Lesson Six

Human Nutrition

Aims

By the end of this lesson you should be able to

- describe the chemical elements and structure of carbohydrates, proteins and lipids, and the tests for glucose and starch
- identify sources and functions of carbohydrates, proteins, lipids, vitamins A,C & D, the mineral ions calcium and iron, water and dietary fibre
- understand the processes of ingestion, digestion, absorption, assimilation and egestion, and the role of digestive enzymes in the breakdown of starch, proteins and lipids
- understand the production, storage and action of bile
- describe the structure of a villus, and understand how this helps absorption of the products of digestion in the small intestine
- describe the structures of the human alimentary canal and the functions of the mouth, oesophagus, stomach, small intestine, large intestine and pancreas
- explain how and why food is moved through the gut by peristalsis
- ***understand the contents of a balanced diet**, **and *understand that energy requirements vary with age, pregnancy and activity levels**

Context

This lesson covers elements 2.5–2.7 and 2.23–2.31 of Section 2: ‘Structures and functions in living organisms’ of the Edexcel specification.

Edexcel IGCSE Biology Chapter 4 pages 37–51.

Introduction

This lesson is about human food and diet, and about how we process food and extract nutrients from it.

In biology, the term **diet** means whatever a person eats and drinks. So we are all of us on a diet, even if it is one of cream cakes and fizzy drinks! The term **food** means any item you might eat or drink, like apple, crisps, lamb, lemonade etc. Most foods are a complex mixture of several different sorts of chemical, each of which is called a **nutrient**. Nutrients include the carbohydrates, protein and vitamins that you have heard of.

Processing food and extracting nutrients from it is the job of the **digestive system**. This is made up of a long tube called the **gut** or **alimentary canal** with extra organs such as the liver and pancreas attached to it - see the diagram on page 47 of *Edexcel IGCSE Biology*.

The Major Nutrients

The major groups of nutrients needed in the human diet are as follows:

- **carbohydrates**: both starch and sugars are carbohydrates
- **lipids**: both fats and oils are lipids
- **proteins**
- **vitamins**: there are several different vitamins, including vitamin A, vitamin C and vitamin D
- **minerals**: more correctly called **mineral ions**. There are several different mineral ions, including sodium, calcium and iron
- **water**
- **dietary fibre**: also called roughage.

Each of these nutrients is needed for a different reason, so it is not possible to do without one of them by eating more of the rest.

We will now work through each of these nutrient types in turn.

Activity 1	Raid your kitchen cupboard, fridge and freezer and examine the labels on your foods. How many of the major nutrient types are contained in each food you examine?

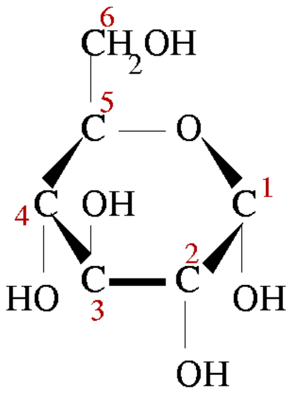
Carbohydrates

Structure

Carbohydrates are so-called because they contain only three chemical elements: carbon (C), hydrogen (H) and oxygen (O). In the name “carbo-hydr-ates”:

- “carbo” is short for carbon
- “hydr” is short for hydrogen
- “ate” is used in names of chemical compounds to indicate that they contain oxygen

The simplest carbohydrates are called **simple sugars**. A simple sugar molecule is a single ring of carbon atoms with hydrogen and oxygen atoms attached to them. **Glucose**, which we have met already, is the most important example. The full structure of a single glucose molecule looks like this – notice the ring shape (the six carbon atoms have been numbered 1 to 6):



A glucose molecule

However you only need to remember its chemical formula $C_6H_{12}O_6$, which tells you the numbers of each sort of atom in the molecule.

Activity 2

Count the number of carbon (C), hydrogen (H) and oxygen (O) atoms in the diagram of the glucose molecule. (<u>Hint</u>: There is an extra hydrogen atom on each of carbon atoms 1-5 that has not been drawn in to make the diagram less cluttered.) Verify that there are 6 carbon atoms, 12 hydrogen atoms and 6 oxygen atoms as the chemical formula implies.

Fructose (found in grapes) is also a simple sugar. Interestingly, **sucrose** – the chemical name for the “sugar” you buy from the supermarket - is *not* a simple sugar. Each sucrose molecule is made of a glucose and a fructose molecule joined together (see figure 4.3 on page 38 of the textbook).

Starch and **glycogen** molecules are both made of large numbers of glucose molecules joined end to end (see again figure 4.3), so they are sometimes called “complex carbohydrates". These large molecules are insoluble in water, so they are the forms in which organisms store their glucose for later use.

