the uptake of oxygen is increased because the red blood cells are forced to squeeze slowly through the alveolar capillaries & therefore expose a greater surface area over a longer period of time for gaseous exchange to take place.
- Understand that because the alveoli are **thin** (0.000 mm thick) there is **rapid diffusion** of gases in & out of the lungs.
- Understand that because the alveoli are **moist** (secretion called surfactant), the effort needed to inflate the lungs is reduced and it allows the gases to **dissolve** so that they can diffuse across the alveolar membrane.
- Know that the surfactant stops the alveoli collapsing when the pressures in the lung change during ventilation.

(g) describe the process of gaseous exchange in the alveoli;

- The path of the air through the lungs is as follows
    - Trachea – wall of trachea has “C” shaped cartilage rings to preventing it from collapsing under low pressure and has smooth muscle, elastic fibres and blood vessels
      - is lined with goblet cells that produce mucus to trap any dust, micro organisms or unwanted particles
      - is lined with ciliated epithelial cells that “sweep” mucus up to the mouth where it is swallowed and passed into the hydrochloric atmosphere of the to kill any micro organisms

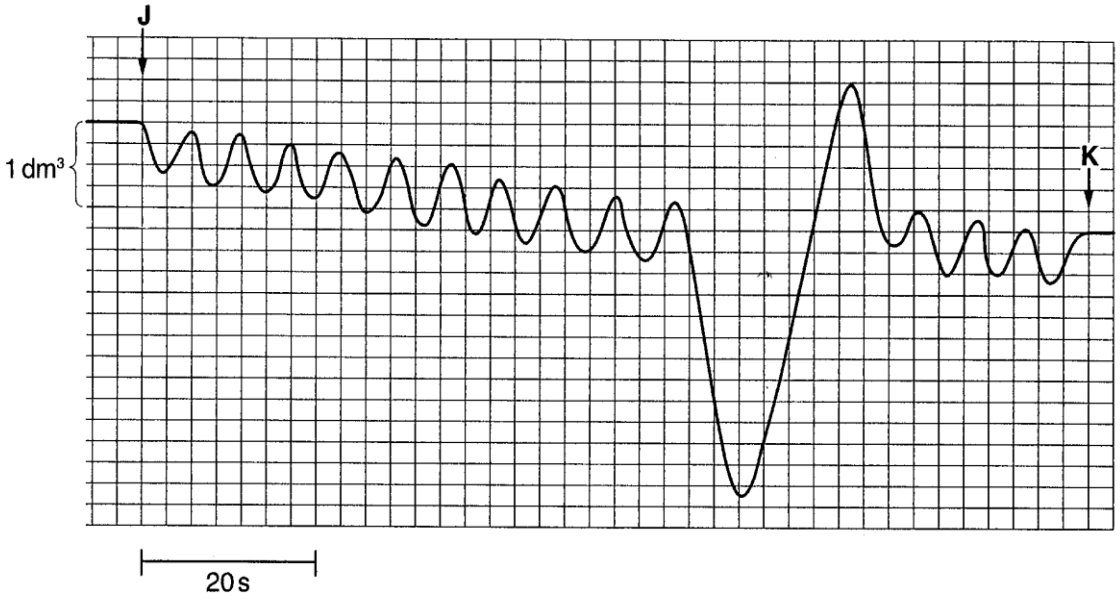


Fig. 4.2

- note that the trace moves down to the right, this is because the oxygen in the chamber of the spirometer is being used by the person breathing (red arrow)
- this person took a deep breath just after a minute on the spirometer

Using the trace above

a. calculate the persons initial breathing rate for the first minute

Answer: determine what constitutes 60 seconds from information from graph. Next count from trough to trough as equal to one breath, therefore = **9 breathes min^{-1}**

