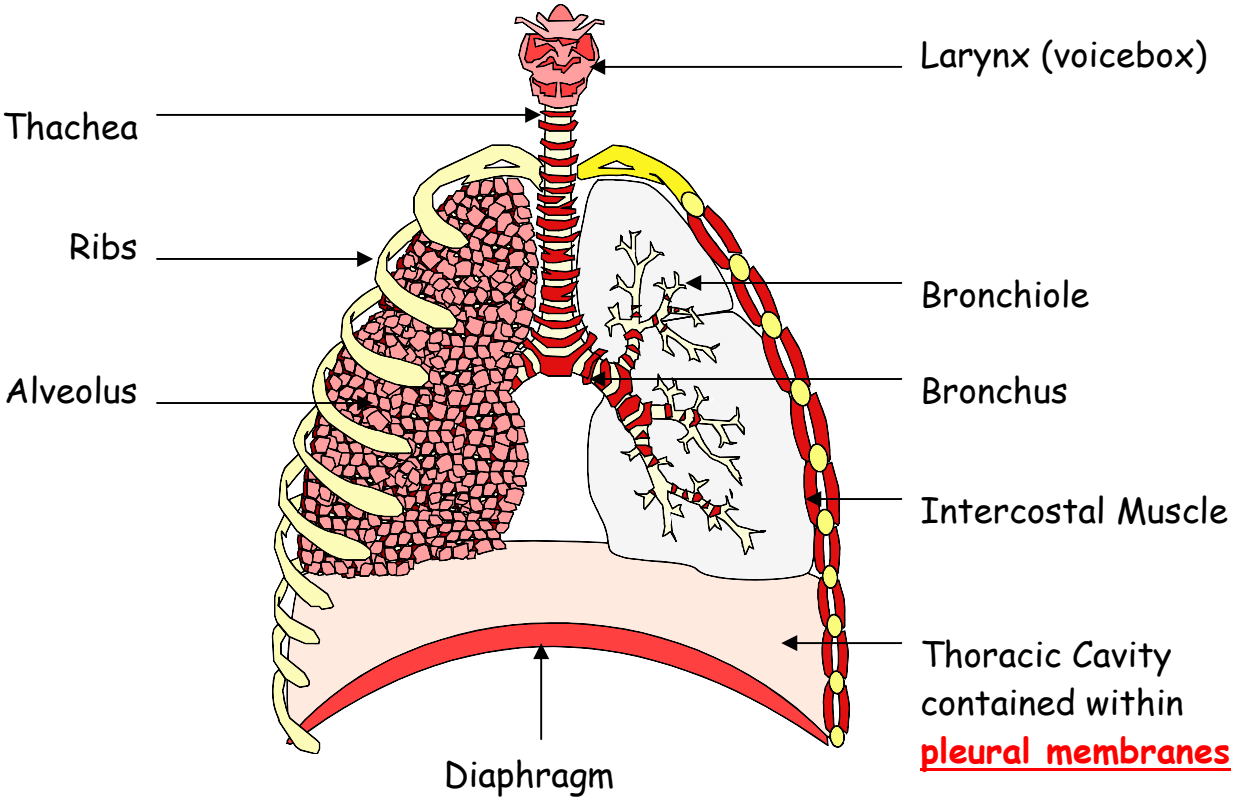
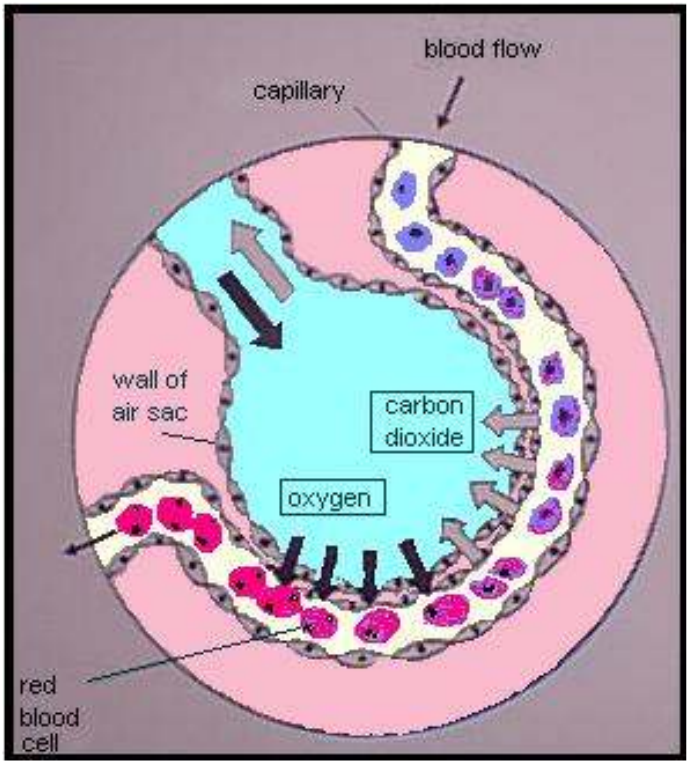
Gas Exchange in Humans:



