The science of nutrition and healthy eating

About this free course

This free course is an adapted extract from the Open University course .

This version of the content may include video, images and interactive content that may not be optimised for your device.

You can experience this free course as it was originally designed on OpenLearn, the home of free learning from The Open University –

There you'll also be able to track your progress via your activity record, which you can use to demonstrate your learning.

Contents

Introduction and guidance

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Welcome to this free course, *The science of nutrition and healthy eating*.

In this course, you'll look at the science behind nutrition, covering aspects of biology, chemistry and physics as well as gaining insight into healthier eating. Reading food labels, choosing healthier foods, hydrating appropriately and understanding how we taste food will allow you to be more informed about the choices you make for the food you eat. You'll also investigate how information about healthy eating differs around the world.

The biology part of the course will focus on the digestive system and how the body uses the elements in our food to function. It is important to understand the macro and micro nutrients in the foods we eat and how our bodies use them. Some people follow food restriction due to choice or religious observation. Malnutrition is not just a concern for developing countries – it can mean over nutrition as well as under nutrition. Sometimes certain components of food can be an enemy rather than beneficial, so special diets have to be followed.

When you've finished the course, you may even wish to consider what you eat at the moment and what changes you will make as a result of what you have learned!

The course lasts eight weeks, with approximately three hours of study each week. You can work through the course at your own pace, so if you have more time one week there is no problem with pushing on to complete another week's study.

You will be able to test your understanding of the course through the weekly interactive quizzes, of which Weeks 4 and 8 will provide you with an opportunity to earn a badge to demonstrate your new skills. You can read more on how to study the course and about badges in the next sections.

After completing this course, you will be able to:

- demonstrate and understand how food is processed and then used in the body
- apply knowledge to understand healthy eating advice and identify how ti varies in different countries
- make sense of food labels and perform basic calculations of energy in food
- describe and know about food allergies and intolerances
- describe and understand possible reasons for the current obesity epidemic.

Moving around the course

In the 'Summary' at the end of each week, you can find a link to the next week. If at any time you want to return to the start of the course, click on 'Course content'. From here you can navigate to any part of the course. Alternatively, use the week links at the top of every page of the course.

Introduction and guidance

It's also good practice, if you access a link from within a course page (including links to the quizzes), to open it in a new window or tab. That way you can easily return to where you've come from without having to use the back button on your browser.

What is a badged course?

While studying *The science of nutrition and healthy eating* you have the option to work towards gaining a digital badge.

Badged courses are a key part of The Open University's mission *to promote the educational well-being of the community*. The courses also provide another way of helping you to progress from informal to formal learning.

To complete a course you need to be able to find about 24 hours of study time, over a period of about 8 weeks. However, it is possible to study them at any time, and at a pace to suit you.

Badged courses are all available on The Open University's OpenLearn website and do not cost anything to study. They differ from Open University courses because you do not receive support from a tutor. But you do get useful feedback from the interactive quizzes.

What is a badge?

Digital badges are a new way of demonstrating online that you have gained a skill. Schools, colleges and universities are working with employers and other organisations to develop open badges that help learners gain recognition for their skills, and support employers to identify the right candidate for a job.

Badges demonstrate your work and achievement on the course. You can share your achievement with friends, family and employers, and on social media. Badges are a great motivation, helping you to reach the end of the course. Gaining a badge often boosts confidence in the skills and abilities that underpin successful study. So, completing this course should encourage you to think about taking other courses.

How to get a badge

Getting a badge is straightforward! Here's what you have to do:

- read each week of the course
- score 50% or more in the two badge quizzes in Week 4 and Week 8.

For all the quizzes, you can have three attempts at most of the questions (for true or false type questions you usually only get one attempt). If you get the answer right first time you will get more marks than for a correct answer the second or third time. Therefore, please be aware that for the two badge quizzes it is possible to get all the questions right but not score 50% and be eligible for the badge on that attempt. If one of your answers is incorrect you will often receive helpful feedback and suggestions about how to work out the correct answer.

For the badge quizzes, if you're not successful in getting 50% the first time, after 24 hours you can attempt the whole quiz, and come back as many times as you like.

We hope that as many people as possible will gain an Open University badge – so you should see getting a badge as an opportunity to reflect on what you have learned rather than as a test.

If you need more guidance on getting a badge and what you can do with it, take a look at the OpenLearn FAQs. When you gain your badge you will receive an email to notify you and you will be able to view and manage all your badges in My OpenLearn within 24 hours of completing the criteria to gain a badge.

Get started with Week 1.

Week 1: The basics of food

Introduction

Welcome to the first week of the course!

Over the next eight weeks, you will learn about the components of food and how your digestive system uses them inside your body. You will also look at food labels and how to interpret the information on them. The course ends with a closer look at balanced diets and nutrition globally.

In the following video, Audrey Brown of The Open University finds out how some of the members of staff at the University choose when to have lunch.

Video content is not available in this format.

After this week's study, you should be able to understand:

- why we eat and the factors that affect hunger
- the different macronutrients and their function in the human body
- the different micronutrients and their function in the human body.

Before you start, The Open University would really appreciate a few minutes of your time to tell us about yourself and your expectations of the course. Your input will help to further improve the online learning experience. If you'd like to help, and if you haven't done so already, please fill in this optional survey.

1 Why do we eat?

Now that you have heard about how other people decide when to eat, you can start thinking about your own motivation for eating.

Activity 1 What motivates you to eat?

Allow approximately 10 minutes.

Think back to the last thing you ate.

- What was it and what was your motivation for eating it?
- How does your motivation for eating compare with those you heard in the video in the Introduction?
- Who did you eat with?
- Where did you eat?

Write two or three sentences in the box below. Click ‘Save’ when you are satisfied with what you have written.

Provide your answer...

1.1 What are the reasons for eating?

Food provides the energy that our bodies need to keep going. Without food, a person would typically survive for a few weeks. Without water, they could only live for a few days.

In developed countries, most people have access to enough food that they would not consider ‘to stay alive’ as one of their reasons for eating. However, in parts of the world where food is scarce, this may be the main motivation for eating.

In Activity 1 you might have written that you ate because you were hungry. Apart from hunger, there are several other reasons why people eat. Consider the following reasons.

- Habit. When food is readily available, people could eat at any time of the day or night. But most people have a routine of ‘meal times’ with snacks in between. Many of us have three meals a day. It is easy to think this is what we ‘should’ have and we find it unsettling if circumstances prevent us from eating one of those meals. Yet elsewhere in the world, particularly in poorer societies, people may eat only one or two meals a day. Typically in a main meal, people have a selection of items providing a range of nutrients, which helps towards a balanced diet. However, having several different types of food available at a meal can lead to a higher intake. You have probably experienced the feeling of ‘fullness’ after eating a large main course and yet, somehow, there is still room for a tempting dessert.
- Social. This is linked to habit. We eat because other people are eating at the same time and we use the time to chat with them. We may also use food to please others, preparing meals for them and eating with them.

- Sensory appeal. The preparation of food can produce very tempting smells. For example, supermarkets often position their bakery so that the smell of baking bread wafts into the store, rather than being removed by extractor fans. Cookery books and food packets display tempting dishes and some menus and fast-food outlets advertise with pictures. We use herbs and spices to liven up bland-tasting foods to make them more attractive to eat. The sound of food sizzling on a grill or barbecue can tempt us to eat too. So, the stimulation of our senses of smell, sight, taste and hearing can be another reason why we eat.
- Psychological. Eating is a pleasurable activity, so another reason for eating is because we like a particular food. We may also eat because we are bored, lonely or depressed (often called 'comfort eating'). The food eaten under those circumstances is often in the form of snacks, rather than meals. Snacks can be higher in fat and sugar than a typical meal, providing more calories and fewer nutrients. This can cause people to put on excess weight if taken to extremes.

There can also be reasons why some people reduce the amount of food and fluid eaten or they may have days when they don't eat very much and then binge at other times. This can lead to an eating disorder which requires specialist support to normalise eating and rationalise their relationships with food and behaviour.

1.2 Ghrelin

People often say that they eat because they are hungry, but what makes you feel hungry?

This has puzzled physiologists (scientists who study living systems) for many years and there are still no really clear answers. More than 20 different sorts of hormones (chemical messenger molecules that travel in the blood) are produced by the cells of the digestive system (gut). But it is not clear how many of these have a role in making us feel hungry or feel full (satiated) after we have eaten. Ghrelin is one hormone that has been studied in detail since it was first identified in 1999 (Kojima et al., 1999, Kojima, 2010).

Ghrelin is often called the 'hunger hormone', although its name is derived from a different function – causing the release of growth hormone (**G**rowth **H**ormone **Rel**ease **In**ducing). It is released into the blood when the stomach is empty and travels to the brain. There, it acts on a control centre in the brain called the hypothalamus and makes you feel hungry (Figure 1).

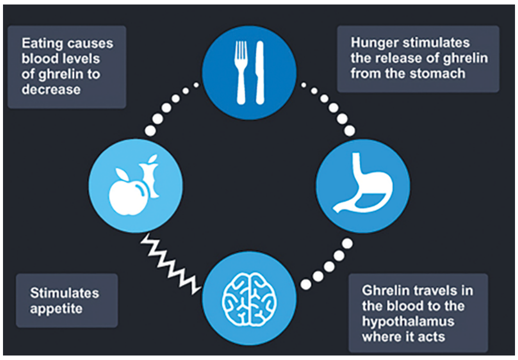

Figure 1 How the hormone ghrelin acts on the body

If you measure ghrelin levels in the blood, they are high just before a meal and then drop steeply after eating. It may be ghrelin that causes your stomach to rumble when you are hungry. When your stomach is full, ghrelin levels decrease and you feel less hungry (Figure 2).

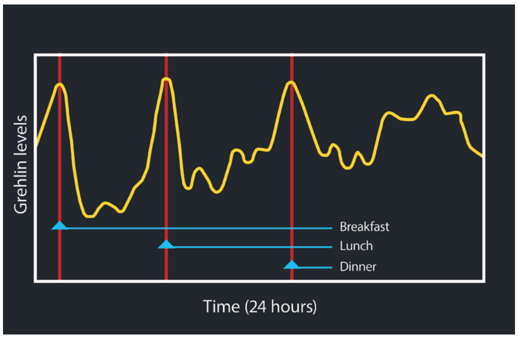

Figure 2 Fluctuation of ghrelin levels in the blood.

However, other parts of the brain can block the effects of ghrelin. For example, you have probably noticed that when you are busy, you don't even think about being hungry.

1.3 The components of food

The reasons given for eating are many and complex. Everyone probably eats for different reasons at different times of the day and on different days. Ultimately, we need to eat to stay alive, but what do we *need* to eat?

Our bodies are made up of many tens of thousands of different chemical molecules. The food we eat needs to contain enough raw materials to produce all of these molecules while we are growing, and to repair and replace them once we become adults. Food must also give us the energy we need to live. If we take in lots more food than is needed, the excess can be converted into fat and stored.

On all manufactured food in the UK, you will find a label on the back or side of the packaging (see Figure 3). There is usually a label on the front too, which carries some slightly different information. If you have not already done so, this is a good time for you to start collecting some food labels, which will be used at various stages during the course.

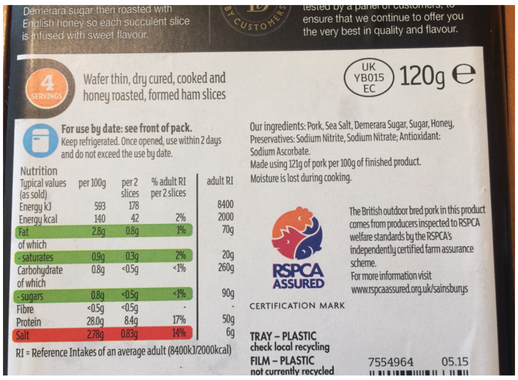

Figure 3 Nutrition information on a typical food label

For now, we will concentrate on the components of food listed in Figure 3 below 'Energy'. They are not always listed in the same order, so we will start with protein.

2 Protein

While the nutrition label lists ‘protein’ as though it is one substance, there are thousands of different proteins in our food, and thousands in our body. We need to eat protein in our food mainly so that we can make our own proteins.

Our digestive system breaks down the proteins in the food we eat into their component molecules, called amino acids. Then the amino acids join up again, using different numbers of them (from fewer than ten to several thousand) in a different – but very definite – order, to make our own proteins. Each amino acid molecule has a chemical ‘hook’ on each end, so that it can attach to any other one, to make the proteins we need, like a series of carriages on a very long train. The code that determines the sequence of amino acids (the order of the ‘carriages’) is in our DNA.

There are about 20 different amino acids. Eight of them are essential in the diet. We can make the others from those eight if necessary (see Table 1). Most people take in a sufficient amount and good mix of protein that they don’t need to worry about getting enough of the essential amino acids. People on a strict vegan diet may need to take more care to eat a mix of different plant proteins (particularly beans) to ensure that they have enough.

For adults, the *reference nutrient intake* (RNI) is 0.75 g of protein per kilogram of body weight per day. For an average man weighing 83kg, his protein needs are 62g per day. For an average woman weighing 70kg, her protein needs are 53g. However, an average western diet contains much more protein than that.

Table 1 Essential and non-essential amino acids (with their three-letter abbreviations)

Essential amino acids	Amino acids synthesised from essential amino acids	Non-essential amino acids
lysine (Lys)	tyrosine (Tyr) *	glycine (Gly)
methionine (Met)	cysteine (Cys) +	alanine (Ala)
threonine (Thr)	histidine (His) – made only in very small amounts in the body	serine (Ser)
leucine (Leu)	arginine (Arg) – essential for young children	proline (Pro)
isoleucine (Ile)		glutamate (Glu)
valine (Val)		glutamine (Gln)
phenylalanine (Phe)		asparate (Asp)
tryptophan (Try)		asparagine (Asn)

Proteins are an essential component of our muscles and other structures in our body, such as hair, nails and tendons. As well as these structural proteins, there are proteins in our blood that function as hormones. Others form part of our immune system, which protects us against infection. The proteins in the food we eat are digested by enzymes which are also proteins.

The excess amino acids in our diet cannot be stored for long in the body, if they are not needed for building new proteins. They are taken in the bloodstream to the liver, where they are broken down. The part of the amino acid containing the nitrogen is converted into urea. This circulates in the blood to the kidneys, which provide an amazing biological filtering system. They filter out the urea and send it down tubes to the bladder, along with other substances the body does not need, and excess water, forming urine. So, when you urinate, you are getting rid of surplus amino acids.

2.1 Protein sequencing

For many years, finding out the order of amino acids in a protein – called *protein sequencing* – was a major goal of biologists.

The first one to be completed was insulin. This is a hormone secreted by the pancreas and involved in regulating glucose in the blood. Glucose is a sugar that the body uses for energy. Insulin is the hormone that is not produced in people with Type 1 diabetes and does not function as it should in people with Type 2 diabetes.

Although insulin is composed of only 51 amino acids, it still took almost six years for a group of research scientists in Cambridge to complete the task. The group was headed by Frederick Sanger, who was awarded the Nobel Prize for his work in 1958. Insulin turned out to be composed of two linked chains of amino acids, as shown in Figure 4. Each amino acid is identified by a three-letter abbreviation of its name.

Since then, protein sequencing has been automated. As a result, the time for the process can now be measured in hours, rather than years.

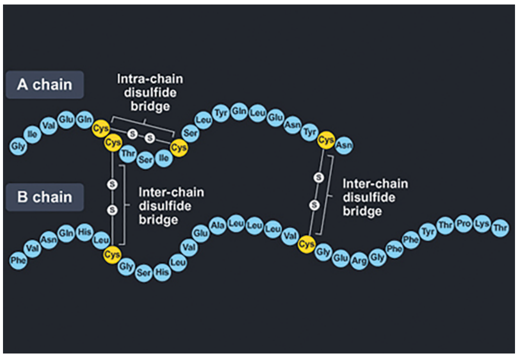

Figure 4 Linked chains of amino acids in insulin

2.2 Phenylketonuria

One of the common amino acids in our diet is phenylalanine (pronounced fee – nile – alla – neen). Its abbreviation is Phe. Have a look at the structure of the insulin protein in Figure 5 and see how often phenylalanine occurs in it.

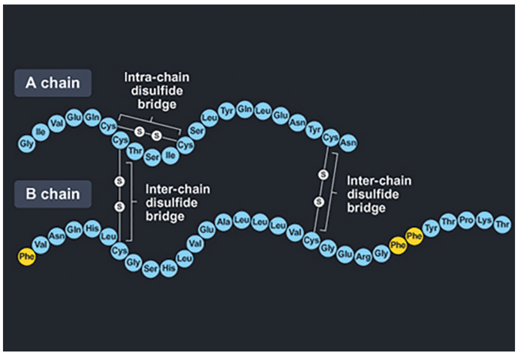

Figure 5 Position of phenylalanine amino acids in insulin

Phenylalanine is found in many high-protein foods such as meat, fish, eggs, cheese and milk. However, there is a rare genetic defect – phenylketonuria (PKU) – present from birth, which makes some people unable to break down this amino acid. In people with PKU, the extra phenylalanine they take in, which is not needed to make their own proteins, builds up in their blood and other tissues. There is more information about PKU on the website of The National Society for Phenylketonuria:

If undetected, PKU damages the brain and nervous system. This can lead to learning disabilities and other problems, probably requiring lifelong care. However, if the PKU is detected early enough, the person can be put on a low-protein diet with amino acid supplements without phenylalanine. This ensures that there is enough of the other amino acids and they should then remain perfectly well.

'Early enough' means very early in life! All babies in the UK and most other developed countries are routinely screened for phenylalanine level by the heel prick test. This is done within the first week of a baby's life. Other rare but serious conditions are also tested for, using the same drop of blood.

If PKU is detected, the baby will be put on a special low-protein formula milk with supplementary amino acids. The child will need to continue on a low-protein diet. As an adult, they may be able to resume a normal or near-normal diet. If not, they may need to maintain a low-protein diet throughout their life.

2.3 Protein in foods

In the next activity you can test your knowledge about protein.

Activity 2 Protein content

Allow approximately 10 minutes.

When you go to the activity, you will see eight foods that contain protein. Can you work out which has the most protein?

Arrange the foods in order from that containing the most protein at the top, to the least protein at the bottom. To move a food option, click on it and drag it to a new position. There is no limit to the number of moves you can make. As soon as you move the boxes into the correct order, a message will appear.

After eight moves, you will be asked whether you want some assistance. This will add green ticks next to those that are in the correct position and red crosses next to those that are not.

Interactive content is not available in this format.

Answer

The correct order is as follows:

1. chicken breast
2. grilled lean beef steak
3. cheddar cheese
4. grilled salmon
5. almonds
6. egg (hen's)
7. bread
8. kidney beans

You may be surprised to find that eggs, which are often considered to be a good source of protein come a long way down the list.

An egg contains only 12% protein compared with over 30% in chicken and steak. That is because they eggs contain a lot more water than meat, which is also why the inside of a raw egg is quite runny. When an egg is hard-boiled, although it appears dry, it has not lost any of the water. In the uncooked egg, the microscopic protein molecules (made up of chains of amino acids) are curled up into neat balls. The water molecules lie between them, allowing them to roll over one another, so that the egg is runny.

When the egg is cooked, the heat causes the neat little balls to unravel and the protein molecules then form bridges across from one to another, similar to the ones shown between the two chains of insulin in Protein sequencing. This makes the egg solid. The water molecules are still present, but trapped in the network of protein molecules.

3 Fats and oils

The obvious characteristics used to recognise fats and oils are that they have a slippery feel and do not dissolve in water.

We tend to use the term ‘fat’ to refer to those that are solid or semi-solid at room temperature (such as butter or lard). We use the word ‘oil’ for those that are liquid at room temperature. However, the word ‘fat’ on a food label refers to both.

Molecules of the common fats in our diet, including oils, have a similar structure. They consist of a ‘head’ of glycerol with three fatty acid ‘tails’ joined to it (Figure 6). Of course, they are far too small to see. Each one is a few millionths of a millimetre long.

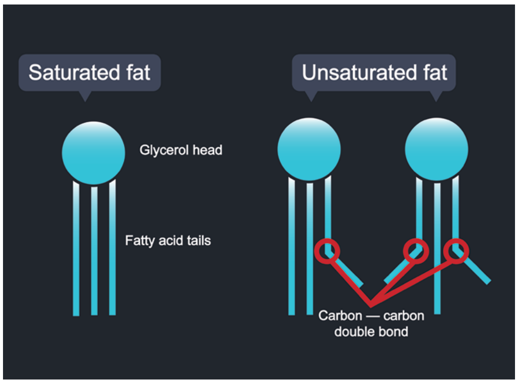

Figure 6 Diagrammatic representation of fat molecules with ‘heads’ and ‘tails’

These fat molecules are technically called triacylglycerols – three tails (triacyl-) attached to a glycerol head. How solid a fat is depends on the fatty acid tails. Solid fats generally have straight tails. These are called saturated fats. The straight tails mean that the molecules can lie very neatly up against one another. There is also an attraction between the straight tails that keeps nearby fat molecules together. Fats composed of closely packed molecules like this tend to be solid at room temperature (for example, butter and lard).

If the tails are bent, the molecules end up jumbled. These are called unsaturated fats. Monounsaturated fats have tails with one bend in them. Polyunsaturated fats have two or more bends. When the molecules are not packed neatly, because of their bent tails, the fat tends to be a liquid at room temperature (for example, olive and rapeseed oil).

Both fats and oils are common in our diet. From animals, we get lard, butter and fat on meats such as steak, pork chops and bacon. From plants, we get olive oil, walnut oil, sunflower oil, and so on. You have probably noticed that fats from animals are generally solid, saturated fats (with straight tails) and ones from plants are generally unsaturated, liquid oils (with bent tails).

3.1 Saturated fats

The medical advice is that eating a diet high in saturated fat can raise the level of cholesterol in the blood. However, further research (Press Association, 2015) suggests there may not be such a clear link. One of the risk factors for coronary heart disease (CHD) is an inappropriate ratio of different types of fat in the blood, including the three sorts of cholesterol; Triglycerides (TG), High Density Lipids (HDL) and Low Density Lipids (LDL) .

Do you know your cholesterol number? Heart UK – the cholesterol charity – says it is important to know it. If you are between 40 and 75 years old, you should have your cholesterol tested every five years (yearly if you have raised cholesterol). A simple venous blood sample (from your arm, not your finger) will give you the number for all types of cholesterol.

Table 2 shows the normal range for adults and what the different lipid fractions mean.

Table 2 Lipid fractions and the ideal amount

Type of fat	Ideal amount	Comments
Total cholesterol (TC)	5 mmol/L or less	Higher levels do not necessarily require treatment, as other factors must also be taken into account.
Non-HDL cholesterol	4 mmol/L or less	HDL is ’good’ cholesterol, so this number relates to ‘bad’ cholesterol.
LDL-C	3 mmol/L or less	This is ‘bad’ cholesterol.
HDL-C	Over 1 mmol/L for men and 1.2 mmol/L for women	This is ‘good’ cholesterol which clears fat from blood.
TC:HDL ratio	Above 6 mmol/L is high risk	Ideally, this should be less than 6.
TG (triglycerides)	Less than 2 mmol/L	Needs to be a fasting sample. This is your ability to clear fat from blood after a meal. The higher the number, the less your body is clearing fat from blood. It is often affected by alcohol and glucose levels in the blood.

(Source: Heart UK, n.d.)

Fatty deposits can build up on the inside walls of your arteries and prevent the blood from flowing smoothly. This is a particular problem if the arteries that ‘fur up’ are the ones supplying blood to the muscles of your heart to keep it pumping. If they get blocked, you are at serious risk of a heart attack. Sometimes, pieces of the fatty deposit break off, which can lead to the formation of blood clots. These can lodge in the brain, cutting off the blood supply to part of it, causing a stroke (Figure 7).

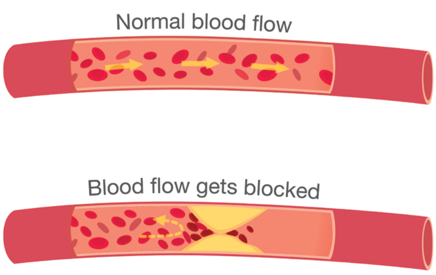

Figure 7 When arteries become blocked

The reference intake value for total fat is 70 g per day (just over a quarter of a pack of butter, if you ate no other fat!). No more than 20 g of this should be saturated fat. In other words, total fat intake should be no more than 35% of total energy and saturated fat no more than 11%.

3.2 Fat makes food taste good

Fat plays many essential roles in the body. It is needed to produce the membrane surrounding every cell, and all our nerves are surrounded by an insulating layer of fatty molecules. It is also involved in blood cell formation, immune responses and heart function. Steroid hormones are formed from fats and, of course, fat provides a layer of protection and insulation beneath the skin.

So, we do need some fat in our diet, just not too much. Fat is energy-dense; that is, we get a lot of energy from a small amount of fat. And, unlike amino acids from protein, which the body gets rid of in urine if we eat too many, the body does not get rid of the excess fat we eat. It is just added to the stores beneath our skin.

The problem is that many people find the fat in food tastes good (Figure 8).

Figure 8 Fat in fish and chips adds to the flavour

Fried food is very popular. But if you eat too much, and don't use up the energy it contains in exercise, it can lead to furred-up arteries and obesity. When manufacturers try to reduce the fat in food, by producing low-fat versions, people don't always like them as much.

It is possible to add extra herbs and spices to give an attractive flavour and aroma to low-fat savoury dishes. In low-fat desserts, such as yoghurts, the flavour is often improved by adding sugar. In fact, some low-fat yoghurts can have almost as many calories as the full-fat versions because of the added sugar. However, taste perception can be changed. Although changes in fat content can alter the taste of food, you can get used to having less. You will discover more about how we taste food later in the course.

3.3 Butter and chocolate

Natural fats, such as butter, are made up of a mix of triacylglycerols with different lengths of tail. And, like the number of kinks, the length of the tail also affects the melting temperature (Figure 9).