Sources

We get our supplies of carbohydrate mainly from plant foods:

- Rice, wheat, potatoes and other staple foods contain a lot of starch, as do the bread, chips, crisps breakfast cereals and so on which are made from them;

- Sucrose (ordinary sugar) comes mainly from sugar beet and sugar cane, and is added to many foods to make them sweet.

Uses

Carbohydrates are mainly used in the body to provide **energy**, which is released during **respiration**. The body cannot store much glucose, as it is a soluble and reactive chemical which easily interferes with the rest of the body's chemical reactions. For this reason, spare glucose is converted into glycogen and stored in the muscle and liver cells. Glycogen can rapidly be broken back down to glucose when more of it is needed for respiration:

GLUCOSE	---------->	GLYCOGEN
used in respiration	<----------	stored in liver and muscles

Once the liver and muscles are filled up with glycogen, any more spare glucose is converted into lipid (fat) and stored under the skin.

Tests

We met the chemical test for starch in Lesson 5: starch turns iodine solution from yellow / brown to blue / black. The chemical test for glucose is more complicated and is carried out as follows:

1. Dissolve the material you want to test for the presence of glucose in water.

2. Add some Benedict's solution, which is a clear blue liquid.

3. Heat until almost boiling.

4. If glucose is present (a) the liquid goes cloudy, because an insoluble chemical is formed (chemists call this cloudiness a **precipitate**); (b) the colour changes to **brick red** (or green or yellow if only a little glucose is present).

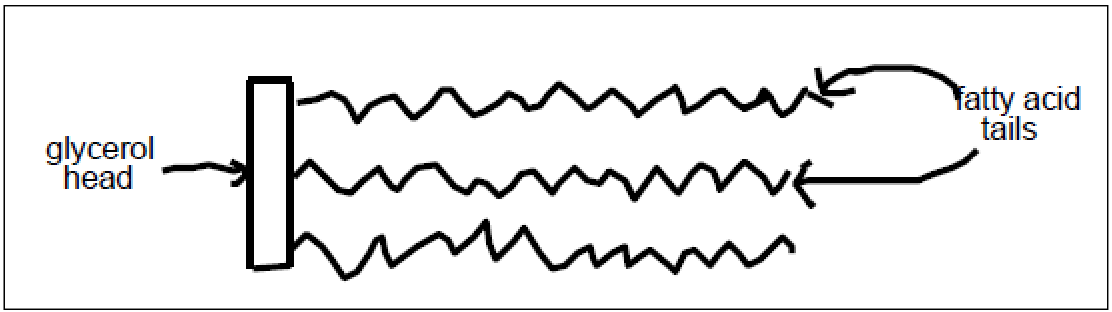
Fructose will give a positive result with the same test: sugars which will do this are called **reducing sugars**. However sucrose does not give a positive result: the liquid stays clear and blue.

Lipids

Structure

Lipids is the general name for the compounds which, in everyday life, are called fats and oils. A "fat" is a lipid which is solid and room temperature, whereas one which is liquid at room temperature is called an "oil".

Like carbohydrates, lipids usually only contain the elements carbon, hydrogen and oxygen, but the atoms are arranged differently which gives the compounds different properties. A lipid molecule is made of one **glycerol** molecule joined to three **fatty acid** molecules, and is shaped rather like this:



A lipid molecule

Activity 3

In the kitchen add a teaspoon of sugar (sucrose) and a teaspoon of cooking oil to two different glasses of water and stir. What do you see? Can you work out a major difference between sugars and lipids?

Sources

We get our supplies of lipids from both plant and animal sources:

- Butter, most cheeses, eggs, oily fish and red meat are rich in lipids from animals
- Margarine, sunflower oil and olive oil are almost pure lipids from plants

Uses

Lipids have more than one use in our bodies:

- Like carbohydrates, they can be used in respiration to provide energy. However the reactions involved are slower, so they form our long-term energy store which is the fat layer under the skin. (The short-term energy store is the glycogen in liver and muscles.) This fat layer, called **adipose tissue**, doubles up as an insulating layer to keep us warm and to protect our delicate organs from damage when we are bumped.
- Special lipids called **phospholipids**, which also contain the element phosphorus, are an essential component of cell membranes. Because we are unable to make the fatty acids they contain (called **essential fatty acids**), it is not possible to replace all of the lipids in the human diet with carbohydrate.

  Children fed a diet short in essential fatty acids (a common occurrence in developing countries) are unable to make enough brain tissue, because this contains a lot of cell membranes. They have lower intelligence in later life as a consequence.

