

Section A : Mammalian Nutrition

1. Breakdown of Food

As humans, we need to eat a variety of different foods to make sure that we take in enough of each main food group.

The main food groups should be consumed in the correct quantities, in order to maintain a healthy body.

- | | |
|---------------------------|---------------------------------|
| a. Carbohydrates : | used as an energy source |
| b. Proteins: | used for growth and repair |
| c. Fats: | used as an energy source |
| d. Vitamins and Minerals: | used to maintain a healthy body |

(a) Carbohydrates

- are made of the elements carbon, hydrogen and oxygen.
- can be divided into two groups.
 - simple sugars : e.g. glucose and fructose.
 - complex carbohydrates : e.g. starch, cellulose and glycogen.
- complex carbohydrates are made up of monomer subunits, of simple sugars.

Different carbohydrates can be identified using different chemical tests.

Glucose can be identified using Benedict's Solution.

To test foods for glucose:

1. Half fill a beaker with freshly boiled water.
2. Add small samples of foods to separate test tubes.
3. Add water to a depth of 2cm, in each test tube.
4. Add 10 drops of Benedict's Solution to each test tube.
5. Place test tubes in hot water, leave for 10 minutes .

If a food contains glucose, then Benedict's solution will change colour from blue to red / orange.

Table sugar (sucrose) will not cause Benedict's solution to change colour on heating.

Starch can be identified using Iodine Solution.

To test foods for starch:

1. Add small samples of foods to separate dimples of a dimple tile.
2. Add a few drops of iodine solution to each dimple.
3. Leave for 2 minutes and observe any colour changes.

If a food contains starch, then iodine solution will change colour from brown to blue / black.

Starch is the only complex carbohydrate to cause iodine solution to change colour from brown to blue / black.

(b) Proteins

- are made of the elements carbon, hydrogen, oxygen and **nitrogen**.
- are polymers made up of monomer subunits called **amino acids**.
- each amino acid is linked to its adjacent neighbours by an amide link.
- the sequence of amino acids found in a protein molecule is directly related to the sequence of **bases** found in a cell's **DNA** molecule.
- the sequence of amino acids will dictate the folded shape a protein molecule will take on, and hence, directly influence the function of a protein.

Foods containing proteins can be identified using **Biuret Reagent**.

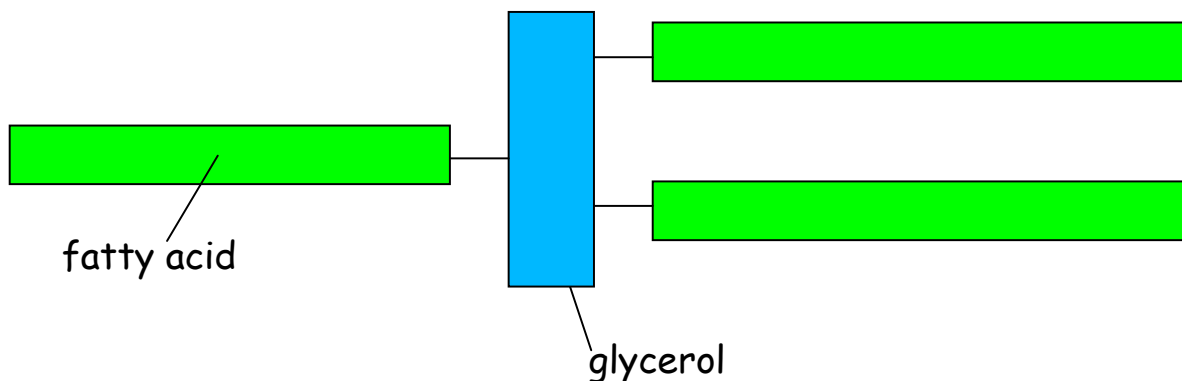
To test for protein:

1. Half fill a beaker with freshly boiled water.
2. Add small samples of foods to separate test tubes.
3. Add water to a depth of 2cm, in each test tube.
4. Add 10 drops of Benedict's Solution to each test tube.
5. Place test tubes in hot water, leave for 10 minutes.

If a food contains protein, then it will cause the Biuret reagent to change colour from blue to purple / lilac.

(c) Fats

- are made of the elements carbon, hydrogen and oxygen.
- are made up of one glycerol and three fatty acids per molecule.
- different combinations of fatty acids with glycerol give fats with different properties. e.g. saturated and polyunsaturated fats and oils.
- example structure of a fat molecule.