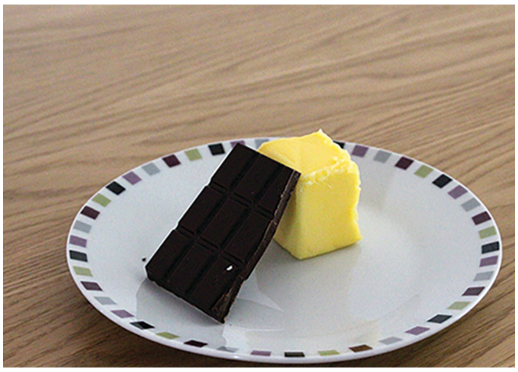

Figure 9 Chocolate and butter contain triacylglycerol fat molecules

When you first take butter out of the fridge, it is very hard. But, as it begins to warm up, the triacylglycerols with the lowest melting temperatures melt first. Then, as the temperature increases further, those with slightly higher melting temperatures change from solid to liquid. So, over a range of temperatures, butter is neither completely solid nor a runny liquid. It is a mix of solid triacylglycerols in a matrix of a thick liquid made up of the triacylglycerols with the lower-melting temperatures. So, as butter warms up, it becomes easier to spread.

Spreadable 'butters' have added vegetable oils which have bent tails and are liquid at fridge temperatures. So the spreads containing them are spreadable straight from the fridge.

Chocolate is made from cocoa, cocoa butter and sugar. Cocoa butter comprises very few different types of triacylglycerol molecules, with similar melting temperatures. So it has quite a sharp, well-defined melting temperature. In fact, the molecules can pack together in several different ways. One of these forms melts at 33.8 °C. Thus it melts in your mouth (36.9 °C) but not in your hand, which is usually cooler. This form is also smooth and glossy. To make it solidify in this form, the melted chocolate is cooled and kept at just below 33.8 °C, while being stirred so that the fat crystallises into very small crystals. This gives chocolate its velvety texture.

If chocolate is subject to fluctuations in temperature, a bloom develops on the surface. This is caused by the fat solidifying in a different crystalline form.

4 Carbohydrates

Carbohydrate is a general term that includes various kinds of sugar, together with starch and cellulose. The carbohydrates that we eat almost all come from plants.

Honey is a rare example of a carbohydrate that seems to come from an animal –bees. However, the sugars in honey are made by plants, in the nectar in their flowers. All the bees do is collect and process the sugars to produce honey, so it is a plant carbohydrate.

Cellulose is said to be the most abundant molecule made by living organisms on Earth. About one million million (10^{12}) tonnes are produced each year. It is so common because it forms the framework of the walls of all plant cells. It is composed of at least 500 glucose molecules all linked together in a long, unbranched chain. (Remember that glucose is a type of sugar.) The chains pack very closely side-by-side, similar to how some fat molecules pack, to give a very tough fibre (Figure 10). Because of the way in which the glucose molecules are linked, we cannot digest cellulose and it is known as the 'fibre' in our diet.

Figure 10 Cellulose fibres viewed through a microscope

Probably the next most common carbohydrate in most people's diet is starch. We can digest starch and, being much less energy-dense than fat, we can safely eat much greater amounts. The medical advice is that you should not have more than 50% of your total energy intake from carbohydrates. The reference intake is 260 g per day – about the same weight as a packet of butter.

When plants have spare sugars, made during photosynthesis, many of them store it as starch. In some species, we eat it before they can use it themselves! Let's start with potatoes. These are tubers produced by the potato plant, to survive the winter and be ready to generate new plants the following spring – as long as we don't dig them up and eat them!

Wheat and other cereal crops produce grains – their seeds for next year – containing starch. We grind them into flour – which is used to make bread and pasta – or we treat them in various ways to make breakfast cereals. Rice is a similar grain which we normally eat whole. You can probably think of other starchy foods that are similar stores put aside by plants for their own benefit, but are very nutritious for us, too.

4.1 Sugars

Like saturated fats, sugars are singled out for special mention on food labels. Again, as you might have guessed, this is for health reasons.

Figure 11 Sweet drinks are popular everywhere – this fair stall in India is selling sugar-cane juice

We are advised not to eat more than 90 g of sugar per day. There are several different sorts of sugar. So far, glucose has been mentioned as one type. The sugar that is obtained by extraction from sugar cane or sugar beet is another sort called sucrose (Figure 11). Different methods of purification and processing of the sugary liquid from the cane or beet give us the various sorts of sugar (sucrose) that we buy (granulated sugar, brown sugar, etc.). Other sugars also occur naturally in fruit (fructose) and milk (lactose).

We have taste buds on our tongues that are sensitive to sugar and most people like sweet things. However, foods that are high in sugar may have very few other nutrients. They are also high in energy, so eating too much sugar can contribute to obesity. The sucrose that we eat is digested in the body and broken down into glucose, which circulates in the blood.

When the level of blood glucose rises after a meal, or after eating a sugary snack, the hormone insulin (which you met in Protein sequencing) is released. This has two effects. One is to stimulate cells in the muscles and liver to take up the extra sugar and store it as glycogen, thus safely removing it from the bloodstream. The other function is to stimulate fat cells to take up fat from the bloodstream and store it, rather than breaking it down for energy. So, there's the link – eat too much sugar, and you risk putting on weight by storing fat.

There is an even clearer link between the intake of sugar and tooth decay. Sugar in the mouth is an ideal source of food for the bacteria that normally live there, in the moist film of saliva covering the teeth and gums. These bacteria, which form a layer called plaque, produce lactic acid and enzymes that digest proteins. The plaque can keep the acid in contact with the tooth surface for up to two hours before it is neutralised by the saliva.

Over time, the acid gradually dissolves the calcium salts in the tooth enamel, and the enamel protein is destroyed by the bacterial enzymes. Despite the resistance of the enamel, eventually the surface is breached and the underlying softer dentine is dissolved and cavities form in the teeth. The problem is made worse by 'snacking' on sugary items between meals. This increases the amount of time that the teeth are surrounded by sugar which the plaque bacteria can feed on, leading to tooth decay.

5 Salt makes food taste good

We have now looked at all of the items that are usually on a food label except salt. Why does salt get a special mention?

There appears to be a link between high salt intake and high blood pressure in some people. If there is too much salt in the diet, the body tends to retain too much water, the volume of blood increases and this raises the blood pressure. High blood pressure is linked with a higher risk of coronary heart disease (CHD) and stroke. As people get older, a small increase in salt intake seems to have a greater effect on blood pressure than it does in younger people. Reducing the salt intake over several weeks can reduce blood pressure.

A small amount of salt is essential for a healthy body but there is plenty in the foods we eat without adding any. Yet we do add salt to lots of our food because we like the taste of it. We have receptors on our tongues that detect salt – alongside the ones that detect sugar – and many people like the taste of salty things. Our taste buds get used to the salty taste. Over time, it is possible to get used to a diet containing less salt. However, the taste buds take time to adjust and for several weeks food without salt will not taste so good.

The advice in the UK is that you should eat no more than 6 g (about 1 teaspoon) of salt each day. However, the average salt intake is around 9 g each day. This may be much higher if you eat a lot of ready-prepared food. To make the amount clearer on food packaging, the ‘traffic-light system’ shows red if there is more than 1.5 g of salt per 100 g of the food, amber for between 0.3 g and 1.5 g and green for less than 0.3 g (Figure 12).

Figure 12 Nutrition label warning, with a red square, that the food contains more than 1.5 g of salt per 100 g

The chemical name for salt is sodium chloride. You may see ‘sodium’ on some packaging, rather than ‘salt’. You can convert sodium values to salt values by multiplying by 2.5; for example, 0.5 g of sodium is 1.25 g of salt.

Another substance similar to sodium is potassium. Studies have shown that potassium has the opposite effect on blood pressure to sodium: the higher the potassium intake, the lower the blood pressure. In 2013, the World Health Organization issued the first guidelines on potassium intake. Adults should consume more than 4 g of potassium a day. The best sources are fruit, particularly bananas, and vegetables. As you will discover later in the course, there are additional health benefits to increasing fruit and vegetable consumption.

You might like to look at food labels and the range of salt values.

- What is the highest value you can find in a portion of food?

- How much of your daily intake would that be?

6 Vitamins and minerals

Vitamins and minerals are needed in our diet in very small quantities. They are called micronutrients and normally there is enough of each one in a balanced and varied eating pattern. (Figure 13).

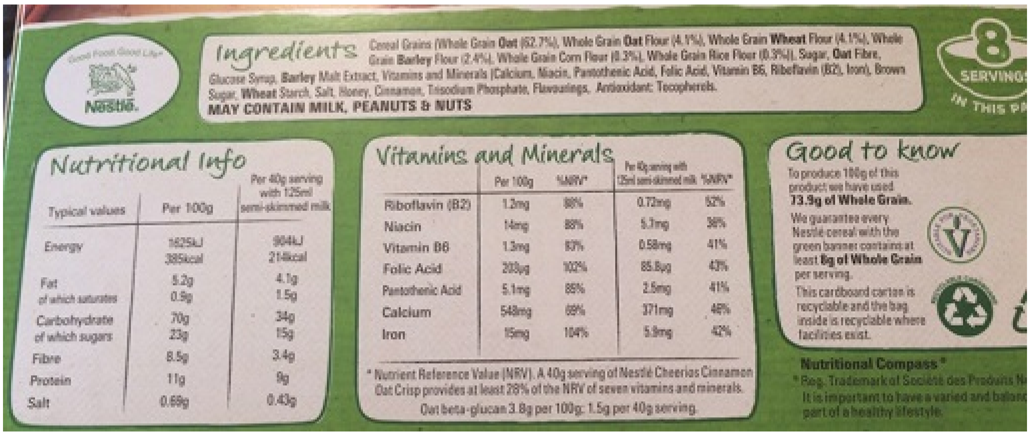

Figure 13 Nutrition label listing vitamins and minerals

As well as sodium and potassium, numerous other minerals are needed for good health. For example, iron is needed to prevent anaemia, calcium for bones and iodine for thyroid functioning. There are two main groups of vitamins:

- fat-soluble ones – vitamins A, D, E and K
- water-soluble ones – the B group (B1, B2, etc.) and vitamin C.

Foods such as breakfast cereals often have extra vitamins added. They are described as ‘fortified’. If you want to know more, here is a fascinating resource about vitamins and minerals.

7 Where can you find fibre?

In the next activity you will test your knowledge about fibre (Figure 14).

Figure 14 Salad onions, tomatoes and lentils – are they high in fibre or not?

Activity 3 Fibre content

Allow approximately 15 minutes.

Look at some of the food labels you have collected. See if you can identify which sorts of foods are high in fibre. What is the highest amount of fibre per 100 g of the product that you can find?

Write two or three sentences in the box below. Click ‘Save’ when you are satisfied with what you have written.

Provide your answer...

7.1 The benefits of fibre

Foods that are classed as high in fibre must have at least 6 g of fibre per 100 g. In Activity 3, you probably found that many breakfast cereals fall into this category (Figure 15).

Figure 15 Breakfast cereal is usually high in fibre

Fibre – also called ‘roughage’ – is one of those ‘foods’ that you eat but don’t digest. It contains no useful calories. It goes through your digestive system largely unchanged. But it helps the food to move along through your digestive system, so that constipation is less likely.

Nearly all of the fibre we eat comes from plant sources, such as fruit, vegetables, nuts and seeds. Some food labels separate fibre into insoluble and soluble fibre, and beta glucan, which is a special type of soluble fibre.

Insoluble fibre is mostly cellulose. As you learned when you read about carbohydrates, cellulose is the most abundant large molecule made by living organisms on Earth. It is in the walls of all plant cells, so fruit and vegetables contain large amounts.

Soluble fibre is found particularly in peas, beans, lentils and oats. It is soluble because it dissolves in water, although it is still not digested. Beta glucan is a type of soluble fibre found particularly in oats. It seems to play a role in lowering the level of cholesterol in the blood. When it dissolves inside the gut, it appears to form a thick gel, which binds substances such as cholesterol and prevents them from being absorbed into the blood.

There are other health benefits of fibre in the diet. A diet rich in soluble fibre in particular has been reported to reduce the incidence of bowel cancer, gallstones, irritable bowel syndrome (IBS), heart disease and diabetes. There is also some evidence that increasing the fibre in your diet can lead to weight loss, although the mechanisms that cause this are not entirely clear. It may simply be that, because the fibre makes you feel ‘full’ for longer, it means you eat less. Higher fibre intake also changes your gut bacteria in a positive way. It can help you metabolise your food better and reduce the risk of bowel cancer.

8 This week's quiz

Check what you've learned this week by taking the end-of-week quiz.

Week 1 quiz

Open the quiz in a new window or tab (by holding ctrl [or cmd on a Mac] when you click the link), then return here when you have done it.

9 Summary

This week you looked at the basics of food. You learned about how your body responds to hormones such as ghrelin. You also learned about the role of nutrients such as proteins, fats and carbohydrates in your body.

You should now be able to understand:

- why we eat and the factors that affect hunger
- the different macronutrients and their function in the human body
- the different micronutrients and their function in the human body.

Next week, you will look at what happens to your food after eating it. You will look at the path your food travels through your body and how it is broken down inside your body. You will also have the opportunity to carry out a fun experiment before examining how nutrients are transported around your body.

You can now go to Week 2.

Week 2: What happens to the food we eat?

Introduction

Welcome to Week 2 of the course.

This week, you will find out what happens to food after you eat it.

By the end of this week's study you should be able to understand:

- the journey of food through the digestive system
- how different foods are broken down to allow their absorption
- what each food group does in the body for metabolism.

In the following video, Audrey Brown from The Open University finds out what some of the members of staff at the University know about their digestive system.

Video content is not available in this format.

1 Holes, tubes and valves

The food tube running through the body (Figure 1) is extremely coiled. When opened out, it is about 7.5 to 8 metres long (the length varies with body size and nutritional status). It also has valves (muscular ones called sphincters) allowing the food to move one way only – under normal circumstances. Generally, these sphincters work automatically, although we have control over the one at the far end!

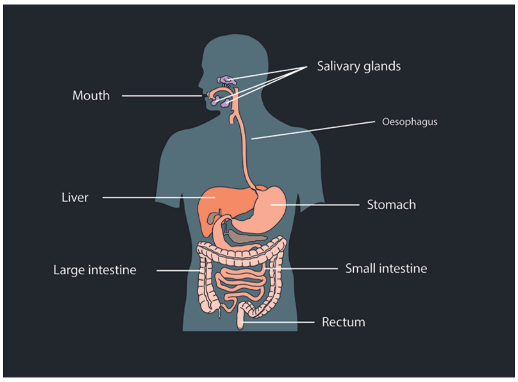

Figure 1 The main organs of the digestive system

1.1 Opening out the human digestive system

Food moves through the body, but how exactly is it digested?

When food is eaten, it is chewed up and mixed in the mouth with saliva. This starts the process of digestion and makes the food easier to swallow. It passes down a tube called the oesophagus and enters the stomach through what is normally a one-way valve. It is possible to swallow food into your stomach when you are upside-down!

After spending some time in the stomach, where the food is further broken down, it is released into the small intestine. Digestive juices are added from the gall bladder and pancreas, so more of the food breaks down. Many of the small molecules produced are absorbed into the blood.

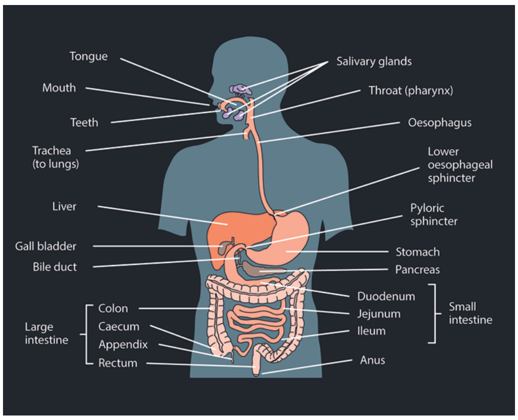

Figure 2 Parts of the organs of the digestive system

In the large intestine, large numbers of microbes help with the final stages of digestion. Most of the water is absorbed from the food to leave the undigested fibre and countless millions of microbes. These are stored in the rectum and finally expelled from the body through the anus as faeces.

1.2 Digestive system of a pig

Pigs are a similar size to humans and they also eat a range of different foods. The following video shows the digestive system of a pig. What differences can you identify between the pig and the human digestive system?

Video content is not available in this format.

Please note this video has graphic images of the digestive system of a pig. If this is too gruesome for you, you might prefer to read the transcript instead.

1.3 Move along in there, please

To investigate certain medical conditions, tiny cameras have been developed that can be swallowed to send back pictures from inside the gut (the lower half of the digestive system).

Movements of the gut push the camera, in the same way that they would push food through the digestive system. In the next video you can see the route that a camera, and therefore food, would take.

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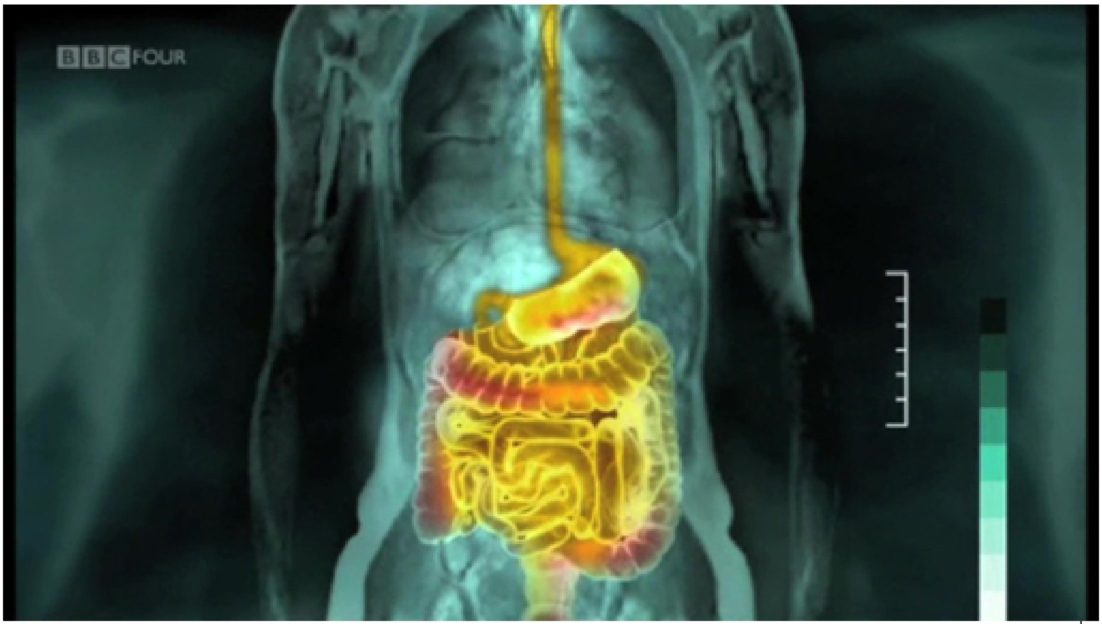
Please note, this video has no spoken audio.



The length of time that it takes food to travel from mouth to anus depends largely on the components of the diet, particularly the amount of fibre. Fibre bulks out the contents of the gut, giving more for the intestines to squeeze on to move the food along. A typical time is 24 hours but it can be up to three days.

1.4 The path your food travels

In the following activity you will test your knowledge of the order in which food passes through the human digestive system.

Activity 1 Follow the food journey.

Allow approximately 15 minutes.

In what order does food pass through the human digestive system on its journey through the body?

○ stomach, oesophagus, liver, large intestine, rectum

Incorrect: try again? The oesophagus is the tube that leads down from the mouth, so that comes before the stomach.

You may find 1.2 Digestive system of a pig useful.

○ oesophagus, stomach, liver, large intestine, rectum

Incorrect: try again? Food does not pass through the liver on its journey through the body.

You may find 1.2 Digestive system of a pig useful.

○ oesophagus, stomach, small intestine, colon, rectum

Correct.

You may find 2.1.2 Digestive system of a pig useful.

○ stomach, small intestine, gall bladder, large intestine, rectum

Incorrect: try again? The food does not pass through the gall bladder. Instead, the gall bladder releases bile into the digestive system.

You may find 2.1.2 Digestive system of a pig useful.

2 A window into the stomach

The next video describes an unfortunate accident in June 1822 which led to a real breakthrough in understanding how the digestive system works, particularly the stomach.

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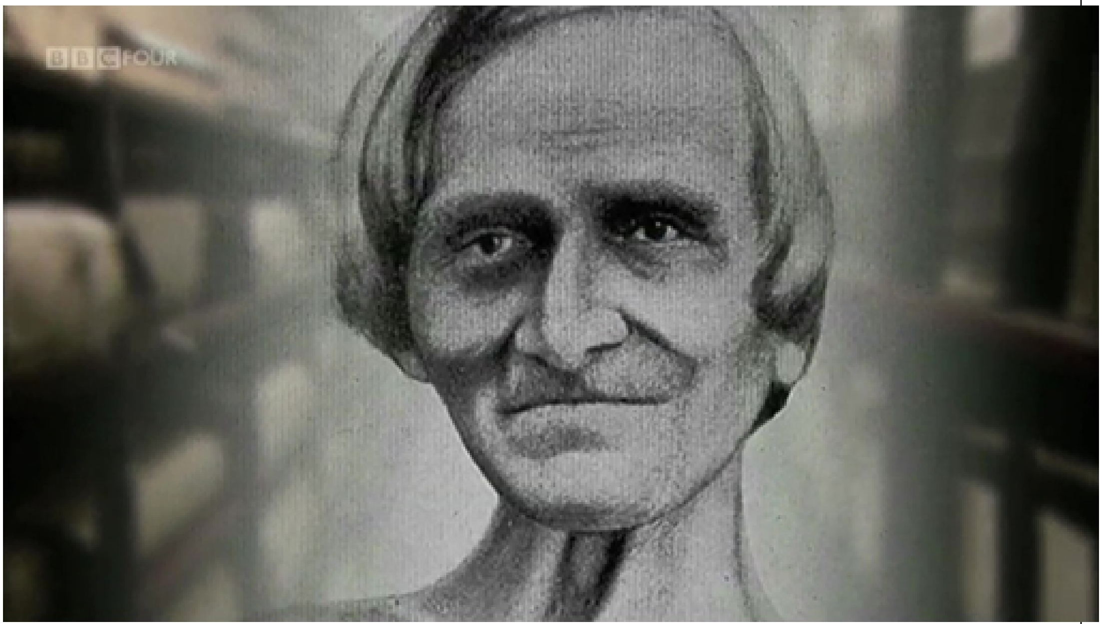

A young man, Alexis St Martin, was accidentally shot by a musket at close range on Mackinac Island, in Michigan, USA. He was treated by Dr William Beaumont, a surgeon from a nearby army base. The injury to his ribs and stomach was expected to be fatal but, amazingly, he survived. When the wound eventually healed, it did not close up completely. The edge of the hole in the stomach healed to the edge of the skin, leaving a small permanent hole from the outside directly into the stomach.

This gave Dr Beaumont the perfect chance to try some experiments. He tied small pieces of food on a string and popped them into the stomach through the hole. Then he fished them out again after a few hours to see what had happened to them. He also siphoned out some of the fluids from the stomach and tested them.

Up until that time, people had thought that digestion was a purely mechanical process. But this proved that the stomach contained acid and enzymes which were helping to digest the food.

2.1 The pH scale

The unfortunate accident to Alexis St Martin led doctors to understand more about the workings of the stomach than ever before. Let's start by looking in more detail at the acid.

A special scale is used to measure how acidic a solution is – the pH scale (Figure 3). Anything reading less than 7 on the pH scale is an acid. The more acidic it is, the lower the number. Water, which is neutral, has a pH value of 7. Anything greater than 7 is said to be alkaline. The pH of stomach acid is about 2, less acidic than car battery acid (pH 1) but more acidic than lemon juice (pH 2.4) and vinegar (pH 2.9). Bicarbonate of soda is alkaline – a solution of it has a pH of about 8.

Figure 3 Indicator paper detects pH by changing colour – the colours and numbers on the right show the pH value

Some people get indigestion or 'heartburn'. This can be caused by the acid from the stomach irritating the lower part of the oesophagus, which is called *acid reflux*. If the condition occurs only occasionally and is mild, the symptoms can be alleviated by taking over-the-counter medicines called antacids. These contain alkaline substances which neutralise the stomach acid, usually producing carbon dioxide gas at the same time, which may cause wind (flatulence).

2.2 Measuring pH

The next activity gives you the opportunity to measure pH by looking for a change in colour of a solution that you can make from red cabbage. First, watch the following video to see how to carry out the experiment.

Video content is not available in this format.

Please note this video has no spoken audio.

Activity 2 Using an indicator to test pH

Allow approximately 45 minutes.

a. Chop up a quarter of a red cabbage.
b. Place the chopped cabbage in a blender with 250 ml of water and blend well.
c. Strain the indicator liquid and pour into sample glasses.
d. Clearly label each glass before adding the samples you wish to test.
e. Test samples that you think may be acid or alkali.

Which colours indicate that an acid is present and which colours indicate an alkali?

Try other substances from the kitchen, such as washing-up liquid, liquid soap, dishwasher powder (be especially careful not to get that on your hands), cola drink, tomato ketchup, etc. You can probably think of many more.

Write two or three sentences in the box below to describe what your tests discovered. Click 'Save and Reveal Discussion' when you are satisfied with what you have written.

Provide your answer...

Answer

We mentioned using an alkali to neutralise an acid (in antacid medicines). You could try that for yourself now. Take one of your acid solutions (lemon juice, for example) with the indicator, and start adding an alkali (such as baking powder or an antacid tablet). You should see the colour change from the acid colour, through the neutral colour, to the alkali colour. You may also see a lot of fizzing as carbon dioxide is released.

2.3 Why is the stomach so acidic?

There seem to be two important reasons why the stomach produces so much acid. Firstly, it kills most of the bacteria that we accidentally take in with our food which might cause food poisoning. Unfortunately, some kinds of bacteria can resist the stomach acid and go on to cause problems, often because of the toxins they produce.

More importantly in terms of digestion, the stomach acid coagulates some of the proteins in the food that you eat, this makes it easier for the enzymes to attach and digest them.

It's not just in the stomach that acids coagulate proteins. Many people add a splash of vinegar (acetic acid) to the water when they boil eggs (Figure 4). Have you ever thought why?