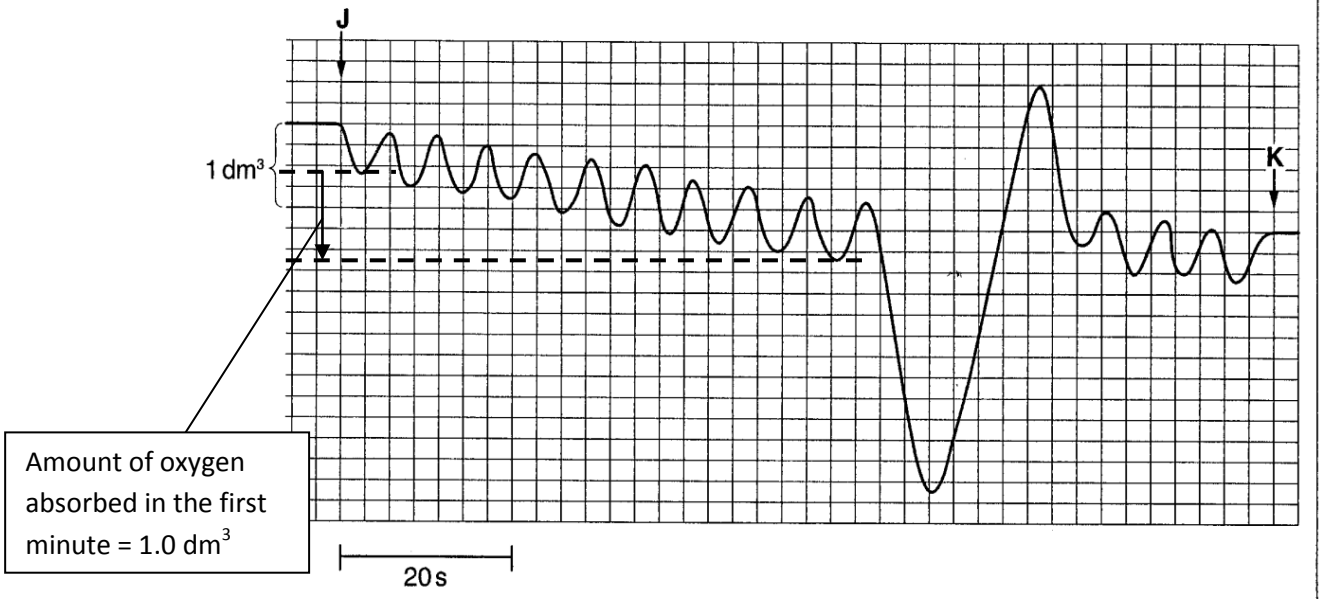
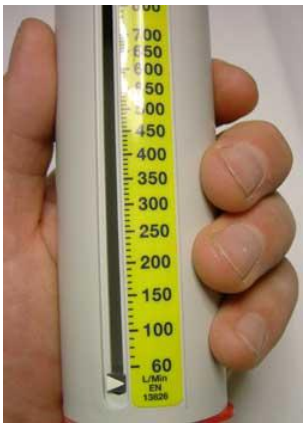


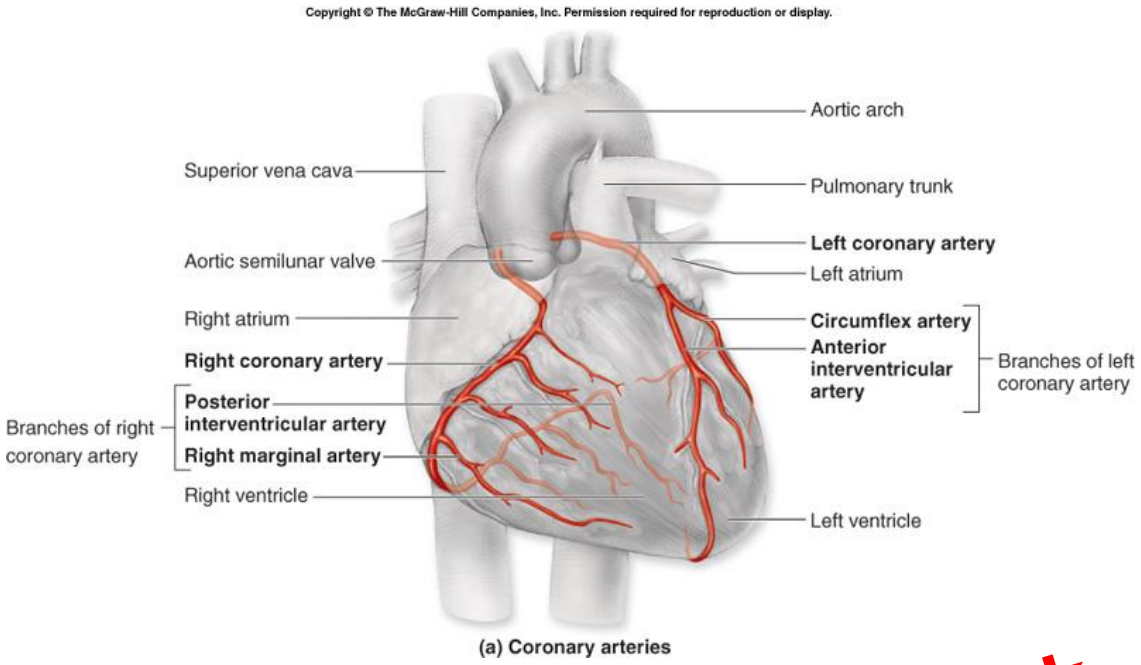
Fig. 4.2

- Peak expiratory flow rate (PEFR) is the speed of the air moving out of your lungs at the beginning of the expiration, measured in litres per second.
- Peak expiratory flow rate (PEFR) is measured using a **peak flow meter**.
- To use a peak flow meter you have to stand up straight, make sure the indicator is at the bottom of the meter then exhale as hard as you can. Repeat 3 times and take the highest reading.