How breathing works

Breathing in (inhaling)	Breathing out (exhaling)
1. Intercostal muscles contract, pulling the ribcage **forwards** and **out** 2. Diaphragm contracts moving **down** 3. The volume of the Thoracic Cavity **increases** 4. The **pressure** in the Thoracic Cavity **decreases** 5. Air is drawn **into** the lungs to equalize the pressure	1. Intercostal muscles relax, the ribcage moves **inwards** and **down** 2. Diaphragm relaxes moving **up** 3. The volume of the Thoracic Cavity **decreases** 4. The pressure in the Thoracic Cavity **increases** 5. Air **leaves** the lungs to equalize the pressure
Inhaling is an active process, i.e. it requires energy for muscle contraction	The entire process is passive, i.e. no energy is required as there is no muscle contraction.

Alveoli and their adaptations:



Adaptations for gas exchange:

- Alveolus is one cell thick
- Capillary wall is one cell thick
- Many alveoli produce a huge surface area
- Alveoli wall is moist
- Breathing maintains a high concentration gradient for O_2 and CO_2
- Blood movement maintains a high concentration gradient for O_2 and CO_2

Smoking:

Cigarette smoke contains **tar**, **nicotine**, **carcinogens**, **CO** and **poisons**

Chemical	Effect
Tar	Blocks up alveoli, making gas exchange more difficult. Also clogs up **cilia** (little hairs lining the lungs, whose job is to "wave" and remove mucus and trapped bacteria out of the lungs).
Nicotine	Speeds heart rate and damages arteries, causing furring of artery walls (**atherosclerosis**). This leads to heart disease and vascular diseases. It is also **addictive**.
Carcinogens	Damages the DNA of alveoli cells. This can lead to them reproducing faster than normal, which will cause a **tumour** to form. The tumour is the start of **cancer**.
Carbon Monoxide	Attaches permanently to haemoglobin, reducing the ability of the blood to carry O_2
Poisons	The list is endless. There are over 5000 poisonous chemicals in cigarette smoke (e.g. benzene, arsenic, lead, cyanide etc)

You need to know an experiment that will show the effect of exercise on humans. The easiest experiment is to take your own heart rate, breathing rate and skin temperature at rest. Do some exercise, then take the same measurements again. You'll find they've all increased. The reason for this is that your rate of respiration has increased (to supply the muscles with extra energy for contraction). In order to get respiration to happen faster, you need more O_2, so the breathing and heart rate increase. Unfortunately, you also release more waste heat energy, so your body heats up and you might have to start sweating to cool it down again.

h) Transport

All organisms respire (well, nearly all, but according to your syllabus they all do). Therefore, all organisms need to **exchange gases** with their environment.

Unicellular organisms: exchange gases directly through their cell membrane. They can do this because their surface area is large compared to their volume (**large SA:Vol ratio**). They do not need a circulatory system.

