

FOOD AND DIET

BigPicture

ISSUE 14 | SUMMER 2011

BRINGING CUTTING-EDGE SCIENCE INTO THE CLASSROOM

A free
resource for
teachers and
learners



A LOT ON OUR PLATE?

*The different roles of
food in our lives*

Credit: © Steve Buchanan/the food passionates/Corbis

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Celebrating 75 Extraordinary Years

BigPicture

Humans, like all living things, cannot survive without food. For many of us, though, food is about so much more than sustenance. Culture, identity, religion, relationships, mood, fashion, pleasure – what we choose to eat touches on many aspects of our lives. In this issue, we look at what drives us to eat, what happens to food once we've eaten it, and what impact our dietary choices have on our health and wellbeing and that of people across the world.

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ONLINE

Go to www.wellcome.ac.uk/bigpicture/food for more teaching resources on food and diet, including extra articles, videos, image galleries, curriculum links, lesson ideas, a glossary and an animation of atherosclerosis. You can also download the PDF of this magazine or subscribe to the Big Picture series.

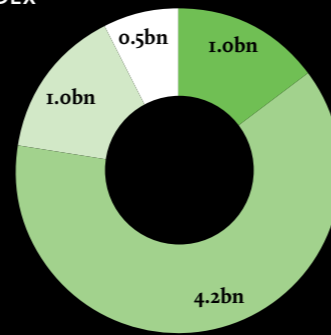
Eating by numbers

A snapshot of our lives through food

GLOBAL POPULATION BY BODY MASS INDEX

BMI classification

Underweight	<18.5
Normal	18.5–24.9
Overweight	25.0–29.9
Obese	>30.0



Ref: The State of Food Insecurity in the World, 2008: High food prices and food security – threats and opportunities. Food and Agriculture Organization of the United Nations, 2008, www.who.int/mediacentre/factsheets/fs311/en/

UK SPEND ON FOOD



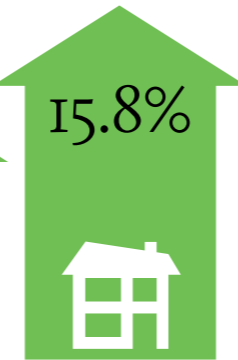
Average spend per person per week in the UK on food and non-alcoholic drink purchases.
Ref: www.defra.gov.uk/statistics/files/defra-stats-food-family-annual-2009/pdf

ALL HOUSEHOLDS

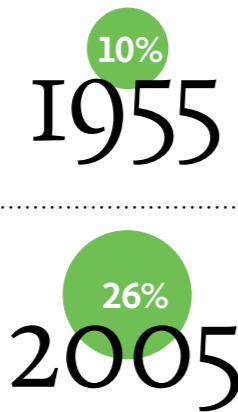


Percentage of total budget spent on food and non-alcoholic drink for all households vs. the fifth of households with the lowest income.
Ref: www.defra.gov.uk/statistics/files/defra-stats-food-family-annual-2009/pdf

LOWEST FIFTH

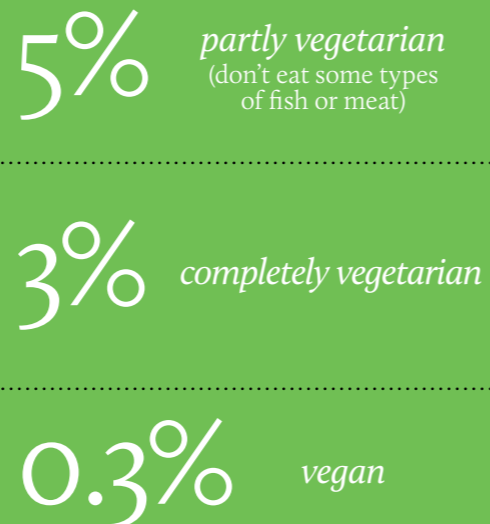


UK SPEND ON EATING OUT



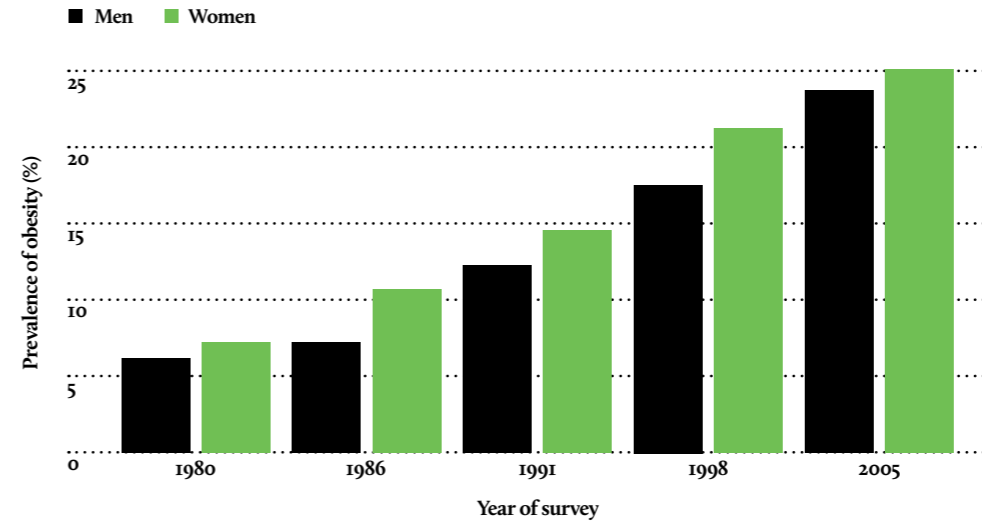
Average spend per person per week on eating out, out of total food spend, was 26% (£8.26) in 2005 compared to less than 10% in 1955.
Ref: www.defra.gov.uk/statistics/files/defra-stats-food-family-annual-2009/pdf

UK VEGETARIANS AND VEGANS



Ref: Food Standards Agency Public Attitudes to Food survey 2009, www.imaner.net/panel/statistics.htm

UK TRENDS IN OBESITY



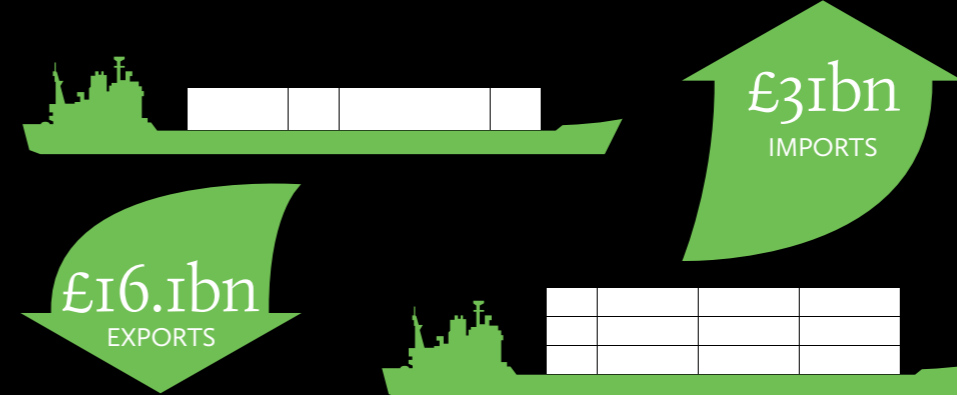
Ref: www.admin.cam.ac.uk/offices/research/documents/local/events/downloads/fd/Susan_Jebb.pdf

UK SPEND ON DIETARY SUPPLEMENTS



In 2006, the vitamins, minerals and supplements market was valued at £364 million a year.
Ref: www.hsis.org/faq/faq15.html

