

Human nutrition

Revision notes · A balanced diet, nutrient sources and functions, the alimentary canal, enzymes, bile, absorption and food energy.

For Pearson Edexcel International GCSE Biology 4BI1 and Science (Double Award) 4SD0. **Biology only** is not in the Double Award and is only examined on Paper 2.

Human nutrition Spec 2.24-2.33B

A balanced diet and energy needs Spec 2.24, 2.26

A **balanced diet** contains the right proportions of all seven components: **carbohydrate, protein, lipid, vitamins, minerals, water and dietary fibre**. Most of the energy in a diet comes from carbohydrate and lipid. Smaller amounts are needed of vitamins and minerals, but they are still essential.

- Carbohydrate and lipid: the main sources of energy, so they are needed in larger amounts.
- Protein: needed for growth and repair of tissues.
- Vitamins and minerals: needed in small amounts to stay healthy.
- Water: needed in large amounts, because the body loses it all the time.
- Dietary fibre: needed to keep food moving through the gut.

The amount of energy a person needs each day depends on how much energy their body uses. Energy requirements vary with **activity level**, **age** and **pregnancy**.

How energy requirements vary		
Factor	Effect on energy needed	Why
Activity level	More active people need more energy	Contracting muscles use energy from respiration. A person who trains or has a physical job respire more than a person who sits at a desk.
Age	Teenagers need more energy than young children. Older adults need less than younger adults.	Teenagers are larger and growing quickly. Older people are usually less active and are no longer growing.
Pregnancy	A pregnant woman needs more energy	Extra energy is needed for the growth of the fetus and for the changes in the mother's body.

If a person takes in more energy than they use, the extra is stored, mainly as fat. If a person takes in less energy than they use, they lose body mass.

Exam tip: A balanced diet is about the right proportions, not the same amount of each nutrient. For energy questions, link the answer to respiration: more activity means more muscle contraction, so more respiration and more energy needed.

Nutrients: sources and functions Spec 2.25

You need to know a source and a function for each of the nutrients in the table.

Sources and functions of nutrients		
Nutrient	Sources	Functions
Carbohydrate	Bread, pasta, rice, potatoes	Provides energy (released by respiration)
Protein	Meat, fish, eggs, beans	Growth and repair of tissues. Proteins are made from amino acids.
Lipid (fats and oils)	Butter, cooking oils, nuts, oily fish	Energy store, insulation (keeps heat in), and part of cell membranes
Vitamin A	Liver, carrots, dairy foods	Healthy eyes and vision in dim light. A lack causes night blindness.
Vitamin C	Citrus fruits, fresh vegetables	Keeps skin and gums healthy. A lack causes scurvy.
Vitamin D	Oily fish, eggs, margarine (also made in skin in sunlight)	Helps the body absorb calcium. A lack causes weak bones (rickets in children).
Calcium (mineral ion)	Milk, cheese, green vegetables	Needed for strong bones and teeth
Iron (mineral ion)	Red meat, liver, spinach	Needed to make haemoglobin in red blood cells. A lack causes anaemia.
Water	Drinks and most foods	Solvent for chemical reactions, and the main part of blood plasma, which transports substances
Dietary fibre	Wholemeal bread, vegetables, fruit	Adds bulk, which helps peristalsis move food through the gut and prevents constipation