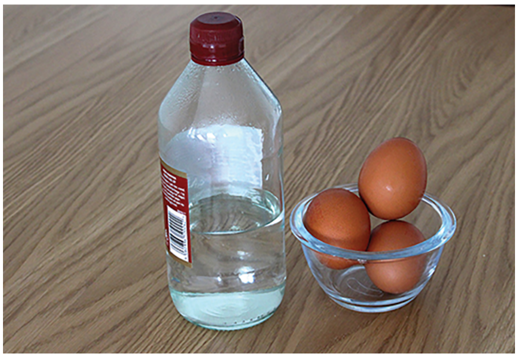

Figure 4 Vinegar can help when boiling an egg

Egg white is mostly a mix of protein and water. If the egg shell cracks while the eggs are being boiled, the liquid white begins to escape from the crack. Vinegar makes it coagulate faster than it otherwise would and seals up the crack in the shell, so that no more escapes.

Similarly, vinegar is often added to the water in which poached eggs are cooked, to make the white coagulate more quickly and spread out less in the water. A teaspoon of lemon juice or vinegar added to egg whites when making meringues has the same effect. It helps the meringue to keep its shape better by slightly solidifying the egg white protein. The coagulation effect is the same on any proteins in your diet. For instance, the proteins in meat are made more solid. Once the proteins are solidified, the enzymes produced by the stomach wall act on them.

2.4 Stomach ulcers

Stomach acid is produced by some special cells in the stomach wall. But why doesn't the acid attack the stomach wall and coagulate the proteins in the cells of the stomach wall?

The answer is that the stomach wall also produces a thick lining of sticky mucus, which generally keeps the acid away. But sometimes this barrier does not work, the acid gets through and an inflamed and sore patch called an ulcer develops in the stomach wall.

Until the mid-twentieth century, it was thought that stress, a poor diet or both caused stomach ulcers. Eating a lot of spicy foods was also considered a possible cause. However, changes in diet and lifestyle rarely made any difference. Then it was suggested that ulcers were caused by excess acid in the stomach. A drug called ranitidine, which blocked acid production, was commonly prescribed. In the 1980s, ranitidine was the world's number one drug, with several billion pounds being spent on it annually. But it did not cure the problem – as soon as people stopped taking it, the ulcers came back.

But things were changing. In the late 1950s, Dr James Likoudis, working in a small town in Greece, diagnosed himself with an ulcer. He successfully treated himself, and subsequently several of his patients, with a mix of antibiotics. However, his work was not well received by the medical establishment and it was another 30 years before it was widely recognised that he was right. A common bacterium, found in about half of the world's population, was the primary cause of most stomach ulcers. It doesn't have a common name but its scientific name is *Helicobacter pylori*, or *H. pylori* for short.

The pioneering work on the role of *H. pylori* in causing stomach ulcers was done by two Australian scientists, Barry Marshall and Robin Warren in the 1980s. To convince the scientific world of their hypothesis that *H. pylori* caused stomach ulcers, Marshall deliberately infected himself with a culture of the bacteria. As expected, his stomach became painful and inflamed until he took the right antibiotics. It appears that the bacteria can burrow through the lining of mucus that normally protects the stomach wall from damage. Ultimately, the stomach wall becomes inflamed (Figure 5).

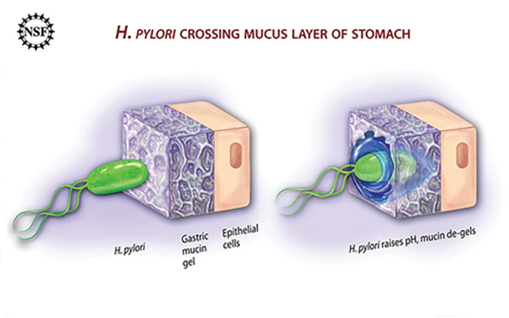

Figure 5 Bacterium penetrating the protective layer in the stomach and damaging cells in the wall

Within a few years, the treatment of stomach ulcers was revolutionised. In 2005, Marshall and Warren were awarded the Nobel Prize in Physiology or Medicine for their discovery of the bacterium *Helicobacter pylori* and its role in gastritis and peptic ulcer disease.

2.5 Enzymes

Have you ever noticed that if you keep chewing potatoes or rice for a few moments, you get a faintly sweet taste in your mouth? This is the effect of a digestive enzyme in your saliva called salivary amylase. It begins the breakdown of starch to sugars such as glucose which is what tastes sweet.

Digestive enzymes, such as amylase, are specially shaped protein molecules that can latch on to a particular type of molecule (carbohydrate, protein or fat) and break it down into smaller molecules (Figure 6). Eventually, the molecules are small enough to be absorbed into the bloodstream through the cells of the intestines.

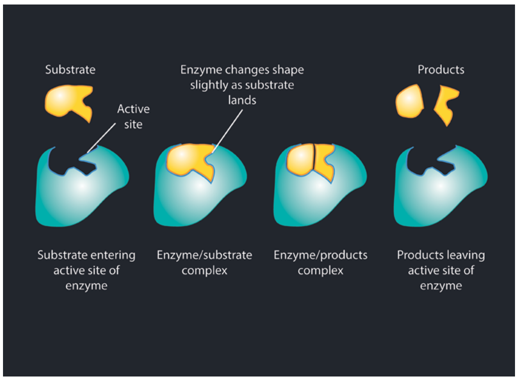

Figure 6 Enzyme (blue) breaking down some food (yellow)

Each particular type of enzyme usually only works on one type of food molecule. They are named according to the sort of molecule that they affect. For example:

- enzymes that break down proteins are proteases
- those that break down fat are lipases (fats are also called lipids)

- those that break down carbohydrates are amylases (amylose is a component of starch).

2.6 Enzymes in washing powder

If you use a biological washing product for your clothes, you are using enzymes to help to digest any food (and other) stains on the clothes (Figure 7). The product may contain one, two or all three of the types of enzyme (proteases, lipases and amylases).

Figure 7 Preparing to wash clothes with a biological washing powder

Activity 3 How does a biological washing powder work?

Allow approximately 15 minutes.

Answer the following questions.

1. What sort of food stains are likely to be removed by a biological washing powder?
2. Why do you think the powder works best at low temperatures of around 40 °C and does not work well in boiling water?
3. Why should you not use this washing powder on clothes made of silk? (Hint: think about what silk is and how it is made.)

Write your answers in the box below. Click ‘Save’ when you are satisfied with what you have written.

Provide your answer...

2.7 Digestion inside and outside the body

Biological washing powder contains enzymes that, although extracted from microbes such as bacteria, are very similar to those produced in our digestive system.

Proteases work in much the same way inside and outside the body, by breaking down proteins. These proteins could be inside the digestive system – a poached egg eaten for breakfast – or egg spilt down a child's T-shirt digested inside the washing machine by a biological washing powder (Figure 8).

Figure 8 Difficult stains on clothes may need special preparation before washing to start the process of 'digestion'

Lipases break down fat, whether they are inside or outside the body. They act on the butter eaten with the poached egg, or in the washing machine, getting rid of the mark where the buttery knife fell into the child's lap. Once the protein and/or fat in the stain have been digested by the enzymes in the washing powder, they no longer cling to the fabric and can be rinsed away.

Enzymes are a type of protein and proteins coagulate at high temperatures. So, if boiling water is used with a biological washing powder, the enzymes are denatured and do not work. Because silk is a protein, biological washing powder containing protease can start to digest and weaken the threads, which could seriously damage clothes made of silk.

2.8 Do the liver experiment

You can see the action of one type of enzyme for yourself. But first, here is some background information.

Hydrogen peroxide is a harmful by-product of many normal chemical reactions that happen in the cells of our body. It needs to be eliminated as quickly as possible.

The enzyme that breaks down hydrogen peroxide is called catalase. (Despite the earlier information about how enzymes are named, this one does not break down cats!) One catalase molecule can break down about five million molecules of hydrogen peroxide in one second. The breakdown products are water and oxygen and, because oxygen is a gas, the activity of catalase can be detected by looking for bubbles.

One place in the body where many reactions occur is the liver. It also has a particularly high concentration of catalase. So, if you would like to do this yourself, you will need some uncooked liver and some hydrogen peroxide. The easiest source of hydrogen peroxide is in some types of contact lens soaking solution. You will need to check the ingredients to be sure. Alternatively, you may be able to buy dilute hydrogen peroxide from a pharmacy.

If you put a tiny bit of raw liver on a plate and add a few drops of contact lens fluid, you should see a reaction quite clearly. You can scale it up if you like, in a jar or glass tumbler, by dropping a bigger piece of liver into some hydrogen peroxide solution (see the next video).

Video content is not available in this format.

Please note this video has no spoken audio.

2.9 Digestive enzymes

Now we return to the digestion of food inside the body, after it has been mixed with saliva.

In Enzymes,we mentioned the enzyme salivary amylase, a starch-digesting enzyme in the saliva.

In infants lipase is produced in the mouth, and a second lipase is produced by special cells in the stomach wall. Both of these lipases start the digestion of fats, by removing the first of the three fatty acids from some of the triacylglycerol molecules. This is because the production of pancreatic lipase has not started yet. (The structure of triacylglycerols was described in Fats and oils in Week 1.)

In adults lipase is made in the pancreas. However, once the food is thoroughly mixed with the acid in the stomach, the pH is too low for these enzymes to continue working efficiently. One of the protein-digesting enzymes called pepsin is also produced by cells in the stomach wall. This does work well in the acidic conditions and it begins to digest the coagulated proteins to amino acids.

A short way along the small intestine, a little tube (duct) empties more digestive fluids from the pancreas and gall bladder onto the food. Bile from the gall bladder is alkaline and neutralises acid from the stomach. This makes the conditions better for other enzymes to work. Bile also helps to emulsify the fats into tiny droplets, enabling one of the enzymes from the pancreas (lipase) to work better at breaking down the fats in the food.

Pancreatic lipase breaks one or two of the fatty acid tails off the triacylglycerol. This leaves just one attached, creating a monoacylglycerol. The pancreas also produces more proteases to complete the digestion of proteins into individual amino acids. The remaining digestion of carbohydrates – breaking them down into sugars – is done by amylases produced by the walls of the small intestine itself.

One of these amylases is called lactase, which breaks down the sugar in milk (lactose). Lactase is, of course, essential in babies and young children whose main dietary component is milk. But it is unusual for the adults of one species (us) to drink the milk of another (cows), so you would not expect adults to produce lactase.

In fact, that is the case in about 80–95% of adult African and East Asian people. If they consume milk, the lactose is not digested and remains in the intestine. The populations of gut bacteria that can digest lactose increase, producing unpleasant-smelling gases. This can cause bloating and wind, abdominal pain and diarrhoea. These can be symptoms of lactose intolerance. However, most Northern European people, and their descendants elsewhere in the world, have retained their ability to produce lactase. They can continue to drink cow's milk without ill effects throughout their lives.

Table 1 Enzymes and their role in digestion

Site	Enzyme	Role in digestion
mouth	salivary amylase	breaks down starches into disaccharides
	Lingual Lipase	begins to break down fats into fatty acids
stomach	pepsin	breaks down proteins into large peptides
small intestine (from pan-creas)	amylase	continues the breakdown of starch
	trypsin	continues the breakdown of protein
	lipase	breaks down fat
Small intestine	Maltase, sucrase, lactase	Breaks down remaining disaccharides into monosaccharides
	Peptidase	Breaks down dipeptides into amino acids

3 Peristalsis

The food is moved along the gut by the action of two sets of muscles. One set runs along the gut and the other set runs around it, as you can see in the next video.

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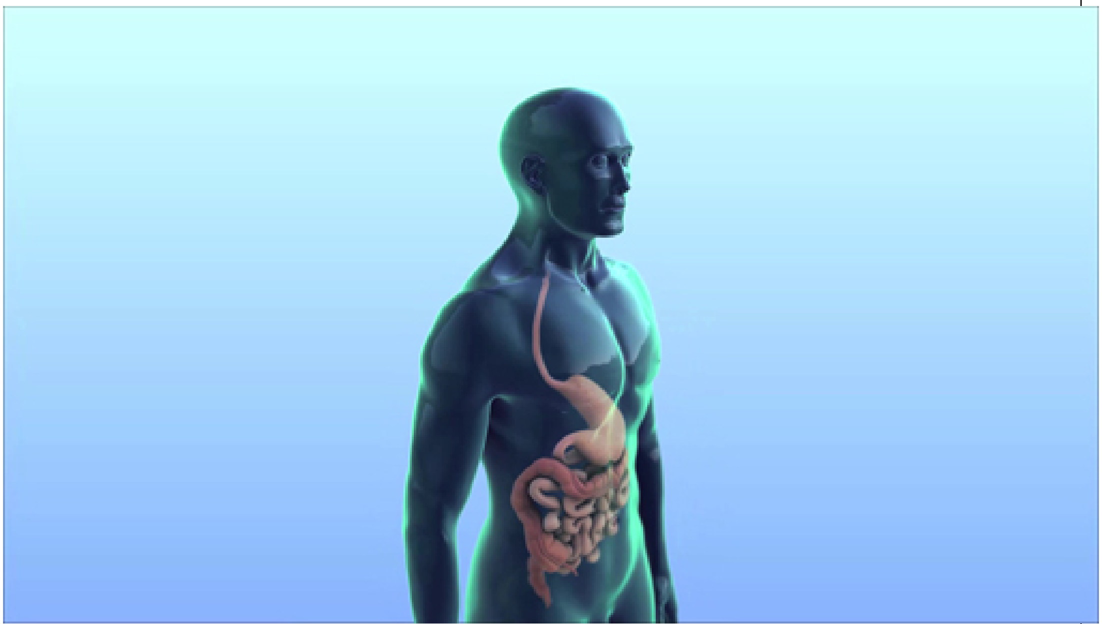

The combined activity of these muscles produces 'waves' of contraction that push the food along (*peristalsis*). This enables you to eat and drink, and for the digesting food to travel along your gut, while you are lying down or even while standing on your head. The muscles work best if the food you eat contains plenty of fibre.

3.1 Absorption into the blood

Once the food has been digested, the next step is for the products – sugars, amino acids, fatty acids and monoacylglycerols – to be absorbed (see Figure 9).

The inside of the small intestine is covered in minute, finger-like projections, called villi (Figure 9). This makes the lining look and feel – but not smell – like velvet. These villi give the lining of the small intestine a huge surface area, calculated to be about 30 m^2, over which the digested food can be absorbed.

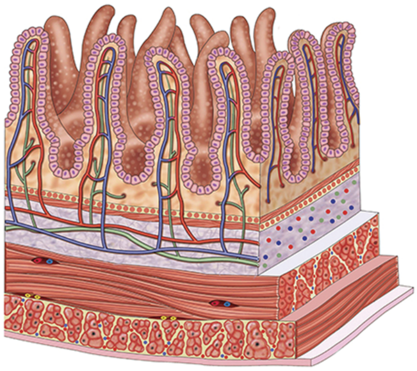

Figure 9 Villi (top) project into the small intestine and each one has capillaries supplying blood

Capillaries supply blood to each villus. The blood brings oxygen to keep the cells of the intestine alive and absorb and take away the sugars and amino acids. These tiny capillaries join together to form a vein called the hepatic portal vein, which takes all of the blood to the liver. The fatty acids and monoacylglycerols are absorbed, not into the blood directly, but into blunt-ended tubes in the villi called lymphatic vessels. These all join together and the fluid in them empties into the blood system close to the heart.

3.2 What does the liver do?

The liver weighs about 1.5 kg in an adult and sits just below your ribs. The liver is reported to have 500 different functions. One of them is to make bile and store it in the gall bladder, so that it can be released to help with digestion, as mentioned earlier.

You know already that the liver contains powerful enzymes. You saw in Do the liver experiment just how quickly catalase can break down hydrogen peroxide, a dangerous by-product of some chemical reactions in the body.

Enzymes in the liver also break down any unwanted substances that arrive in the hepatic portal vein from the intestines. Alcohol is one of the main ones. If a person consumes alcoholic drinks, the alcohol is absorbed into the blood through the walls of the stomach or through the villi of the small intestine into the blood. Up to 5% of this alcohol is removed in urine by the kidneys and up to 5% is breathed out (that is the alcohol that breathalysers detect). At least 90% of the alcohol a person consumes is dealt with by the liver. It is broken down by enzymes to acetate molecules, which can be used to produce energy. Excessive consumption of alcohol can damage the liver, causing cirrhosis.

Any spare sugars are stored by the liver as glycogen. When needed, the glycogen can be released back into the blood to keep the blood-sugar level constant. The level of sugar (glucose) in the blood needs to be quite closely regulated. This is done using insulin produced by the pancreas. This ensures that the brain, the muscles and the rest of the body are supplied with the correct level of glucose they need for energy.

The liver also deals with the fatty acids and monoacylglycerols. Some are joined back together to make the fats that the body needs, possibly after some modification. Others are used for energy, and any spare ones are probably sent to the fat cells, mostly under the skin, where they are stored as fat. Excess amino acids in the blood arriving at the liver are broken down to ammonia and then to urea. This is filtered out of the blood when it reaches the kidneys, which is where urine is produced.

3.3 Taking the nutrients around the body

The blood system delivers the products of digestion to all parts of the body (Figure 10).

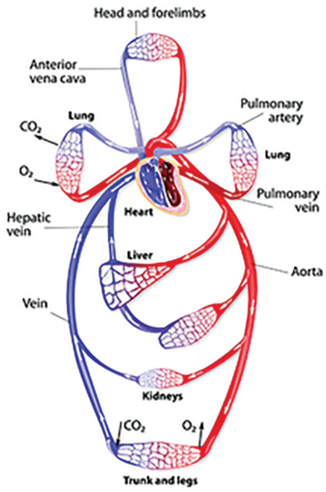

Figure 10 Blood system, showing the organs for digestion and the exchange of oxygen and carbon dioxide

Arteries take the blood away from the heart to all of the various parts of the body. There, the arteries branch into smaller and smaller blood vessels, until they form tiny capillaries. Capillaries are damaged when you get a small cut, graze or bruise. The capillaries then rejoin to take the blood back to the heart again, in veins.

Pictures of the body are always drawn as though you are facing the person. So the right side of the heart appears on the left side of Figure 10 and vice versa. The blood enters the right side of the heart in the big vein called the vena cava. From there it is pumped to the lungs, to pick up oxygen. Then it travels back again to the heart and sets off in the big artery called the aorta, back around the body again. Some of it goes to the intestines and, as already mentioned, there is then a special vein taking the blood from the small intestine to the liver, to carry the digested food.

3.4 Taking glucose from the intestine to the brain

In the next activity you will test your knowledge of the route that blood takes through your body.

Activity 4 What is the order from small intestine to brain?

Allow approximately 15 minutes.

Identify what route blood, containing glucose, will take from the small intestine to the brain.

Arrange the parts below in order, with the small intestine at the top and the brain at the bottom. To move a part of the blood system, click on it and drag it to a new position. There is no limit to the number of moves you can make. As soon as you move the boxes into the correct order, a message will appear.

After 11 moves, you will be asked whether you want some assistance. This will add green ticks next to those that are in the correct position and red crosses to those that are not.

Interactive content is not available in this format.

Answer

The order is as follows:

1. hepatic portal vein
2. liver
3. hepatic vein
4. vena cava
5. right side of heart
6. pulmonary artery
7. lungs
8. pulmonary vein
9. left side of heart
10. aorta
11. carotid artery

Quite a complicated route, isn't it? Did you get the sides of the heart the right way round first time? It's easy to forget that the right side of the heart is on the left of the diagram.

3.5 The large intestine

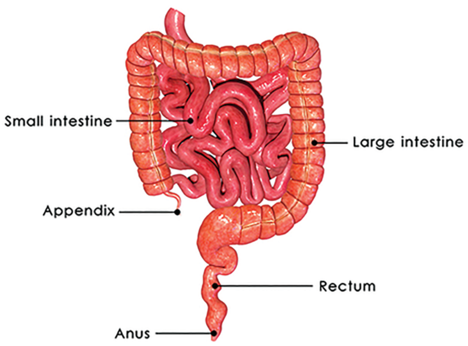

Figure 11 Main regions of the gut

Once most of the 'goodness' has been absorbed from the food through the walls of the small intestine, the fibre part of the diet and lots of water are left in the large intestine (Figure 11). If you have ever had diarrhoea, you know what the large intestine contents are like before they are properly processed. The inside surface of the large intestine is much flatter than that of the small intestine. This is because water is much easier to absorb into the blood than nutrients.

Also making their home in the large intestine are enormous numbers of microbes. Although people can survive without any bacteria in their large intestine, these microbes perform several really useful functions. For example, they can help to break down some food molecules that were not susceptible to breakdown by the digestive enzymes, particularly some carbohydrates, including cellulose. People who eat a high-fibre diet often have more of these sorts of bacteria.

Microbes in our large intestine are also the source of some vitamins – such as biotin and vitamin K. They play an important role in keeping any dangerous microbes under control that might get into our gut in food and manage to escape being destroyed by the stomach acid. Taking antibiotics for an unrelated infection can destroy these ‘good’ microbes and cause diarrhoea, particularly in hospital patients and elderly people.

Once the water has been absorbed in the large intestine, fibre and a lot of dead bacteria are left, to be disposed of by the body. Peristaltic movements compress these into faeces, which are about one-third bacteria and two-thirds fibre and other undigested food. They are stored in the last part of the large intestine – the rectum – before being expelled from the body through the anus.

4 This week's quiz

Check what you've learned this week by taking the end-of-week quiz.

Week 2 quiz

Open the quiz in a new window or tab, then return here when you have done it.

5 Summary

This week, you looked at what happens to your food after you eat it. You also looked at the path food travels through your body and how food is broken down inside your body. We hope you enjoyed carrying out the liver experiment!

You should now be able to understand:

- the journey of food through the digestive system
- how different foods are broken down to allow their absorption
- what each food group does in the body for metabolism.

Next week, you will look at the importance of keeping your body hydrated.

You can now go to Week 3.

Week 3: The importance of hydration

Introduction

Welcome to Week 3 of the course.

In this week, you will find out why it is important to keep your body well hydrated.

By the end of this week's study, you should be able to understand:

- what hydration is required physiologically, including what hydration is and how much you need
- how much and what you drink and whether it is enough
- dehydration and its consequences
- exercise and hydration
- whether alcohol is part of your fluid intake.

1 What is hydration?

This week is all about fluids. So far, you have considered food as macro and micro nutrients, absorption and how these nutrients are used. Although a person can survive for several weeks without food, without fluids, they can only survive for a few days.

Figure 1 Fluids are important for survival.

The term 'hydration' will be used which the *English Oxford Dictionary* defines as: 'the process of causing something to absorb water'.

This 'something' is the cells in our body (intracellular) and blood and the spaces between cells (extracellular). There is a lot of water in the human body. On average, it is 60% water in adult men and 51% in adult women, 75% in infants and about 55% in elderly people. There are variations with age and gender: males have more water than females. This is because women have a larger percentage fat content and fat contains less water (about 20%) than muscle.

According to the Office for National Statistics (2010) an average male in England weighs 83.6kg and an average woman in England weighs 70.2kg therefore a person weighing 70 kg has 42 litres of water. Most of this fluid is in the cells (about 65%). Water can move easily in and out of cells, so it can go wherever it is needed.

Different parts of the body have different concentrations of fluid. This is related to the function of the fluid in that part of the body. Did you know that an adult brain is approximately 73% water? What about other parts of the body?

Activity 1 water in different parts of the body

Allow approximately 15 minutes.

Move the relevant percentages next to the relevant organ for average water contents in adults.

- 83%
- 79%
- 73%
- 73%
- 71%
- 64%
- 31%

Match each of the items above to an item below.

- lungs
- kidneys
- heart
- brain
- liver
- skin
- bone

Discussion

Order is highest to lowest: lungs 83%, kidneys 79%, heart 73%, brain 73%, liver 71%, skin 64%, bone 31%. (Source: National Hydration Council, 2018)

2 Why you need to drink

Your body cannot manufacture enough of its own fluid. On average, your body loses 2.5 litres of water daily, but this can vary according to the environment and physical activity levels. On average, water is lost in sweat (0.45 litres), breathing (0.35 litres), faeces (0.2 litres) and urine (1.5 litres), so, you can see that most fluid is lost in urine. The kidneys are involved in maintaining body fluid homeostasis and the balance of electrolytes (sodium, bicarbonate, potassium and chloride).

This fluid needs to be replaced by drinking and what is available in the food you eat. The latter accounts for about 20–30% depending on how ‘sloppy’ your food is! Soups, fruit and vegetables can be more than 80% fluid; 40–70% in hot meals. It is said that eating food stimulates drinking and studies have shown that 75% of fluid intake is while eating, which also facilitates chewing and swallowing.

Your body controls its water volume tightly and under normal circumstances, it fluctuates less than1% daily. The brain detects changes in the concentration of electrolytes in the blood, and releases hormones to either conserve or excrete water.

- How much would this be for you?
- What is your weight and what is 1% of that weight?

These subtle changes allow the body to maintain homeostasis. Hormones are used to either excrete more urine or concentrate urine when more fluid is needed in the body. The level of hydration changes throughout the day, but the body can regulate itself over a 24-hour period. This is why your urine can be different colours during the day. Don’t flush before you have had a peek to see what colour yours is.

A urine colour chart can be useful (Figure 2). Dr Lawrence Armstrong published the first validated urine colour chart in 1994. There are eight colour scales, 1–3 being normal. The darker the urine, the more concentrated it is. A pale straw colour is what you would expect for normal hydration.

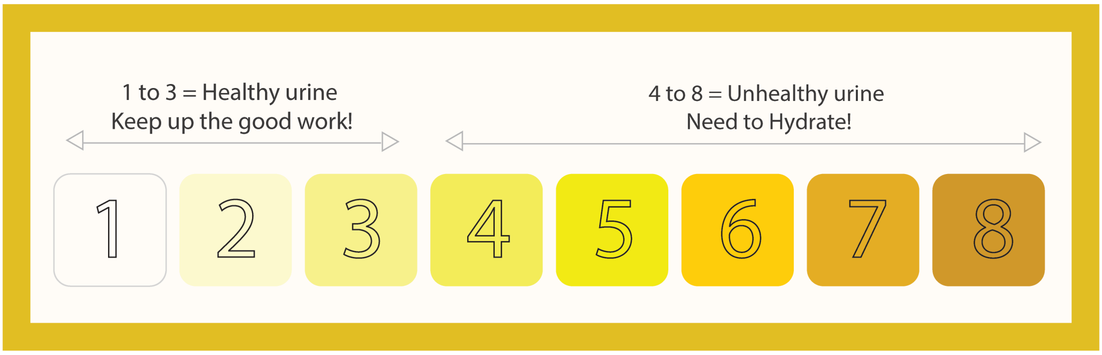

Figure 2 A typical urine colour chart.