UK FOOD AND ALCOHOL IMPORTS AND EXPORTS



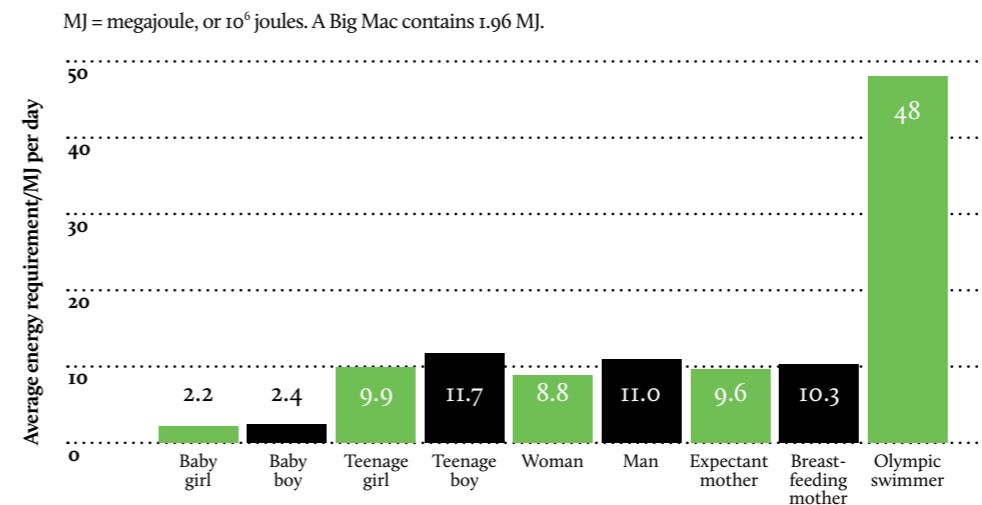
- Export sales of whisky account for 22% of all food and drink exports (by value).
 - The UK is only 60% self-sufficient in agricultural produce, so it still imports goods.
- Ref: www.fdf.org.uk/exports/ukexports/topline_performance.aspx

UK FOOD WASTE PER YEAR



UK households throw away 8.3m tonnes of food (£680 per family) – the same as one in three bags of shopping going in the bin.
Ref: www.lovefoodhatewaste.com/about_food_waste

DAILY ENERGY REQUIREMENTS



Estimated average requirements for people of average activity (average mass in kg in brackets): six-month-old baby (boy, 8; girl, 7.3); 15-year-old (boy, 55.5; girl, 53); 35- to 49-year-old (man, 69.7; woman, 59). Ref: www.sacn.gov.uk/reports_position_statements/reports/draft_energy_requirements_report_scientific_consultation_-_november_2009.html. Ref for swimmer: www.guardian.co.uk/sport/2008/aug/14/michaelphelps.swimming1. Big Mac info: www.weightlossresources.co.uk/calories/calorie_counter.htm. Conversion used: 250 kilocalories to 1MJ.

FINDING DATA

Putting this diagram together, we found that different sources gave different numbers for the same thing. Why don't they match?

Well, data can be interpreted in different ways, and estimates can be made using different methods and/or baseline data. Definitions matter, too – different sources might define 'overweight' or 'adult' differently.

Which should you choose? The source itself is important – is it reliable? Are the figures recent? How might an organisation's 'agenda' affect how it calculates and presents data?

Chemistry of consumption

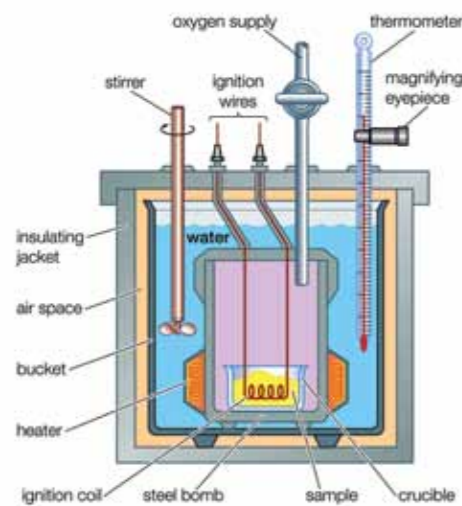
All living things need matter and energy. We get ours from food. Everything you eat – except highly refined foods like the sugar you stir into your tea – is a complex mixture of molecules, usually made by other living things. Digestion breaks down these molecules into smaller ones that the body can use.

MEASURING ENERGY

How do we measure the energy in food?

One way to measure all the different things you eat in a week is by the amount of energy the food contains. The International System of Units (SI) unit for energy is the joule (J); often, energy in food is discussed in kilojoules (kJ, 10^3 J) or megajoules (MJ, 10^6 J). Some food packaging and

other nutritional information uses the kilocalorie (kcal). One kcal is equal to 4.184 kJ. The energy content of food is estimated by burning it in a bomb calorimeter, which measures heat production. Some foods yield more energy than others – sweet or fatty foods are likely to be more energy-dense.



© Universal Images Group Limited/Alamy

EASILY DIGESTED

Different enzymes work in different parts of the body

Hydrolytic enzymes are the main agents of digestion. They break down proteins, DNA, fats and carbohydrates into smaller soluble molecules that can diffuse easily out of the intestines and can be used by the body to provide energy for repair and growth.

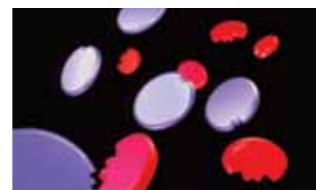
Digestion is not a single event. Your saliva, for instance,

starts breaking down starchy carbohydrates while you are chewing because it contains the enzyme amylase. When protein passes into the stomach, it is digested (hydrolysed) by protease enzymes working in the acidic environment. Other enzymes that work in alkaline conditions (e.g. trypsin) are secreted from the pancreas

into the small intestine to act on fats and complex sugars. Finally, substances untouched by our enzymes (e.g. soluble fibre) may be partially broken down by bacteria in the large intestine.

Digestion is a catabolic process, which generates energy. By contrast, anabolic enzymes use energy to

synthesise larger molecules from small products. Catabolism plus anabolism makes metabolism.



Artwork of enzyme action

Pasieka/Science Photo Library

BARE ESSENTIALS

Some necessary molecules we can only get from our diet

Many key molecules are produced by chemical modification of what we eat, a process catalysed by enzymes. Some molecules – known as ‘essential’ – can’t be made in this way and have to come directly from our food. They were probably in good supply in our evolutionary past and so we lost the ability to make them. Of the 20 amino acids in human proteins, ten are essential. Diets including meat, dairy products and soy contain proteins with a similar average amino acid composition to ours. Vegans do not eat animal-derived protein, so they have to mix grains (e.g. wheat, rice and oats) and legumes (e.g. peas, beans and lentils) to make sure they get a complete and balanced supply of amino acids. Eating beans on toast is one way to do this.

Other components we must get from our diet include a few essential fatty acids, found in a range of seeds and vegetable oils and in fish. We also need vitamins, which can be made by plants or animals, and minerals, which are found in soil or water. Water-soluble vitamins, such as several B vitamins and vitamin C, cannot be stored in our tissues and must be replenished regularly.

Most vitamins and minerals are needed only in minute amounts and are plentiful in common foods. Health agencies publish minimum requirements worked out by nutritionists. Averages are a rough guide, but individual values need to be adjusted for age and sex, height and weight, and how active you are. Too much of certain vitamins can harm your health (see page 12). See www.nutrition.org.uk/nutritionscience/nutrients/nutrient-requirements

IN TERMS OF APPROXIMATE ENERGY CONTENT...



Burger

= 6 x



Iceberg lettuce

anopdesignstock/iStockphoto

INHERITED METABOLIC DISEASES

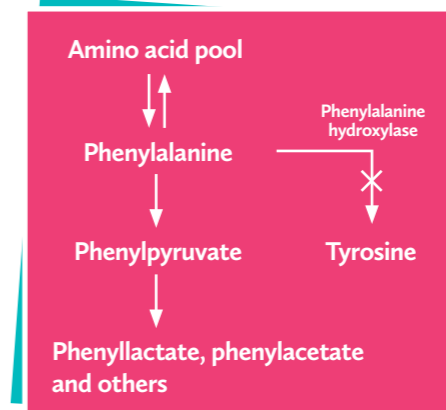
Defects in enzymes can lead to disease

Some specific gene variations mean that an enzyme fails to work properly. These inborn errors of metabolism were first suggested by the British doctor Archibald Garrod in 1908 and were confirmed by later geneticists. One of the most common is phenylketonuria (PKU), in which an enzyme defect blocks the conversion of the amino acid phenylalanine into tyrosine (see diagram, right). Although phenylalanine is essential, an excessive build-up is harmful, eventually leading to brain damage.