Proteins

Structure

Each protein molecule consists of a large number of smaller **amino acid** molecules joined end to end in a chain. There are about 20 different sorts of amino acid molecule. The exact ones used in a protein molecule, and the order or sequence in which they occur, decides the properties of the protein. Each protein molecule has its own unique **amino acid sequence**, properties and use in the body.

All amino acids (and therefore all proteins) contain the elements carbon, hydrogen oxygen and nitrogen. One amino acid also contains sulphur, so proteins may also contain a variable amount of sulphur.

Sources

It is not strictly true that we need proteins in our diet. What we actually need is an adequate supply of *each of the 20 amino acids* required to make our body proteins. We are able to make some of these from other amino acids, but 10 – called the **essential amino acids** – must be eaten.

Of course we usually get our amino acids by eating proteins. But there is a catch: not all protein foods contain the proportion of each of the 10 essential amino acids that we need. On the whole, proteins from animals have an amino acid balance closer to our needs than proteins from plants. So a vegetarian or vegan will need to eat more protein than other people to get a sufficient supply of the scarcest essential amino acid.

Good sources of protein include:

- Meat, fish, eggs, milk and cheese from animals
- Peas, beans and nuts from plants

Uses

Once we have obtained our amino acids from food, they are assembled to form the wide variety of proteins that make up our bodies. Proteins have many functions including:

- **enzymes**, **antibodies** that defend against disease, and **haemoglobin** which carries oxygen in the blood

- a wide variety of **structural proteins** which form the structure of the body. Every cell membrane contains some structural protein, for example, and hair and finger nails are largely made of a structural protein called **keratin**

Because so much of the body contains protein, protein is needed in general for:

- **growth**: making new cells as you get bigger

- **repair**: mending parts of the body that are damaged or worn out

Lack of protein in the diet causes a deficiency disease called kwashiorkor. This retards growth in children, because there are insufficient amino acids for making new tissue (see figure 4.6 on page 40 of the textbook).

Vitamins

There are a number of chemicals which our bodies need, but which we are unable to make for ourselves from carbohydrates, lipids and proteins. Small amounts of each of these chemicals must be eaten as part of the diet, and they are called **vitamins**. You need to know about three vitamins, called A, C and D.

- **Vitamin A** is needed to make the light-sensitive pigment in receptors called **rods** in the retina of the eye. These rods enable us to see in dim light. Lack of this vitamin in the diet causes **night blindness**, because the rods stop working.

  Butter, margarine, fish liver oils, and carrots are good sources of vitamin A.

- **Vitamin C** is needed for the construction of the **connective tissue** which binds cells together in the body. Lack of it in the diet causes a **deficiency disease** called **scurvy**: wounds heal slowly, the gums bleed, and the teeth fall out.

Fresh fruit and vegetables, for example oranges and blackcurrants, are good sources of Vitamin C. Scurvy used to be common among sailors, who spent many months at sea without access to such foods before the invention of fridges and freezers.

- **Vitamin D** is needed to help the small intestine absorb **calcium** from food into the bloodstream. Because calcium is needed to construct teeth and make bones strong, lack of vitamin D causes trouble with teeth and bones. In children whose bones are growing it causes a deficiency disease called **rickets**, where the bones are soft and the leg bones bend. In pregnant women it leads to **tooth decay**, as the calcium in the teeth is dissolved away to grow new bones in the foetus.

  Butter, margarine and fish liver oils (but not carrots) are good sources of vitamin D as well as vitamin A. In addition it is made in the skin of fair-skinned people when sunlight shines on it.

Activity 4

Time for more research in the kitchen! What foods can you find there that contain Vitamin A, C or D?

Log on to Twig and look at the film titled: **Life Cycle Nutrition**

www.ool.co.uk/1630jx

From newborn babies to the elderly, changes to our diet at are vital as our age progresses. Find out how different nutrients help our bodies function at different stages in life.

Activity 5

Extension

You can investigate the fascinating detective story of the discovery of the various vitamins at the website of the Nobel Prize:

http://nobelprize.org/nobel_prizes/medicine/articles/carpenter/index.html

Mineral Ions

As well as the vitamins, we also need to eat a number of chemical elements which are built into structures in the body. These elements are taken in as ions, so they are called **mineral ions**. You need to know about two:

- **Calcium** is needed to build teeth and bones. Bones are a mixture of protein (which makes them flexible rather than brittle) and calcium phosphate (which makes them hard rather than bendy). Calcium is needed to make more calcium phosphate, particularly when the bones are growing during childhood.

  Our food is rarely short of calcium as such, because most plant foods contain a lot. But calcium which is soluble in water, and can therefore be absorbed into the blood in the small intestine, is rarer. By far the best source is milk, or milk products such as cheese. As we saw above, vitamin D is needed to absorb even this calcium effectively.