Activity 2 Check your hydration status

Allow approximately 15 minutes.

To check your hydration status, you could collect your urine in a clear cup and compare it against the urine colour chart. Have a look at different times of the day: for example, first thing, during the day and last thing at night.

Please note: certain foods you eat may colour your urine (for example, beetroot or asparagus). You may also find this happens with certain medications. Always check the medicine leaflet, so you are not alarmed when you check your urine.

3 How much should you drink?

Current guidelines in the Eatwell Guide are six to eight glasses of fluid daily. This equates to 2000 ml for men and 1600 ml for women from drinks alone. This includes children 14 years old and above. Don't forget that 20–30% of your fluid intake is from food.

Figure 3 shows some average amounts in different containers.

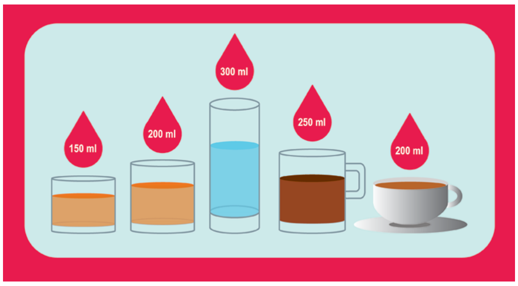

Figure 3 Examples of fluid measures.

What are the average measures for the containers you use? Make a note as this will help you monitor how much you drink throughout the day.

Activity 3 Daily intake

Allow approximately 20 minutes.

Keep a two-day diary, so that you can average what your daily intake is.

Are there particular times you tend to drink more or less? Do you drink with food?

Click 'Save' when you are satisfied with what you have written.

Provide your answer...

Is it thirst or habit that makes you drink?

Click 'Save' when you are satisfied with what you have written.

Provide your answer...

What is your style of drinking – gulping or sipping?

Click 'Save' when you are satisfied with what you have written.

Provide your answer...

Is it enough?

Click 'Save' when you are satisfied with what you have written.

Provide your answer...

What colour is your urine related to how much you drink?

Click 'Save' when you are satisfied with what you have written.

Provide your answer...

You will look at the types of drinks later, so just consider how much you are drinking for now.

4 What should you drink?

Health advice on the types of fluid to drink include water, milk (lower fat varieties if required), sugar-free drinks, tea and coffee (Figure 4). Some drinks such as fruit juice and smoothies contain free sugars. It is recommended that you have no more than 150 ml of these a day (this also contributes to one of your five a day). Alcohol also contributes to fluid intake but you will learn more about that later.

Figure 4 Examples of drinks.

It is always worth considering the energy value of the drinks you have because this contributes to your overall dietary energy for that day. There are calls for a sugar tax on drinks to reduce the incidence of obesity. Looking at food labels of different drinks can be very enlightening. Some drinks that you may have considered healthy can have a lot of naturally occurring or added sugars.

Activity 4 Sugar tax

Allow approximately 25 minutes.

Read the article Soft Drinks Industry Levy: 12 things you should know (Gov.uk, 2016). Then note your answers to the following questions.

- Is the sugar tax on drinks a good idea or not?
- What about dental health?
- Which foods affect the health of your teeth and gums?

Click ‘Save’ when you are satisfied with what you have written.

Provide your answer...

Should you sip or gulp your drinks? Drinking all of your fluids for the day at once may not be the best way of hydrating yourself. The kidneys will eliminate extra fluid at any particular time. Thus, having regular drinks throughout the day is recommended.

Fluid from food also contributes to your daily intake. You may find that you are less thirsty with a more liquid meal compared with a dry meal.

It is possible to have too much fluid. This is called water intoxication and can occur if a large amount of fluid is taken in over a short period of time. In this case, the blood volume increases and dilutes certain electrolytes, especially sodium, causing hyponatremia (normal levels are 135–145 mmol/L). Low extracellular sodium levels force fluid inside cells, making them swell. In the brain this swelling can be dangerous and, in extreme situations, can be fatal. Don't worry: you would have to drink a lot of fluid in a very short space of time and most people don't do that.

You have already looked at how much you drink. Now consider the following questions.

- What do you tend to drink?
- What do you think most people drink in the UK?

5 Caffeine intake

Fluids and foods containing caffeine can have a diuretic effect. The European Food Safety Authority (2015) suggests safe daily limits of 400 mg for adults and no more than 200 mg for women who are breastfeeding or pregnant. Coffee is also a stimulant and can be addictive in larger quantities.

Caffeine is found in coffee, tea, cola, chocolate and energy drinks, as well as some medications.

The average caffeine content of some common drinks is as follows:

- instant coffee: 100 mg per mug
- filter coffee: 140 mg per mug
- cola: up to 40 mg per can
- energy drinks: up to 80 mg per can.

Dark chocolate contains about 43 mg caffeine per 100 g; milk chocolate has less at about 20 mg per 100 g; white chocolate has no caffeine. Also, it is important to remember the fat and sugar content of the various chocolates.

Some medications also contain caffeine, for example some formulations of paracetamol and cold and flu remedies. The popularity of caffeine tablets with caffeine contents from 100 to 200 mg can cause concern if they are misused as a method for weight loss or keeping psychologically active.

Activity 5 Caffeine intake

Allow approximately 10 minutes.

- How much daily caffeine do you estimate you ingest?
- Is it more than the recommended amount?
- What else could you have instead of coffee if you need to reduce your intake?

Click ‘Save’ when you are satisfied with what you have written.

Provide your answer...

6 Effects of dehydration

Figure 5 The difference between hydration and dehydration.

Medical dictionaries define dehydration as the excessive loss of body water due to restricting fluid intake, sweating, diarrhoea, vomiting and certain medications. Dehydration is classified according to water weight loss as mild (1–2%), moderate (5%) and severe (10%). Dehydration is defined as a 1% or greater loss of body mass when there is no weight loss due to a negative energy balance. For example, you may be trying to lose weight and following an eating pattern that means you are eating less energy from food than you are using in your activity levels.

Controlled fluid restriction experiments have shown that it can only take 13 hours for 1% dehydration, 24 hours for 2% dehydration, and 3% after 37 hours. Ethically, it was not safe to continue the experiment but it did demonstrate how quickly dehydration can happen.

The symptoms of dehydration depend on the degree of dehydration.

- Mild to moderate dehydration has symptoms such as constipation, dark urine, headache, increased thirst and dry mouth, muscle tiredness and general tiredness.
- Fluid losses of 2% or more can reduce mental (cognitive) performance.
- Regular inadequate fluid intake can contribute to chronic kidney (renal) disease.
- Older people are at increased risk of dehydration which can lead to confusion and even hospitalisation.

Diarrhoea and vomiting can also cause dehydration. Therefore, fluid and electrolytes should be replaced.

Activity 6 Are you dehydrated?

Allow approximately 20 minutes.

Are you aware of the Bristol Stool Chart? Search online for it and see what type you tend to have.

Now answer the following questions.

- Have you ever experienced symptoms of dehydration?
- Why do you think you became dehydrated?
- Is it possible to have too much water?

Click 'Save' when you are satisfied with what you have written.

Provide your answer...

7 Physical activity and fluid intake

Physical activity is important. The more active you are, the more fluid you require. This is because more fluid is lost in sweat and physiological processes. The environmental conditions of this physical activity also have an effect (that is, temperature, humidity and altitude). Swimming can dehydrate you, even though you are surrounded by water!

It is important to be well hydrated before, during (ideally, sip every 20 minutes) and after any activity. Sports drinks may be more beneficial if you exercise for more than an hour.

Activity 7 Fluid intake

Allow approximately 10 minutes.

So what is more effective at hydrating? Water, of course, or is it? Consider the following questions.

- What do you tend to drink?
- What do you feel hydrates more effectively?
- Are there any drinks that may not be as good for you?

Click ‘Save’ when you are satisfied with what you have written.

Provide your answer...

8 Alcohol intake

Alcohol is a liquid, so should it be part of your fluid intake?

Although alcoholic drinks contain water, alcohol has a diuretic effect. Spirits and wines tend to dehydrate because there is a higher alcohol content and lower water content. Consider the alcohol content and the amount of water a full strength or low strength beer, lager and cider may have. Which one could hydrate more effectively? Technically the low strength as it has less alcohol content and more water. However, alcohol provides 7 kcal/g of energy and does contribute to your energy intake, as do some other energy-containing drinks. Alcohol may also increase your appetite in the short term. Alcohol goes to every cell in the body and can have physical and social effects. It can take approximately one hour to process one unit of alcohol until there is none left in your bloodstream. However, physiological factors can make this vary from person to person.

Overall, the content of alcohol in these drinks outweigh the beneficial hydration effects. Therefore, it is best not to use alcoholic drinks as part of your overall fluid intake.

8.1 How much alcohol should you have?

The UK Chief Medical Officer gives these low-risk guidelines:

A maximum of 14 units a week for both women and men, remembering to spread them throughout the week with some alcohol-free days (no binge-drinking all of your units).

What is a unit of alcohol?

One unit is 10 ml or 8 g of pure alcohol in the UK. But different alcoholic drinks come in different strengths and sizes, so it can be difficult to be aware of how much alcohol you are having (Figure 6).

Figure 6 Examples of one unit of alcohol. (Drinkaware, 2016)

Some drinks are labelled ‘ABV’, which means ‘alcohol by volume’. This is also sometimes written as ‘vol’ or ‘alcohol volume’. Again, this makes it difficult to determine how many units of alcohol you are having.

Activity 8 Working out your units of alcohol

Allow approximately 10 minutes.

The formula for working out units using ABV is: Strength (ABV) × volume (ml) ÷ 1000 = units

How many units are there in a pint of strong lager (ABV 5.2%)?

Try to work it out rather than using a unit calculator. Work out the units you drink when you go out compared with having alcohol at home.

Click 'Save' when you are satisfied with what you have written.

Provide your answer...

9 This week's quiz

Check what you've learned this week by taking the end-of-week quiz.

Week 3 quiz

Open the quiz in a new window or tab, then return here when you have done it.

10 Summary

This week you learned that hydration is very important for your mental function and physiological processes.

You should now be able to understand:

- what hydration is required physiologically, including what hydration is and how much you need
- how much and what you drink and whether it is enough
- dehydration and its consequences
- exercise and hydration
- whether alcohol is part of your fluid intake.

Water is the only fluid you are advised to drink freely. But you can have too much fluid, which causes hyponatremia. The recommended daily oral fluid intake for adults is 1.6 litres for women and 2 litres for men.

You also learned that approximately 20–30% of your fluid requirements come from food, which means women have 2 litres and men have 2.5 litres overall.

You also looked at dehydration, which is defined as 1% or greater loss of body mass due to fluid loss.

The simplest way to check your hydration level is from the colour of your urine.

Next week, you will look at food labels. You will find out how manufacturers measure and communicate what is in your food. This is particularly important to people who have allergies and food intolerances. You will also carry out an experiment to discover how much energy is in a peanut.

You will end the week by looking at how much of each nutrient you should be consuming and thinking about what makes a healthy snack.

You can now go to Week 4.

Week 4: What do food labels tell us?

Introduction

Welcome to Week 4 of the course.

This week, you will be learning about the information given on food labels.

By the end of this week's study you should be able to understand:

- what the regulations are for food labelling
- how food is analysed and the food tables
- the traffic-light system for food labelling
- the claims made on packaging.

In the following video, Audrey Brown from The Open University finds out whether some members of staff at the University look at food labels and what they look for on them.

Video content is not available in this format.

Over the last three weeks we've looked at the components of food and what happens to food after you eat it. You have also looked at the importance of hydration for your body and mind. This week, we will look at the parts of a food label – ingredients, nutritional information and reference intake or guideline daily amounts – and try to make sense of the numbers.

Food labels were mentioned in Week 1 and we asked you to start collecting some. Since then, you have learned some more about food and the importance of its components.

- Do you look differently at food labels now?
- How much of the information on it do you understand?

1 What is in my food?

Manufacturers must list the ingredients for a food or drink product if it has two or more ingredients. These must be listed in order of weight, with the main ingredient first. If water has been added, that also appears in the ingredient list.

You will see that a percentage value is sometimes given for some ingredients in the list (Figure 1). Look at a few food packages and see if you can find any examples of this.

Figure 1 Back label on packaged food, showing percentages

Activity 1 UK labelling rules

Allow approximately 10 minutes.

What rules do you think lead manufacturers to include the percentage value for a particular ingredient?

Write one or two sentences in the box below. Click ‘Save’ when you are satisfied with what you have written.

Provide your answer...

1.1 Percentages

The UK government states that the percentage of an ingredient must be shown if it is:

- highlighted by the labelling or a picture on the package, for example ‘extra cheese’
- mentioned in the name of the product, for example ‘cheese and onion pasty’
- normally connected with the name by the consumer, for example fruit in a summer pudding.

Did you identify all of these factors in Activity 1? Do you think manufacturers should give percentages for any other ingredients? Should they give percentages for all of them?

Figure 2 Back label highlighting the main ingredients of corn, palm oil and salt

Manufacturers should know roughly the percentage of all the ingredients in their product, if the ‘recipe’ is followed accurately during the manufacturing process. This is one method they could use to complete the details in the ‘Nutritional information’ part of the food label.

2 Chemical analysis

Although manufacturers are not required to provide the percentage of all ingredients, they are able to use their knowledge of the 'recipe' to work out how many grams of the various components (fat, carbohydrate, protein, etc.) are in the finished product. They need to make allowances for any changes that occur during production: for example, water lost during baking.

Manufacturers need to know the data for each ingredient. For example, how much protein is in the flour used for making bread. This can be done by chemical analysis of the dried product in a laboratory (Figure 3).

Figure 3 Chemical analysis of ingredients being done in a laboratory

Proteins contain the chemical element nitrogen, which is not present in significant amounts in carbohydrates and lipids. The nitrogen in the protein can be converted into ammonia which can be measured. This can then be used to calculate how much protein was originally present. Another technique causes the protein to react with a chemical which causes a colour change. Spectroscopy is then used to detect the colour change.

Similarly, for fat, solvents can be used to extract all the fat from a sample of the food. The extracted fat can then be chemically analysed, usually by techniques such as chromatography.

Now, life could be simpler. If you know how much protein and fat is in your component, by subtraction, the rest must be (almost entirely) carbohydrate and fibre. Different enzymes can be used to break down known types of carbohydrate into sugars, which can then be measured. And the rest must be fibre.

The processes involved are much more complicated than described here. But this should give you an idea of how food can be analysed in a laboratory.

2.1 Using the laboratory data

Of course, the process of analysing foods in a laboratory is too slow and expensive to be used all the time. Once a particular food has been analysed, that data can be made available to other people. The Food Standards Agency and Public Health England produce a book called *The Composition of Foods*, which collects this data (Figure 4). It is currently in its seventh summary edition, published in 2014. It is more commonly known as McCance and Widdowson because of the names of its original authors. Be aware that McCance and Widdowson is aimed at food professionals, not members of the general public.

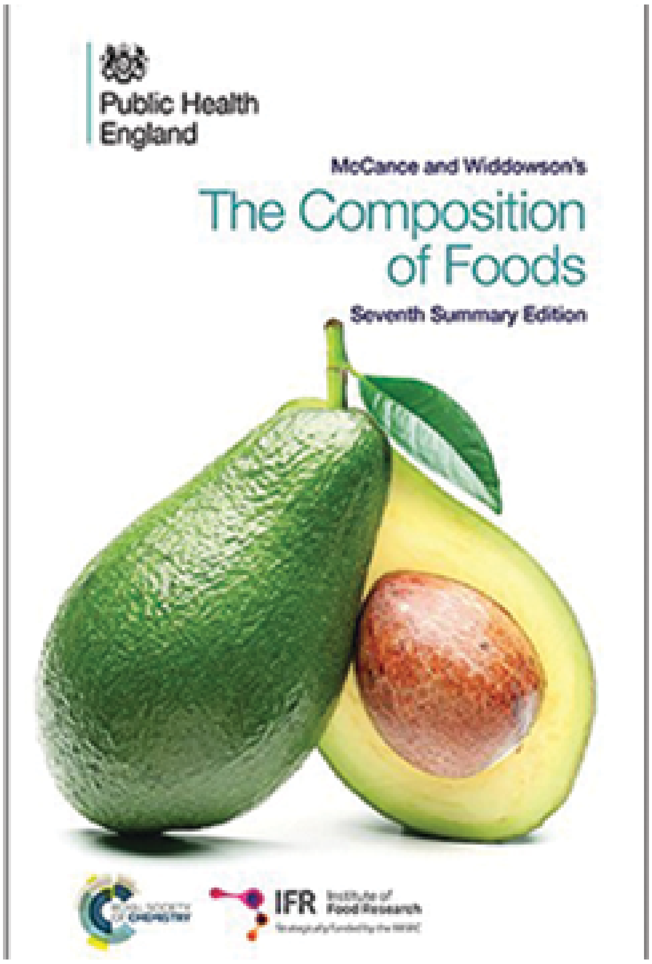

Figure 4 Food data book by McCance and Widdowson containing tables of nutritional values

The data book contains tables in which you can look up the data for any food you like, for example:

- cereals and cereal products
- eggs and egg dishes
- fruit, nuts and seeds
- herbs and spices.

The tables give the full analysis of each food or food product. This includes not only the protein, fat and carbohydrate content (including the breakdown of the fat and carbohydrate types) but also the vitamins, salt, etc. Small businesses producing only few foods can buy just the relevant chapters of the book online.

An enterprising company has produced software that makes the information from McCance and Widdowson more easily available. For any recipe, you can enter the quantity of each ingredient into the program and it will automatically produce the nutritional data. This can then be displayed in the various different forms that are used on food packaging. If you should want to change your ingredients to produce a low-fat or low-salt version of your recipe, you can try different combinations of ingredients with the software to get an immediate analysis.

The one type of food for which it is not recommended that you use anything but chemical analysis of your product is fried foods. Why do you think fried foods are not ideally suited to being analysed using data tables?

3 Presenting the data on the packaging

When food is fried, it is very difficult to know how much fat is absorbed in the frying process. You would miss this by just analysing the food itself before it was fried. So laboratory analysis is needed for the fat content.

The nutritional content of most other foods can be determined from data tables. Of course, the numbers can never be absolutely accurate. For example, one pack of sandwiches might contain slightly more lettuce, or an extra slice of tomato, compared with another pack. Or the amount of protein in the flour used to make the bread might vary slightly. So, if you checked one pack of sandwiches against another, you might find up to a 10% variation from the numbers given on the pack.

Look at the food labels which you have collected. You will notice that the nutritional information is given both per portion (per bar, serving, pot, pack, etc.) and per 100 g (Figure 5).

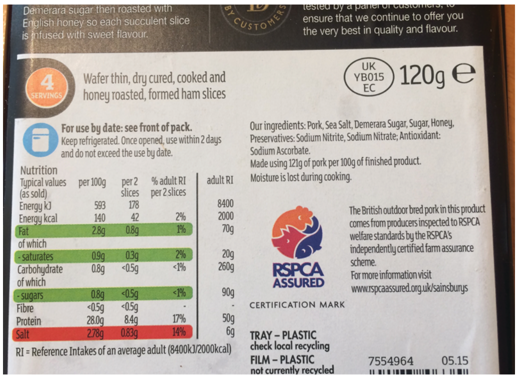

Figure 5 Back label with a column for 'per 100 g' and another for 'per 2 slices' as a serving

Activity 2 Benefits of having more detailed information

Allow approximately 10 minutes.

Answer the following questions.

- Do you think it is useful to have two columns of information i.e. per 100 g and per serving?
- Does it help you personally in your choice of foods?

Write your answers in the box below. Click 'Save' when you are satisfied with what you have written.

Provide your answer...

4 Allergens

You may or may not find it useful to have the food amounts given per 100 g. However, there is little debate about the importance of highlighting substances in the food which people might be allergic to – the allergens.

Our immune system enables us to fight off invading organisms, mostly bacteria and viruses. These can enter the body through our food, in the air we breathe, via our skin, etc. This is a very complex process but it involves the body producing antibodies, a type of protein, that bind to any molecules the body recognises as not belonging to itself.

These invading molecules are called *antigens*. They are often present on the outside coat of a bacterium or virus, for example. The attachment of the antibodies to the antigens triggers a cascade of reactions, which should eventually destroy the invading organism. This may take some time, during which, the person may show symptoms of a disease caused by the infecting organism.

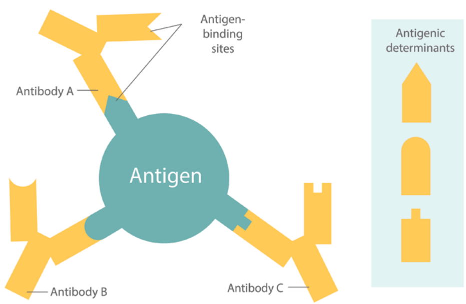

Figure 6 Antigens

Sometimes, the immune system may need some help with antibiotics if it is a bacterial invasion, or antiviral drugs if it is a viral invasion, to help vanquish the invader. Usually, however, the person recovers which primes the immune system. A subsequent attack by the same organism will be much less severe and there may not be any symptoms at all.

Occasionally, something goes wrong with the immune system, and the body reacts to a completely harmless molecule as though it is a dangerous invader. It is not clear why this happens but, when it does, it is called an allergic response. The molecule that triggers it is called an allergen.

Depending on the person and the severity of the allergy, the symptoms of an allergic response can range from itchy skin and swollen lips and mouth, to wheezing, shortness of breath, vomiting and diarrhoea, etc. In some cases, very small amounts of an allergen, such as nuts, can cause a severe reaction called anaphylactic shock. This leads to collapse and unconsciousness, which constitutes a medical emergency and can be fatal.

There is now a list of foods (given below) that are allergenic in some people. European Union (EU) food regulations require that if a food contains any of these allergens, the 'allergenic ingredients need to be emphasised using a typeset that clearly distinguishes it from the rest of the ingredients, for example by means of the font, style or background colour' (European Commission, 2018).

Figure 7 shows an example of this on the food packaging of biscuit bars.

Figure 7 Allergens highlighted in an ingredients list

The EU regulations list:

- cereals containing gluten, namely wheat (such as spelt and khorasan wheat), rye, barley and oats
- crustaceans, namely prawns, crabs, lobster and crayfish
- eggs
- fish
- peanuts
- soybeans
- milk – including lactose
- nuts – namely almonds, hazelnuts, walnuts, cashews, pecan nuts, Brazil nuts, pistachio nuts and macadamia (or Queensland) nuts
- celery – including celeriac
- mustard
- sesame
- sulfur dioxide or sulfites used as a preservative in dried fruit – when added at a level above 10 mg/kg or 10 mg/L in the finished product
- lupin – including lupin seeds and flour which can be found in types of bread, pastries and pasta
- molluscs – including mussels, whelks, oysters, snails and squid.

In the UK, new allergy advice about food products which are sold loose came into force in December 2014. And now, foods which are sold unpackaged in catering outlets, delicatessens, bakeries, sandwich bars, etc. must also provide allergen information.

5 Food additives

Certain chemical additives in food are permitted. These are also listed in the ingredients. Table 1 shows why permitted additives are included in foods.

Table 1 Effects of food additives

Additive	Effect
Colouring	Improves the appearance of the food.
Flavouring	Improves the taste of the food.
Sweetener	Makes the food taste sweeter – artificial sweeteners are used to sweeten 'diet' foods.
Emulsifier	Stabilises mixtures containing oil and water.
Preservative	Stops the growth of microbes – such as bacteria or moulds– in food, giving it a longer 'shelf life'.
Antioxidant	Stops chemical reactions in food that make it go stale.

Food additives that have been approved by the European Food Safety Authority are given E numbers (the 'E' stands for Europe). Some additives are natural and some are artificial. Vitamin C has the number E300 and vitamin B2 (riboflavin) is E101, so it is not necessarily good to have a food that is free of all E numbers.

There may be health hazards linked to some food additives. The most widely known link is between certain food colourings and hyperactivity in children. However, the precise mechanism of that link is not understood. Similarly, there appear to be links between the increased inclusion of additives in food and an increase in childhood asthma and other medical conditions. Research into whether there is a direct causal link continues.

You can find out more information about food labelling and packaging on the Gov.UK website (Gov.uk, 2018).

6 Traffic-light system

You will notice in Figure 8 that the nutrient values are coloured red, amber or green, depending on whether the value is high, medium or low. Table 2 shows the values for each colour per 100 g of food product. These values are based on the Scientific Advisory Committee on Nutrition (SACN). You can find out more using this link (Gov.uk, 2018b).

Figure 8 Examples of how traffic-light colours are used on food packaging

Table 2 Low, medium and high values per 100 g in Figure 8

Substance	**Green (low)**	**Amber (medium)**	**Red (high)**
Fat	less than 3 g	between 3 g and 17.5 g	more than 17.5 g
Saturated fats	less than 1.5 g	between 1.5 g and 5 g	more than 5 g
Sugar	less than 5 g	between 5 g and 22.5 g	more than 22.5 g
Salt	less than 0.3 g	between 0.3 g and 1.5 g	more than 1.5 g

The limits for 100 ml of drinks are half those given for 100 g of food – except for the salt value, which is unchanged.

The advantage of this way of presenting the data is that shoppers can see at a glance which are ‘healthier’ foods, without having to check the percentages. Manufacturers were originally concerned that shoppers might stop buying foods that were classed as red. Some were reluctant to adopt the traffic-light system. However, it has now been adopted by many.

7 Eating like a horse!

In November 2014, a ‘Double Donut’ burger made the headlines in the UK (BBC News, 2014). According to the company selling this burger, the full nutritional composition is that shown in Table 3.

Table 3 Values for the ‘Double Donut’ burger

Nutrition type	Energy or mass
Energy	1996 kcal
Fat	125 g
Saturates	53 g
Salt	8.20 g
Sugar	53 g
Carbohydrate	138 g
Protein	75 g

With this in mind, think about the following questions:

- How do these values compare with the recommended intake values?
- Is it ethical for a restaurant to be selling a burger like this?

8 Packaging claims – to confuse the unwary shopper

Many food products make claims on the packaging such as ‘high protein’, ‘balanced carbs’, ‘high fibre’, ‘contains calcium – good for bones’ or ‘low fat’ (Figure 9). These claims are now regulated by EU legislation and must have scientific evidence to support them.

