Digestion & Respiration & Circulation Key Notes

Balanced Diets

Our energy is derived from food - whereas plants can produce their own energy from sunlight, we must consume food

This food is our raw material - needed to make new substances for: -

- Energy (movement etc…)
- Growth and repair
- Health

A balanced diet contains the different nutrients in the correct amounts, keeping us healthy.

Foods contain nutrients: these are substances, which provide raw materials for the body (we need nutrients, along with fibre and water for a healthy diet)

Nutrient	How the body uses it	Food sources it is contained in
Carbohydrate	To provide energy	Cereals; bread; pasta; potatoes (sugars and starch)
Protein	For growth, making new cells and repair of our bodies	Fish; meat; eggs; dairy products
Fat	To provide energy, as a store of energy & for insulation	Butter; oil; nuts
Minerals	Needed in small amounts to maintain health	Salt; milk (calcium); liver (iron)
Vitamins	Needed in small amounts to maintain health	Dairy foods; fruit; vegetables
Fibre	To provide roughage to help keep food passing through the gut	Vegetables; bran; wholemeal bread
Water	Needed by cells and for body fluids	Fruit juice; milk; water(!)

Different foods contain different substances - there is no one food that contains all the substances the body needs. Instead you must eat a wide variety of foods - balancing your diet

Different people need different amounts of food. You need more food if you are particularly active, are pregnant etc…

If you have too little of a particular nutrient, we say that you have a deficiency in that nutrient, e.g. fibre deficiency can lead to constipation

Food tests: -

Iodine tests for starch - it turns blue / black

Benedict's test for simple sugars - produces an orange precipitate if simple sugars are present

Biuret test for protein - turns copper sulphate purple. If the pale blue colour turns purple, protein is present

Fat test - rub a food sample onto a piece of paper and leave to dry. If fat is present, the paper will have a translucent stain round the sample, when held to the light

Digestive System

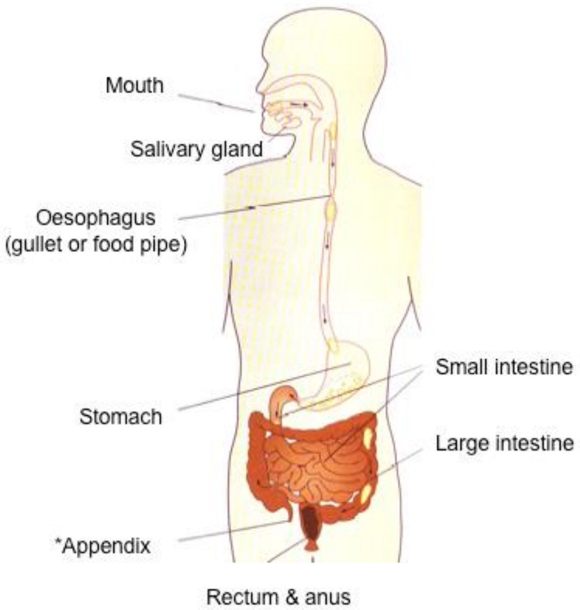
Food we eat has to be broken down into a form that our bodies can use - this is digestion

Digestion is needed to absorb food into our bodies - obtaining as many nutrients from the food as possible

Digestion happens in the digestive system, beginning at the mouth and ending at the anus

After we swallow, food passes through these organs: -

- Oesophagus (gullet or food pipe)
- Stomach
- Small intestine
- Large intestine



Mouth - putting food in your mouth is called *feeding* or *ingestion*. Teeth grind the food down, and saliva (produced from salivary glands) help make the food moist, easing swallowing (as well as the enzyme *amylase* which helps break down starch)

Oesophagus (gullet) - when you swallow, the trachea (windpipe) is shut off, and food passes down the oesophagus. Muscles in the wall above the food contract, making the piper narrower above the food, pushing it down (this is why you can eat, even when upside down)!

Stomach - food is churned up with the strong acid (pH 1-2)

Small intestine - small molecules are absorbed through the small intestine wall

Large intestine - food which we cannot digest (e.g. fibre) is passed into the large intestine, where water is removed. This forms a more solid material - faeces

Rectum & anus - faeces is stored in the rectum, eventually being pushed out of the anus - faeces is egested

*Appendix - in some animals, helps to break down cellulose, but no known use in humans

Some organs play a vital role in digestion, even though food does not pass through them: -

- The liver produces bile helping with the digestion of fat
- The pancrease produces chemicals called *digestive enzymes*, which help break down food molecules

Undigested food is stored in the rectum, the lower part of the large intestine, until we are ready to go to the toilet

It then comes out of the rectum through the anus as faeces

This process is called egestion

Enzymes

During digestion our teeth break food down into small pieces. However, these chewed pieces of food are still too large to be absorbed by the body.