- **Iron** is needed to make the red protein called **haemoglobin** which carries oxygen in the blood. Each haemoglobin molecule contains four iron atoms as an essential part of its structure. Lack of iron in the diet causes the deficiency disease **anaemia**. An anaemic person does not have enough haemoglobin, so carries less oxygen in their blood than normal. They are tired and may look pale. Women are more likely to become anaemic than men because of the regular loss of blood during menstruation.

Animal foods such as red meat, eggs and liver, and plant foods such as spinach are good sources of iron.

Log on to Twig and look at the film titled: **Malnutrition**

www.ool.co.uk/1631mw

Malnutrition is the biggest risk to health worldwide. It has become a common problem in the developing world. What is it and how does it develop?

Also look at the film titled: **Vitamin Deficiencies**

www.ool.co.uk/1632ft

How an investigation into a skin disease in the American Deep South revealed the true value of a healthy diet - and what happens when you don't consume enough vitamins.

Activity 6

Use what you have learned to suggest reasons for the following:

(a) Rickets was common among children living in central Glasgow during the 19th century.

(b) British sailors used to be force-fed lime juice on a daily basis (this is the origin of the American name “Limies” for the British).

(c) Anaemic people feel tired, and may look pale.

Water and Dietary Fibre

These two components of a balanced diet are not used as raw materials like the other nutrients. They are, nevertheless, essential for health:

- It is obvious that **water** is needed; it is less obvious exactly why. The key point is that *all of the chemical reactions of life take place in solution in water.* So if there is not enough water the reactions stop and we die. A good supply of water is also needed to maintain many of the structures found in cells, and for the transport (blood) system.

  It is also obvious that we can get water by drinking water! But there are three other ways we get water as well. (1) From other drinks: all the liquids we drink are based on water, including milk and alcoholic drinks. (2) All solid foods contain some water as well as other materials. (3) Some water is actually *made* during respiration: indeed animals like flour beetles can survive solely on this source of water!

- **Dietary fibre**, also called **roughage**, is needed to keep the colon (the main part of the large intestine) healthy.

  Our main source of fibre is the cell walls of plant cells, which are largely made of the material **cellulose**. Crunchy vegetables like celery, and "high fibre" cereals like bran, are a particularly good source.

  Cellulose is a complex carbohydrate made from glucose molecules, as are starch and glycogen. We do not have right enzymes to digest it, however, so unlike them it passes through our digestive systems and out in the faeces. Some bacteria and single-celled animals do have the right enzymes to digest cellulose, so they can make use of the glucose it contains.

Log on to Twig and look at the film titled: **Balanced Diet**

www.ool.co.uk/1629nc

Discover which foods are vital for a healthy diet. What should you be eating, how much, and why?

The Stages by which Food is Processed

As we said in the Introduction, processing food and extracting nutrients from it is the job of the digestive system, also called the gut or alimentary canal.

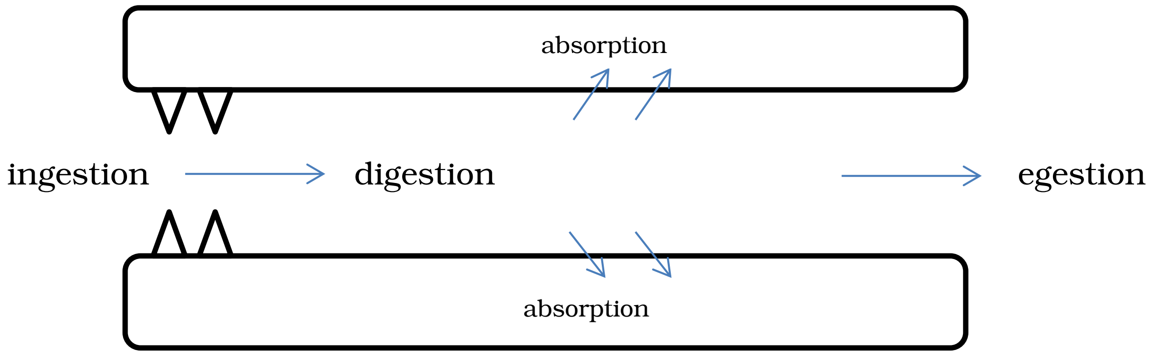
Log on to Twig and look at the film titled: **Intro to Digestion**

www.ool.co.uk/1014fb

A journey through the digestive system, from the moment food enters your mouth, through your stomach and intestines, until it leaves your body as waste.