Foods containing fats can be identified using the **Filter Paper Test**.

To test a food for fat, rub a small sample of food on a clean piece of filter paper. If fat is present in the food, the filter paper will show a "greasy mark" and turn translucent (semi-see-through).

(d) Vitamins and Minerals

Vitamins and Minerals are two distinct groups of food compounds.

Vitamins are complex carbon based compounds. These are essential for continued health. We only observe the requirement of a particular vitamin when it is deficient.

Vitamins A and D are only soluble of "oily" solvents.

Vitamins B and C are soluble in water.

Examples:

An individual lacking Vitamin C will eventually develop scurvy.

An individual lacking Vitamin D during childhood will develop rickets.

Minerals are chemicals essential to the body for it to function correctly.

They are only required in tiny amounts.

Examples:

Calcium is required to build strong **teeth** and **bones**.

Iron is required to form red blood cells, in particular **haemoglobin**.

Zinc is required for many body **enzymes** to function correctly.

If minerals, and other **trace elements**, are present in too high quantities then they are **toxic** to the body. They will poison the body from within.

(e) Energy content of foods

Different food groups contain different amounts of **chemical** energy, stored in their molecules. **Fat** molecules contain the **more energy** per gram than either **carbohydrate** or **protein** molecules.

Foods are made up of **mixtures** of the three main types of food molecules. Those foods that contain **more fat** will contain **more chemical energy**.

We can demonstrate the amount of chemical energy stored in a food, by comparing a number of different foods' abilities to heat up a known volume of water.

It is possible to make a fair comparison between the energy contents of different foods, we should ensure that:

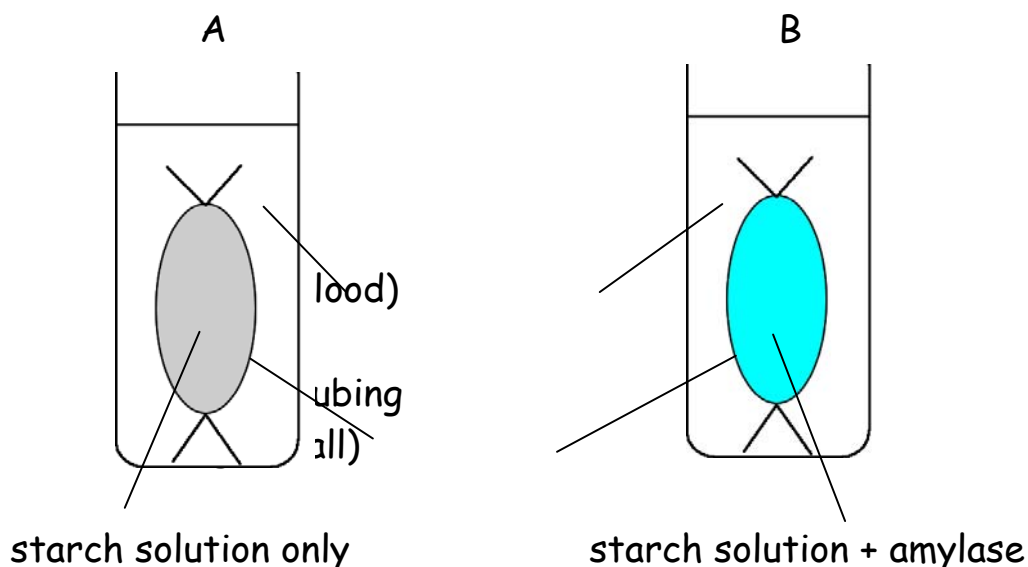
- burn the **same mass** of food (ideally 1 gram)
- heat the **same volume** of water (approximately 15 ml)
- same **starting temperature** for water (around 20 °C)
- ensure burning food is kept the **same distance** of away from the boiling tube at all times.

(f) The need for Digestion

The food we eat is mainly made up of **large insoluble polymer molecules**. These insoluble polymers must be broken down into **smaller soluble monomer molecules** before we can absorb them through the **gut wall** into the **blood**. Once in the blood, the small soluble molecules can be **transported** to all the **cells** of our **body**.

We can demonstrate the need to digest large polymer molecules before we can absorb them into our blood using a model gut.

Method:



- Incubate tubes A and B at 37 °C for 25 minutes.
- Then test water for the presence of starch and glucose.

Results:

- Tube A : The water surrounding tube A does not show the presence of starch or glucose.
- Tube B : The water surrounding tube B was shown to contain glucose, but not starch.