Figure 9 Typical attention-grabbing claims on food packaging

The European Food Safety Authority produces a list of approved health claims allowed on food. Scientific evidence must be provided for any others. Examples of approved health claims include:

- beta-glucans contribute to the maintenance of normal blood cholesterol levels
- calcium is needed to maintain normal bones
- folate contributes to maternal tissue growth during pregnancy
- iron contributes to reducing tiredness and fatigue.

Where a particular ingredient is mentioned, the amount of it must be given in the nutritional information on the pack.

However, this may still confuse unwary shoppers. As mentioned in Week 1, the low-fat versions of some yoghurts may have more sugar than the full-fat version. Low-fat foods must have less than 3% fat but they can have any amount of other nutrients. The ‘reduced-fat’ label can be even more confusing. Reduced-fat food must have 30% less fat than the manufacturer’s standard product, but it can still be high in fat.

Many food outlets now post the full nutritional information online. For example, a ‘skinny’ blueberry muffin from a well-known coffee chain contains only 2.5 g of fat, compared with 23.1 g in the classic blueberry muffin. But it still contains 24.6 g of sugar, which is over a quarter (27%) of the RI value. In terms of energy, the skinny muffin still provides 317 kcal – about 16% of the RI value!

9 Do you look at food labels differently now?

In the next activity, you can reflect on how you now look at food labels.

Activity 3 Learning from food labels

Allow approximately 10 minutes.

Figure 8 (repeated) Do these labels convey more information now?

We started this week by asking how you look at food labels. Do you look at them any differently now? And, if so, how?

Write two or three sentences in the box below. Click ‘Save’ when you are satisfied with what you have written.

Provide your answer...

10 This week's quiz

Now it's time to complete the Week 4 badge quiz. It is similar to previous quizzes, but this time instead of answering 5 questions there will be 15.

Week 4 quiz

Remember, this quiz counts towards your badge. If you're not successful the first time, you can attempt the quiz again in 24 hours.

Open the quiz in a new window or tab, then return here when you have done it.

11 Summary

This week, you looked at food labels and how they should appear on packaging. Next week, you will look at energy from food and how sweeteners are used in our food.

You should now be able to understand:

- what the regulations are for food labelling
- how food is analysed and the food tables
- the traffic-light system for food labelling
- the claims made on packaging.

You are now half way through the course. The Open University would really appreciate your feedback and suggestions for future improvement in our optional end-of-course survey, which you will also have an opportunity to complete at the end of Week 8. Participation will be completely confidential and we will not pass on your details to others.

You can now go to Week 5.

Week 5: Energy from food and sweeteners

Introduction

Welcome to Week 5 of the course.

This week you will get a better understanding of the energy from food and how sweeteners are used in our food and drink.

By the end of this week's study you will understand:

- the difference between calories and joules
- how each food group contributes to the energy in your food and drink
- how to work out the energy in food
- the reference values of the different food groups.

Figure 1 is an image of a bomb calorimeter, which you will learn more about in the next sections.

Figure 1 A bomb calorimeter.

1 How much energy is in food?

The top of the nutritional information on a food label usually shows you how much energy the food contains. It will be given in both *joules* and *calories*. These are just two different ways of measuring energy – similar to how you can measure length in either inches or centimetres.

The unit of energy is named after James Prescott Joule, who was born in Salford, Lancashire in 1818. As an adult, he took over from his father as manager of the family brewery. Science was just a hobby.

Figure 2 image of James Joule.

Joule was fascinated by different types of energy and how one could be converted to another. Particularly puzzling was how the energy generated by, say, a falling weight could be converted to heat.

On his honeymoon in the Swiss Alps, Joule took a very accurate thermometer with him to measure the temperature of the water at the top and bottom of a waterfall. He wanted to work out how much heat was generated by the falling water. (There is no record of what his new wife Amelia thought about his honeymoon activities.)

Figure 3 shows the apparatus Joule built for one of his other experiments. The 'box' on the left contains water and a paddle that is turned by the falling weight and a thermometer measures the temperature rise of the water.

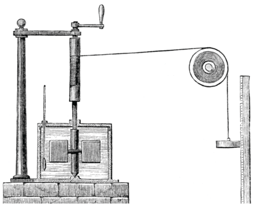

Figure 3 Joule's apparatus for measuring the mechanical equivalent of heat.

In 1889, Joule died and on his tombstone the number 772.55 is engraved. This was the value he calculated for the energy in foot-pounds that would cause a temperature rise in one pound of water from 60 to 61 degrees Fahrenheit. One foot-pound is the energy produced when one pound in weight falls by a distance of one foot.

When the modern SI system of naming units was formalised, pounds were replaced by kilograms and feet by metres. The equivalent unit of energy was called a joule, after this great scientist.

One joule is a very small amount of energy. It is approximately the energy released when a small apple falls one metre to the ground. So, generally we work with the unit of a kilojoule (one thousand joules). One kilojoule (kJ) would heat one kilogram (one litre) of water by 0.24 °C.

Also on the food label, and commonly used when discussing food and nutrition, is the energy value in kilocalories (kcal). Sometimes, you may see the unit that should correctly be called a kilocalorie is instead called a Calorie, with a capital C. When people talk about how many 'calories' there are in food, they generally mean kilocalories.

Despite the calorie not being an SI unit, it has remained in common usage. It was first defined by Nicolas Clément (1779–1841), who lived in France at about the same time as Joule. The name is derived from the Latin word calor, meaning 'heat'. It has the advantage of being rather convenient in experimental situations.

1.1 How do we find out the energy in food?

Figure 4 is a cross-section through the apparatus that is used to find the amount of energy in food. It is called a *bomb calorimeter*.

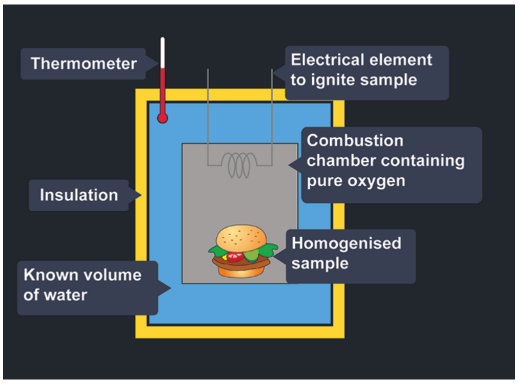

Figure 4 Diagram of a bomb calorimeter for measuring the energy in food.

The ‘bomb’ refers to the thick-walled container used, which is filled with pure oxygen at a pressure of about 30 atmospheres. The food has to be homogenised, dried and weighed before being put into the chamber. You can’t use a whole burger like this!

When the power is switched on, the electrical element causes the sample to burn completely in the oxygen. The heat given off by the burning food heats up the water surrounding the chamber. The temperature rise is detected by the thermometer.

From this temperature increase, and the volume of the water, the amount of energy given off by the combustion of the food can be calculated. The number of kilocalories in the food can be calculated easily because 1 kilocalorie will raise the temperature of 1 kilogram of water by 1 °C.

However, it is not quite this simple. Combustion in a bomb calorimeter burns everything in the sample and all the energy is released. But this is not the case in the human body. Dietary fibre, for instance, is not used for energy in the body but passes through unchanged. So the value on the food label is usually about 85% of the value obtained by calorimetry.

The typical calorie content of the main food types is shown in Table 1.

Table 1 Calorie content of foods

Food type	Energy (kcal/gram)
Fat	9
Protein	4
Carbohydrate	4
Alcohol	7

1.2 How many kilocalories in a peanut?

If you can do the following experiment, you should get a rough idea about how many kilocalories there are in a peanut.

This experiment involves burning a peanut, so you need to take the appropriate precautions. If necessary, ask someone to help you. It is probably best done outside on a calm day because quite a lot of smoke might be produced. If you cannot do this experiment, you might still be able to follow the ideas and try the calculations.

Activity 1 Measuring energy in food

Allow approximately 45 minutes.

Equipment and materials

- a peanut – ideally the fresh ones you can buy in their shells or for feeding to birds. These work much better than salted peanuts
- a cork
- a sewing needle

- some aluminium foil
- an old metal tablespoon
- some water
- a lighter or matches.

Method

Video content is not available in this format.
Please note this video has no audio.

1. Push the eye of the sewing needle carefully into the end of the cork, and spike the peanut onto the sharp end. This will allow you to hold the peanut while it burns, so you don't burn your fingers.
2. Place some aluminium foil underneath where you will burn the peanut, so that bits falling off the peanut won't cause any damage.
3. Fill the tablespoon with water and set it to one side. This is the equivalent of the jacket of water around the bomb calorimeter.
4. Use a lighter or a match to set the peanut alight. This may take a few attempts.
5. Once the peanut is burning steadily, hold the spoonful of water over it. Watch carefully to see if you can get the water hot enough for it to boil.

Remember that everything will get hot once your peanut is alight. Please be careful!

So, can you use a peanut to boil your tablespoon of water?

1.3 Some numbers

We hope you enjoyed doing Activity 1 and managed to get your water up to boiling point. Now, let's do the calculation.

First, you need to know the mass of water in kilograms on your spoon. A normal tablespoon holds about 15 millilitres of water. Since 1 millilitre of water has a mass of about 1 gram, that's about 15 grams. You need to divide the mass of water in grams by 1000 to get the mass of water in kg.

Now, you need to estimate the temperature of the water when you started. In the UK, water that comes straight from the tap is usually about 10 °C, but this will, of course, vary according to your circumstances. Water boils at 100 °C, so by subtraction, you can work out the temperature rise in °C. As you found in How do we find out the energy in food?, you can calculate the energy in kilocalories (kcal) by multiplying the rise in temperature by the mass of water in kg.

So, how many kilocalories did your peanut contain?

1.4 Scientific uncertainty

In the next activity you will think about the accuracy of the experiment in Activity 1.

Figure 5 Part of experimentation is estimating uncertainties.

Activity 2 Reasons for uncertainty

Allow approximately 10 minutes.

There are all sorts of reasons why Activity 1 is not a really accurate scientific measurement. Think about these reasons. Is there anything you could do to reduce these uncertainties?

Write two or three sentences in the box below. Click ‘Save’ when you are satisfied with what you have written.

Provide your answer...

Answer

Whenever you do a scientific experiment, there are always uncertainties. It is never possible to measure everything with perfect accuracy. One of the skills of a practical scientist is estimating how close your result is likely to be to the perfect value. The uncertainties are pretty big here!

You probably considered:

- the uncertainties in measuring the volume (and, therefore, the mass) of water in your spoon
- the issue in determining the exact starting temperature of the water
- the fact that the peanut did not burn away completely – some energy must have been left in the peanut
- the fact that some of the energy from the peanut did not go into heating the water, but went into heating the spoon, whatever you held the peanut with and the air around it.

The ‘official’ value for the energy from one whole peanut is just over 7 kcal. How does your result compare with that?

2 Calories and joules

You probably calculated that you got only 2–3 kcal of energy from your peanut. If so, you only used well under half of the energy of the peanut to heat your water. If you ate the peanut, your body would use a much higher percentage of the energy.

If you compare the values on a food label, you will see the numerical value for the energy given in kilojoules is much bigger than the numerical value given in kilocalories. So, the kilojoule is a smaller unit (Figure 6).

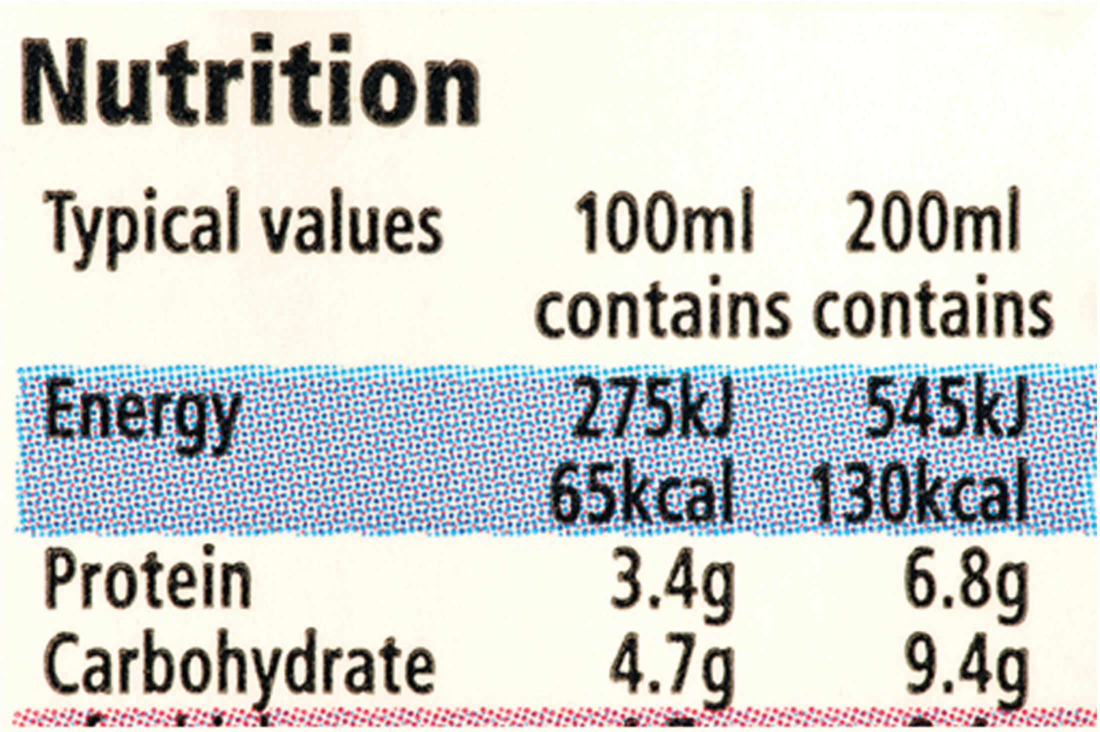

Figure 6 Kilojoules compared with kilocalories.

Activity 3 Unit conversion calculation

Allow approximately 10 minutes.

For this activity you will need a calculator.

Work out how many kilojoules there are in one kilocalorie, based on the numbers from a food label. (Hint: you need to enter a number given in kJ and divide it by the equivalent number in kcal.)

What is the conversion factor? Write two or three sentences in the box below. Click 'Save' when you are satisfied with what you have written.

Provide your answer...

Answer

To convert kJ to kcal, you need to divide by 4.2; to convert kcal to kJ, you need to multiply by 4.2.

3 How much food do we need?

Have you ever thought that most people go through life without ever knowing how much of the various sorts of nutrients, including vitamins and minerals, they actually need? And yet they manage to obtain just the right amount of nutrients to stay healthy.

The human body has an amazing ability to keep the nutrients it needs and dispose of those it does not. As long as we eat a reasonably mixed diet, most people need not worry about precisely how much of the various nutrients they take in. However, today, with tempting foods everywhere in developed countries, the main concern is that we take in too much of some of the dietary components, rather than not enough.

3.1 Physiological requirement

Our bodies use a certain amount of nutrients each day. This needs to be replaced or taken from the body stores.

Figure 7 Food labels can help to estimate the daily intake of nutrients.

The amount of each nutrient used each day is called the physiological requirement. This is the amount required to prevent any signs of clinical deficiency. However, this leaves no margin for safety. It also does not allow for the fact that some people might need more because of their state of health, activity levels, etc.

It is often difficult to define when precisely someone is seriously short of a particular nutrient. This is because there may be no signs or only vague and generalised indicators, such as tiredness or poor skin condition. Instead, nutritionists use values much higher than the physiological requirement. These are called *reference intakes* or RIs.

In 2014, RIs replaced guideline daily amounts (GDAs), which you may still see on older packaging. Can you find examples of both among the labels you have collected or on foods on supermarket shelves?

One reason for replacing the GDAs was that there were several different versions of the guidelines for different groups in the population – men, women and children. Now, there is only one set of RIs. They are based on the maximum amounts needed by an average woman. Can you think of any reasons why RIs are better than GDAs – and any drawbacks to the RI system?

3.2 Reference values

There are also dietary reference values (DRVs) in the UK. These are estimates for energy and nutrients for different healthy populations. But they should not be considered as nutritional recommendations or goals. In 1991, the Committee on Medical Aspects of Food and Nutrition Policy (COMA) set these values.

There are four types of DRV.

- Estimated Average Requirements (EARs): an average where 50% people will require less and 50% will require more for energy or a nutrient.
- Reference Nutrient Intakes (RNIs): meet the needs of 97.5% of that population group.
- Lower Reference Nutrient Intakes (LRNIs): only 2.5% of the population would find this level adequate for health.
- Safe Intake: used when there is not enough evidence to set EAR, RNI or LRNI, but will not have any undesirable effects.

Vitamins and minerals have RNIs and LRNIs.

COMA was disbanded and now the Scientific Advisory Committee on Nutrition (SACN) advises the UK government on diet and health. SACN made revised recommendations in 2011 for energy. A more recent report in 2015 considered carbohydrates, free sugars and fibre. Vitamin D recommendations were also changed in 2016. The aim was to develop food-based guidelines that would contribute to a healthy and well-balanced diet.

There are detailed energy, macronutrients (fat, carbohydrate and protein) and micronutrients (vitamin and mineral) in the British Nutrition Foundation Report (2016).

The development of RIs for food labelling on packaged food reduced the confusion that GDAs had produced. RIs also allow consumers to make better food choices for a healthier diet. RIs are based on an average adult female and are not individualised or age-specific.

Currently, there are no RIs for children, hence food labels are for adults and not children (Table 2). The main criticism of the RI values is that, on products aimed at children, the values given on the packaging are much too high. This may lead to a higher intake than is appropriate. That is particularly worrying in the light of high levels of childhood obesity in the UK and some other countries.

Table 2 Reference intake values

Energy or nutrient	Reference intake
Energy	8400 kJ (2000 kcal)
Total fat	70 g
Saturates	20 g
Carbohydrate	260 g

Total sugars	90 g
Protein	50 g
Salt	6 g

In Table 2, you need to remember that saturates are part of the total fat and sugars are included within carbohydrates. Although there are RI values for six nutrients and energy in Table 2, you will see that only four of them are used on the front-of-pack labels on food. Carbohydrates and protein are missing. This is because most nutritionists consider that these are less important to avoid, whereas high levels of fat, particularly saturated fats, sugar and salt should be avoided by most people. The full nutritional information should still be provided elsewhere on the packaging.

3.3 Calculating RIs

In the next activity you will practise working out reference intake values.

Activity 4 Calculating daily intake

Allow approximately 10 minutes.

1) If a pack of sandwiches contains 7 g of fat, of which 6 g is saturated fat, what percentages of the total fat and the saturated fat are these for the day?

Remember that, to calculate the percentage, you need to divide the number of grams of fat in the sandwich by the RI value before multiplying the result by 100.

○ a) they are each 86% of the fat for the day

Incorrect: try again? You need to deal with each of the values separately, using the information from the Reference Intake table in 3.2. You may find 5.3.2 Reference intake (RI) values useful.

○ b) the sandwiches contain just under 9% of the total fat and 10% of the saturated fat

Incorrect: try again? Check that you are using the correct RI values for your calculation. You may find 5.3.2 Reference intake (RI) values useful.

○ c) the sandwiches contain 10% of the total fat and 65% of the saturated fat

Incorrect: try again? The total fat percentage is correct but check that you are using the correct RI value for saturated fat in your calculation. You may find 5.3.2 Reference intake (RI) values useful.

○ d) the sandwiches contain 10% of the total fat and 30% of the saturated fat

Correct: Because the RI for total fat is 70 g, and the sandwiches contain 7 g, then calculating 7/70 and multiplying by 100, shows that the sandwiches contain 10% of the total fat for the day.

The RI for saturated fat is 20 g and the sandwiches contain 6 g, so a similar calculation (6/20, multiply by 100) shows that the sandwiches contain 30% of the saturated fat for the day. You may find 5.3.2 Reference intake values useful.

2) Consider the data in Table 3 for a chocolate and caramel snack bar.

Table 3 Nutrients and kilocalories in a 100 g snack bar

Energy or nutrient	Reference intake
Calories	448 kcal
Carbohydrate	68.1 g
Protein	4.2 g
Fat	17.4 g
Fibre	1.1 g

Calories in a chocolate and caramel snack bar (62.5 g): 280.6 kcal

- What is the most number of bars that a person could eat without exceeding the daily RI of 2000 calories (kcal)?
- How much fat would they consume if they ate those bars?

○ a) they could eat 4 bars and would consume close to the RI of fat for a day

Incorrect: try again? You may not have noticed that one bar weighs only 62.5 g, not 100 g. So, remember to use the number of calories in one bar. You may find 5.3.2 Reference intake (RI) values useful.

○ b) they could eat 5 bars and would consume just over the RI of fat for a day

Incorrect: try again? You may not have noticed that one bar weighs only 62.5 g, not 100 g. So, remember to use the number of calories in one bar. You may find 5.3.2 Reference intake (RI) values useful.

○ c) they could eat 7 bars and would consume slightly more than the RI of fat for a day

Correct: Because one bar weighs 62.5 g, the amount of calories in one bar is about 280. The maximum number of bars that would provide a calorie count of less than 2000 is , which gives more than 7 bars, but less than 8. Each bar contains just over 10 g of fat (there are 17.4 g of fat in 100 g of the bar), so 7 bars would contain just over the RI value advice for fat of 70 g. You may find 5.3.2 Reference intake values useful.

○ d) they could eat 7 bars and would consume more than 50 g over the RI of fat for a day.

Incorrect: try again? You have correctly calculated the number of bars, but have probably forgotten that each bar contains significantly less than 17.4 g of fat, since each bar weighs only 62.5 g. You may find 5.3.2 Reference intake (RI) values useful.

4 Sweeteners

Figure 8 Different packets sweetener sachets.

Sweeteners are used in some foods to reduce the energy from food, in an attempt to reduce obesity. There have been many headlines about the safety of sweeteners. In 2010, there was a Panel discussion about sweeteners and they came up with ten points in a document called 'The Science of Low Calorie Sweeteners – separating fact from fiction'.

Low calorie sweeteners are food additives that provide a sweet taste with very few calories (Table 4). Click on this link and read the document:
The science of low calorie sweeteners – separating fact from fiction (British Nutrition Foundation, 2010)

Table 4 Sweeteners used in the UK to reduce the amount of sucrose (table sugar) which provides 4kcal/gram

Type of sweetener	**Name**	**E number**	**Acceptable daily intake (ADI)** mg/kg body weight	**Energy provided**	**Comments**
Bulk	sugar alcohols: sorbitol mannitol xylitol	E420 E421 E967	None specified	2.4 kcal/g	Amounts 10g/100g or more require a warning statement as it can lead to gastrointestinal side effects in sensitive individuals.
Intense	saccharin aspartame acesulfame K (ace K)	E954 E951 E950	5 40 9	zero zero	200 times sweeter than sucrose Ace K: cannot be used by people with PKU
Intense	stevia	E960	4	zero	Plant based: 200–300 times sweeter than sucrose
Intense	sucralose	E955	15	zero	600 times sweeter than sucrose

Intense	neotame	E961	None specified	zero	7000 times sweeter than sucrose

4.1 How safe are sweeteners?

There has been a lot of media coverage about the safety of sweeteners. You will note that Table 4 has acceptable daily intake levels for some sweeteners. The majority of people will not go over the safe levels in a lifetime and food products often contain combinations of sweeteners.

There have been risk assessments on low and no calorie sweeteners (LNCS). The European Food Safety Authority (EFSA) Panel on Food Additives and Nutrient Sources Added to Food (ANS Panel) carries out risk assessments and provides scientific advice on food additives used as sweeteners, including the amounts which can be used.

The amount of sweeteners used in products should not cause any adverse effects, including cancer, affect reproduction, or cause allergic reactions. They should not be stored in the body or metabolised into other potentially unsafe products.

Acesulfame K is clearly labelled as not suitable for people with PKU (phenylketonuria).

It is important to note that foods aimed at children aged up to 3 years old cannot contain sweeteners according to EU law.

Many people use products with sweeteners to help with weight loss or weight maintenance. People also feel they are artificial and it is best to just reduce or avoid foods with a high sugar content. This is very much a personal choice but the regulations that are in place support the safe use of sweeteners in the products we consume or use.

Activity 5 Hunting for the sweetener

Allow approximately 15 minutes.

Have a look in your cupboards and fridge/freezer and make a note of all the food you have that contains a sweetener.

Which foods have you noticed contain sweeteners? Write your comments in the box below. Click 'Save' when you are satisfied with what you have written.

Provide your answer...

You might have noticed that sweeteners can be found in drinks, desserts, jam, dairy products, cereals, ready meals, salad dressings, cakes, chewing gum, alcohol, toothpaste, mouthwash and lip gloss, as well as some vitamins and sugar-free medications. Does it surprise you that sweeteners can also be found in non-food items?

You can find more information about the safety of sweeteners in NHS choices (2018).

A Public Health England report in 2017 sets out a 20% reduction in the use of sugar in products by 2020. The report states:

> All sectors of the food and drinks industry are challenged to reduce overall sugar across a range of products that contribute most to children's sugar intakes by at least 20% by 2020, including a 5% reduction in the first year of the

> programme. This can be achieved through reducing sugar levels in products, reducing portion size, or shifting purchasing towards lower sugar alternatives.

Do you feel it is the responsibility of the food industry to make these changes? Or is it the choice of members of the public to make these decisions for themselves?

You can see the full report on the Public Health England website (2017).

5 This week's quiz

Check what you've learned this week by taking the end-of-week quiz.

Week 5 quiz

Open the quiz in a new window or tab, then return here when you have done it.

6 Summary

This week, you looked at the energy in food and perhaps successfully extracted the energy from a peanut. You are also now more up to date on the debate about sweeteners and safety.

You should now be able to understand:

- the difference between calories and joules
- how each food group contributes to the energy in your food and drink
- how to work out the energy in food
- the reference values of the different food groups.

Next week, you will look at healthy eating advice in the UK and around the world, global nutrition issues (particularly obesity), and diets spanning from wartime Britain to today's food banks.

You can now go to Week 6.

Week 6: What do people eat?

Introduction

Welcome to Week 6 of the course.

Last week you looked at how much energy food contains and the reference values for different components of food. This week, you will consider how all of this fits together as part of a balanced eating pattern.

By the end of this week's study you will be able to understand:

- the Eatwell Guide and dietary approaches in different countries
- vegetarian and vegan diets
- the meaning of malnutrition
- how to measure obesity.