The food enters at the **mouth**, in a process biologists call **ingestion**. The large lumps are broken up by the teeth, and the food is swallowed. In the mouth, stomach and small intestine the large, insoluble molecules of protein, starch and lipids and broken up into smaller, soluble molecules. This is what biologists mean by **digestion**. Then the small, soluble molecules are **absorbed** across the wall of the small intestine into the bloodstream. They are used by the body, which biologists call **assimilation**. Finally, the waste that cannot be digested or absorbed exits through the **anus** as **faeces**, in a process called **egestion**.

The Digestive System



We shall now follow the food through in its journey from the mouth to the anus. It is best to have page 47 of the textbook open so you can follow the journey of the food on a diagram.

Mouth

In the mouth, the food is chewed using the **teeth** and mixed with **saliva** made by the **salivary glands**.

Chewing breaks the food up into smaller lumps. This:

- makes it easier to swallow, and
- allows the enzymes which are added to the food to get at all of it – otherwise they could not reach the food at the centre of the large lumps.

The saliva:

- lubricates the food (makes it slippery) so that it will slide down the gut more easily;
- contains the enzyme **amylase** which starts the digestion of starch (although this is only completed much later);
- is slightly alkaline, which helps neutralize acids which otherwise cause tooth decay.

Get it right! Breaking food up into smaller lumps does not change the molecules inside it. You will sometimes see the breaking up of lumps called "mechanical digestion" and the breaking up of molecules "chemical digestion".

Oesophagus

Once swallowed, the food passes down a tube called the *oesophagus* (or "gullet"), which carries it through the chest and down into the **stomach**. A flap covers the entrance to the **trachea** (the air tube leading to the lungs) when you swallow, so that the food does not "go down the wrong way".

The food is moved along the oesophagus, and the rest of the gut, by **peristalsis**. See the diagram of this on page 46 of *Edexcel IGCSE Biology*. The tube is surrounded by layers of both **circular muscle** (in a ring around it) and **longitudinal muscle** (in strands along it).

- When the circular muscle **contracts** (gets shorter) it squeezes the tube narrower. This forces the food along, like forcing toothpaste along a toothpaste tube by squeezing it.
- The longitudinal muscle then contracts to pull the tube wide open again ready for the next piece of food.

Stomach

Log on to Twig and look at the film titled: **Stomach**

www.ool.co.uk/1015cp

A close examination of the mechanical and chemical digestive processes that break down food in the stomach.

In the stomach the food is mixed with a liquid called **gastric juice** produced by the cells which line the stomach cavity. This juice contains:

- a strong acid called **hydrochloric acid**. This kills many of the pathogenic (disease-causing) bacteria in the food which would otherwise cause food poisoning.

- A **protease** enzyme which starts the digestion of protein. Because of the hydrochloric acid, this enzyme is adapted to work best under acidic conditions at about pH 2.

The muscular stomach wall churns up the food to mix it well with the gastric juice, and to complete the break up of lumps begun by the teeth. It then squirts the food, little by little, into the next part of the gut.

Get it right! It is not true that all digestion happens in the stomach. In fact the stomach only begins the digestion of protein. Most digestion occurs later, in the small intestine.

Small Intestine: Digestion

In the **small intestine** (the first loop of which is called the **duodenum** and the rest the **ileum**) digestion is completed, then the nutrients are absorbed across the gut wall into the bloodstream. The small intestine is the place where most of the action goes on!

Log on to Twig and look at the film titled: **Small Intestine**

www.ool.co.uk/1017ta

Continuing the journey of food as it travels through your digestive system and into the small intestine.

Digestion in the small intestine is accomplished by three separate digestive juices:

- **pancreatic juice** is produced by the **pancreas** and enters the duodenum via a tube called the pancreatic duct. As well as being alkaline, to partly neutralize the acid in the food added by the stomach, it contains three different enzymes:

- more **amylase**, which continues the digestion of starch, begun in the mouth
- another **protease** which continues the digestion of protein, begun in the stomach
- **lipase,** which digests the lipids in the food

- **bile** is produced by the **liver**, stored in the **gall bladder**, and enters the duodenum via the **bile duct**. This contains no enzymes as such. However it contains bile salts which **emulsify** the lipids in the food: it breaks them up into small droplets. This gives them a much bigger surface area for the lipases to work on, speeding up lipid digestion. It is also alkaline, to help the pancreatic juice neutralize stomach acid.
- **Intestinal juice** is produced by the lining of the small intestine itself. It contains two enzymes:
  - **maltase,** which completes the digestion of starch
  - more **proteases** which complete the digestion of protein

See figure 4.17 on page 47 of *Edexcel IGCSE Biology* for the connections between the liver, pancreas and duodenum.