Food has to be broken down chemically into really small particles before it can be absorbed. Some foods can be absorbed (like simple sugar, vitamins, minerals and water) as they are small enough already. Foods such as starch, protein and fat are too big though, and rely on enzymes to break them down

Enzymes are needed so that this break-down happens quickly enough to be useful. Digestive enzymes cannot break down fibre, which is why it cannot be absorbed by the body

Enzymes are not living! They are special proteins which can break large molecules down. There are specific enzymes, which break down specific nutrients: -

- Amylase (carbohydrase) enzymes break down starch into simple sugars
- Protease enzymes break down proteins into amino acids

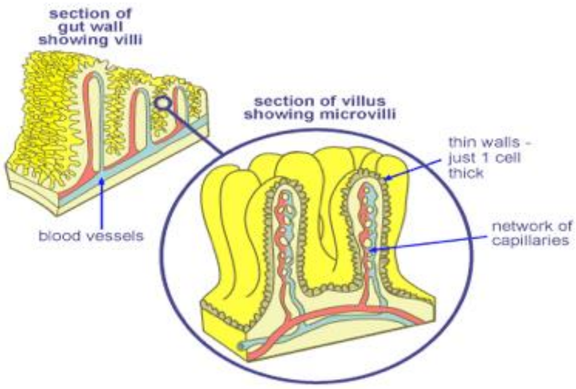
- Lipase enzymes break down fats into fatty acids and glycerol

Digested food molecules are absorbed in the small intestine, passing through the wall of the small intestine into the bloodstream (where they are carried around the body to where they are needed).

Only small, soluble substances can pass across the wall of the small intestine. Large insoluble substances cannot pass through - this is why we need enzymes!

The inside wall of the small intestine needs to be thin, with a really big surface area. This allows absorption to happen quickly and efficiently (so we absorb as much food as possible).

To get a big surface area, the inside wall of the small intestine is lined with tiny **villi** (one of them is called a **villus**)



Enzymes only break down one type of food – e.g. lipase only breaks down fat (lipids); amylase only breaks down carbohydrates; protease only breaks down protein

The rate at which enzymes break food down can be affected by two main factors: pH and temperature

Enzymes are similar to a lock and a key - only a specific key will undo a lock (only a specific enzyme (key) will break down a specific food molecule (lock))

Enzymes need specific conditions - they can *denature* in high temperatures / pH (this is where the enzyme structure is changed so it no longer functions (a bit like bending the key so it no longer fits in the lock))

Respiration

Respiration takes place in the cells (it is not “breathing in and out”)

Respiration is the release of energy (from glucose) in our cells

Animals and plants respire

In the light plants respire, but produce the oxygen for this to occur by photosynthesis - the carbon dioxide they produce via respiration is used for photosynthesis

In the dark plants respire, producing carbon dioxide

glucose + oxygen → carbon dioxide + water + (energy)

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + (\text{energy})$$

Respiration is the process of converting glucose to energy, occurring in every cell. For this to happen we need oxygen – this is aerobic respiration!

Anaerobic respiration is respiration without oxygen

The glucose is only partially broken down, and *lactic acid* is produced

The amount of energy produced is also much smaller

glucose → lactic acid + (energy)

$$C_6H_{12}O_6 \rightarrow 2C_3H_6O_3 + (\text{energy})$$

Anaerobic respiration is extremely useful if the cells cannot obtain enough oxygen – during strenuous exercise

However, it is not as efficient as aerobic respiration, producing far less energy. Also lactic acid builds up (which causes cramps and muscle fatigue)

In order to prevent cell damage this lactic acid must be broken down immediately after exercise

This is why we breathe hard after exercise, paying back our *oxygen debt* (the oxygen breaks the lactic acid down to carbon dioxide and water)

When anaerobic respiration occurs in yeast it is called fermentation

Ethanol (alcohol) is produced instead of lactic acid, and this reaction is used in the brewing of alcoholic drinks

glucose → ethanol + carbon dioxide + energy

Circulatory System & Fitness

The circulatory system is the body's main transport system, carrying food and oxygen to the cells and taking waste products (carbon dioxide) away. It consists of the heart; arteries; veins; and capillaries

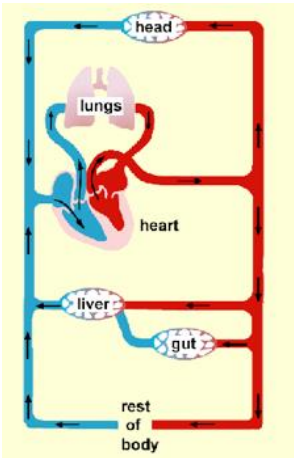
Oxygen is initially absorbed into the blood within the lungs (via diffusion). It will now travel through a variety of systems in order to get to the cell, where it is needed for respiration.