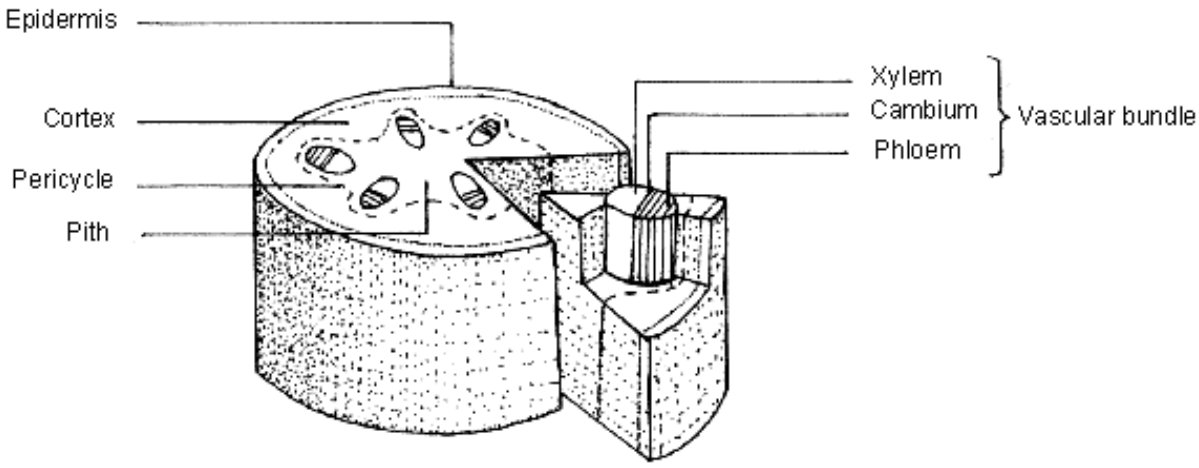
Multicellular organisms: cannot exchange gases directly through their skin. Their surface area is very small compared to their volume (**small SA:Vol ratio**); therefore, they need to have specialized gas exchange organs (e.g. leaf, lung and gill) and a **circulatory system**.

Transport in Flowering plants:

Plants have two different networks of tubes inside them;

Phloem: transports **sucrose** and **amino acids** up and down the stem

Xylem: transports **water** and **minerals** up the stem



Phloem and Xylem are arranged in separate bundles (**vascular bundles**) inside the stem. The xylem is on the **inside** and the phloem is on the **outside**. This arrangement is different in roots (but you don't need to know it)

Transport in the phloem is tricky, but fortunately not on your syllabus. It is **not** the same as transport in the xylem, which occurs by the process of **transpiration**.

Transpiration is the movement of water up a plant, from the roots, through the stem and finally out of the leaves.

In the Roots:

Water enters root hair cells by **osmosis**. The roots are full of **minerals**, which artificially lower the concentration of water inside the root cells, so water is always drawn into them from the soil. This enables transpiration to happen even if the soil **is very dry**. The roots take the minerals up against the concentration gradient and is, therefore, an example of **active transport**.

Root hair cells increase the root's surface area

In the Stem:

1. Water evaporates out of the top of the xylem
2. This generates a low pressure at the top of the xylem (a mini vacuum, if you like)
3. This sucks water molecules up the xylem
4. This is called **transpiration pull**

Extension (not on syllabus, but very interesting…)

Water molecules are slightly charged (**polar**). The oxygen atom is slightly negative and the hydrogens are slightly positively charged. This means that water molecules tend to stick to each other. Therefore, when transpiration pull sucks at the water molecules in the top of the xylem, the entire column of water moves up the xylem, not just the molecules at the top!