More about Digestion

Now that the digestion of the food is complete, it is time to consider the process as a whole. The detail is confusing, involving many enzymes, produced and working in many different places! However, these are the main steps, with the enzymes written in italics:

starch $\xrightarrow{\textit{amylase}}$ maltose $\xrightarrow{\textit{maltase}}$ glucose

protein $\xrightarrow{\textit{proteases}}$ amino acids

$$\text{lipids} \xrightarrow{\textit{lipase}} \text{glycerol + fatty acids}$$

Notice that the three sorts of large molecule – starch, protein and lipids – are broken up into the small molecules from which they are made, as we discussed earlier in the lesson. It is these small molecules – glucose, amino acids, glycerol and fatty acids - which are now absorbed in the small intestine and assimilated.

N.B. Enzymes involved in the breakdown of starch (amylase and maltase) are called **carbohydrases**. Notice that most enzyme names end in –ase: if you meet a chemical with an ending like this, it is probably an enzyme!

Activity 7

Use the information above to complete this table:

Enzyme	*Place(s) produced*	*Place(s) acts on food*	*Wh t it does*
amylase			
lipase			
maltase			
protease			

Small Intestine – Absorption

Absorption is the name given to the nutrients escaping from the space in the middle of the small intestine, called the

lumen, into the blood stream. It takes place in the ileum, the longer second section of the small intestine.

To make absorption efficient, the ileum has a very large **surface area**. This is achieved in three ways:

- it is long – several metres long in an adult human being
- its surface is covered with thousands of finger-like projections called **villi.** See the pictures of these at the bottom of page 49 of *Edexcel IGCSE Biology*.
- the surface of each **villus** is covered with minute projections called **microvilli**, as shown on page 50 of *Edexcel IGCSE Biology*.

This makes the surface area of the adult ileum about the size of a tennis court! As a consequence, few nutrients escape absorption to be lost in the faeces.

Each villus is a complex structure, as shown on page 50:

- It has a **network** of **blood capillaries** running under its surface cells. Once absorbed the glucose and amino acids pass into these and are swept away in the blood.
- It also has a **lacteal** running down the middle. The products of lipid digestion end up in here, instead of in the blood. Each lacteal drains into a second transport system in the body called the **lymphatic system** which eventually empties the lipids into the bloodstream elsewhere.

The blood in the blood capillaries is unusually rich in nutrients, having just received them from the digested food. So the capillaries join together to form a large blood vessel flowing to the **liver** called the **hepatic portal vein**. The liver processes this blood, removing the extra nutrients from it, so it is safe to release around the rest of the body.

Large Intestine

Return now to the diagram on page 47 of *Edexcel IGCSE Biology*. The ileum is the narrow, folded tube in the middle of the abdomen. The ileum ends near the appendix at the bottom left of the picture and empties into the **large intestine**. The main part of this, the **colon**, runs up the left, across the top and down the right of the picture.

Log on to Twig and look at the film titled: **Large Intestine**

www.ool.co.uk/1018fw

The final chapter in the journey of food through our digestive system: how bacteria transforms undigested matter into waste.

The job of the colon is to absorb water back into the blood so it is not lost in the faeces. When it does not do this job properly you get diarrhoea!

By this stage, much of the bulk has been lost from the food, because the starch, protein and fat have been digested and absorbed. This is where the dietary fibre in food comes into its own. It gives the remaining waste bulk, which stretches the colon wall. This encourages the circular muscles to contract, keeping the waste moving through the tube fairly briskly.