To start you thinking, here are some questions.

- What do you already know about what a balanced eating pattern may mean?
- What healthy eating advice have you heard or seen?
- Do you think that what is portrayed in the media helps with understanding?

In the following video Audrey Brown from The Open University finds out whether some members of staff at the University think they are eating a healthy and balanced diet.

Video content is not available in this format.

1 The Eatwell Guide

There have been various attempts to try to show the constituents of a healthy eating pattern to the general public in the UK. The Eatwell Guide (Figure 1) is a policy tool used to define government recommendations on eating healthily and achieving a balanced diet. It is commonly used and what the government portrays as a visual tool towards healthy eating.

The government website states:

> The Eatwell Guide is a policy tool used to define government recommendations on eating healthily and achieving a balanced diet.
>
> (Gov.uk, 2017)

Interactive content is not available in this format.

Figure 1 (interactive) The Eatwell Guide

You may notice that not only is food included but also fluid intake. Sweet and savoury snacks are not within the daily suggested proportions and fats are the smallest part. There is information about labelling with a suggestion for choosing foods that are lower in fat, salt and sugars.

The Eatwell Guide is not suitable for children less than 2 years old. From 2 to 5 years, it is expected that children are eating family meals in the same proportions as in the Eatwell Guide.

Activity 1 Understanding the Eatwell Guide

Allow approximately 45 minutes.

Click on the following link where you will find the details on how to use the Eatwell Guide and more about the different food groups. Read the document here (Public Health England, 2016a) and then answer the following questions. Drag each answer into the correct slot.

Answer: 80 g

Some examples are vegetarian meat e.g. mycoprotein-based, soya, beans, pulses, eggs,

One portion

No more than 30 g per day which is seven cubes of sugar.

It used to be the Eatwell Plate but in 2016 this changed to the Eatwell Guide.

Match each of the items above to an item below.

What is the weight of one portion or fruit or vegetable?

If you are vegetarian, what protein sources can you have?

How much oily fish should you eat in a week?

What is the maximum amount of free sugar recommended for adults?

How have the recommendations changed?

You might remember the Eatwell Plate (Figure 2), so why did it change?

Figure 2 The Eatwell Plate

Look at both versions and write down in the box below what you see is different. What did you notice?

Answer

You may have noticed:

- The knife and fork is no longer used.
- The proportions have been changed.
- The pictures are not of real food.
- High sugar and fat snacks have been removed.
- Hydration is included in the new Eatwell Guide.
- There is some guidance on food labelling in the new Eatwell Guide.
- The recommended energy levels for males and females is included in the new Eatwell Guide.

There is detailed information about why the Eatwell Guide was developed and replaced the Eatwell Plate on the Public Health England website (2016b).

Do you think the Eatwell Guide is useful?

Write two or three sentences in the box below. Click 'Save' when you are satisfied with what you have written.

Provide your answer...

1.1 Dietary advice from around the world

Dietary advice from around the world tends to be very similar but can be explained in different ways.

In the next activity you will look at dietary advice from different countries.

Activity 2 Dietary advice from Japan, India, Mexico, USA, Canada and the Mediterranean

Allow approximately 20 minutes.

Figures 3–8 are some food guides from other countries around the world. Compare them with the UK Eatwell Guide. Do you think any of them provide better advice?

Write two or three sentences in the box below the figures. Click 'Save' when you are satisfied with what you have written.

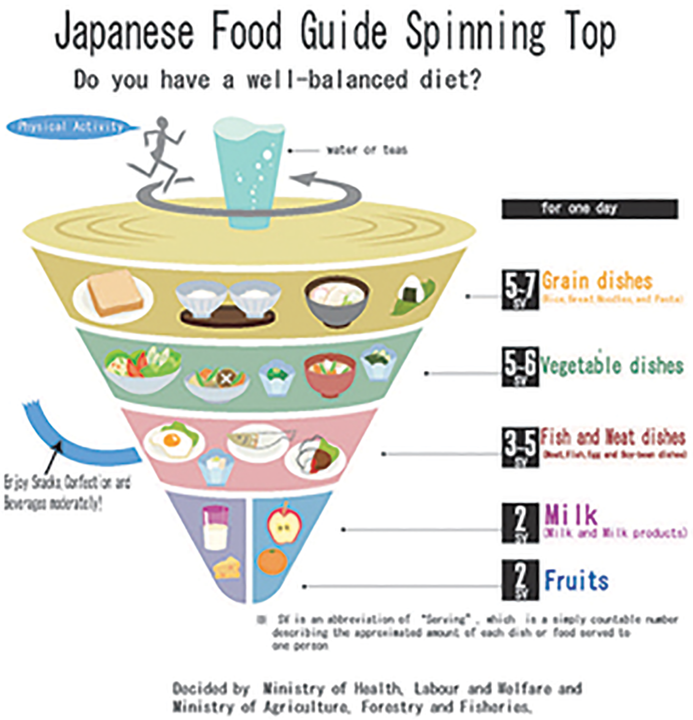

Figure 3 Japan's food guide

Graphic representation of the Japanese food guide spinning top. The top of the figure has the heading, Japanese food guide spinning top, do you have a well-balanced diet? The top of the spinning top has a cartoon figure running, with the label physical activity, and water or teas labelled, representing the centre of the spinning top. There are four different segments going vertically to the bottom of the spinning top, with images of different food items. There is a label coming from the second segment from the bottom: Enjoy snacks, confection and beverages moderately! On the right of the spinning top, there are the following labels, suggesting the guidelines for one day, marking each of the segments: 5–7 SV grain dishes, 5–6 SV vegetable dishes, 3–5 SV fish and meat dishes, 2 SV milk, and 2 SV fruits. SV is an abbreviation of serving, which is a simply countable number describing the approximated amount of each dish or food served to one person. The bottom of the figure has the text: decided by Ministry of Health, Labour and Welfare and Ministry of Agricultute, Forestry and Fisheries.

Figure 4 India’s food guide

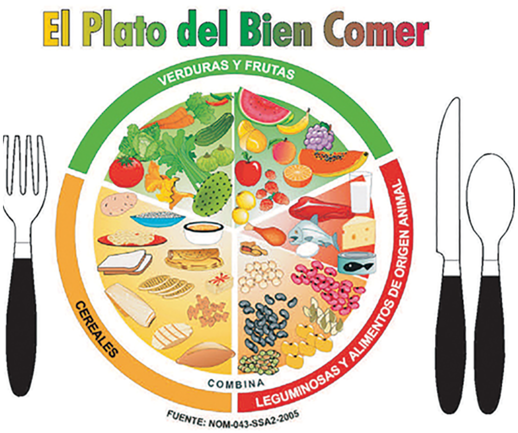

Figure 5 Mexico’s food guide

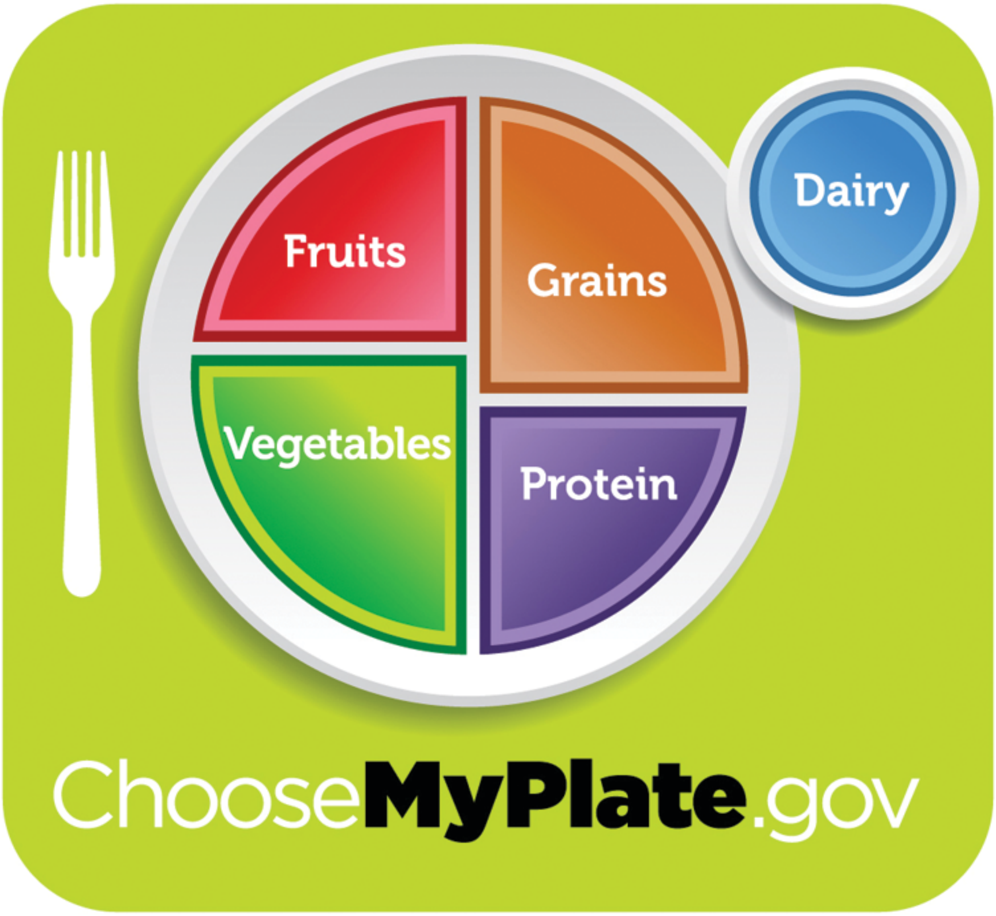

Figure 6 USA’s food guide

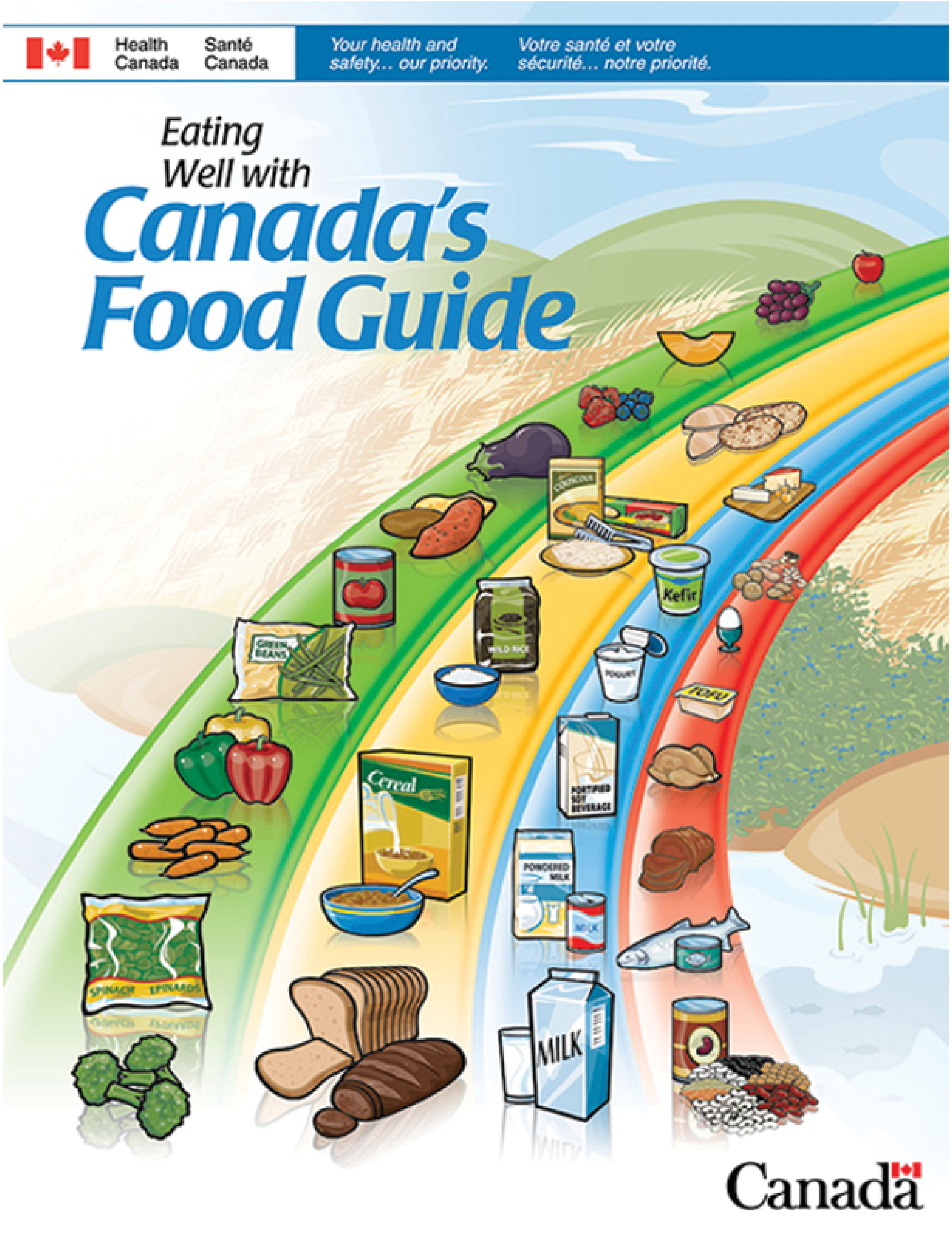

Figure 7 Canada's food guide

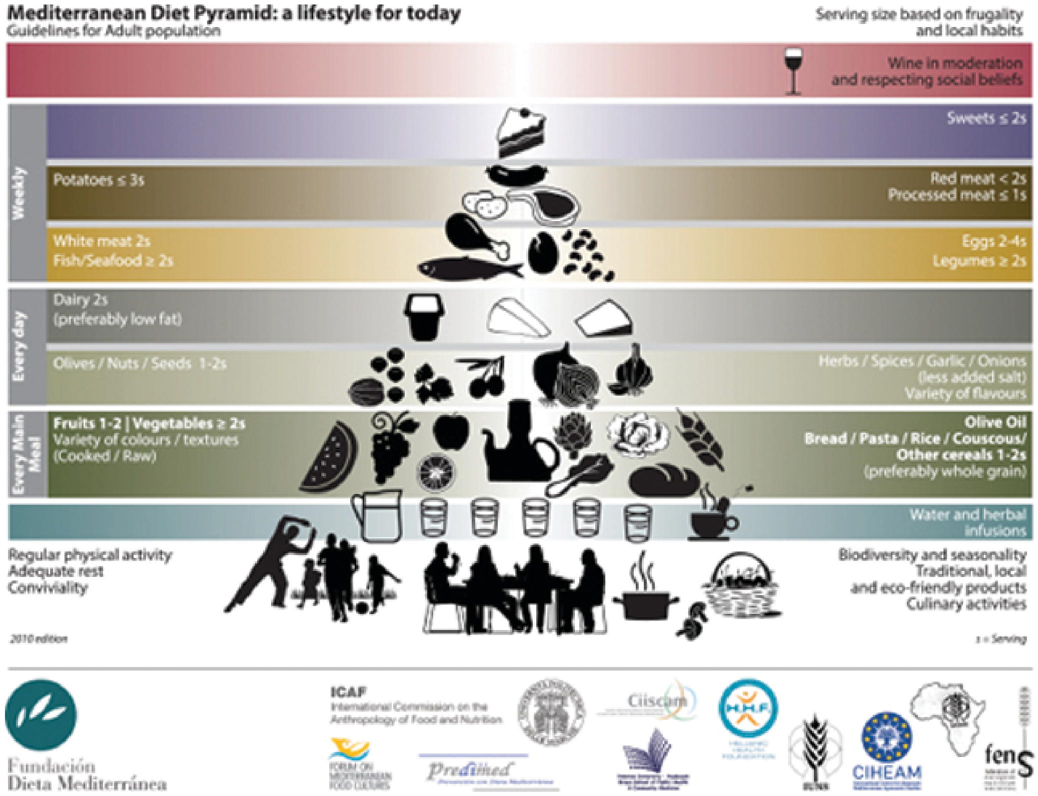

Figure 8 Mediterranean diet pyramid

Provide your answer...

1.2 Five a day – or more?

The current UK healthy eating advice is at least five portions of fruit and vegetables a day. These provide a good source of vitamins and minerals, particularly folate, vitamin C and potassium, and dietary fibre, which is important for a healthy gut.

Large-scale studies also indicate that individuals who eat more fruit and vegetables have a lower risk of heart diseases, stroke and cancer. Fruit and vegetables are usually low in calories and fat, so they can help with weight control.

Activity 3 Eating five a day

Allow approximately 35 minutes.

First, watch the following video.

Video content is not available in this format.

Now read the BBC article Seven-a-day fruit and veg 'saves lives' (Stephens, 2014). How close do you get to your five (or seven) portions of fruit and vegetables a day? Write two or three sentences in the box below. Click 'Save' when you are satisfied with what you have written.

Provide your answer...

1.3 Seven a day

Death rates appear to be reduced in people who eat more fruit and vegetables. But it is not yet clear whether more than five gives a significant additional benefit (Figure 9).

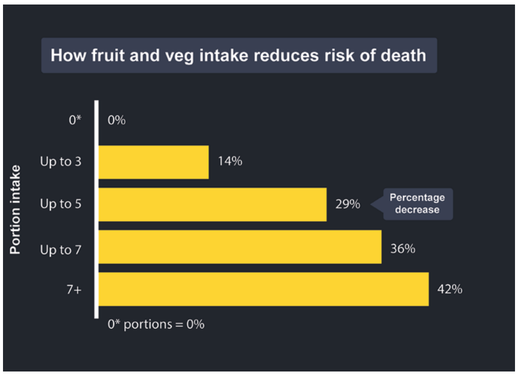

Figure 9 Number of fruit and vegetable portions in relation to risk of death

In addition, fruits may contain large quantities of sugar, which can contribute to tooth decay and can lead to obesity if the energy consumed is more than the energy used (see Section 4.1 Sugars). Vegetables generally contain much less sugar, so perhaps the advice would be better given as ‘vegetables and fruit’, rather than ‘fruit and vegetables’ to emphasise the importance of vegetables.

1.4 What about ten a day?

A recent study found that having ten portions of fruit and vegetable a day considerably reduced the risks of developing long-term conditions such as heart disease, stroke and cancer. You might think the evidence and advice is getting a bit confusing. Read the following article and make up your mind.

Read the article Five a day of fruit and veg is good, but ‘10 is better’ (NHS Choices, 2017) and make up your mind.

You could argue that most people don’t even manage to eat five portions a day, although that is a reasonable aspiration. But eating seven portions, let alone ten, might seem impossible, so they might just ignore the advice completely.

2 Healthy snacks

Do you eat snacks like those in Figure 10? Should we be eating them?

Figure 10 Examples of snack foods

Activity 4 Being more aware of what is in your snack

Allow approximately 20 minutes.

Make a list of the snacks you eat and when you tend to eat them. Think about the Eatwell Guide and make an assessment of whether they fit into the healthy eating guidelines. Compare the labels of the snacks according to the labelling guides in Week 4. Now answer the following questions.

- Do you eat snacks?
- If yes, from your list are there any you would consider changing?
- If so, which ones and why would you change them?
- What makes you have a snack? Reflect on your reasons and write them in the box below. Click ‘Save’ when you are happy with what you have written.

Provide your answer...

Discussion

There is nothing wrong with having snacks. Some people need snacks to ensure they have enough energy from food throughout the day. The main point to remember is that you choose the type of snack that suits your needs for health.

The Change 4 life website has many tips and ideas that will help you make suitable choices (Figure 11).

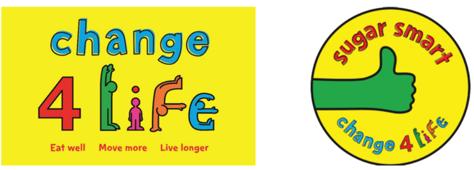

Figure 11 The Change 4 life initiative for children and adults (Change 4 life, 2018)

This is an England and Wales initiative but there are initiatives in Scotland and Ireland too (Figure 12).

Figure 12 Healthy eating campaign for Scotland (Eat better feel better, 2018)

Figure 13 Healthy eating campaign for Ireland (Choose to live better, 2018)

3 Vegetarian and vegan diets

Does the Eatwell Guide help people who follow a vegetarian or vegan approach (Figure 13)? The protein section does include suitable options and, therefore, is very relevant.

Figure 14 The official trademarks used on products endorsed by the Vegan and the Vegetarian Society

The Vegetarian Society defines a vegetarian as follows.

> A vegetarian is someone who lives on a diet of grains, pulses, legumes, nuts, seeds, vegetables, fruits, fungi, algae, yeast and/or some other non-animal-based foods (e.g. salt) with, or without, dairy products, honey and/or eggs. A vegetarian does not eat foods that consist of, or have been produced with the aid of products consisting of or created from, any part of the body of a living or dead animal. This includes meat, poultry, fish, shellfish, insects, by-products of slaughter or any food made with processing aids created from these.
>
> Vegetarian society (2018)

There are four main different types of vegetarianism as you will see in the next activity.

Activity 5 Types of vegetarianism

Allow approximately 15 minutes.

Match the relevant type of vegetarianism with the types of food eaten.

Lacto-ovo-vegetarians

Lacto-vegetarians

Ovo-vegetarians

Vegans

Match each of the items above to an item below.

eat both dairy products and eggs

eat dairy products but avoid eggs

eat eggs but not dairy products

do not eat dairy products, eggs, or any other products which are derived from animals

Answer

- Lacto-ovo-vegetarians eat both dairy products and eggs; this is the most common type of vegetarian diet.
- Lacto-vegetarians eat dairy products but avoid eggs.
- Ovo-vegetarians eat eggs but not dairy products.

- Vegans do not eat dairy products, eggs, or any other products which are derived from animals.

There is another category called pescetarianism or pesco-vegetarianism. Most vegetarians maintain a lacto-ovo vegetarian diet with the addition of fish and shellfish.

The choice of following certain dietary approaches can result from ethical or religious reasons. Either way, the principles of healthy eating and balancing the different food groups are still relevant.

Certain dietary restriction means there is a possibility of nutritional deficiencies. If you are vegetarian, it is important to have sources of iron, vitamin B12 and calcium and omega fats. The NHS Choices website has information about vegetarian and vegan dietary approaches.

The most restrictive type of diet is veganism but, if followed correctly, it can offer a varied, balanced way of eating.

4 Malnutrition

The World Health Organization defines malnutrition as:

Deficiencies, excesses or imbalances in a person’s intake of energy and/or nutrients.

There are two main groups of malnutrition.

- *Undernutrition*, including:
- stunting (low height for age)
- wasting (low weight for height)
- underweight (low weight for age)
- micronutrient deficiencies or insufficiencies (a lack of important vitamins and minerals).
- *Overnutrition*, including:
- overweight
- obesity
- diet-related non-communicable diseases (such as heart disease, stroke, diabetes and cancer).

It is important to identify and address both types of malnutrition. Globally, countries collect data about nutrition. We will consider the latest Global Nutrition Report next.

4.1 The Global Nutrition Report

The 2016 report states:

‘END ALL FORMS OF MALNUTRITION BY 2030.’

That was the challenge world leaders laid down to all of us at the end of 2015 when they adopted the Sustainable Development Goals (SDGs).

It is a formidable challenge. Every country is facing a serious public health challenge from malnutrition … One in three people is malnourished in one form or another … Malnutrition manifests itself in many forms: as children who do not grow and develop to their full potential, as people who are skin-and-bone or prone to infection, as people who carry too much weight or whose blood contains too much sugar, salt, or cholesterol. The consequences are literally devastating … An estimated 45% of deaths of children under age 5 are linked to malnutrition … Malnutrition and diet are now the largest risk factors responsible for the global burden of disease – by far …

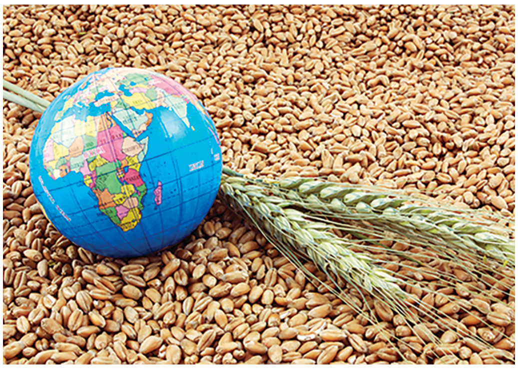

Figure 15 a globe placed on top of seeds

The current world population is about 7.5 billion. In 1955, it was approximately 2.76 billion and in 1990 approximately 5.3 billion. The world population clock forecasts that the population will rise to approximately 9.7 billion. You can find more details at the Worldometers website.

In June 2016, the *2016 Global Nutrition Report* was published. It focuses on ending malnutrition and is called 'From Promise to Impact: ending malnutrition by 2030 (Figure 16). This is the third annual global report, showing sustained momentum and priority in ending all forms of malnutrition.

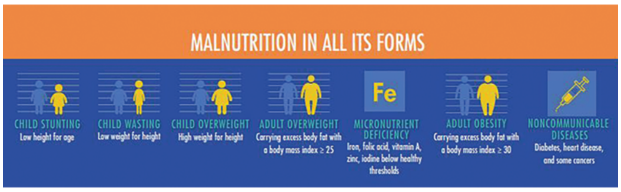

Figure 16 2016 Global Nutrition Report

Activity 6 Global nutrition

Allow approximately 15 minutes.

Watch the following video and make notes on what is being said. How do you feel about global nutrition?

Video content is not available in this format.

Write down your thoughts in the box below. Click ‘Save’ when you are satisfied with what you have written.

Provide your answer...

The *Global Nutrition Report* states seven key findings

1. Malnutrition creates a cascade of individual and societal challenges and opportunities.Malnutrition and poor diets constitute the number-one driver of the global burden of disease.
2. The world is off-track to reach global targets — but there is hope. If we continue with business as usual, the world will not meet the global nutrition and Non-communicable Diseases (NCD) targets adopted by the World Health Assembly.
3. Nutrition is central to the Sustainable Development Goals. At least 12 of the 17 sustainable Development Goals contain indicators that are highly relevant for nutrition, reflecting nutrition’s central role in sustainable development.
4. Current commitments do not match the need. Given the scale of the malnutrition problem, current spending designed to overcome it is too low.
5. Specific, Measureable, Attainable, Realistic and Timed (SMART) commitments and targets matter.The report finds that donors and governments that prioritised nutrition in their policy documents spent more on nutrition.
6. We must move beyond talk to action. The report highlights the need to dramatically strengthen the implementation of both policies and programmes.
7. Today’s data and knowledge are not sufficient to maximise investments. The report supports the call for a data revolution for nutrition.