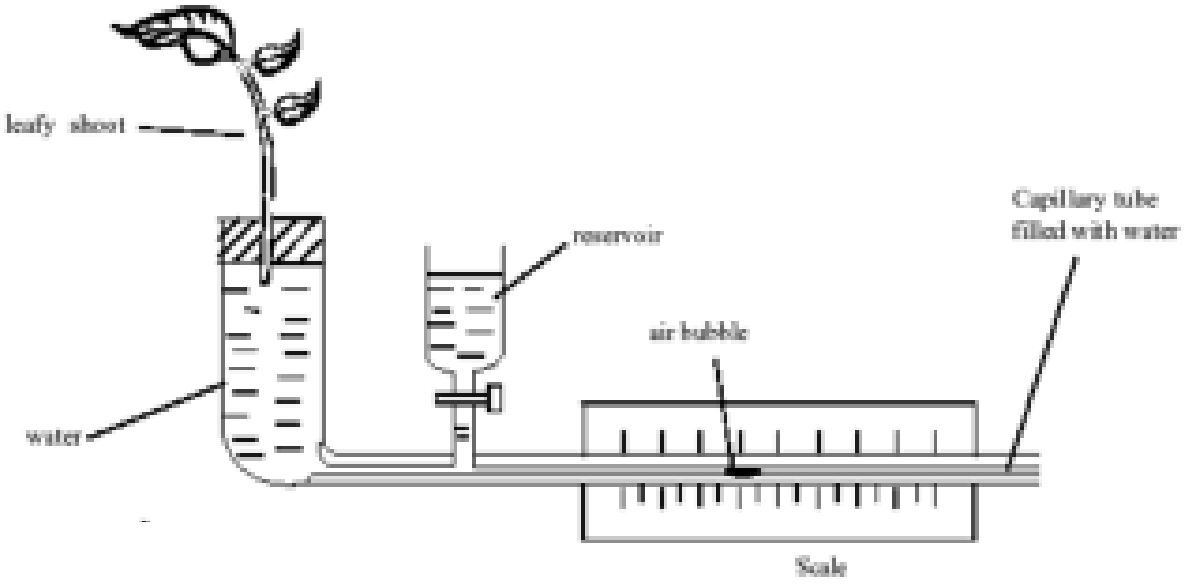
In the leaf:

Water enters the leaf in xylem vessels in veins (basically, another name for a leaf vascular bundle). The water moves by **osmosis** into leaf mesophyll cells, where it **evaporates** into the air spaces and finally **diffuses** out of the stomata into the air.

Factors affecting the rate of transpiration:

Factor	Effect on transpiration rate
Temperature (increases transpiration)	Increasing temperature increases the **kinetic energy** of molecules. This makes diffusion, osmosis and evaporation happen faster
Humidity (decreases transpiration)	When the air is humid then there is more water vapour in it. Humid air is less able to accept more water molecules by evaporation.
Wind (increases transpiration)	Wind blows water vapour away from the stoma, keeping the concentration gradient high.
Light intensity (increases transpiration)	Light causes stoma to open. Wider stoma can allow faster diffusion of water vapour out of the leaf.

*You need to know an experiment that can show the effect of the above factors on the rate of transpiration. The best experiment is a **potometer**, which measures how quickly a little bubble of air moves up a glass tube attached to the bottom of the stem. Adding a fan, changing the humidity, increasing the temperature etc will all change the speed the bubble moves up the tube.*



Why do plants need water (why do they bother to transpire)?

- Used in photosynthesis (~10%)
- A solvent for transporting other things (e.g. minerals) (~10%)
- Used in chemical reactions (~5%)
- A site of chemical reactions (~5%)
- **Cooling the plant (~70%)**

Transport in Humans:

Blood consists of 4 main parts;

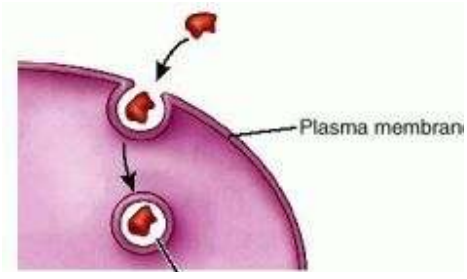
Plasma – mostly water used for **transporting** things around the body (i.e. **CO_2 glucose**, **amino acids**, other products of digestion, **urea**, **hormones** and **heat energy**.

Red Blood Cells – adapted to carry O_2 around the body. O_2 attaches to **haemoglobin** protein, which the RBCs are filled with. Other adaptations of RBCs include;

- Smooth edges
- **Biconcave** shape (increases surface area and allows folding)
- Made in huge quantities
- No nucleus (so more room for haemoglobin)

Platelets – help clot the blood. This stops blood loss and also prevents microorganisms entering the body.

White Blood Cells – are part of the immune system. There are two main types; **macrophages** and **lymphocytes**.