Children born with PKU must have very little protein in their diet and avoid drinks containing the sweetener aspartame, which is made from phenylalanine and another amino acid. Such drinks have to carry a warning that they contain phenylalanine. With the restricted diet, affected babies suffer no harm. Since the 1960s, all babies in the UK have been tested for PKU within a week of birth by the Guthrie test on a drop of blood from a heel prick. About

nine babies in every 100 000 have PKU, and the test costs £1 a time. As well as avoiding disability, mass testing is cheaper than the cost of caring for children with PKU who are untreated.

Read about life with PKU on page 14.



An enzyme defect in PKU leads to a build-up of phenylalanine as minor reactions (left path) occur more.

CAN'T EAT, WON'T EAT?

How does an aversion to a food differ from an allergy?

If something you eat makes you sick, you shrink from eating it again. Omnivorous animals like us show this avoidance reaction strongly. It evolves from two pressures: it's good to try small amounts of new stuff when regular foods are in short supply, but if they harbour toxins, a second dose is a bad idea. Some people with a particular aversion can convince themselves they are allergic to this food and will vomit if given it. This reaction is psychological.

A true allergy is a reaction of the immune system. A strong allergic reaction, known as anaphylaxis, can involve a dangerous drop in blood pressure and difficulty breathing.

Food allergies develop in 5–8 per cent of children and appear to have increased in number in recent decades. They can be quite short-lived. Severe food allergies

and deaths, however, are rare and have remained constant. There were six deaths from food allergies in England in 2008.

Some food allergies can be controlled by gradual exposure to small amounts of the offending food. In a carefully monitored study, researchers in Cambridge showed that sensitivity to peanuts could be reduced by feeding children increasing daily doses of peanut flour mixed into yoghurt. A larger-scale trial of this treatment began in 2010. See www.nhs.uk/news/2010/02February/Pages/Peanut-allergy-therapy-tested.aspx



LauriPatterson/iStockphoto

FAST FACT

Grapefruit juice contains compounds that block enzymes involved in metabolising a range of drugs, so drug levels stay higher for longer. These drugs include calcium-channel blockers used to treat high blood pressure. Source: Bailey DG et al. *Lancet* 1991;337(8736):268–9.



tedestudio/iStockphoto

HARD TO TOLERATE?

The way we metabolise chemicals varies between populations

Human milk contains the sugar lactose, and babies make the enzyme lactase to digest it. Some adults who don't consume lactose stop making lactase, and they become lactose intolerant. Any lactose they drink is digested by the bacteria in their colon and can cause bloating and cramps. In regions where people drink cows' milk, lactase production often stays switched on. People in northern Europe, for instance, are often lactose tolerant, whereas people from China are more likely to be lactose intolerant. The genetic changes that lead to the persistence of lactase have occurred independently several times and in different populations, as people have domesticated milk-producing animals.

The levels of alcohol dehydrogenase can also vary between people. This enzyme works in the liver to break down ethanol produced by bacteria that live in the gut, as well as that from alcoholic drinks. Heavy drinkers make more, but not enough to prevent the damage caused by the toxic ethanol and its breakdown products. Mutated forms of alcohol dehydrogenase and aldehyde dehydrogenase, which are both involved in alcohol breakdown, are prevalent in East Asian populations. They have been linked to increased sensitivity to alcohol, including a facial flushing reaction, and even to the risk of alcoholism. See Thomasson HR et al. *Am J Hum Genet* 1991;48(4):677–81.

Why do we eat?

Delicious food doesn't just taste good but looks good, smells good and feels good to eat too. What are the factors that drive our urge to eat, and what tells us to stop when we've had enough? How do we sense and experience food, and how are these processes exploited to make food more palatable and appealing?



APPETITE FOR CONSUMPTION

Appetite involves the brain, stomach and hormones

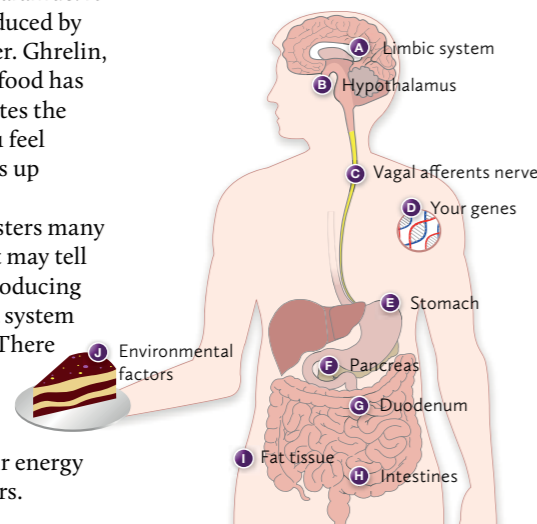
"Anyone for seconds?" Your answer will depend on how tasty the first helping was, who is asking, and whether you might look ungrateful. Unconsciously, a shifting network of interactions between brain, stomach and hormones will also influence whether you still feel peckish or are completely stuffed.

Many controls on appetite (see diagram) affect a small part of the brain known as the hypothalamus. It responds to hormones produced by the stomach to drive hunger. Ghrelin, which is secreted when no food has arrived for a while, stimulates the hypothalamus to make you feel hungry. The secretion eases up as your stomach fills.

The hypothalamus registers many other chemical signals that may tell you to eat less, as well as producing hormones of its own. It is a system with checks and balances. There is increasing evidence that it can keep your weight fairly constant by making you hungrier if you cut your energy intake – bad news for dieters.

Disruption to the appetite system helps us understand how it works. For example, one of the genetic changes in the inherited disorder Prader-Willi syndrome leads to very high ghrelin production, and children with the condition are hungry all the time.

See our video, article and interactive diagram on appetite at www.wellcome.ac.uk/bigpicture/food



SKINNY GENES

What part do our genes play in body size?

Genes and environment work together to influence your body size and shape, and a few genetic variants can make a big difference. Leptin, an appetite-regulating hormone that reduces hunger, is normally produced by cells that are storing

fat; genetic mutations that block production of the hormone or its receptor can lead to an unremitting drive to eat. In addition, obesity seems to go with a loss of sensitivity to leptin. A newly identified gene known as *FTO* can also induce obesity in

mice when its activity is increased by giving the mice extra copies of the gene. Evidence from human data also indicates that variations in the gene are linked to becoming overweight, although it is not yet known exactly what the gene does.

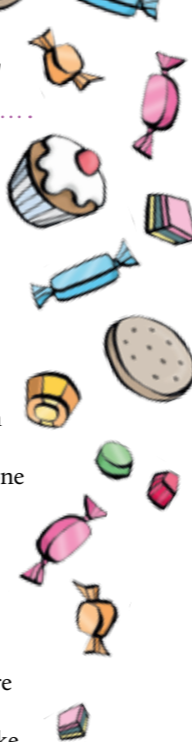
HAPPY MEALS

Eating food can make us feel good

Evolution builds rewards into activities that are important for survival and reproduction, so the drive to eat when hungry is strong. Eating activates our brain's reward system, which produces a good feeling via the neurotransmitter dopamine.

Recent studies suggest that some people who have genetically low levels of dopamine – and also show low activity in the food reward regions of the brain in imaging experiments – are especially prone to putting on weight. Their overeating could be an attempt to get a stronger response from their sluggish neurons or could stem from a higher than normal reward from eating: it feels so good you want more.

Both could be true. On one hand, there is evidence that obese people start out getting more reward from tasty snacks like chocolate ice cream. After they gain weight, their reward centres become less active when tasting the same treats. On the other hand, imaging studies also suggest that extreme hunger makes the reward centres respond more strongly to high-calorie foods (which, again, makes evolutionary sense).



FAST FACT



Eating soup makes you feel full for longer than eating solid food with a glass of water. Why? Water mixed with solids (e.g. soup) stays in the stomach longer than water alone. Source: news.bbc.co.uk/1/hi/magazine/8068733.stm

travellinglight/istockphoto

FAST FACT



Work at the University of Oxford has found that people tend to associate sweet and sour tastes with high-pitched sounds and umami and bitter tastes with low-pitched ones, and that people enjoy food more when 'matching' music is played during eating. Source: www.ncbi.nlm.nih.gov/pubmed/20952795

SondraP/istockphoto

MATTER OF TASTE

How do we recognise different tastes?