Explanation:

- **Starch** is a large polymer molecule, so it is **unable to diffuse** through the small pores present in the walls of the visking tubing into the surrounding water.
- The enzyme **amylase** is required to **breakdown** the large **starch** molecules into small soluble glucose molecules.
- Once released from the starch polymer, the **glucose** molecules are **small** enough so that they can **diffuse** through the pores present in the walls of the visking tubing, into the surrounding water.
- Our bodies need to breakdown (**digest**) the large food molecules using **enzymes** found in the gut.
- Once broken down, the **smaller soluble** molecules are free to **diffuse** through the **gut wall** (in the small intestine) into the **blood**.
- Once in the blood, the small soluble molecules can be transported around the body, to the cells which require them for cell processes.

2. Alimentary Canal

The **alimentary canal** is another name given to the long muscular tube, together with its associated organs, that leads from the **mouth** to the **anus**. In humans, the alimentary canal is approximately 9 m long.

The **digestion** of our food, **absorption** of its nutrients and **expulsion** of any waste occurs in a number of stages. Different sections, and

associated organs, are responsible for each stage in the digestion of the food we eat.

(a) Anatomy of the Alimentary Canal

See diagram from your own notes.

(b) The Mouth

- Any **chemical reaction** will occur at a **faster rate** if reactants are present in a **smaller particle size**. Digestion relies on a series of chemical reactions occurring.
- To allow digestion to occur at the fastest possible rate, we need to **break** the **large** lumps of food down into **smaller** lumps, by mechanical means.
- The first stage of digestion occurs in the mouth, here we use our **teeth** and **tongue** to grind up the food into smaller lumps.
- In the mouth, the ground up food is mixed with **saliva**, produced by the **salivary glands**.

(c) The Salivary Glands

- The salivary glands produce **two** substances required for digestion:
 - **mucus**
 - **salivary amylase**
- **Mucus** produced by the salivary glands helps **lubricate** the mouth, and food. Lubrication allows the food to be moved from the mouth, and down the **oesophagus** more easily.
- **Salivary Amylase** is an **enzyme**, produced by the salivary glands, which begins the **chemical breakdown** of food in the mouth. **Amylase** is responsible for the breakdown of **starch** into **maltose** (a sugar).

(d) The Oesophagus

- The **oesophagus** is a **muscular tube** that leads from the **mouth** to the **stomach**.

- Food does not simply travel down the oesophagus from the mouth to the stomach by **gravity**. Instead, the process of **peristalsis** occurs.
- **Peristalsis** is the wave-like **contraction** and **relaxation** of circular **rings of muscle** found in the **walls** of the oesophagus.
- A ring of muscles **behind** the food **contract** narrowing the oesophagus, whilst the rings of muscle **in front** of the food **relax** allowing the oesophagus to expand.
- This co-ordinated **contraction** and **relaxation** of muscles in the oesophagus wall forces the food along from the mouth to the stomach.
- **Peristalsis** occurs along the length of the alimentary canal, not just the oesophagus. Therefore, food is transported from the **mouth** to the **anus** by **peristalsis**.

(e) The Stomach

- The **stomach** is a **muscular bag**, which links the **oesophagus** to the **small intestine**.
- The **walls** of the stomach are made up of **muscular** layers. A **longitudinal** layer which runs the **length** of the stomach, and a **circular** layer which forms a **ring** around **center** of the stomach.
- Rhythmic **contractions** and **relaxations** of the **longitudinal** and **circular** muscle layers cause **mixing** of **food** with **gastric** juices.
- During the periods of **contraction** and **relaxation** of the stomach walls, special valves called **sphincters**, prevent the escape of stomach contents into the oesophagus and small intestine.
- Across the walls of the stomach are found areas known as **gastric glands**.
- **Mucus** secreting cells, found at the **neck** of the gland, produce a slimy **mucus** that sticks to the walls of the stomach. The mucus **protects** the sensitive walls of the stomach from **chemical** attack by acid and digestive **enzymes**.
- **Enzyme** secreting cells, found at the **base** of the gland, produce an enzyme precursor (**pepsinogen**). On contact with the **acid** found in the stomach, pepsinogen is activated to make **pepsin**. Pepsin is responsible for the **partial breakdown** of large **protein** molecules to smaller chains of amino acids, called **peptides**.