Blood travels through three types of vessel - arteries, veins and capillaries with have specific properties: -

- Arteries are thick-walled muscular tubes which carry blood *away* from the heart - fast flowing!
- Veins are thin walled tubes which carry blood *back* to the heart – they have a large diameter and valves as the blood flows slower
- Capillaries are extremely narrow tubes which carry blood through our tissues: their walls are just one cell thick - so thin that oxygen, food and waste products can easily pass through them

Blood is a liquid tissue whose function is to fight disease and to transport materials around the body.

The heart pumps blood around the body – in humans this is a four-chambered pump. The right side of the heart pumps deoxygenated blood to the lungs to pick up oxygen. The left side of the heart pumps the oxygenated blood from the lungs around the rest of the body (which is why it is more muscular)



Oxygen and glucose leak out of the capillaries and the cells close by absorb the required oxygen and glucose

The waste products (including carbon dioxide) pass out of the cells and into this fluid, that is then re-absorbed by the blood

Capillaries do not join up to every cell - instead fluid is passed out of them, with cells close by absorbing what they need

In order to prevent cell damage this lactic acid must be broken down immediately after exercise

This is why we breathe hard after exercise, paying back our *oxygen debt* (the oxygen breaks the lactic acid down to carbon dioxide and water)

This is why a good measure of fitness in a person is how quickly their breathing and pulse rate return to normal

A fit person has efficient aerobic respiration, so they don't build up a big oxygen debt and return to normal quickly

Breathing System

The breathing system is used by the body to get the oxygen needed for respiration + used to get rid of the waste product carbon dioxide

It is made up of: -

- The lungs
- Tubes leading from the lungs to the mouth and nose
- Various structures in the chest, allowing air to move in and out of the lungs

It is vital we get as much oxygen as possible during every breathe, as well as remove as much carbon dioxide as possible

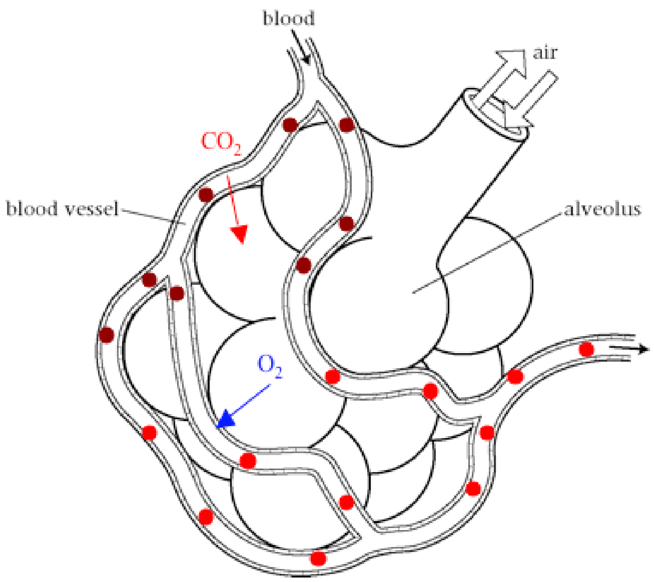
In the lungs, oxygen travels to thousands of tiny air sacs called **alveoli** - covered with tiny blood vessels

The alveoli are adapted to make gas exchange in lungs happen easily and efficiently: -

- Alveoli give the lungs a really big surface area
- Alveoli have moist, thin walls (just one cell thick)
- Alveoli have a lot of tiny blood vessels called capillaries

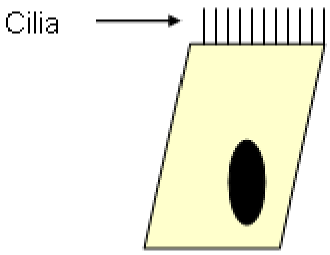
The gases move by diffusion - net movement from a [high] to [low]: -

- Oxygen diffuses from air in alveoli into blood
- Carbon dioxide diffuses from blood into air in alveoli
- Some water vapour is also lost from the surface of the alveoli



There are specialised cells in the lining of the breathing tubes which produce a sticky mucus to trap dirt and microbes. Specialised cells called cilia help to move this mucus out of the lungs

Smoking can damage these delicate cells (hot smoke and tar) and they are less effective. This is why smokers cough a lot, trying to move this mucus



Movements of the ribs, rib muscles and diaphragm allow air into and out of the lungs: this is called breathing or ventilation

When we breathe in, we inhale

When we breathe out, we exhale

Exhaled air contains less O_2, but much more CO_2

Smoking

Cigarettes contain about 4,000 different chemicals, most of which are harmful to the body. These include:

- nicotine - the addictive substance in tobacco smoke
- carbon monoxide.

Smoking and blood pressure

Smoking increases blood pressure by raising the heart rate.

Smoking can increase the risk of heart disease

Nicotine itself increases the heart rate and carbon monoxide reduces the oxygen-carrying capacity of the blood. It combines with haemoglobin in red blood cells, preventing oxygen combining with the haemoglobin. This causes an increase in heart rate to compensate for the reduced amount of oxygen carried in the blood.