Macrophages (sometimes called Phagoctyes)	**Lymphoctyes**
Travel in the blood. They detect foreign bodies (i.e. foreign cells, toxins, cells infected with virus and cancerous cells) and **engulf and destroy** them.  Engulfing and destroying is called **phagoctyosis**	Stay in the lymph system (you don't need to know what this is). They make **antibody proteins** in large numbers. Antibody proteins travel in the blood and stick to foreign objects. This helps because; 1. foreign objects are stuck to each other, stopping them spreading 2. Macrophages can engulf many foreign objects at the same time, speeding up the killing process

Extension (not technically on syllabus, but not sure…)

Plasma carries CO_2 around the body. How?

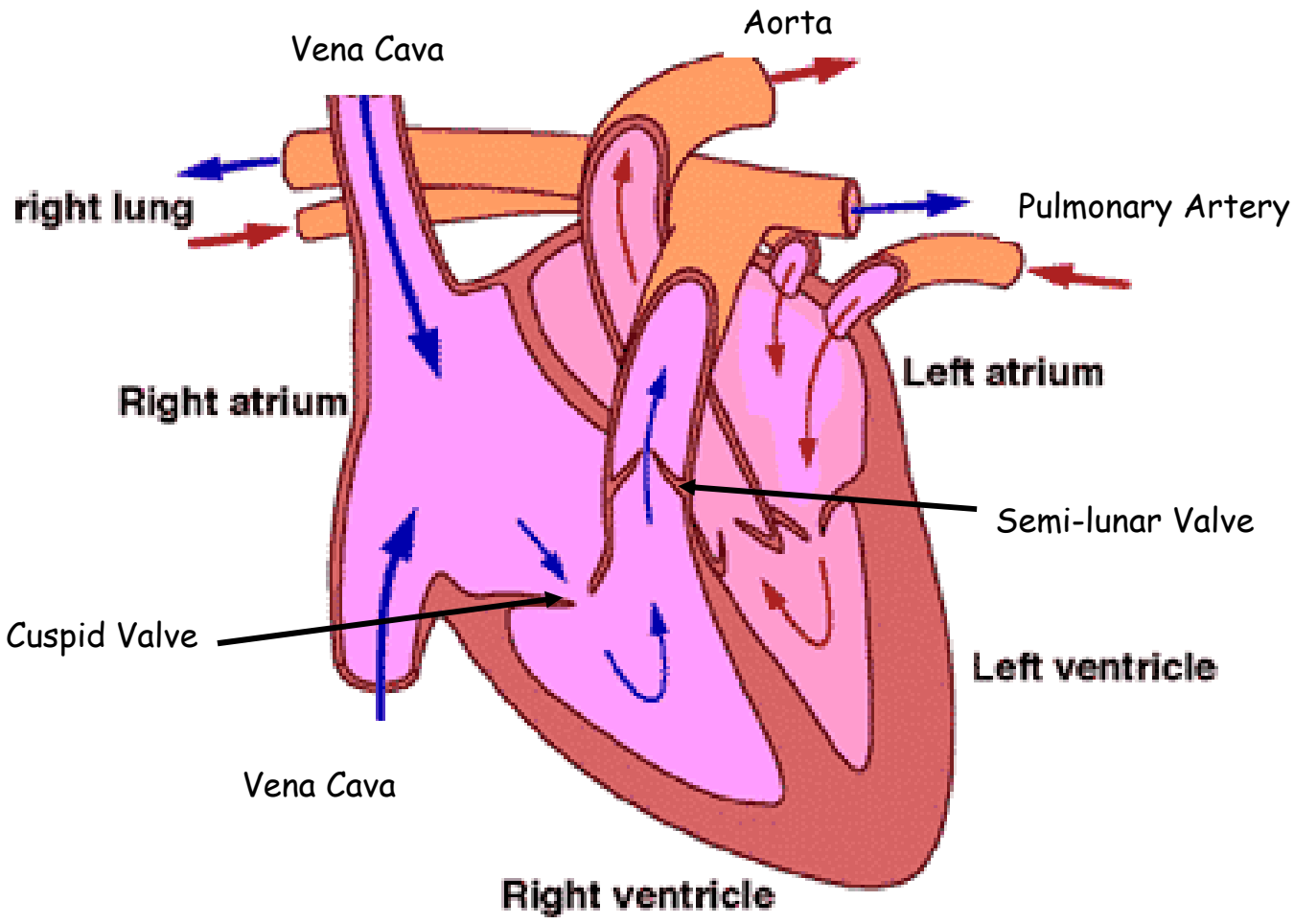
$$CO_2 + H_2O \rightarrow HCO_3^- + H^+$$