Different chemicals can give rise to five different types of taste. Sweet, sour, salty and bitter tastes have been known for some time. More recently, the savoury taste umami – think of soy sauce or the juices from a roasted joint of meat – has been added to the set.

Specialised taste cells send signals to the brain, triggered by a range of chemical sensors. Salty or sour substances act on proteins that form channels on the surface of the cells and control the movement of positive ions. Sweet- and bitter-tasting ones bind to different receptor proteins, as

do molecules that we sense as umami. The brain interprets patterns of cell activation, as each taste cell responds to a range of chemicals with differing sensitivity. The final taste also depends on the texture and temperature of the food.

Old textbooks mention a 'taste map' on your tongue, with different regions picking up different tastes. However, detailed tests show that all parts of the tongue with taste buds can register all types of taste.

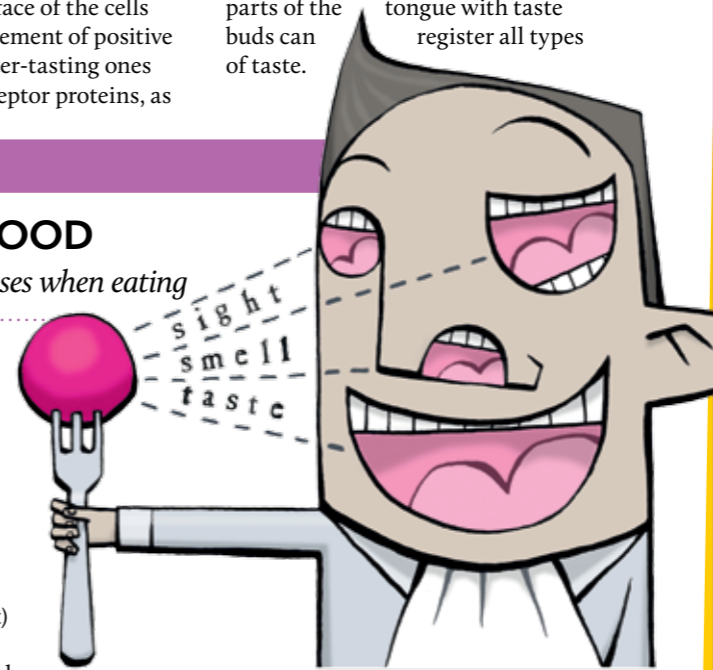
SENSING FOOD

We use many senses when eating

Tasty food usually smells good, and eating with a blocked-up nose makes food seem bland. Appearance is important, too – colours can be a warning (blue foods just don't seem right) or add to the appeal.

What looks good is also influenced by fashion. White bread was once a luxury but is now seen as cheap and less wholesome than brown.

An unusual neurological case shows how colour affects appetite. A patient of the neurologist Oliver Sacks lost colour vision from a brain injury, remembering colour but seeing the world in black and white. Food seen in black and white became unappetising (imagine eating a black tomato), but he could manage to eat white rice, yoghurt, black olives and black coffee.



Older people's taste and smell become less acute, and their appetite goes down. They may pile salt or sugar onto their food, which is unhealthy. Adding ingredients that evoke the savoury taste of umami may help them eat more, and a hospital diet that does just that is under trial in the UK.

Texture is also crucial in our food likes. Some people are extra sensitive to particular textures, usually soft ones, and find certain foods impossible to keep down. For most of us, crunchiness is compulsive. Who wants stale crisps?

PART OF THE PROCESS

Why do we process food?

Cooking, fermenting, salting, drying and pickling all help preserve food or make it nicer to eat. Modern food processing is still about preservation – frozen peas, for instance, were not marketed until the 1950s – but is also geared to convenience, choice, accessibility and consumer appeal. Colours, flavours and textures are modified by food scientists and food technologists. The resulting product, which might be brightly coloured, freeze-dried, blended or aerated, would perhaps not be recognised as food by our ancestors but certainly appeals to many of us.

As research shows which ingredients are good for you, food producers try to improve what they offer. Things are added (like vitamins to 'fortified' breakfast cereal) or taken away (like fat from fat-free milk).

Poor diets can sometimes lead to deficiencies in essential micronutrients. An important example is folic acid – the synthetic form of folate, a B vitamin that is found in leafy vegetables. Low folic acid levels increase the risk of a range of developmental problems in babies, especially neural tube defects such as spinal bifida. The USA made the addition of folic acid to many cereal products compulsory in 1998, which produced a 28 per cent reduction in neural tube defects by 2000. The addition of folic acid to foodstuffs has been recommended by the UK Food Standards Agency but is not yet compulsory. For more, see page 12.

Foods may be processed to offer health benefits beyond those of their inherent nutritional value. So-called 'nutraceuticals' include margarine supplemented with processed plant esters (stanols) that allow the margarine's makers to claim it will lower cholesterol levels. The genetic modification of crops could produce finer control over the composition of foods. Tomatoes, which are naturally high in lycopenes (a kind of antioxidant), have been engineered to produce high levels of another antioxidant – anthocyanins, which are normally found in berry fruits. The potential benefits of antioxidants are still under investigation (see page 12). Salt is included in many processed foods; see our online article for more on this.



Juanmorino/istockphoto

A healthy diet?

We're constantly being told about the importance of eating a balanced diet and being a healthy weight, but how are these things defined? How can what you eat today affect your weight, mood and health now and in the future? How might your dietary choices affect the health of your children and grandchildren?

ALL CONSUMING

How might your diet affect how you behave?

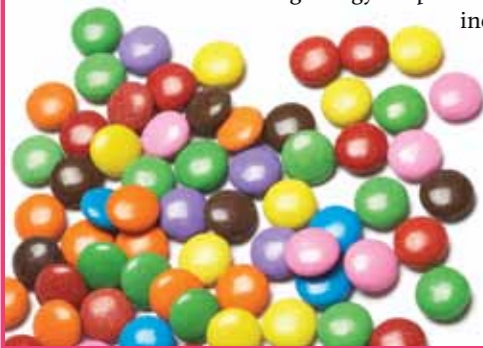
Some food additives have been linked to hyperactivity in children, and coloured drinks now carry health warnings if they contain any of the six additives that the UK Food Standards Agency wants to phase out. The warning came after a 2007 study showed that children given drinks with the colourings were more likely to be hyperactive than those who drank fruit juice.

Some children with epilepsy have fewer seizures if they adopt a high-fat, low-carbohydrate diet. This is known as a ketogenic diet because deriving energy

from fat produces high levels of the substances known as ketones. It involves ultra-close scrutiny of meals and snacks.

More controversial are claims that too little of some nutrients can affect behaviour. Supplementing trial diets with vitamins, minerals and essential fatty acids has reduced violence among prisoners. Supplements – especially of the essential fatty acids known as omega-3s, which are important for brain function – have been claimed to reduce a range of problems in schoolchildren,

including problems with attention span. There is little evidence to back their use, however. See www.guardian.co.uk/commentisfree/2010/jun/05/bad-science-omega3-fish-oil



LauriPatterson/iStockphoto

FAST FACT



Cats are unable to detect sweet-tasting food because one of the two genes needed is inactive. Unlike humans, though, they can taste adenosine triphosphate (ATP), a signal for meat. Source: www.scientificamerican.com/article.cfm?id=strange-but-true-cats-cannot-taste-sweets



A HEALTHY WEIGHT

BMI is one way to define a healthy weight

Doctors usually rate people as underweight, normal, overweight or obese by their body mass index (BMI). A higher BMI normally means a higher percentage of body fat; however, this varies according to age, ethnic group and sex. There are also differences between, say, a body-builder who eats piles of protein to add muscle mass and a couch potato who weighs the same but lives on snack foods and, hence, has more body fat.