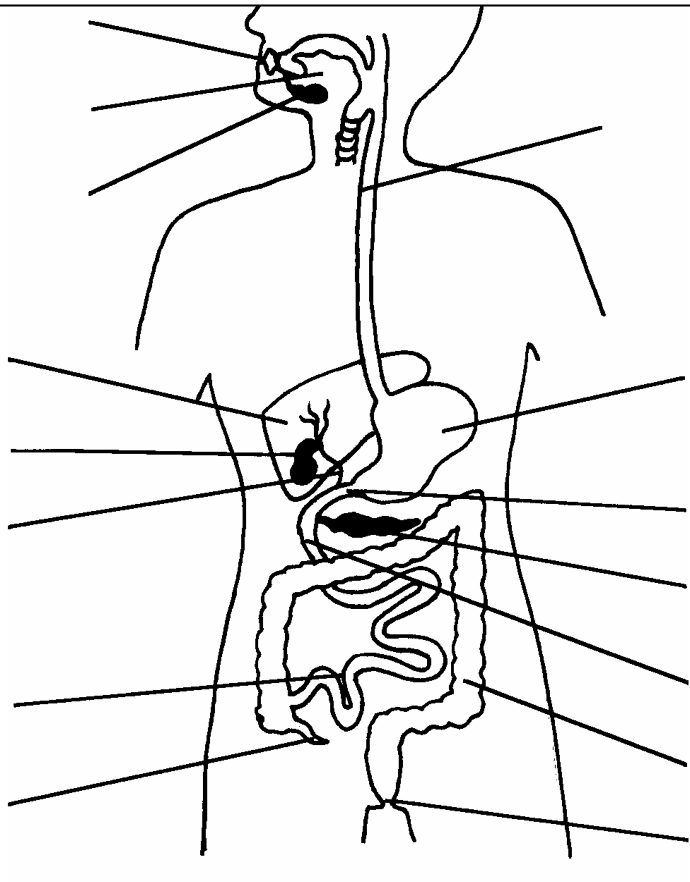
Rectum and Anus

The **rectum** is the small, last section of the large intestine. The faeces collect here before being expelled periodically (the polite names for which are **defaecation** or **egestion**!).

The **anus** is the end of the gut. Its circular muscle is strongly developed to form a **sphincter**, which, as it contracts, shuts the tube completely. It relaxes during defaecation so the anus can open and the faeces can escape.

Activity 8

Fill in as many of these labels as possible. Work first from memory, and then with the help of the textbook, before checking with the answers at the end of the lesson.



Get it right! The small intestine is so called because, although it is long, it has a small diameter. The large intestine is shorter, but it has a larger diameter.

The large intestine is not involved with digestion, or the absorption of nutrients, but only with reabsorbing water.

*Variations in Diet

A **balanced diet** is one that contains the right amount of each of the nutrients listed at the beginning of this lesson. It is needed for the person to remain in full health. **Malnutrition** occurs when there is a lack of, or far too much of, one or more nutrients in the diet.

However, although every human being needs to eat a balanced diet, the *amount* of each nutrient needed varies with a person's age, sex, occupation, and a variety of other circumstances.

The amount of *energy* needed depends upon the following:

- *Age*: during childhood, the amount of energy required increases as the child gets bigger. Also, children need more energy than adults of the same size as they tend to be more active and use energy during growth. During old age, the energy need falls as the metabolic rate drops.

- *Activity levels*: the more active a person the more energy they need, because their muscles release more energy in respiration for movement. A person's *occupation* will therefore affect their energy needs: a manual worker is more active during the working day than an office worker.

- *Pregnancy*: rather like in childhood, extra energy is need for growth during pregnancy. In this case the energy is needed for the growth of the foetus. More may also be needed for the added work involved in moving an increased body mass around.

Most of the energy of food is contained in the carbohydrates and lipids, so a higher proportion of these is needed in the diet of a person with a higher energy need.

Now is the time to read through Chapter 4 pages 37–51 of *Edexcel IGCSE Biology*. It covers the same topics as this lesson, so will add to your understanding of the material.

Keywords

Food	**Nutrient**
***Balanced diet**	**Lipids**
Simple sugar	**Fatty acid**
Amino acid	**Mineral ion**
Glycogen	**Gut**
Digestion	**Peristalsis**
Protease	**Villus**
Alimentary canal	**Absorption**
Pancreas	**Amylase**
Emulsify	

Summary

Lesson Six: Human Nutrition

CARBOHYDRATES	-------------	starch, glycogen, sugars
LIPIDS	------------	glycerol + fatty acids
PROTEINS	------------	amino acids
VITAMINS	------------	A, C, D
MINERAL IONS	------------	iron, calcium
WATER & FIBRE	-----------	colon
MOUTH `	--------------	teeth, amylase, saliva
STOMACH	--------------	acid, protease
SMALL INTESTINE	-------------	digestion, absorption
LARGE INTESTINE	--------------	water

What you need to know

- the element content and structure of carbohydrates, lipids and proteins

- the sources, uses and deficiency diseases associated with each group of nutrients
- the structure and tests for: glucose and starch
- the parts of the digestive system and the functions of each
- where, and by which enzymes, starch, protein and lipids are digested
- how the ileum is adapted for efficient absorption

What you might be asked to do

- identify missing nutrients in a diet
- suggest reasons for the occurrence of deficiency diseases
- label a diagram of the digestive system, and say what happens in each part of it
- describe where the activities of digestion and absorption take place

Suggested Answers to Activities

Activity 3

After a while, the water with the sugar stirred in should go clear. This is because sugars are **soluble** in water. A **solution**, like the sugar solution here, looks clear. Taste the solution to verify that the sugar really is in there! However long you wait, the sugar will not separate out again.