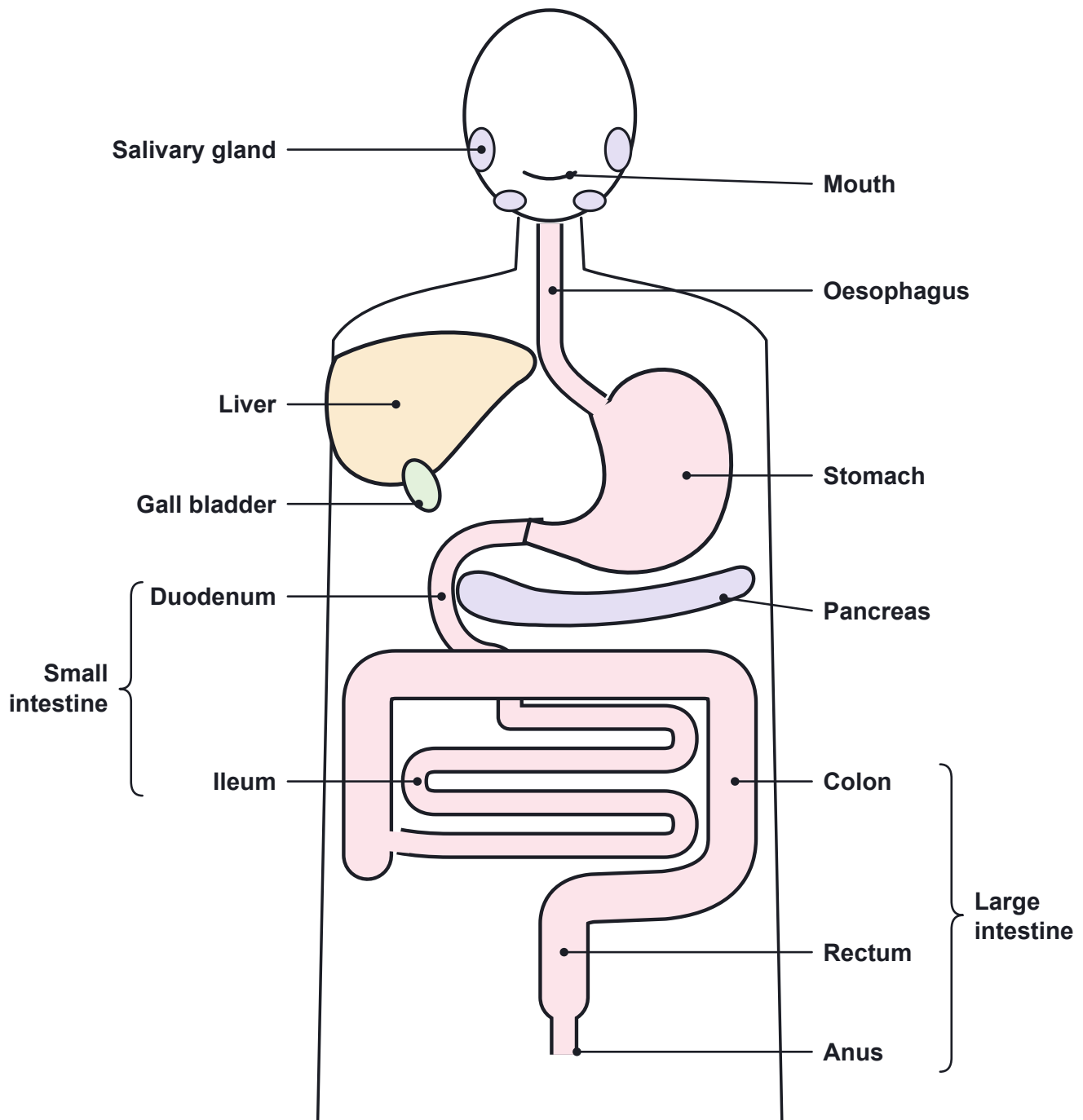
Exam tip: Mark schemes want a specific function, not just 'it is good for you'. Learn one clear function for each nutrient. Fibre is not digested, so it provides no energy.

The alimentary canal and peristalsis Spec 2.27, 2.28

The **alimentary canal** is the tube that runs from the mouth to the anus. Food is digested and absorbed as it moves through. The liver, gall bladder and pancreas are not part of the tube, but they help with digestion.

Structure and function of the alimentary canal

Part	Function
Mouth	Teeth chew food into smaller pieces. Saliva contains amylase, which starts the digestion of starch.
Oesophagus	Carries food from the mouth to the stomach by peristalsis
Stomach	Churns food with acidic juice. Hydrochloric acid kills many bacteria. Protease digests protein.
Small intestine: duodenum	First part. Receives bile and pancreatic juice. Digestion continues here.
Small intestine: ileum	Second, longest part. Digestion is finished and the small soluble molecules are absorbed into the blood.
Pancreas	Makes digestive enzymes (amylase, protease and lipase) and releases them into the duodenum
Large intestine: colon	Absorbs water from the remaining material
Large intestine: rectum	Stores faeces, which leave the body through the anus