The BMI is not a perfect measure. It applies best to people who are mainly sedentary, have roughly average body composition and are not too short or tall. Some researchers think that waist size and/or waist-to-hip ratio – or combining these with the BMI – are more useful indicators of a healthy weight.

$$BMI = \frac{\text{mass (kg)}}{\text{height}^2 (\text{m}^2)}$$

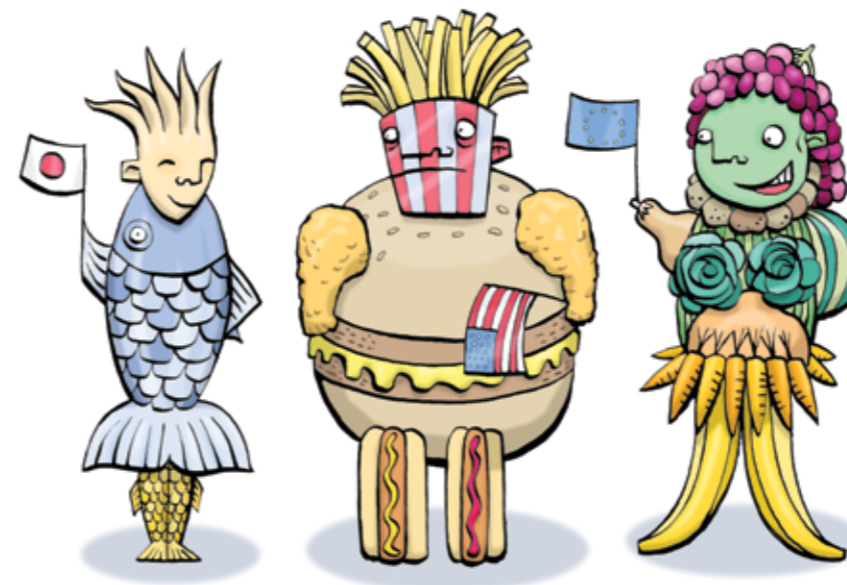
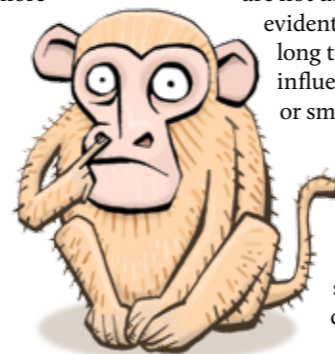


CALORIC RESTRICTION

Will eating less give you a longer life?

Cutting food intake to the bare minimum might be helpful for a longer life. It seems to work in flies, mice, rats and even rhesus monkeys, where a long-term trial is still in progress – but the idea that so-called caloric restriction slows ageing is hard to test in people. It would take a long time, and keeping to a diet that excludes many treats and needs medical supervision to ensure adequate nutrition is hard. Extreme caloric restriction can lead to dangerous weight loss, especially for young people.

More research is needed in this area. Some recent studies in fruit flies suggest that the balance of amino acids in the diet may be more important than the calorie count and that low-calorie diets can lead to diminished fertility. Eventually, limiting calories may not be necessary, as work in mice may lead to drugs that mimic some of the metabolic changes induced by caloric restriction. See www.wellcome.ac.uk/News/Media-office/Press-releases/2009/WTX057739.htm



FOREIGN BODIES

Is a Mediterranean diet better for us?

Food in some other countries seems to keep people healthier there, but it takes population-wide studies of health and disease to pin down what it is about different diets that provides particular benefits.

The effects of a diet featuring lots of olive oil, fresh fruit and vegetables, whole grains, and fish but little dairy or red meat – as traditionally seen in Spain, Greece, southern Italy and Morocco – were tested by the Seven Countries Study, which began in 1958. It compared food habits and health in the USA, northern Europe, southern Europe and Japan and confirmed that a high blood cholesterol level increases the risk of heart disease. It also suggested, however, that the

Mediterranean diet tended to reduce coronary heart disease separately from other factors such as cholesterol levels, smoking and exercise.

Shifts in eating habits also shed light on links between diet and disease. Japan – where the traditional diet includes plenty of fish, rice, soy and vegetables – has seen a move toward the larger portions of meat and dairy fats consumed in the West. Patterns of disease in Japan have become more like those of the USA. Heart disease rates have risen, although they remain relatively low. The death rate from strokes, associated with high blood pressure from a large sodium intake (e.g. a diet high in soy), has fallen steeply.

DIET, DISEASE AND DEVELOPMENT

Studying how diet affects health costs a lot and takes a long time

The effects of diet on health are not usually immediately evident, but they work in the long term alongside other influences like exercise or smoking. That means

long-term studies on large numbers of people and careful statistical analysis. Such epidemiological studies show that diet affects the risk of

many cancers, heart disease, stroke and type 2 diabetes. They reveal the swings and roundabouts of diet – for example, eating lots of red meat increases the risk of bowel cancer, while upping your fibre intake can reduce it.

Studies to tease out the details are getting larger. The EPIC (European Prospective Investigation into Cancer and Nutrition) study, across

ten countries in Europe, is following 500 000 people for at least ten years. This will show up a whole range of risk factors for cancers, especially diet, which varies widely across the countries involved.

Diet also influences early development. This extends beyond infancy, when poor diets slow normal weight gain. Being underweight in adolescence can delay

puberty, and women who become seriously underweight commonly stop having periods. People classed as underweight, obese or overweight by their BMI have higher death rates than those with BMIs in the normal range.

What are the challenges when studying how our diet affects our health? Find out at www.wellcome.ac.uk/bigpicture/food

FAST FACT

Jelly containing fresh pineapple, papaya and kiwi won't set as the proteases in them break down the protein gelatin in the jelly. The proteases also digest some of the proteins in your mouth and tongue when you eat these fruits, causing tingling and stinging! Source: www.thenakedscientists.com/HTML/content/kitchenscience/exp/science-of-fruit-jellies/



© Erid Westmacott/Alamy

EPIGENETIC EFFECTS

Our parents' diets can influence our health

Are you eating the perfect diet to boost your health? Make sure your parents did, too. Recent evidence suggests that epigenetic effects – patterns of switching in the on/off controls on genes – can pass down one or even two generations.

Babies who were born during extreme food shortages in the Netherlands during World War II had low birth weights. They also had higher rates of heart disease in later life, a sign of metabolic stress during early development. To geneticists' surprise, so did their children, even though they were born long after the famine was over.

Mothers who have poor diets and grow obese may also alter their offspring's metabolism. Studies in rats in 2010 suggested that obesity in adult males can increase the risk of their daughters developing diabetes. It is possible this effect arises from the long-term consumption of a high-fat diet. Alternatively, there may be crucial periods in a father's development when sperm are affected. Further research is needed. Other studies continue to broaden the known effects of these epigenetic influences. Experiments with rats on 'junk food' diets suggest that an increased breast cancer risk associated with a high-fat diet persisted for three generations.

Feast or famine?

Food policy is all about what governments, companies and other organisations do or don't do to influence food – from production to consumption and everything in between.

A new direction for food policy, based on creating sustainable development, is emerging. It is influenced by a number of issues,¹ including water, energy, climate change, land use, human health, social justice, labour processes, demographics, and food availability and stocks.

Below, we present data around some of the global issues surrounding food policy. We've begun to think about the ways in which we could change the way we produce, distribute and consume food – can you think of more?

1. Lang T et al. Food Policy: Integrating health, environment and society. Oxford: Oxford University Press, 2009

EATING ANIMALS: A MEATY PROBLEM?

In the UK we ate, on average, nearly 80 kg of meat per person in 2002 – around 12.5 stones! Although this level is relatively high, it has remained roughly stable since the 1960s. In other countries, such as China, meat consumption has increased as people become richer. Now, half of the world's pork is eaten in China. Does it matter how much meat you eat? Should countries try to limit

consumption? How might eating more meat affect our health? Look at the data below and think about what they show about meat consumption, then look at the suggested solution.