- **Acid** secreting cells are found on the walls of the gland, halfway between the neck and base of the gland. These cells secrete the **hydrochloric acid** required to **activate pepsinogen**, and assist in the **chemical breakdown** of proteins.

(f) The Pancreas and Gall Bladder

- The **pancreas** and **gall bladder** both release substances to **aid digestion**. They release these substances into the **small intestine**, where they have their action.
- The **pancreas** releases the **enzymes**:
 - **lipase** to assist in the digestions of **fat** molecules, fatty acids and glycerol.
 - **trypsin** to assist further digestion of **peptides** to individual amino acids.
 - **amylase** to assist in the further digestion of **starch**.
- The **gall bladder** stores **bile**, which is produced by the **liver**. Bile is a fluid which **emulsifies fats** to assist in their digestion to **fatty acids** and **glycerol**. Bile has a similar action to that of washing up liquid on oily water.

(g) The Small Intestine and Liver

- The **small intestine** is the site of further **digestion** of the large **insoluble** molecules found in our food.
- The small intestine is also the site in the gut where the body begins to **absorb** the **small soluble** molecules produced during **digestion**.
- Together with the substances released by the pancreas and gall bladder, the small intestine itself produces **two enzymes** to assist the further digestion of large insoluble molecules found in our food.

- **trypsin** to assist further digestion of **peptides** to individual **amino acids**.
 - **lipase** to assist in the digestion of **fat** molecules to **fatty acids** and **glycerol**.
- All of the enzymes present in the small intestine, together with the bile released from the gall bladder, function to digest the large insoluble molecules found in our food.
 - Digestion results in the production of small soluble molecules that are capable of being **absorbed** through the **wall** of the small intestine into the blood.
 - The small intestine has structural features to assist absorption:
 - **Increased surface area** - a **folded** inner surface, creating **thousands** of **villi**. The cells which line the surface of the villi have specially **folded** cell membranes, creating **millions** of **microvilli**.
 - **Ease of diffusion** - the layer of cells covering the surface of the villi are only **one cell thick**. This means that substances can easily move from the **small intestine** to the **blood stream / lacteal**.
 - **Circulation and Lymphatics** - Each villus has a **rich blood supply** from a network of **blood capillaries**. A **lacteal** links to the **lymphatic system**.
 - **Glucose** and **amino acids** released from food molecules are absorbed into the blood present in the dense **capillary network** present in the villi.
 - **Glucose** is then transported to the **liver** via the **blood**. The **brain** senses the blood glucose concentration. If it is higher than the body needs - such as straight after a meal - the body instigates the storage of glucose as **glycogen**, in the **liver**. This process is a complex interaction between various **hormones** and **enzymes**.
 - The blood **glucose** concentration is maintained at an appropriate level by the brain, to provide all the cells of our bodies with a **energy source**

(glucose). The blood transports the required amino acids around the body.

- **Amino acids** are also transported to the **liver** via the **blood**. Once again, the **brain** senses the blood amino acid concentration. If it is higher than required, any **excess** of amino acids are **removed** from the blood. The excess amino acids undergo **deamination** in the liver, being converted into **urea**. Urea is then returned to the **blood** for transport to the kidneys, where it is removed by the **kidneys**.
- The blood **amino acid** concentration is maintained at an appropriate level by the **brain**, to provide raw materials for the cells of our body to make **proteins** from. The **blood** transports the required amino acids around the body.
- The products of fat digestion - fatty acids and glycerol - are absorbed by the **lacteal**. The **lacteal** is linked to the **lymphatic system**. The lymphatic system transports the **fatty acids** and **glycerol** around the body.
- Once at the cells of our body, the fatty acids and glycerol are used as an **energy source** for **respiration**.
- Should the blood contain any **excess** of fatty acids and/or glycerol, then they are deposited in **fat cells** located around the body. The fatty acids and glycerol are re-assembled into **fat molecules**. The **fat cells** then store the **fat molecules** as a **future energy source**.

(h) The Large Intestine and Rectum

- The **large intestine** and **rectum** link the **small intestine** to the **anus**.
- The material passing from the small intestine to the large intestine is made up of **undigested food**, **dead cells**, **bacteria** and **water**.
- In the large intestine, **excess water** is absorbed through the wall of the large intestine, leaving all the other material behind. This material is now known as **faeces**.
- **Faeces** passes to the **rectum** for storage, prior to expulsion from the body. Various special valves, called **sphincters**, prevent the premature movement of faeces out of the body through the **anus**.