Figure 17 shows the scale of global malnutrition in 2016.

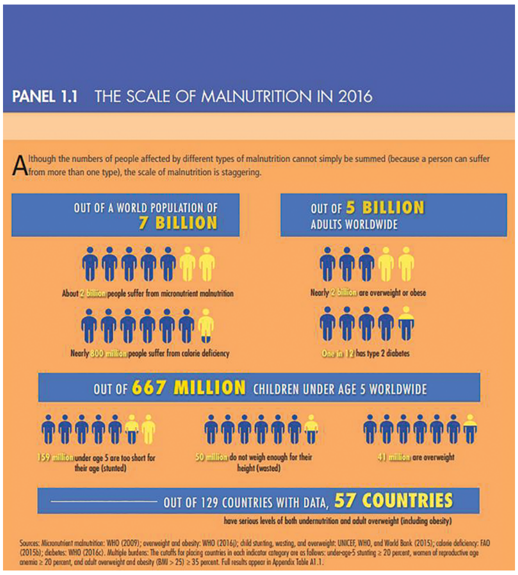

Figure 17 2016 Global Nutrition Report, page 2

4.2 The obesity epidemic

Next we will concentrate on adults who are overweight.

At least 2.8 million people are thought to die each year as a result of being overweight or obese. Obesity has reached epidemic proportions not only in high-income countries but also in low- and middle-income countries.

The World Health Organization (WHO) have published a series of key facts on obesity (WHO, 2018).

- Worldwide obesity has more than doubled since 1980.
- In 2014, more than 1.9 billion adults, 18 years and older, were overweight – of these, over 600 million were obese.
- In 2014, 39% of adults aged 18 years and over were overweight and 13% were obese.
- Most of the world's population live in countries where overweight and obesity kills more people than underweight.
- In 2013, 42 million children under the age of 5 were overweight or obese.
- Obesity is preventable.

You might have noticed that the WHO puts the number of people worldwide who are overweight or obese at an even higher level than the International Food Policy Research Institute's report published the previous year.

The health consequences of obesity and being overweight are significant. People who are overweight are more likely to have cardiovascular diseases, such as heart attacks and strokes, diabetes, osteoarthritis and other diseases of the muscles and joints, and some cancers.

Children who are obese are more likely to have breathing difficulties and their risk of fractures is greater. They may also show early signs of high blood pressure, cardiovascular diseases and diabetes. There are also psychological effects. Overweight children are likely to have low self-esteem and depression, and to be bullied by their peers. And they are more likely to become obese adults.

4.3 Measuring obesity

Overweight and obese are defined as the abnormal or excessive accumulation of fat that may impair health. The measure of whether someone is of normal weight, overweight or underweight is conventionally obtained by calculating their body mass index (BMI). This takes into account their height as well as their body mass (weight).

After calculating the BMI, the result is compared with the values in Table 1.

Table 1 Body mass index classifications

Category	**BMI range (kg/m^2)**
Very severely underweight	less than 15
Severely underweight	15.0 to 16.0
Underweight	16.0 to 18.5
Normal (healthy weight)	18.5 to 25
Overweight	25 to 30
Obese Class I (moderately obese)	30 to 35
Obese Class II (severely obese)	35 to 40
Obese Class III (very severely obese)	over 40

However, there are problems with using a simple calculation like this. First, these values were only ever designed to be appropriate for adults. There are separate height–weight charts for children. These values are also not appropriate for all adults. For example, many rugby players and shot putters would be classed as obese although they probably carry very little body fat.

A BMI above the healthy range puts most people at risk of adverse health consequences. These include an increased risk of coronary heart disease (CHD), stroke and Type 2 diabetes.

It appears that some population groups are more susceptible to these health problems than others. In the UK, the National Institute for Health and Care Excellence (NICE) has issued additional BMI advice to people in South-Asian and Chinese ethnic groups, who appear to have a higher risk of developing Type 2 diabetes than white populations. They are advised to keep their BMI below the standard value of 25. The evidence is less clear-cut for people in black ethnic groups, but again, keeping their BMI below 25 is recommended.

You might like to calculate your own BMI and compare it with Table 1. (Don't worry – you don't have to share it with other people!)

In 2013, an alternative formula for calculating BMI was proposed by the mathematician Professor Nick Trefethen of the University of Oxford. It is based on mathematical analysis of the physics and mechanics of how bodies grow. His suggestion is that the equation should be:

This change means that some tall adults who were previously considered overweight would now be within the normal range. And some short adults, previously within the normal range, would now be considered overweight. You might like to try calculating your BMI using this alternative measure, although the maths is slightly more complicated.

4.4 Different BMI classifications for some population groups

In 2004, new BMI categories were stated for many Asian populations as additional trigger points for public health action (see Table 2) with:

- 23 kg/m^2or higher representing increased risk
- 27.5 kg/m^2 or higher representing high risk.

Table 2 BMI classifications for the Asian population

Category	BMI (kg/m^2)
Underweight	less than 18.5
Increasing but acceptable risk	18.5 to 23
Increased risk	23 to 27.5
High risk	27.5 or higher

(Source: WHO, 2004)

4.5 Measuring your waist

The size of your waist is a strong indicator for the risk of developing conditions such as Type 2 diabetes, heart disease and cancer. Central obesity should also be considered, irrespective of your BMI.

Your risk increases if your waist is:

- 94 cm (37 inches) or more for men – 90 cm (35 inches)
- 80 cm (31.5 inches) or more for women.

Measuring your waist circumference correctly is very important. So how is it done?

Activity 7 Measuring your waist and working out your BMI

Allow approximately 15 minutes.

Figure 18 Measuring your waist

1. Get a measuring tape. Don't use a metal one – keep that for measuring your height. Use a tailor's flexible measuring tape, or one that is specifically for measuring waist circumference.
2. Find the bottom of your ribs and the top of your hip bone on the side of your abdomen.
3. Measure your waist midway between these points, while standing upright.
4. Don't breathe in – that's cheating… Just breathe in and then breathe out naturally.
5. Also make sure that the measuring tape is not pulled tight, but just resting on your skin, parallel to the floor.
6. Make a note of your waist circumference.

Do you know your height? If not, you may need help to do this.

1. Get a metal tape and tape it to the wall, making sure you don't damage the wall! Or ask someone to hold it for you, measuring from the floor up. Stand with your back against the tape on the wall. Your assistant needs to measure from the top of your head. Perhaps a ruler might help. Make a note of your height.
2. Then measure your weight using reliable scales on a hard floor.

Table 3 your results

My waist circumference is:	cm
My height is:	m
My weight is:	kg
My BMI is:	kg/m^2

Make a note of your thoughts about your results in the box below. Click 'Save' when you are satisfied with what you have written.

Provide your answer...

4.6 Obesity levels

In the next activity, you will test your knowledge of the obesity levels in 12 countries.

Activity 8 Ordering countries for obesity level

Allow approximately 15 minutes.

Can you place them in order of obesity levels in adult males? Arrange the countries in order from those with the highest obesity levels at the top, to the lowest obesity levels at the bottom. To move a country, click on it and drag it to a new position. There is no limit to the number of moves you can make. As soon as you move the boxes into the correct order, a message will appear.

After 12 moves, you will be asked whether you want some assistance. This will add green ticks next to those which are in the correct position and red crosses to those which are not.

Interactive content is not available in this format.

Answer

Here is the correct order with the obesity level percentages for each country:

- Kuwait 36.4%
- USA 33.3%
- Mexico 26.8%
- England 26%
- Australia 25.6%
- Scotland 23.7%
- Germany 23.3%
- France 16.1%
- Russian Federation 10.3%
- Brazil 12.5%
- China 3.8%
- India 1.3%

4.7 What has caused the obesity epidemic?

There is said to be an obesity epidemic in the world and it certainly looks that way from the data (Figure 17).

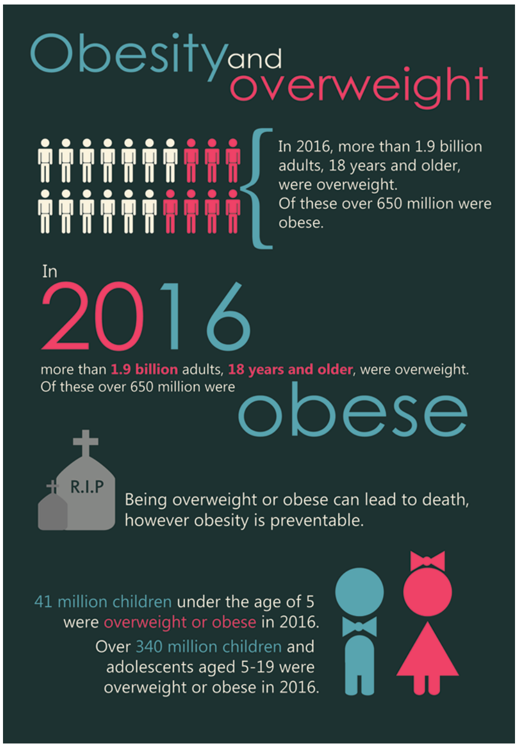

Figure 19 Obesity statistics compared for 1980 and 2008

Activity 9 Why is obesity so common?

Allow approximately 10 minutes.

The Overseas Development Institute (ODI) is the UK's leading independent think-tank on international development and humanitarian issues. It reported that the number of obese people in the developing world tripled between 1980 and 2008 and, in high-income countries, the number increased by 1.7 times in the same period.

- What are the causes for this?
- Why are we getting fatter?

Write two or three sentences in answer to these questions in the box below. Click 'Save' when you are satisfied with what you have written.

Provide your answer...

4.8 A drastic solution: bariatric surgery

There are numerous reasons for the 'obesity epidemic' that have all come together at a similar time. In countries where incomes have risen, there has been a marked shift from a diet based on cereals and tubers (mostly carbohydrate) to one based on fats and sugars and the inclusion of more meat.

In higher-income countries, there is a much wider range of food than ever before to tempt consumers into eating more. There are many more places to eat or to buy ready-made meals, and portion sizes are larger. In addition, people have become less active and therefore need fewer calories to maintain a steady weight. The entertainment provided by electronic devices has contributed to this. So, when you have finished studying this week, leave your computer for a while and go for a walk or do some exercise!

When we eat, normally our stomach expands from about the size of a small apple to about two litres – that is a 40-fold increase. When the stomach is empty, the hormone ghrelin is released into the blood, making you feel hungry. When the stomach is full, ghrelin secretion stops (see Ghrelin). The resulting fall in ghrelin level in the blood is detected by the brain. This may be one of the factors that make us feel full after a meal. In obese people this, and other means of appetite suppression, do not seem to work in the normal way. So they tend to eat more than thinner people.

Once people have become obese, getting their weight back down to within the normal limits is incredibly difficult, despite the enormous range of diets and dietary advice. The drastic solution for some people, when all else fails, is a gastric bypass operation.

This reduces the size of the stomach to about one-tenth of its normal size, so that it has a volume of only a few tablespoons. You can see the operation being carried out in the following video.

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Weight loss after a gastric bypass operation appears to be caused not only by the small size of the stomach, which physically reduces the amount that can be eaten. It is also caused by changes in the amounts of some of the gut hormones. The cells of the stomach that produce ghrelin are completely cut off from the food and so do not function normally.

The new small stomach is attached next to some of the cells that produce PYY, which is a polypeptide produced in the small intestine which reduces the feeling of hunger. Its production conveys the information to the brain that food has been eaten. This process normally takes about 20 minutes. But, after a gastric bypass operation, it occurs within about 5 minutes of eating, causing the patient to feel full much more quickly.

Bob, whose operation is shown in the video, lost nearly 20 kg in the first six weeks after the operation. However, gastric bypass surgery is a major operation and must never be the first option for an obese person.

5 Food in the Second World War and food banks now

In this section you will briefly look at food during the Second World War. You will then go on to look at food banks in the UK today.

5.1 Food in the Second World War

Before the Second World War, much of the protein part of the British diet (meat, eggs and cheese) was imported (Figure 20).

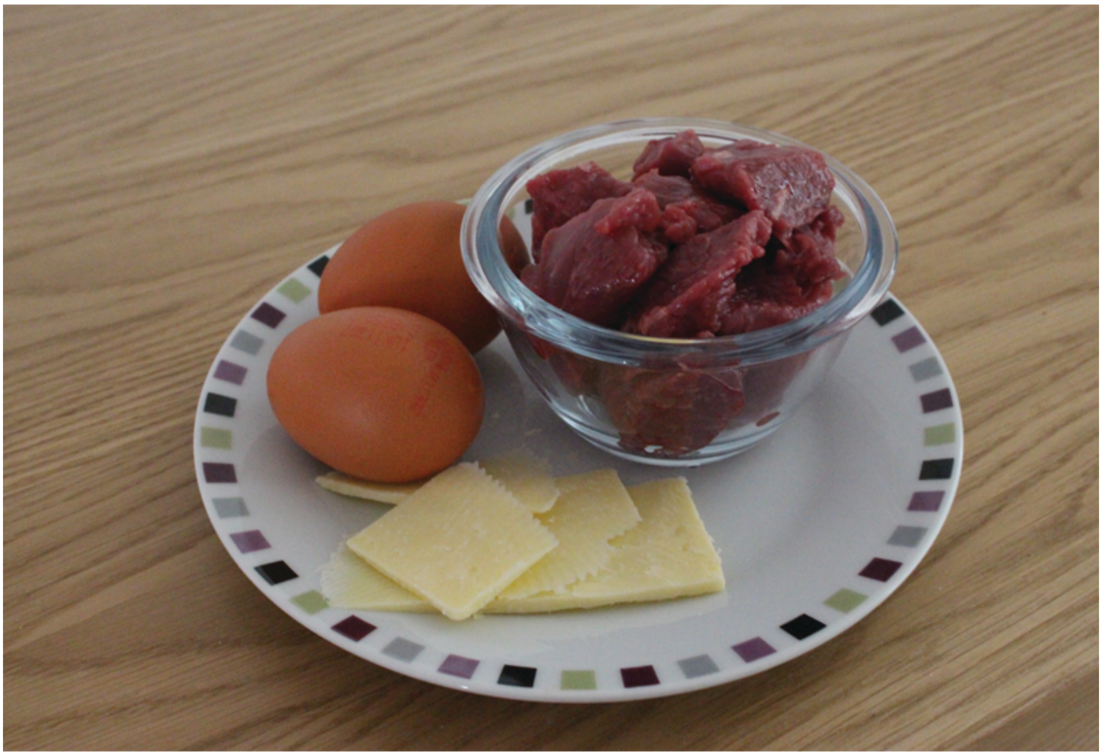

Figure 20 These sources of protein were imported to the UK before the Second World War

After the war began in 1939, there were fears that a blockade of the coast would prevent these food imports, leading to significant changes in the nation's diet. This might even result in the population being unable to stay healthy and productive. Two nutrition experts from the University of Cambridge (whose names you might recognise) decided to see if they, and a group of colleagues, could stay 'fighting fit' on a diet containing much less protein than was usually consumed. Their story was featured in an article in the *Guardian* newspaper in September 2013 (Dawes, 2013).

5.2 Food banks

In the UK in 2014, an estimated 13 million people were living below the poverty line, out of a total population of about 64 million.

Since 2000, food banks have been set up by charities, such as The Trussell Trust, to help people who do not have enough money to buy food. The three main causes are low income, benefit delays and benefit changes. The Trussell Trust food banks provide three days worth of emergency nutritionally balanced, non-perishable food. Between April 2016 and April 2017, 182 954 three-day emergency food supplies were given by The Trussell Trust.

Food banks rely largely on the generosity of members of the public. Typically, they contain nutritionally balanced, non-perishable tinned and dried foods which have been donated by the local community (Figure 21).

Figure 21 Suggested donations for a food bank

The items in Figure 21 are used as part of a food package for an individual or a family in crisis. Depending on the age and situation of the recipients, different numbers of these items are included in the package. Other items are also included.

Activity 10 Does the food bank list represent a balanced diet?

Allow approximately 10 minutes.

Think about the following questions:

a. How well do the items on the food bank shopping list match with the Eatwell Guide?
b. What additional items should be included to help make this a long-term nutritionally balanced diet?

Write two or three sentences in the box below. Click ‘Save’ when you are satisfied with what you have written.

Provide your answer...

6 This week's quiz

Check what you've learned this week by taking the end-of-week quiz.

Week 6 quiz.

Open the quiz in a new window or tab, then return here when you have done it.

7 Summary

This week you learned more about the Eatwell Guide for healthy eating and about global malnutrition.

You should now be able to understand:

- the Eatwell Guide and dietary approaches in different countries
- vegetarian and vegan diets
- the meaning of malnutrition
- how to measure obesity.

Next week you will explore food allergy and intolerance and some common conditions where food intake has to be adapted.

You can now go to Week 7.

Week 7: Food allergy or food intolerance?

Introduction

Welcome to Week 7 of the course.

Last week you looked at balanced healthy eating and malnutrition. This week you will learn more about how certain food causes an immune response in the body.

By the end of this week's study you will be able to understand:

- food allergy and how it differs from food intolerance
- the tests available that can help diagnose food allergy or intolerance
- what happens in anaphylactic shock
- irritable bowel syndrome and some treatments
- coeliac disease and being gluten-free.

Figure 1 An ingredients list with the allergens highlighted in bold

In Week 4 you looked at food labelling and the legislation about allergens in food (Figure 1). This information is extremely important for someone with a food allergy as well as intolerance. There is an important difference between allergy and intolerance: one can cause death and the other can cause discomfort.

1 Food allergy

Allergy UK is the largest registered charity with a wealth of information. It defines allergy as follows.

> Food allergy is caused when the body mistakenly makes an antibody immunoglobulin E (IgE) to 'fight off' a specific food. When the food is next eaten (or sometimes is just in contact with the skin), it triggers an immune system response which results in the release of histamine and other substances in the body.
>
> (Allergy UK, 2018)

The British Dietetic Association states in its Food Allergies and Intolerances Fact Sheet:

> It is estimated that between 1–10% of adults and children have food hypersensitivity. However as many as 20% of the population experience some reactions to foods which make them believe they do have food hypersensitivity.
>
> (BDA, 2015)

The British Society for Allergy and Clinical Immunology (BSACI) states that food allergy affects 3–6% of children in the developed world. In the UK, it is estimated that the prevalence of food allergy is 7.1% in breast-fed infants, with 1 in 40 developing peanut allergy and 1 in 20 developing egg allergy. There is evidence that breast feeding can reduce food allergies compared to bottle fed. Read this article and decide what you think? Read the article Breast milk 'raises' immunity (NHS Choices, 2010) and decide what you think.

1.1 Symptoms of a food allergy

The symptoms of a food allergy are often seen in the gastrointestinal tract, skin and respiratory system (Table 1).

Table 1 Common symptoms of a food allergy

Organ affected	Symptoms seen
Gastrointestinal system	Abdominal pain, vomiting, diarrhoea
Skin	Itching, swelling (rash calledurticaria or nettle rash)
Respiratory system	Runny nose, sneezing, wheezing, cough

These reactions can occur very quickly, within minutes of eating or even touching the offending food. This is known as an immediate-type reaction. Reactions can even occur days after eating the food, which is called a delayed reaction.

A strong allergic response to the allergen can cause a severe reaction called *anaphylaxis*. There was a 615% increase in the rate of hospital admissions for anaphylaxis in the UK in the 20 years to 2012 (Turner et al., 2015). Admittedly, this was not just for food-related anaphylaxis, but this increase is worrying and cannot be ignored. Anaphylaxis needs to be treated urgently and we will explore this later.

1.2 Top 14 food allergens in the UK

In the first activity for this week, you will think about food allergens.

Activity 1 Food allergens in the food we eat

Allow approximately 10 minutes.

Make a list of what you think the main food allergens are. (Hint: look at Figure 1 to help you.) Click 'Save' when you are satisfied with what you have written.

Provide your answer...

Answer

The top 14 food allergens are:

- celery
- cereals containing gluten
- crustaceans
- eggs
- fish
- lupin
- milk
- molluscs
- mustard
- nuts
- peanuts
- sesame seeds
- soya
- sulfur dioxide (sometimes known as sulfites).

1.3 Anaphylaxis

In 1902, the phenomenon of anaphylaxis was first described in the medical literature. Researchers noticed an unusual effect in dogs when immunising them with jellyfish toxin. The intention was to protect the dogs but instead it caused a fatal or near-fatal response. This is where the word 'anaphylaxis' was created, from the Greek words *ana* (meaning against) and *phylaxis* (immunity or protection).

Watch the following video from the British Red Cross.

Video content is not available in this format.

What is happening in the body to give such a reaction?

When the body is first exposed to the food that you may be allergic to (the allergen), an antibody (IgE) specific to the allergen is produced. When the body is exposed to that allergen again, the allergen-specific IgE causes the cells to release inflammatory chemicals such as histamine. This surge in histamine then affects different parts of the body, causing anaphylaxis (Figure 2) and potentially anaphylactic shock, which is a life-threatening condition and requires immediate attention.

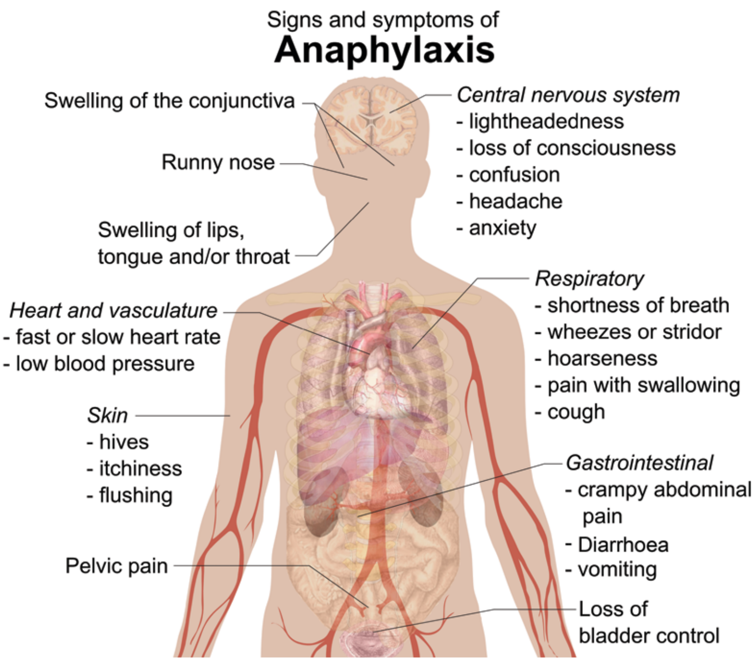

Figure 2 Signs and symptoms of anaphylaxis

You saw in the video that the treatment is an auto-injector pen filled with the hormone epinephrine (also calledadrenalin) in an EpiPen®. This relieves the symptoms but it is essential to seek medical advice also. This is because a single dose may not be enough and any further doses must be administered medically.

1.4 The science bit

It is very important that the body has a defence mechanism against allergens (what causes an allergic reaction). It is a way of protecting us from harmful substances that regularly bombard the body. But the body produces antibodies to safely dispose of these harmful substances. This is the body's natural immune response.

Normally, this response would occur and not cause such symptoms. All you need to do is either avoid that food or have it in small amounts. With a food allergy, often you cannot have that food again because it causes a severe reaction.

1.5 Nut allergy

In the UK, peanut and tree nut allergy is the most common cause of severe and fatal allergic reactions. It affects 2% of children and 0.5% adults. People diagnosed during childhood rarely grow out of the allergy.

Figure 3 A selection of nuts and berries

The most concerning aspect of nut allergy is that, over a 20-year period from 1992 to 2012, there were 69 fatalities in the UK. Therefore, in 2017, the BSACI published guidelines for the diagnosis and management of peanut and tree nut allergy (Stiefel et al., 2017).

Activity 2 Know your tree nuts

Allow approximately 10 minutes.

Consider the following:

a. Make a list of as many tree nuts as you can.
b. What is the difference between peanuts and tree nuts?

Provide your answer...

Answer

a. Your list might include almonds, Brazil nuts, cashews, chestnuts, hazelnuts, macadamia nuts, pecans, pistachios, pine nuts, shea nuts and walnuts.
b. Peanuts are legumes which produce a pod.

Figure 4 Peanuts

Tree nuts are a hard, shelled fruit.

Figure 5 Tree nuts

2 Food intolerance

Food allergy is an allergic response causing food hypersensitivity. It is much less common than food intolerance which is sometimes called non-allergic hypersensitivity.

Food intolerance does not involve the immune system. Symptoms often occur slower than with a food allergy. The delay can make it difficult to identify the particular food that has resulted in the symptoms.

The symptoms can last for hours or even until the next day. Often there is intolerance to more than one food, which again can make identification difficult. Also, symptoms only occur if a reasonable amount of the food is eaten. With an allergy, traces of it can trigger a reaction.

Common food intolerances include:

- **lactose** found in dairy products which may be due to lactase deficiency (the enzyme that breaks down lactose)
- **gluten** found in wheat products and added in some processed products
- **wheat** contains gluten and some products contain traces as they may be produced in areas where wheat of gluten is produced
- **caffeine** found in coffee, tea, coke and added to other products
- **histamine** found in quorn, mushrooms, pickled and cured foods, and alcoholic drinks. Histamine is a natural component of the immune system but overproduction can contribute to anaphylaxis
- **vaso-active amines** e.g. those found in red wine, strong and blue cheeses, tuna, mackerel and pork products. It is overproduction that can cause intolerances, as it is a chemical naturally found in healthy humans.
- chemical naturally occurring foods (e.g. **salicylates,** a family of plant chemicals and **glutamate,** the building block of all proteins)
- food additives, especially **benzoate** and **sulphite preservatives** and **monosodium glutamate (MSG)**.

Activity 3 Foods that may cause intolerance

Allow approximately 10 minutes.

Look in your kitchen cupboards and food storage areas and make two groups of products:

- one containing lactose, gluten, wheat or MSG
- one that does not contain these ingredients.

Which group is the largest? Click ‘Save’ when you are satisfied with what you have written.

Provide your answer...