Forced expiratory volume per second (FEV1) is the amount of air that you can forcibly exhale in one second, it is measured in litres.

External View of the Heart Showing the Coronary Arteries



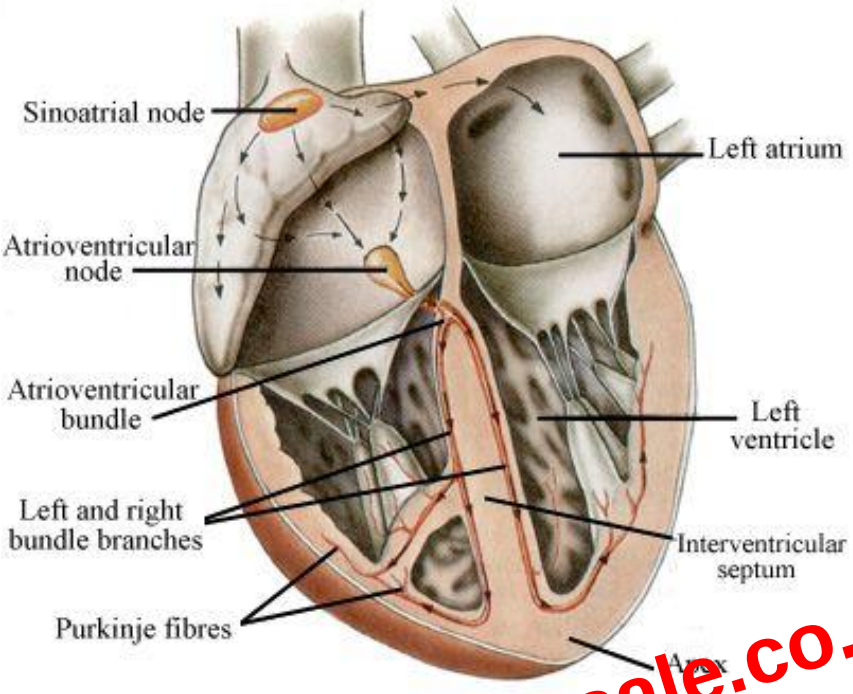
http://www.youtube.com/watch?v=WXwYYsi6z7Q

Movie of valves of the heart, please note the pulmonary and aortic valves can be called semi lunar valves due to their shape, and the mitral valve is also known as the bicuspid valve

(b) describe the cardiac cycle, the roles of the valves and the pressure and volume changes occurring in the heart;

- When the atria contract (**atrial systole**) the pressure in the atria is greater than the pressure in the ventricles, forcing blood through the atrioventricular valves and into the ventricles.
- When the ventricles contract (**ventricular systole**) the pressure in the ventricles becomes greater than the pressure in the atria (which is now low because they are relaxing) and so blood hits the tri and bicuspid valves and pushes them shut (1st heart sound “lub”).
- The pressure is so great in the ventricles that the valves would be forced open in the opposite direction (i.e. allow blood to move from the ventricles → atria), this process is prevented by the papillary muscles contracting at the same time as the ventricles. They pull on the tendinous chords and the valves are held shut and stopped from bursting out into the atria.

Electrical system of the heart



http://www.bostonscientific.com/templatedata/imports/HTML/CRM/heart/interact_8.html

Animation showing the ways of excitation sweeping over the heart controlling the cardiac cycle, and associated ECG

(e) explain how changes in stroke volume and heart rate affect cardiac output;

- Cardiac output is dependent on heart rate and stroke volume.

  Cardiac output (CO) = heart rate (HR) X stroke volume (SV)

- **Cardiac output (CO)** is the volume of blood which is pumped from the heart (specifically the left ventricle) in one minute (approx. 5dm^3/min).

- **Stroke volume (SV)** is the volume of blood being pumped out in a single contraction of the heart (approx. 70cm^3).

- **Heart rate (HR)** is the number of beats per minute (approx. 72/min).