The CO_2 reacts with water molecules to produce the **Hydrogen Carbonate ion**. In the lungs the reaction reverses to produce CO_2 again. CO_2 is, therefore, carried as an **aqueous ion** in the blood plasma.

The Human Heart:

You need to know;

1. the names of the 4 **chambers** of the heart
2. the names of the 2 **arteries** and 2 **veins** attached to the heart
3. The names of the two sets of **valves** in the heart



Contraction in the heart:

Remember, the atria contract first. The L & R atria contract at the same time. The ventricles contract second. The L & R Ventricles contract at the same time.

1. Blood enters the atria
2. Both atria start to contract, pushing the blood into the ventricles through the open cuspid valves
3. When the ventricles are full they begin to contract
4. The cuspid valves shut to stop **backflow**
5. Blood is forced out of the heart into the circulatory system through the open semi-lunar valves
6. When the ventricles finish contracting the S-L valves shut, stopping backflow.

Blood has to pass through the heart twice to complete a full circuit of the body (takes about 10 – 20sec). This is called a **double circulation**.

During exercise **adrenaline** is released from the **adrenal glands**. Adrenaline has two effects of the heart;

1. Makes it beat **faster**
2. Makes each beat **harder**

The combined effect is to **massively increase** the volume of blood pumped by the heart per minute.

Extension (summarizes point above mathematically)

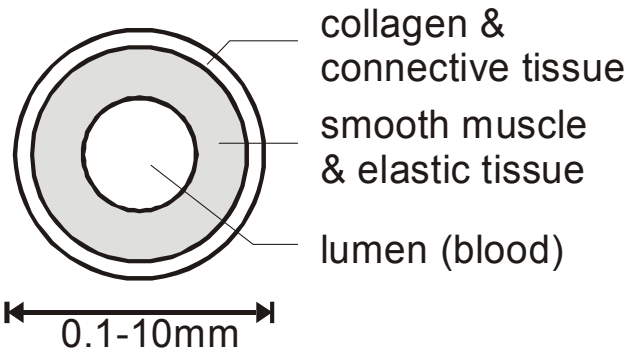
Cardiac Output = Heart Rate x Stroke Volume

CO = Volume of blood pumped per minute
HR = No of beats per minute
SV = Volume of blood ejected per beat

Adrenaline increases both HR & SV, therefore, increasing CO **lots**

Artery, Vein and Capillary:

Artery:

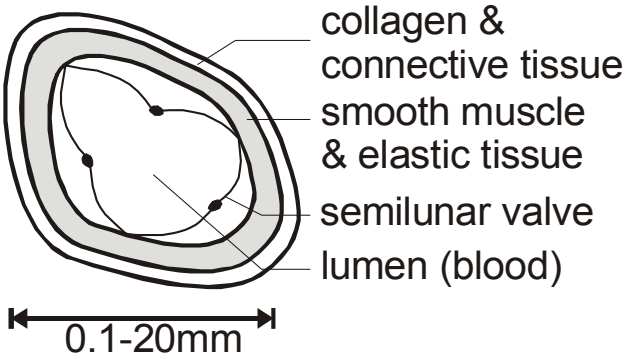


Arteries carry **high pressure blood** **away** from the heart.

Key Points:

1. Thick muscle layer to withstand high pressure blood
2. Elastic tissue allows artery to stretch when blood is forced into it
3. Protective collagen layer
4. Round shape
5. Relatively small lumen

Vein:



Veins carry **low pressure blood** **towards** the heart.

Key Points:

1. Thin muscle layer (low pressure blood)
2. Valve to stop **backflow**
3. Protective collagen layer
4. Not a round shape (wall not thick enough to hold shape)
5. Large lumen (decreases effect of friction)