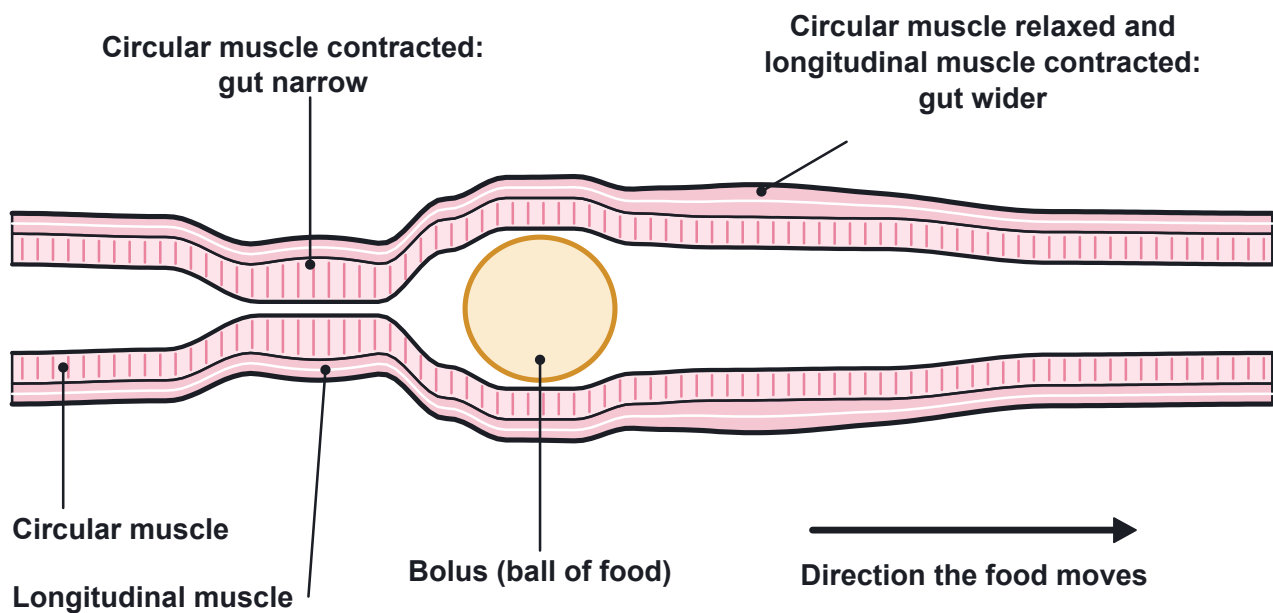


The **alimentary canal** runs from mouth to anus. The liver, gall bladder and pancreas are not part of the tube but help with digestion.

Peristalsis

Food is moved along the gut by **peristalsis**. The walls of the gut contain **circular muscles** and **longitudinal muscles**. Waves of muscle contraction pass along the gut.

1. The circular muscles behind the food contract. This squeezes the food forward.
2. The circular muscles in front of the food relax and the longitudinal muscles contract. This widens the tube ahead of the food.
3. The wave of contraction moves along the gut, pushing the food towards the stomach, then through the intestines.



Peristalsis: circular muscle contracts behind the bolus, squeezing it forward into the wider section in front.

Common mistake: Peristalsis is a wave of muscle contraction that pushes food along. It does not break food down chemically, and it is not the same as chewing.

Digestive enzymes Spec 2.29

Food contains large molecules of starch, protein and lipid. They are too big to pass into the blood.

Digestive enzymes break them down into small, soluble molecules that can be absorbed. Each type of enzyme breaks down one type of food molecule.

Digestive enzymes			
Enzyme	Breaks down	Into	Made in
Amylase	Starch	Maltose	Salivary glands, pancreas
Maltase	Maltose	Glucose	Small intestine
Proteases	Proteins	Amino acids	Stomach, pancreas, small intestine
Lipases	Lipids (fats and oils)	Fatty acids and glycerol	Pancreas, small intestine

The digestion of starch takes two steps. Amylase breaks starch down into the sugar maltose. Maltase then breaks maltose down into **glucose**.

starch → maltose (catalysed by amylase)

maltose → glucose (catalysed by maltase)

protein → amino acids (catalysed by proteases)

lipid → fatty acids + glycerol (catalysed by lipases)

The small molecules are absorbed into the blood. The body uses them to make new carbohydrates, proteins and lipids. Some glucose is used in respiration.