- Find questions about the graphs in the 'Feast or famine?' lesson ideas document at www.wellcome.ac.uk/bigpicture/food

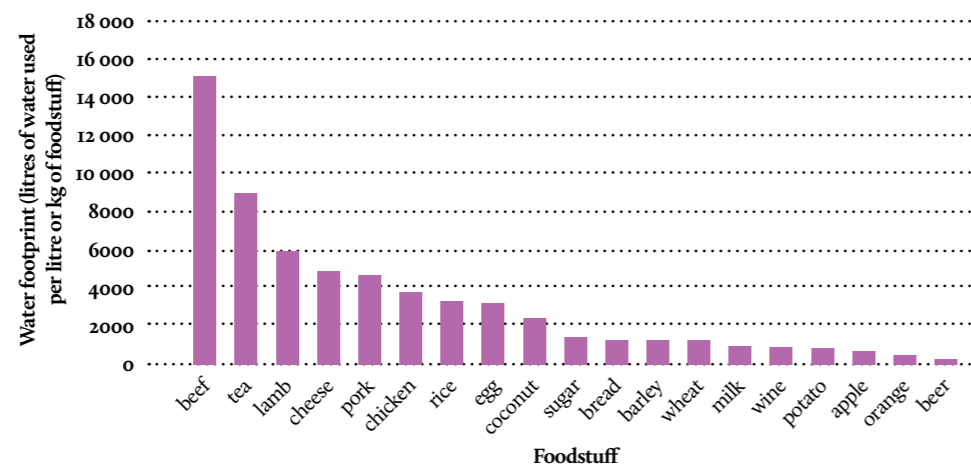
Issue 1: Water consumption

The water footprint is the amount of water used directly and indirectly to make a product. The graph to the right shows the water footprint for several types of food and drink. They are calculated as a global average because variations in farming techniques etc. across the world mean that water footprints can vary for products according to where they are made.

Water footprints are more than the water contained within something. For example, one litre of beer has a water footprint of around 300 litres. Although the beer contains water, most of its footprint is due to the water needed to produce the barley that's in the beer.

Source: www.waterfootprint.org

Graph 1: Water footprints of different foodstuffs

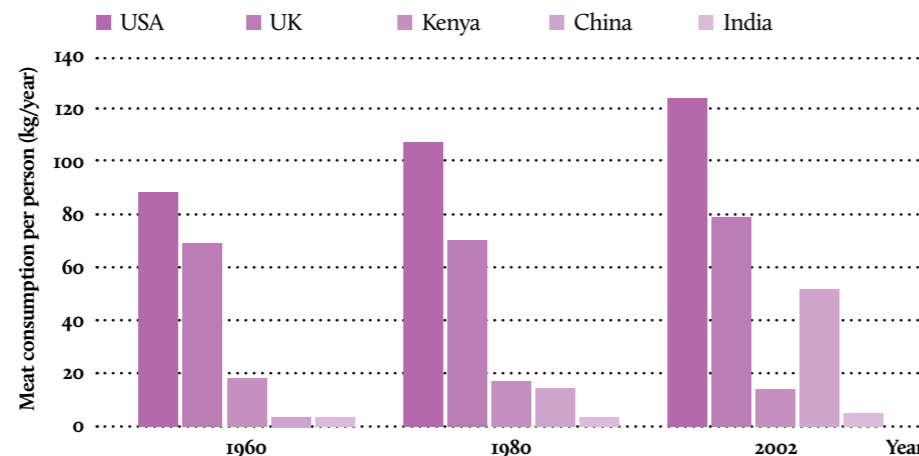


Issue 2: Meat consumption

	1960	1980	2002
USA	89.2	108.1	124.8
UK	69.8	71	79.6
Kenya	18.6	17.4	14.3
China	3.8	14.6	52.4
India	3.7	3.7	5.2

Source: www.guardian.co.uk/environment/datablog/2009/sep/02/meat-consumption-per-capita-climate-change

Graph 2: Meat consumption per person in different countries over time (kg/year)



Issue 3: Childhood obesity

There's no graph for this section, but we've provided the data needed to draw your own (see table, below). A standard graph and questions on this section can be found in the 'Feast or famine?' lesson ideas document at www.wellcome.ac.uk/bigpicture/food

Proportion of schoolchildren aged 7–18 in large cities in China who are classed as overweight or obese

	1985	1991	1995	2000
Overweight boys (%)	1.2	4.5	7.6	11.7
Obese boys (%)	0.2	1.3	2.9	5.4
Overweight girls (%)	1.4	2.9	4.8	6.8
Obese girls (%)	0.1	0.9	1.8	2.9

Source: www.bmj.com/content/333/7564/362.full

POTENTIAL SOLUTION

The Big Picture Institute of Food Policy has proposed a solution to the issues illustrated by the graphs and data above and on page 10.

Solution:

Lab bench to barbecue: The government increases funding for research into bioengineered ('cultured') meat.

We've given some pros and cons (right) – see if you can come up with more of your own. For another potential solution and more pros and cons, see www.wellcome.ac.uk/bigpicture/food

PRO
Scientists might be able to control the amount of protein, fat and other nutrients in this meat.

PRO
Could produce fewer greenhouse gas emissions than current meat-production methods.

CON
People might be uncomfortable about eating cultured meat.

CON
We don't just use animals for meat and milk, but also use their wool, skins and fleeces for leather, and their dung for fuel and fertiliser.

FOOD MILES: WHAT'S FAIR?

It seems logical that local food is better for the environment than food flown halfway across the world, but is it really that simple? Using food miles and working out the distance that food travels from the farm to your plate is one way to measure the environmental impact of food, but there's more to making the 'right' choice about what food to buy. Look at the data below left and think about how they relate to food miles, then read about the pros and cons of one potential solution.

Figure 1: Some facts about food miles

AN ESTIMATED 1 TO 1.5 MILLION LIVELIHOODS IN SUB-SAHARAN AFRICA DEPEND ON THE UK-BASED FOOD CHAIN

£1 MILLION PER DAY IN THE UK IS SPENT ON FRUIT AND VEGETABLES FROM SUB-SAHARAN AFRICA

FOOD PRODUCTION AND CONSUMPTION CONTRIBUTES 18% OF TOTAL UK GREENHOUSE GAS EMISSIONS

THE AVERAGE KENYAN IS RESPONSIBLE FOR 0.3 TONNES OF CO₂, THE AVERAGE BRITON FOR 1.6 TONNES

THE ENERGY USED, FACTORING IN AIRPLANE EMISSIONS, FOR KENYAN GREEN BEANS IS 12 TIMES THAT FOR UK BEANS

Source: Fair miles: recharting the food miles map. pubs.iied.org/pdfs/1551611ED.pdf

POTENTIAL SOLUTION

Lovin' it local! Local councils encourage shops and markets to stock more local produce, increase number of farmers' markets and food festivals etc. Look at some pros and cons (right).

Can you think of more? For questions related to these issues and more pros and cons, see www.wellcome.ac.uk/bigpicture/food

PRO
Buying local means you're supporting your local economy, contributing to local jobs etc.

PRO
Locally produced food doesn't need to be shipped or flown thousands of miles.

CON
Shouldn't we be supporting overseas farmers?

CON
Cultivation in the UK may be more energy-intensive than that abroad – a tomato grown in the UK may require heated greenhouses.

Food for Thought

Adverts, magazines and TV shows are full of talk of wondrous ingredients, from 'antioxidants' to 'superfoods' and from 'bad cholesterol' to 'good bacteria'. At Big Picture we know that there's no substitute for cold, hard evidence, so we've gone straight to the science to separate some classic food fibs from food facts. There's more online, too, including the truth about salt and caffeine. Busted any myths? Tell us at bigpicture@wellcome.ac.uk



DO WE NEED TO TAKE VITAMINS?

A well-balanced diet will usually meet the recommended daily intake for vitamins and minerals. A few people with digestive problems will be prescribed vitamin supplements, but hardly anyone else needs them. One exception is vitamin D, which, like folic acid, is recommended as a supplement for pregnant women in the UK because it is required for growth and development, especially of bones. Vitamins taken as supplements are often in a slightly different form from those found in foods and are less effective. Taking large doses of some can even be harmful.

Vitamin C is one of the most widely taken vitamins. It is not stored in the body, and we need a regular intake. Big doses do not have much effect on how many colds you catch, unless you are under extreme physical stress, like training for a marathon. Vitamin C is an antioxidant, a chemical that can help block the action of particular highly reactive chemicals in the body. Swallowing antioxidants is no guarantee that they will be found inside cells where oxidative damage is happening, and it has been shown that mega-doses of some of the other antioxidant vitamins, including vitamins A, E and beta-carotene, probably increase death rates a little. Exposure to high amounts of vitamin A in pregnancy increases the risk of birth defects. Extra-large doses of minerals can also be harmful: calcium supplements, for example, taken by some women to protect them from the bone depletion known as osteoporosis, have been shown to increase risk of heart attacks. See antioxidants-and-are-they-good-for-us-part-1/ and Bjelakovic G et al. *Cochrane Database Syst Rev* 2008;(2):CD007176



Is eating salt bad?