The water with the oil stirred in may go cloudy, and on standing the oil will separate out as a layer floating on top of the water. This is because lipids are **insoluble** in water. The cloudiness is caused by small oil droplets suspended in the water. These droplets are much bigger than individual molecules, so they scatter the light causing the cloudiness.

Activity 6

(a) These children ate a poor diet, lacking in vitamin D. Smoke from coal fires blocked out most of the sunlight, making them unable to make vitamin D in their skins. (Glasgow is also cold, so there was not much exposed skin about!)

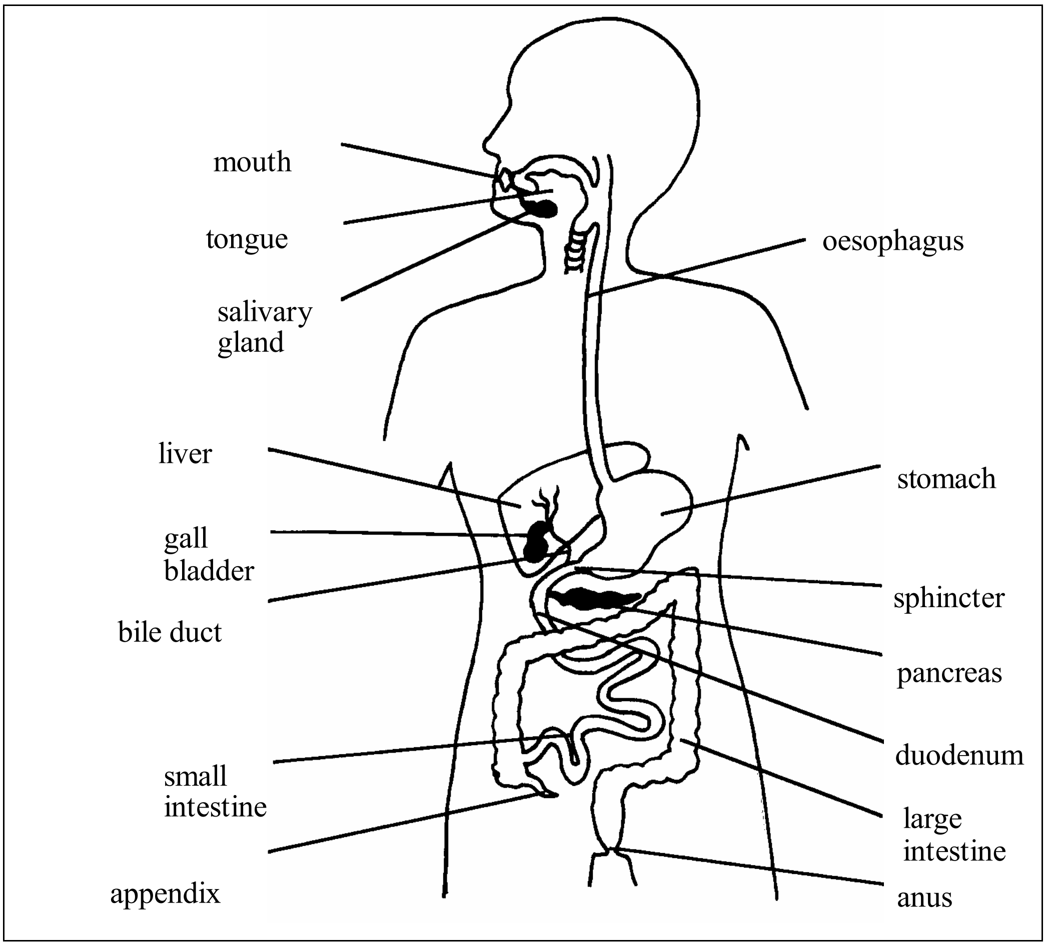
(b) The lime juice contained Vitamin C. They were given it to ward off scurvy on long sea journeys without access to fresh fruit and vegetables.

(c) Less oxygen for respiration, which releases energy. Red haemoglobin, in the blood just under the skin surface, stops the skin looking too pale (in a white-skinned person).

Activity 7

Enzyme	Place(s) produced	Place(s) acts on food	What it does
amylase	salivary glands and pancreas	mouth and small intestine	starch → maltose
lipase	pancreas	small intestine	lipid → glycerol and fatty acids
maltase	small intestine lining	small intestine	maltose → glucose
protease	Stomach lining, pancreas and small intestine lining	Stomach and small intestine	proteins → amino acids

Activity 8



Note the presence of another "sphincter" in the gut at the end of the stomach. This keeps the food in the stomach until it is ready to move on to the next stage.

The part of the small intestine labelled is the ileum, and the part of the large intestine labelled is the colon, so these are valid alternative answers.