Exam tip: Learn the pairs: amylase with starch, protease with protein, lipase with lipid. Mark schemes ask for the name of the enzyme and the products, so write both.

Bile Spec 2.30, 2.31

Bile is produced by the liver and stored in the gall bladder. It is released into the small intestine (the duodenum).

Bile has two roles in digestion:

- It is alkaline, so it neutralises the acid that comes from the stomach. This gives the enzymes in the small intestine the alkaline conditions they work best in.
- It emulsifies lipids: it breaks large drops of fat into many tiny droplets. This increases the surface area of the lipid.

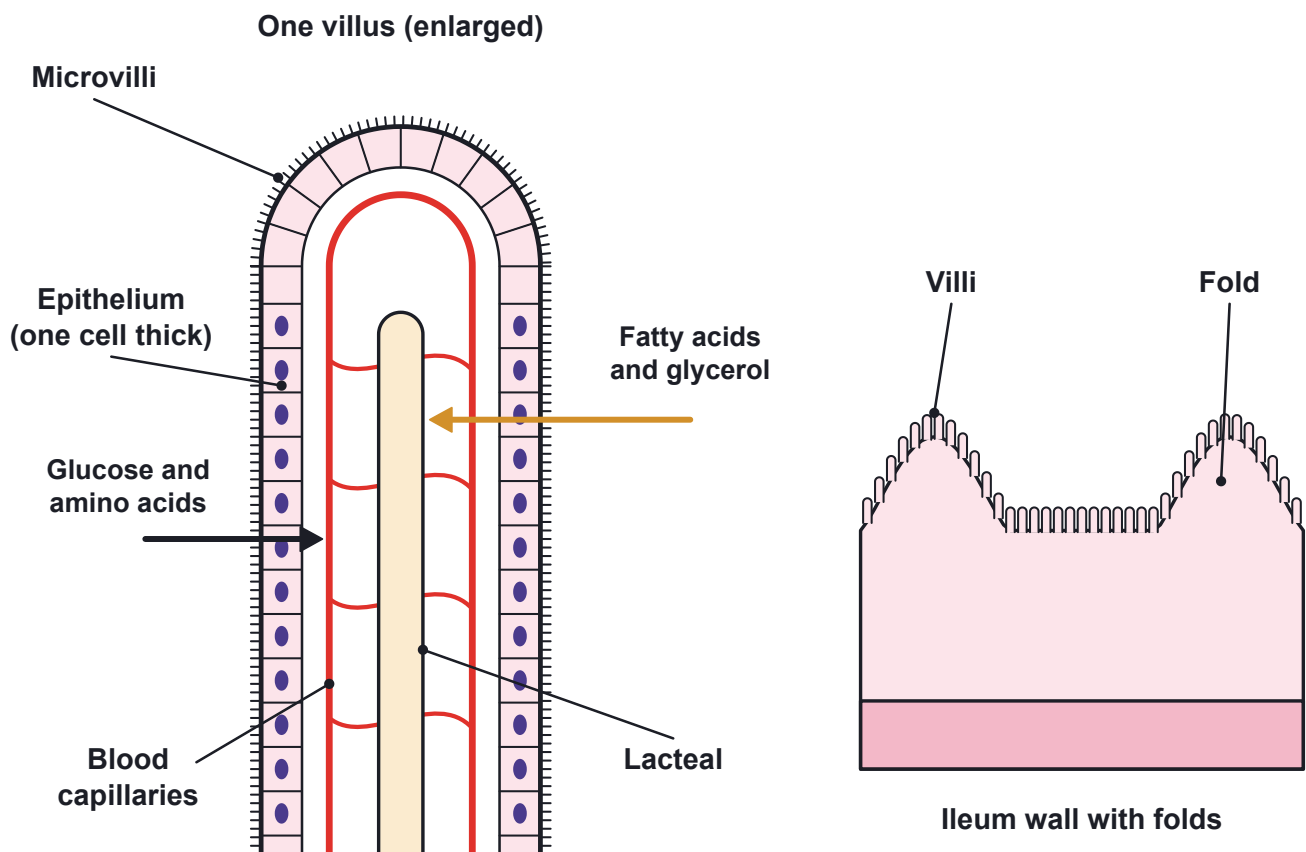
The larger surface area lets lipase work faster, so the lipid is digested more quickly.