Salt is essential to health, but in very small amounts. Too much of it causes hypertension (high blood pressure) and can lead to heart failure. The recommended upper limit is six grams of salt a day for over-11s, but most of us eat more (in the processed foods we eat, rather than salt we add to food). See more at www.wellcome.ac.uk/bigpicture/food

IS THERE SUCH A THING AS A 'SUPERFOOD'?

Pomegranates, blueberries and green tea are all perfectly nice to eat or drink. But that is the only reason to consume them. Their reputation as superfoods owes more to smart marketing – and magical thinking – than scientific studies. As omnivores we eat hundreds of foods containing thousands of different substances. It is unlikely that one or two foods contain vital chemicals that we cannot get elsewhere. Many so-called superfoods contain antioxidants, but as explained below left, there's little evidence of their benefits. You would probably do better to aim at your five a day, or just follow the age-old advice to eat your greens. See an NHS report on 'miracle foods' at www.nhs.uk/news/2011/02/February/Documents/BTH_Miracle_%20foods_report.pdf

Is undernutrition a problem in the UK?

Undernutrition is a deficiency in one or more nutrients and often encompasses being underweight. It is most common among elderly people who find it hard to shop, cook or eat properly. The scale of the problem is hard to measure, but some estimates suggest that ten per cent of over-65s could be malnourished in the UK. Many hospitalised patients suffer from malnutrition, which delays their recovery. www.bapen.org.uk/pdfs/bapen_pubs/mm-toolkit-exec-summary.pdf

WHICH WEIGHT-LOSS DIETS WORK?

Diets can work, as long as you stick to them. Long-term success depends on changing your lifestyle and getting into healthier habits with what you eat and how active you are. Studies comparing different diets indicate that total energy content is the key variable, rather than choosing low fat, low-carbohydrate or high-protein. Typical long-term weight loss is a few kilos, and most people have trouble keeping up their chosen diet. Diets that advertise more drastic weight loss than this usually involve losing water, which is soon replaced. It is easier to avoid gaining weight than to lose it again. Increased body fat often alters metabolism, and appetite, in ways that tend to maintain the new weight. Overweight people may even have a keener sense of smell for food (see www.bbc.co.uk/news/health-11755995). See www.bda.uk.com/foodfacts/TruthFadDiets.pdf

Does it matter what time of day you eat?

No, what matters is how much energy you consume in a day, any time. People who say they don't eat after 5pm to lose weight are just keeping their energy intake down by avoiding an evening meal.

DO 'GOOD AND BAD BACTERIA' EXIST?

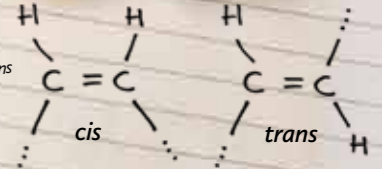
There are ten times more bacteria in your gut than cells in your body, and the latest techniques for DNA analysis show that they are much more diverse than anyone suspected. On average, each of us has more than 150 different species dwelling inside us, and more than 1000 species can live there. This makes it hard to know which are 'good' and 'bad' bacteria to have, or whether they can be improved by eating live yoghurt, for example. It is clear that all of them together are important for digestion and for many other aspects of health and even behaviour. Researchers are now working to understand this ecosystem inside us, called the human microbiome. We already know that its composition is influenced by diet. Some sushi lovers in Japan, for instance, have gut microbes that can digest carbohydrates found in seaweed. It is likely that there are many other subtle adjustments like this yet to be discovered. www.timesonline.co.uk/tol/life_and_style/health/article6875169.ece

IS FAT BAD?

We all need some fat, but not too much. Cholesterol, for example, is needed to make up cell membranes, hormones and other molecules. Along with other lipids (including triglycerides and phospholipids), cholesterol is transported in the blood in complexes called lipoproteins, which include high-density (HDL) and low-density (LDL) forms. The cholesterol carried by these is known as HDL ('good') cholesterol and LDL ('bad') cholesterol, respectively. HDL lipoproteins carry cholesterol from parts of the body to the liver, where it is cleared from the body. High levels of LDL cholesterol lead to a

build-up of cholesterol into brittle plaques that block arteries – heart disease. See our animation on this at www.wellcome.ac.uk/bigpicture/food. Some cholesterol is made in the body (including in the liver), and some we get from our diet. Eating lots of saturated fats, in which all the carbon atoms are linked to as many hydrogen atoms as they can take, tends to increase LDL cholesterol. This effect on blood cholesterol level is much greater than that caused by eating cholesterol.

Unsaturated fats have a double chemical bond between one or more carbon atoms. However, not all unsaturated fats are good. A double bond is more rigid than a single bond, and the way it makes other chemical groups stick out affects its chemical and physical properties. Trans fats are made when unsaturated fats have more hydrogen added but not enough to make them completely saturated. They are relatively rare in nature but are often included in processed foods. Trans fats increase LDL cholesterol and raise the risk of heart disease. See www.bda.uk.com/foodfacts/cholesterol.pdf



In unsaturated fats, the cis arrangement has the carbon chains on the same side of the double bond. In the trans arrangement, they're across the double bond.

Real voices



Three people talk to us about the role of food in their lives. Meet Julie Wilson, a nursery assistant living with a condition that restricts her diet, James Wannerton, who can taste words he hears or sees, and Georgine Leung, whose job as a nutrition scientist means that she advises people on eating healthily.

JULIE WILSON



Nursery assistant living with phenylketonuria

How does phenylketonuria affect you?

People with phenylketonuria (PKU) are advised to avoid high-protein foods (e.g. meat and cheese), which means I've had to follow a special very-low-protein diet since I was born. The diet is based on exchanges. They're the amount of phenylalanine the dietitian at the hospital says I can have each day, based on the levels in my blood. When I was five, I could have three exchanges a day, now I can have ten – that's equivalent to one small slice of bread and three tablespoons of baked beans. We have our own special PKU foods: milk, bread, pasta, cakes, biscuits and flour, which we get on prescription from the doctor, and the hospital dietitian tells us about new PKU foods and recipes.

How do you know if you have too much or too little phenylalanine?

Each person is affected differently. If levels are too high or low, people feel tired or ill, or they get a headache and can't concentrate. For some people, including me, our eyes change. They're normally hazel green, but if I'm under the weather and my phenylalanine levels are high, they turn piercing blue.

How often are your levels checked?

You're supposed to check your blood phenylalanine levels every couple of weeks or so. I don't do it that often, because I've got used to knowing if I've had too much or not enough phenylalanine from how I feel.

What does the test involve?

The test uses a Guthrie card. You prick your finger and squeeze blood into four little circles, then fill out your name, address and the date. You have to say if you've had a cold too, because if you're run down your phenylalanine levels are higher. You send the card off and get the results back four days later, which tell you if your exchanges need to go up or down.

Is it hard watching others eating food you can't have?

It's not too bad, as I've never known any different. I remember when I was about seven going to McDonalds with other kids with PKU I met through the National Society for PKU [NSPKU]. We got some strange looks because we all had our scales out weighing our food, but for us it was normal. From an early age my mum used to say what I could and couldn't eat, and I've stood by that.

Has it affected your career?

Although I couldn't taste much food, I'm a qualified chef. I don't work as a chef any more, but this was not because of PKU but because I was offered a new career and wanted a new challenge. I never let PKU stop me doing anything in life – that's been my rule from a young age.

For more information, see www.nspku.org

JAMES WANNERTON



Lexical-gustatory synaesthete (can taste words)

Who are you?

I work in IT and have lexical-gustatory synaesthesia, an extra connection between two areas of my brain. It means that whenever I hear, see or read something, I get a specific taste.

When did you first realise you had this ability?