You may find that many foods contain these ingredients and it may be difficult to have a variety of foods to eat that do not contain them. Often, people who suspect they have food intolerance eliminate the foods because the symptoms can cause distress. So they may end up eating a restricted diet which could cause malnutrition.

2.1 Symptoms of food intolerance

Some typical symptoms of food intolerance include:

- bloating, wind, stomach ache, diarrhoea
- skin rashes
- migraine
- cough
- generally feeling ‘under the weather’
- irritable bowel.

3 Diagnosing and managing a food allergy and food intolerance

You can diagnose an allergy using four methods:

1. measure antibody IgE using the Radio Allergo Sorbent Test (RAST test) because the allergen protein initiates a reaction
2. skin prick tests done by a qualified health care professional
3. exclude the food and note any changes in a 'food and symptoms' diary
4. food challenge using a very small amount of the food allergen, this must be done in a medical facility where there is resuscitation equipment.

Figure 6 Blood test

These methods all help to build a clinical picture for diagnosis of this kind of allergy which causes people a lot of distress.

It is important to:

- be diagnosed using validated methods
- manage the condition by avoiding the food if you have an allergy or knowing how much you can have if you have an intolerance
- know what to do if the response happens again, especially anaphylaxis.

Don't be fooled by some claims for allergy testing by some commercial companies. They are not validated tests and can give false positive results. They often use the Multi-Allergen Screening Test (MAST) but, without the detailed clinical history, a diagnosis can be difficult.

The advice they give can result in restrictive diets that can cause malnutrition. Have you ever experienced a paper cut? What happens? Well, it hurts and then the area becomes red and raised. This is a natural immune response. It does not mean you are allergic to paper!

Irritable bowel has been mentioned. This is when the bowel has become sensitive to some foods and can cause the symptoms of food intolerance. You have probably heard of IBS.

4 Irritable bowel syndrome (IBS)

The cause of IBS is unknown but it may develop after a gut infection, a course of antibiotics or a traumatic or an upsetting event. Symptoms often increase because of stress and anxiety. IBS is a collection of unexplained symptoms where there is a disturbance in the bowels. This includes abdominal pain, bloating, constipation and diarrhoea. Many of these symptoms are similar to food intolerance because there is sensitivity to certain foods.

Figure 7 Irritable bowel syndrome

The IBS Network website states: ‘At any one time, IBS affects around 10–20% of people living in the UK.’

Women tend to have IBS more than men (in a ratio of 3 to 2) and it tends to start in their teenage or twenties. The symptoms of IBS can be lifelong and alter in intensity according to several factors related to food and stress. IBS does tend to occur in families but there is not necessarily a genetic factor because the environment is a strong contributing factor. The food eaten by the family tends to be the same and hence affects their colonic bacteria.

With IBS, the gut immune system is stimulated, inducing mild inflammation, and colonic bacteria are depleted. This all leads to a sensitive gut.

If a person suspects they have IBS, it cannot be diagnosed. But there is a process of elimination of other conditions such as coeliac disease or inflammatory bowel disease.

4.1 Healthy eating and lifestyle with IBS

People with IBS often eliminate foods they feel cause adverse symptoms. This often results in an unhealthy and unbalanced eating pattern that lacks the essential nutrients.

The following approaches can help to reduce symptoms.

- Eat regular smaller meals, taking time to chew and eating slowly, avoiding long gaps between meals.
- Spread your five a day throughout the day.
- Avoid fatty and fried foods which can make symptoms worse.
- Make sure that your fluid intake is appropriate, as shown on the Eatwell Guide. Make sure it is caffeine-free, and limit the amount of fizzy and alcoholic drinks because they may make the symptoms worse.

- Reduce your stress and anxiety if possible.

Having medical support to reduce symptoms and advice from a registered dietician can also reduce a lifetime of distress. However, if this approach does not work, following a low FODMAP approach can help.

4.2 The low FODMAP approach

FODMAP stands for Fermentable Oligosaccharides, Disaccharides, Monosaccharides And Polyol. These are all found in some carbohydrates that are not absorbed in the small intestine of some people. Instead, they pass along to the large intestine, where there are billions of bacteria. The FODMAPs are fermented by the bacteria, producing gas (wind and bloating). Water is drawn into the large intestine, causing loose stools. In some people, if FODMAPs are reduced, the symptoms improve.

The low FODMAP approach is followed for four to eight weeks, allowing the large intestine to recover. Then there is a period of reintroduction, which can take six to eight weeks. There is a technique to this approach and it is recommended that support is given by a Registered Dietician because it requires dedication and motivation.

4.3 Prebiotics and probiotics for good gut bacteria

There are trillions of bacteria in your gut, weighing up to 2 kg. They are essential in controlling processes and have a vital role in your digestive system. They also have a role in your immune system, inflammation, mental health, cardiovascular system, and metabolic health.

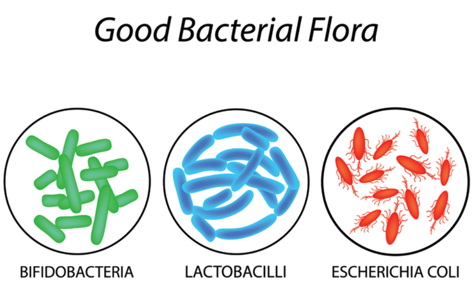

Figure 8 Bifidobacteria, Lactobilli and Escherichia coli

It can be easy to get confused with what prebiotics and probiotics are. So what is the difference?

There are over 400 bacterial species so far identified that live in human guts. They occur in low numbers in the stomach and upper intestine but are abundant in the lower bowel. They play a role in fibre digestion and synthesise certain vitamins (biotin and folate), as well as helping to absorb vitamin K.

Prebiotics literally means 'before life'. Prebiotics are non-digestiblefood components that promote the 'good' bacteria such aslactobacilli and bifidobacteria. In other words, they are food for the bacteria and not live bacteria. Prebiotics are stable and reach the gut intact, feeding the good bacteria. They can trigger symptoms in people with IBS because they are oligosaccharides, Prebiotics should be avoided if you are following a low FODMAP approach.

Probiotics are the actual, live, ‘good’ bacteria. They can be affected by heat and enzymes as they pass down the gut, so have to be taken in adequate amounts. They compete against the resident microflora in the gut for colonisation sites.

It would seem ideal to take prebiotics and probiotics at the same time. These are called **synbiotics** because they contain both in the same preparation. More research is emerging to suggest that the gut bacteria are important to our health.

5 Coeliac disease

For some people, the symptoms of IBS relate to undiagnosed coeliac disease (pronounced *see – lee–ac)*. It is estimated that 1% of the British population has the condition. Coeliac UK states: 'only 24% who have the condition have been diagnosed which means there are currently nearly half a million people who have coeliac disease but don't yet know.'

This increases to a one in ten chance of having this condition if a first-degree family member (such as mother, father, sister or brother) also has the condition.

There are a variety of symptoms which include bloating, diarrhoea, nausea, wind, constipation, tiredness, sudden or unexpected weight loss (but not in all cases), hair loss and anaemia.

So how does coeliac disease differ from IBS?

In section 1.5 we looked at the immune response to an allergen. Imagine if that beneficial immune response resulted in the body attacking its own healthy cells. This is what happens with coeliac disease. The allergen is gluten, which sets off an autoimmune response that attacks the villi in the small intestine (Week 2, section 3.1, Figure 10) and flattens them (Figure 9). Autoimmune means the immune response occurs with the body's own tissues, cells, or cell components.

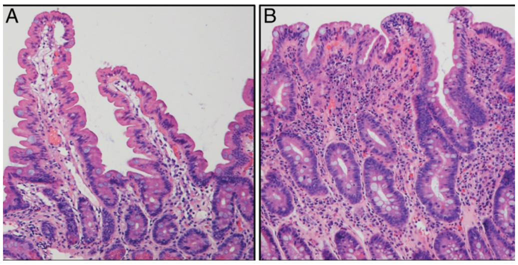

Figure 9 (a) Normal villi; (b) flattening of the villi in coeliac disease

Activity 4 Consequences of flat villi

Allow approximately 10 minutes.

Make a list of how flattening the villi could affect what is absorbed from the food we eat. Click 'Save' when you are satisfied with what you have written.

Provide your answer...

Answer

Your list might include:

- the body is unable to absorb all of the nutrients from food properly, causing malabsorption
- water cannot be absorbed, so dehydration occurs
- there may be diarrhoea.

It can be useful to know which part of the digestive system absorbs which nutrients. Do you remember we looked at where the nutrients are absorbed in Week 2, section 3.1?

The lack of surface area means that nutrients may not be absorbed in sufficient amounts. For example, water-soluble vitamins, vitamin B12, bile salts, amino acids and simple peptides, as well as water and sodium. This can cause malnutrition.

In 2015, the National Institute for Health and Care Excellence (NICE) produced guidelines for the recognition, assessment and treatment of coeliac disease.

- A diagnosis of coeliac disease in adults is from a blood test to check for antibodies and a biopsy. (For children, a biopsy is only done if required.) But the person needs to be eating gluten (found in wheat, barley and rye) at the time of the test.
- The only treatment is a gluten-free diet for life.
- Even the smallest amount of gluten can cause an autoimmune reaction.
- There should be an annual review where blood antibodies are checked. Also a DEXA scan which can identify bone density, because bone health is affected with poorly controlled coeliac disease.

As you can see, this condition requires the maintenance of a gluten-free diet. Some essential foods are available on prescription and a team of health professionals is needed to support people who have coeliac disease.

Activity 5 Finding foods that are gluten free

Allow approximately 10 minutes.

Look in your kitchen cupboards and see which foods have the gluten-free symbol (Figure 10).

Figure 10 The cross-grain symbol denoting gluten-free food

As you can see, many foods contain gluten, some of which are obvious, but some you may not realise, because the factory may contaminate products with traces of gluten. Gluten-free is only gluten-free if prepared in gluten-free, non-contaminated areas.

Can you imagine what it must be like following a strict diet such as gluten-free? Well, that is what a person diagnosed with coeliac disease does every day. It is hard even though some basic foods are available on prescription.

You may be able to be careful at home, but what about eating out? Coeliac UK has been working with caterers. If accredited, they can use the symbol developed by Coeliac UK, showing that the restaurant meets the gluten-free standard (Figure 11).

Figure 11 The Coeliac UK gluten-free logo

6 This week's quiz

Check what you've learned this week by taking the end-of-week quiz.

Week 7 quiz

Open the quiz in a new window or tab, then return here when you have done it.

7 Summary

This week you learned what the difference is between a food allergy and a food intolerance and how this can affect what can be eaten. You should now be able to understand:

- food allergy and how it differs from food intolerance
- the tests available that can help diagnose food allergy or intolerance
- what happens in anaphylactic shock
- irritable bowel syndrome and some treatments
- coeliac disease and being gluten-free.

Next week is the final week of the course. You will have a chance to explore the psychology of eating and how we taste food. Then you will have an opportunity to record and self-analyse what you eat and drink against everything you have learned so far.

You can now go to Week 8.

Week 8 Taste and psychology

Introduction

Well done for getting to the final week of the course.

This week includes more about how we taste food, the psychology of eating and how this can affect what you eat. Finally, you will have an opportunity to put everything you have learned into practice for your own dietary approaches, by keeping a one-day food diary.

By the end of this week's study you will be able to understand:

- what is involved in tasting food
- hunger and satiety
- what can affect eating behaviour
- eating disorders
- your own eating pattern and whether you will change it.

1 How we taste food

Have you ever wondered how we taste food?

Watch the video clip The secrets of your food, which shows how we taste food through our nose.

Activity 1 Can you taste this?

Allow approximately 25 minutes.

For this activity you will need:

- a blindfold
- something to close your nose safely (your fingers or a swimmer's nose clip)
- an assistant who can choose three foods that you will not know (a mouthful of each one)
- a glass of water.

1. First, make sure that you are blindfolded and your nose is blocked.
2. Ask your assistant to put food number 1 in your mouth. Then guess what it is. This person must not give anything away!

3. Next, unblock your nose while you are still chewing and guess again.
4. Wash out your mouth with water.
5. Repeat the process for food number 2 and 3.
    - What did you notice?
    - Could you taste the foods?
6. Now take your blindfold off. Did you guess the foods correctly?

Discussion

You might have guessed the food by its texture or taste and smell and look. This is what we do every time we eat. If the food does not look good, or smell nice, you are less likely to eat it. If you have a cold and cannot smell, often food does not taste as nice.

1.1 The science bit

Often, the first sense is the smell of food, even before you have seen it. You have probably smelt bread, coffee or baking that makes you feel hungry. But if you have anosmia (lack of ability to smell), you cannot smell and the taste of food is altered.

The second sense is sight. The look of the meal has an effect on whether you would eat it. For example, would you eat insects if you saw them (Figure 1)?

Figure 1 Edible insects for sale at a market in Bangkok, Thailand

In some cultures, insects are a good source of protein. It is called *entomophagy* when humans use insects as food.

The third sense in combination with smell and sight is taste. The tongue's receptors can recognise different tastes in different parts (Figure 2).

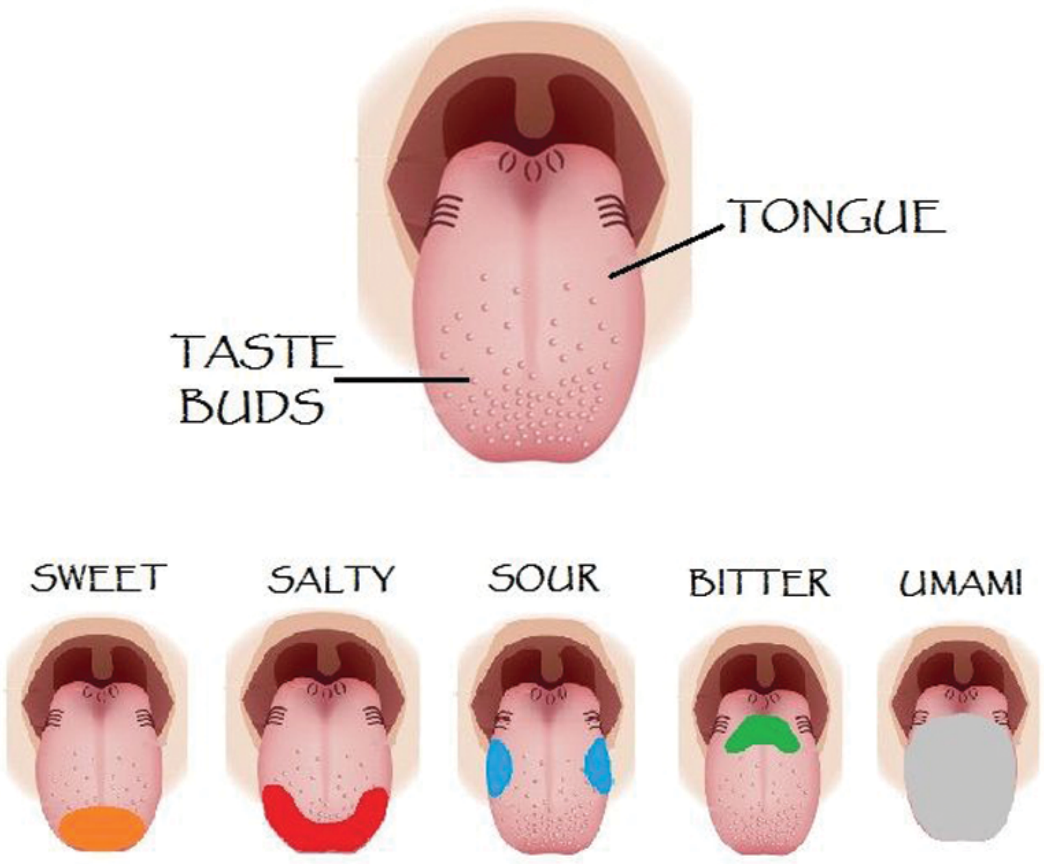

Figure 2 Taste receptors on the tongue

Put all of this together and you get the taste of food, which is an amazing sensory experience.

Now watch the video clip Sneaky strawberries which looks at the sweetness of strawberries and blueberries.

2 Reasons for eating

In Week 1, we briefly looked at the reasons for eating. Now we will go into this in more detail.

Activity 2 Reasons for eating

Allow approximately 10 minutes.

Can you remember why we eat?

Provide your answer...

Answer

The reasons you might have noted are:

- to stay alive
- feeling hungry
- eating is a 'habit' and food was available at that time
- it is time to eat (i.e. breakfast, lunch or evening meal), there are set times to eat these meals
- eating is sociable and enjoyable
- just felt like eating but was not hungry
- upset or feeling anxious and comfort ate.

There are several reasons for eating (see Figure 3).

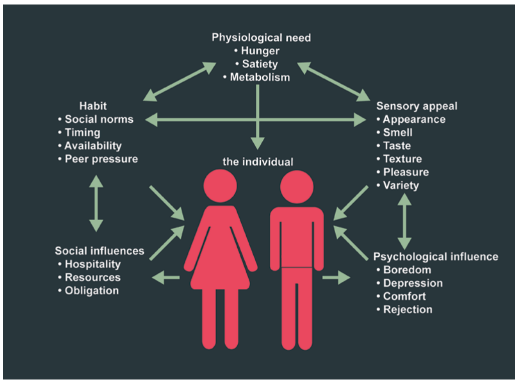

Figure 3 Different reasons for eating

We have already talked about sensory appeal – smell, taste and appearance. There is also, of course, a physiological need to just stay alive! Figure 4 summarises the physiological factors that control hunger and food intake.

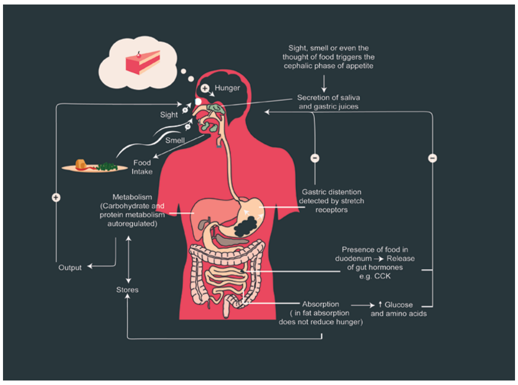

Figure 4 Physiological factors controlling hunger and food

2.1 Sensory signals

Thinking about your favourite cake initiates the *cephalic (of the head) phase*.This causes the feeling of hunger and prepares the digestive tract for the ingestion of food by secreting saliva and gastric juices.

2.2 Pre-absorptive information

The stretch receptors in the stomach send signals to the brain. Combined with the early phase of digestion in the duodenum, gut hormones are released. Cholecystokinin (CCK) is produced by cells in the wall of the small intestine. This affects the brain, reducing the feelings of hunger. CCK is stimulated particularly by the presence of protein and fat digestion products in the duodenum. Peptides such as PYY and ghrelin signal to the brain that the stomach is full.

In Week 1 you were introduced to ghrelin. Can you remember what it does?

As the level of ghrelin increases, you feel hungry. As ghrelin decreases, there is a feeling of satiety (fullness). At the same time, the level of PYY increases, causing satiety.

2.3 Post absorptive signals

Fluctuations in blood glucose level affect appetite. Low blood glucose level (hypoglycaemia) stimulate hunger. There is a homeostatic balance of blood glucose level. As blood glucose increases, a hormone – insulin – is secreted by the pancreas. This is an acute appetite suppressant.

You may have heard of leptin which is released by adipose tissue (fat cells) in the body. This decreases during a period of fasting and increases when you eat. Leptin acts on the hypothalamus in the brain, which causes the release of neuropeptides (e.g. neuropeptide Y), which inhibits food intake.

Another neuropeptide called orexin (hypocretin) is involved with arousal, wakefulness and appetite. This increases the craving for food. Leptin inhibits craving, while ghrelin and hypoglycaemia stimulate orexin-producing cells in the hypothalamus and spinal cord.

So, the next time you crave something to eat, blame it on your orexin!

Activity 3 Hunger and Satiety

Allow approximately 15 minutes.

Put the correct effect next to the relevant hormone below.

- ghrelin
- CCK
- insulin
- leptin
- PPY
- orexin

Match each of the items above to an item below.

- stimulated by empty stomach sending signals of hunger to brain
- released by digestive tract sending signal to brain of satiety
- controls blood glucose levels
- secreted by fat cells, decreasing hunger
- released by digestive tract, sending signal to brain of satiety
- increases craving for food

3 Food habits

In Week 1 we looked at the social aspects of eating. Look at Table 1 below which highlights the factors influencing food choice.

Table 1 Factors influencing food choice

Physiological	Social/psychological	Cultural
the need to live	social and personal status	national identity
appetite	group identity	cultural group
sensory appeal	emotional support	food staples
hunger/satiety	reward/punishment	meal patterns
personal likes and dislikes	ritual/habit	religious practices
special therapeutic diets, e.g. for coeliac disease	communication	restrictions

We looked at malnutrition in Week 6. You may be able to link the factors above with under- and overnutrition, especially when food is readily available and when it is limited.

Certain food habits can affect our health. These are known as *eating disorders*, which are sometimes thought of as ‘fussy eating’. We now look at the difference between fussy eating, disordered eating and an eating disorder.

4 Eating disorders

An eating disorder is a medical diagnosis and requires a specialist team to treat and support the person affected appropriately. A person with an eating disorder has a range of psychological disorders. These result in an abnormal relationship with food that causes a change in the person's eating habits and behaviour.

The following main types of disorder are recognised.

- When food and fluid are restricted, with massive weight loss, it is known as anorexia nervosa.
- There can also be binge eating, which is known as a binge eating disorder.
- When there is vomiting, it is known as bulimia nervosa.
- There are often body image issues associated with eating, as well as other psychological issues such as depression and self-harm.

There is another associated condition called avoidant restrictive food intake disorder (ARFID). Here a small list of foods will be eaten and foods that are avoided because of their smell, taste, colour or texture. The idea of eating can cause anxiety. ARFID is not associated with body image; it is anxiety about the eating process. This could also be considered as disordered eating.

The National Eating Disorders Centre has more information that you may find useful.

Fussy eating is completely different. It often develops through the food choices made during the formative years of weaning and mixed eating. Often, changes in the social environment can change the type of food eaten. Have you eaten something different when you go out, or when cooking for yourself?

5 Your food diary

Now you have an opportunity to analyse what you eat and drink, why you eat and where you are when you eat. Create a food diary and record a typical day's intake of food and drink.

- Make sure that you write the diary while you eat the food or have the drink.
- Note down even when you drink water.
- Use household measures, e.g. two slices of medium sliced bread, five egg-sized potatoes, hand-sized meal portion.

The British Dietetic Association fact sheet about portion sizes may also be useful.

You might want to create your diary using a table. Here are some suggested headings:

- time
- food/drink
- amount (household measure)
- where eaten
- eaten with?
- hungry/thirsty?
- time taken to eat
- your mood before, during and after eating.

5.1 Thoughts on your food diary

Well done for keeping the food diary. It takes commitment and time to keep such a comprehensive diary.

Activity 4 Food diary follow up

Allow approximately 15 minutes.

Admittedly, it is only for one day. But you may be able to look at the following areas and make comments. Click 'Save' when you are satisfied with what you have written.

- Do you tend to eat and drink at fixed times?

Provide your answer...

- Did this day reflect your normal day?

Provide your answer...

- Did you try to follow the advice in the Eatwell Guide (Week 6)?

Provide your answer...

- Where did you eat and with whom? Was this social eating?

Provide your answer...

- Were you hungry when you ate? You can include feeling thirsty here too.

Provide your answer...

- How quickly or slowly do you eat?

Provide your answer...

- Are there other factors that affect the speed of eating and drinking?

Provide your answer...

- Does your mood affect how much or little you eat?

Provide your answer...

- What effect has your learning on this course had?

Provide your answer...

- What two or three things have you learned over the past eight weeks?

Provide your answer...

- Do you plan to make any changes to your eating pattern as a result of what you have learned?

Provide your answer...

6 Summary

This final week allowed you to understand not only the science of nutrition but also the factors that affect what we eat. There can be medical reasons as well as psychological and social reasons for our food choice. The extra reading and web links throughout the course are for you to extend your learning.

You should now be able to understand:

- what is involved in tasting food
- hunger and satiety
- what can affect eating behaviour
- eating disorders
- your own eating pattern and whether you will change it.

Don’t forget to complete and pass the Week 8 quiz to become eligible to earn the badge.

7 This week's quiz

Now it's time to complete the Week 8 badge quiz. It is similar to the badged quiz that you took at the end of Week 4, with 15 questions in total.

Week 8 quiz

Remember, this quiz counts towards your badge. If you're not successful the first time, you can attempt the quiz again in 24 hours.

Open the quiz in a new window or tab, then return here when you have done it.

8 End-of-course round up

Well done for completing this course. You certainly have been through a nutrition journey.

Figure 5 The end of your nutrition journey

Over the past eight weeks you have looked at:

- the components of food and the roles they play in your body
- what happens to your food once you have eaten it, and how the body uses it
- the importance of hydration
- the information provided by food labels and what it means
- energy in the food we eat
- advice on healthy eating and diets from around the world
- food allergy, food intolerance, IBS and coeliac disease
- how we taste food and the psychology of eating.

You have now reached the end of *The science of nutrition and healthy eating*. We hope you have enjoyed the course and learned a lot about the food you eat.

Tell us what you think

Now you've completed the course we would again appreciate a few minutes of your time to tell us a bit about your experience of studying it and what you plan to do next. We will use this information to provide better online experiences for all our learners and to share our findings with others. If you'd like to help, please fill in this optional survey .

Where next?

If you have enjoyed this course you can find more free resources and courses on OpenLearn.

Why not find out more about studying and gaining qualifications at The Open University? Visit the OU prospectus for more information. You might be particularly interested in science.

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Further reading

NHS food poisoning information

NHS peptic ulcer information

A history of *Helicobacter pylori* and peptic ulcer disease

The secrets of the dairy

OpenLearn: Ever wondered about... food additives?

BBC – Food labelling: consistent system to be rolled out

What are health claims and how are they assessed?

The truth about aspartame

Investigate the energy available from over 150,000 other foods

If you are interested, you could read the abstract of Valtin's paper.

Or you could read a BBC news article questioning the 8 × 8 advice.

BMI: Does the Body Mass Index need fixing?

OpenLearn – Obesity: balanced diets and treatment

History and characteristics of Okinawan longevity food

Simple rules for healthy eating

Acknowledgements

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Week 6 Tables

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