Common mistake: Bile is not an enzyme and it does not chemically digest lipids. It only emulsifies them (physical breaking up) so that lipase can work faster. Emulsify is not the same as digest.

Absorption in the small intestine Spec 2.32

The products of digestion are absorbed in the small intestine, mostly in the ileum. The small intestine is adapted to absorb efficiently. It is long and its inner wall is folded. The wall is covered in millions of tiny finger-like projections called villi (one is a villus).

Adaptations of a villus for absorption	
Adaptation	How it helps absorption
Villi and microvilli (tiny projections on each surface cell)	Give a very large surface area
Wall (epithelium) is one cell thick	Short diffusion distance, so absorption is fast
Network of blood capillaries close to the surface	Carries glucose and amino acids away. This keeps a steep concentration gradient.
A lacteal (a lymph vessel) in the centre	Absorbs fatty acids and glycerol



A villus: **microvilli** and a **one-cell-thick epithelium** give a large surface area and short diffusion distance; capillaries and the **lacteal** carry absorbed food away.

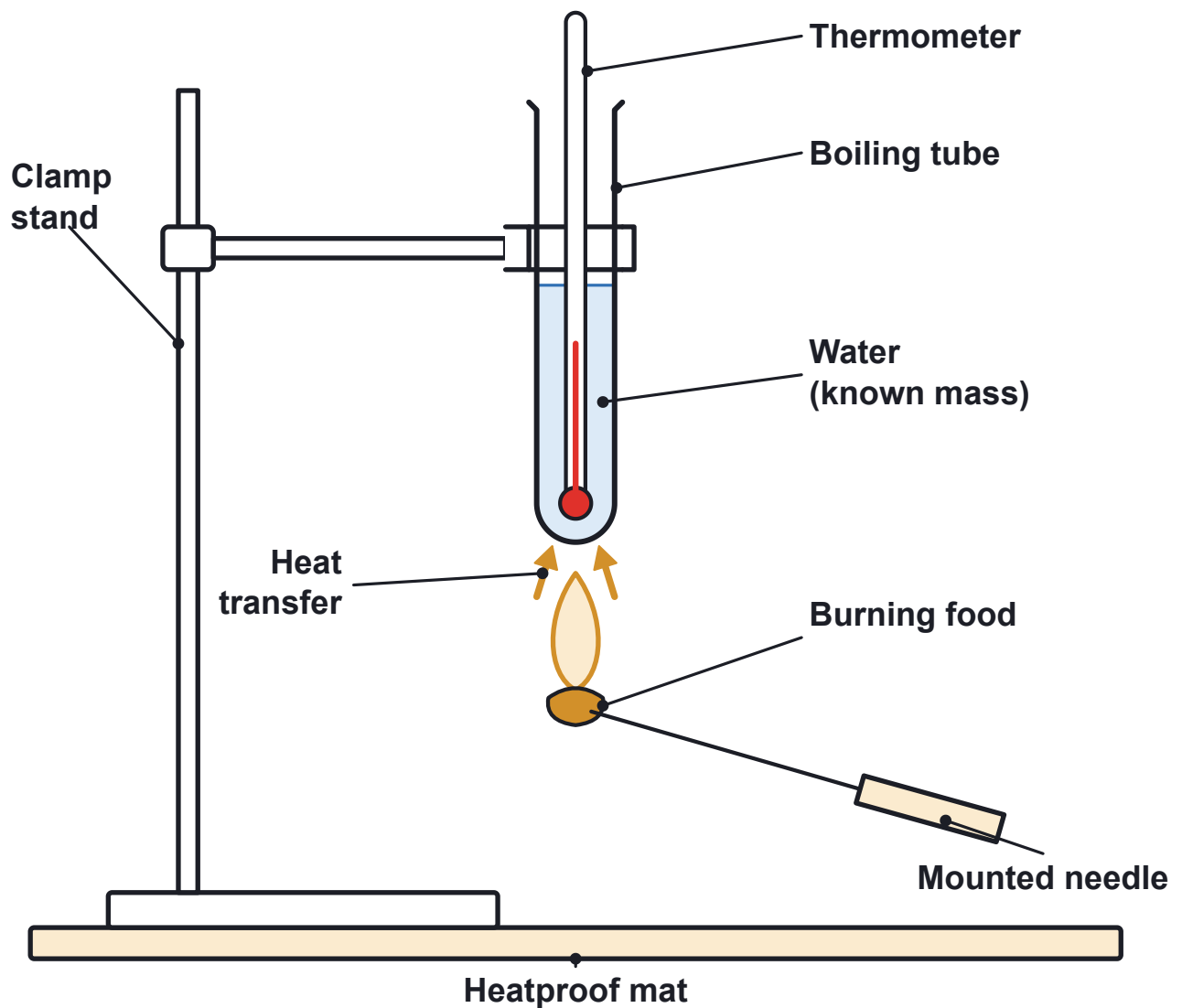
Glucose and amino acids move into the blood capillaries by **diffusion** and **active transport**. The blood carries them to the liver and then around the body. Fatty acids and glycerol move into the lacteal.