You have to bear in mind that this is perfectly normal for me, so it's a bit like asking when was the first time you smelt something and what did it smell like – you can't remember. I can certainly remember picking up tastes when I was at school, around the age of four and a half. I have very strong memories of sitting in assemblies. We were read the Lord's Prayer every morning: it had a taste of very thin crispy bacon. I can taste it now.

Can you describe it?

It's not an extra sense, but it does give me an extra perception. It's like getting an eye-dropper of taste dripped on my tongue. I get a taste, temperature and texture. One of the ways I stop this affecting my concentration on a day-to-day basis is to eat strong-tasting sweets like Wine Gums, and drinking coffee.

How does it affect your life?

When I was younger I used to choose friends according to whether they tasted nice. When I got older it used to affect my choice of girlfriend. Their name would be just as attractive to me as the way they looked or their personality. I won't pick

bland foods if I'm going to a restaurant, I'll pick strong foods with a big mixture of textures.

Do you take part in research?

Yes, including that using magnetic resonance imaging (MRI). In one study, researchers did an MRI scan of the brain of a person without synaesthesia whilst they were eating, and then they scanned my brain, as I listened to particular words without eating. The same brain areas lit up.

How common is synaesthesia?

One study suggested that 1 in 23 people have it in some form. One of the joys of being President of the UK Association is having people say: "I've always done that, I thought it was just me". However, it can cause problems in education; affected schoolchildren might struggle in noisy environments.

Would you switch it off if you could?

To me, having a memory without a taste attached is just weird, I don't know how or if I'd remember things. Of the thousands of people with synaesthesia I've met, not one would want it taken away.

Read a longer version at www.wellcome.ac.uk/bigpicture/food. Find out more at www.uksynaesthesia.com

GEORGINE LEUNG



Nutrition Scientist

Where do you work?

I'm a Nutrition Scientist at the British Nutrition Foundation (BNF), an independent UK charity that provides information about food and nutrition to promote a healthy lifestyle. There are two main teams at the BNF: science and education. The science team helps to translate information about diet, nutrition and lifestyle into resources to suit the needs of consumers and health professionals, based on the latest scientific evidence.

What do you do?

I work in the education group at the BNF, which aims to give young people the facts and skills they need to have healthy diets, through working with teachers. We have worked with the government to produce some core food competencies, specific food skills and knowledge young people should aim to have at certain ages. I am very proud of our free education programme website, Food – a fact of life, which contains a wealth of educational resources on food and nutrition for preschool, primary and secondary students.

How does your organisation make recommendations?

All our recommendations are based on the latest scientific evidence, and we aim to work together with other stakeholders – politicians, scientists, educators and the industry – to help support consumers to make healthier food choices.

What made you choose this career?

I was first interested in nutrition when I was in secondary school in Hong Kong. Like most teenage girls I was very particular about

how I looked. I knew health was very important and I really enjoyed eating so I thought that working in healthy eating was the best way to combine these interests! I did a degree in Food and Nutritional Sciences at the Chinese University of Hong Kong and then came to the UK to do a Master's in Public Health Nutrition. Then came the opportunity to work at the BNF, which has been a fantastic experience.

What was it like coming to the UK?

It was a culture shock! People eat a very different diet here. I think it's important to understand the cultural aspects of eating. I've just written a paper on the diets of minority ethnic groups in the UK, published in *Nutrition Bulletin*. It was an interesting piece of research because the UK is so ethnically diverse and different ethnic groups eat differently, which has an impact on health. For example, I'm Chinese, and the Chinese diet can seem quite healthy and balanced, but in fact it can be high in salt and saturated fat. Although genetically the Chinese are quite slim, a lot of my older friends and relatives have high blood pressure and high cholesterol. I want to help highlight the healthy and unhealthy aspects of the diets of minority ethnic groups and let health professionals understand more about cultural differences, so that they can deliver more appropriate messages.

Find out more about the BNF and healthy eating at:

- www.nutrition.org.uk
- www.foodfactoflife.org.uk
- www.youtube.com/britishnutrition

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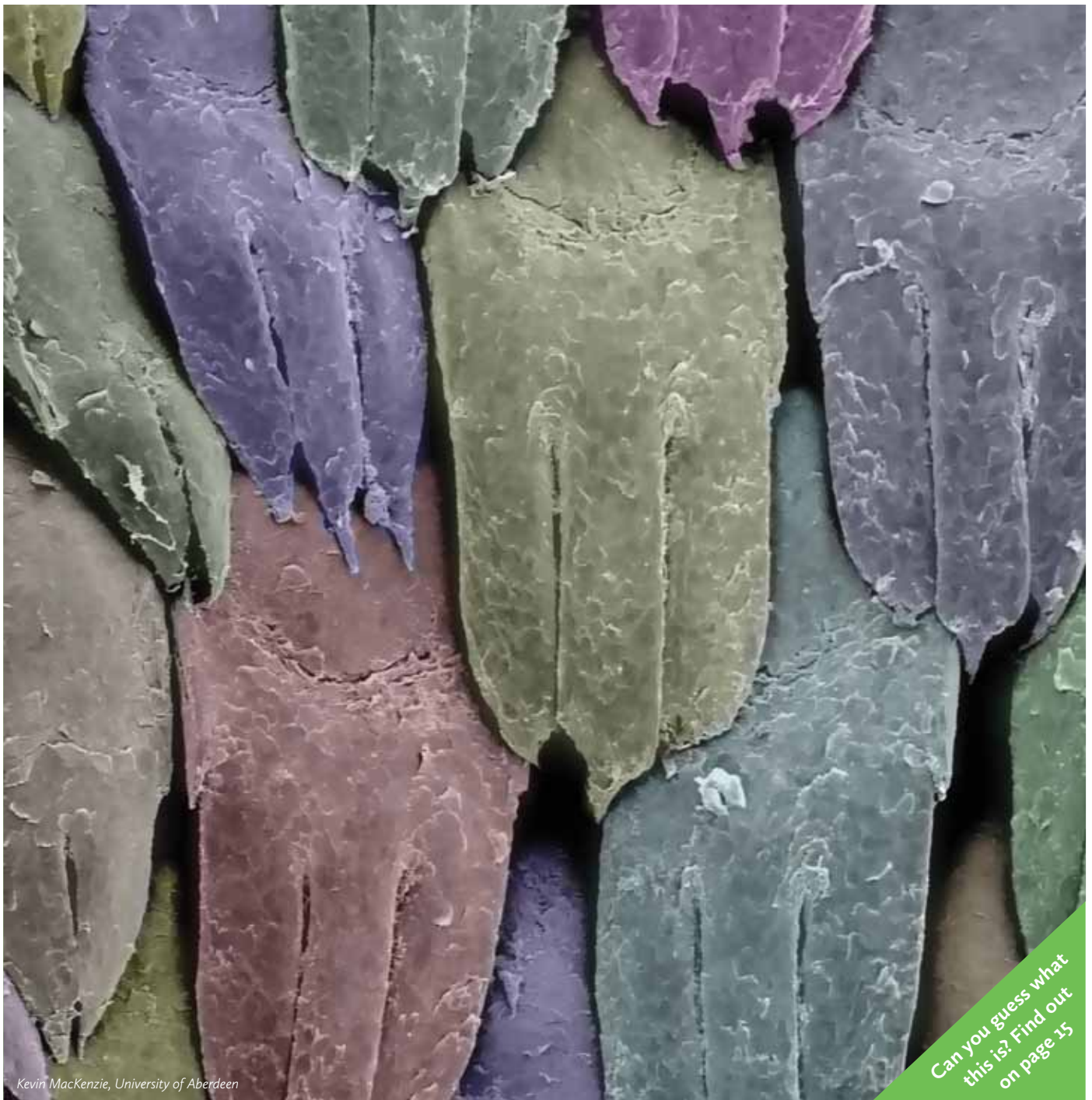
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Back cover: This image is a scanning electron micrograph of the tongue of a fruit bat. It shows the papillae, small bumps that cover the surface of the tongue, which efficiently scoop up nectar and pollen. Find more free medical and scientific images at images.wellcome.ac.uk and see our galleries at www.wellcome.ac.uk/bigpicture/food



Kevin MacKenzie, University of Aberdeen

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