Exam tip: For an 'explain how it is adapted' question, give the feature and the reason: 'one cell thick, so there is a short diffusion distance'. Do not say the villi 'absorb more': say they 'increase the surface area'.

Practical: energy content of food Spec 2.33B Biology only

Food stores **chemical energy**. You can compare the energy in different foods by burning a sample and using the energy released to heat a known mass of water.

1. Measure a known volume of water (for example 20 cm³) into a boiling tube and record its starting temperature. 1 cm³ of water has a mass of 1 g.
2. Weigh a small piece of food and hold it on a mounted needle.
3. Light the food in a Bunsen burner flame, then hold it under the boiling tube straight away until the food stops burning. Stir the water gently.
4. Record the highest temperature of the water and work out the temperature change.



Burning food heats a **known mass of water**; the temperature rise is used to calculate the energy released.

$$\text{energy released (J)} = \text{mass of water (g)} \times 4.2 \times \text{temperature change (}^{\circ}\text{C)}$$

$$\text{energy per gram of food (J/g)} = \text{energy released (J)} \div \text{mass of food (g)}$$

Calculating the energy in food

Burning 0.5 g of a snack raises the temperature of 20 g of water by 12 °C. Calculate the energy released per gram of the snack.

1. energy released = $20 \times 4.2 \times 12 = 1008 \text{ J}$

2. energy per gram = $1008 \div 0.5 = 2016 \text{ J/g}$

Answer: 2016 J/g

The result is usually lower than the real energy in the food. **Heat is lost to the surroundings** and the food may not burn completely. A draught shield, holding the flame close to the tube and stirring the water improve the results. Foods rich in lipid, such as nuts, usually release more energy per gram than foods rich in carbohydrate.

Practical: Variables: the type of food is the independent variable; the temperature rise is the dependent variable. Keep the volume of water, the mass of food and the distance from the flame the same. Wear eye protection, take care with the burning food, and do not use nuts if anyone is allergic.

Quick check

1. Name the seven components of a balanced diet.
2. What is peristalsis?
3. What are the products of digestion by amylase and then maltase?
4. Give two roles of bile.
5. Where is bile made and where is it stored?
6. **Biology only** How do you calculate the energy released when food is burned under water?

Quick check answers

Human nutrition

1. Carbohydrate, protein, lipid, vitamins, minerals, water and dietary fibre.
2. Waves of muscle contraction that move food along the gut.
3. Amylase makes maltose from starch. Maltase makes glucose from maltose.
4. It neutralises stomach acid and emulsifies lipids.
5. Made in the liver and stored in the gall bladder.
3. Mass of water $\times$ 4.2 $\times$ temperature change.