Human Nutrition and Digestion

Matthew Williams • Biology • May 9, 2026

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Humans are heterotrophs — they obtain energy and materials by consuming other organisms. The digestive system breaks down complex food molecules into forms small enough to be absorbed and used by cells.

The five stages of nutrition in animals are:

Ingestion ’Digestion ’Absorption ’Assimilation ’Egestion

- **Ingestion** — taking food into the body through the mouth
- **Digestion** — breaking down large molecules into smaller ones (mechanically and chemically)
- **Absorption** — passing digested molecules from the gut into the blood or lymph
- **Assimilation** — using absorbed molecules in the cells for energy, growth, or repair
- **Egestion** — removing undigested material from the body as faeces

> 📝 **Exam Tip**
> Egestion and excretion are different. Egestion removes undigested material that was never absorbed. Excretion removes metabolic waste products that were produced inside the body (such as urea and CO). Faeces is egested; urine is excreted.

Nutrients

Carbohydrates

Carbohydrates are the body's main source of energy. They are made of carbon, hydrogen, and oxygen.

Type	Examples	Sources
Monosaccharides (simple sugars)	glucose, fructose	fruits, some vegetables
Disaccharides	sucrose, maltose, lactose	table sugar, malt, milk
Polysaccharides	starch, glycogen, cellulose	bread, rice, pasta, potatoes

Starch is the main storage carbohydrate in plants. Glycogen is the storage form in animals (in the liver and muscle). Cellulose forms plant cell walls and provides dietary fibre.

Proteins

Proteins are built from amino acids. The body needs them for growth, repair, enzyme production, hormone synthesis, and building structures such as muscle and cell membranes. Proteins contain carbon, hydrogen, oxygen, and nitrogen.

Sources include meat, fish, eggs, dairy, beans, and nuts. The body cannot store excess amino acids — the nitrogen-containing portion is removed in the liver (deamination) and excreted as urea.

Lipids

Lipids (fats and oils) provide long-term energy storage, insulate the body, protect organs, form cell membranes, and carry fat-soluble vitamins (A, D, E, K). Sources include butter, oils, nuts, avocados, and fatty fish.

Vitamins

Vitamins are organic compounds needed in small amounts.

Vitamin	Function	Sources	Deficiency disease
A	vision in dim light; healthy skin and cell growth	liver, dairy, carrots, leafy vegetables	night blindness
C	wound healing; healthy gums, skin, and blood vessels; antioxidant	citrus fruits, peppers, guava	scurvy (bleeding gums, slow healing)
D	absorption of calcium for bones and teeth	oily fish, eggs, liver, sunlight on skin	rickets (soft, deformed bones in children)

Minerals

Minerals are inorganic ions needed in small amounts.

Mineral	Function	Sources	Deficiency
Calcium	bones, teeth, blood clotting, muscle contraction	dairy, leafy vegetables, sardines	weak bones, poor clotting

Iron	making haemoglobin in red blood cells	red meat, liver, spinach, legumes	anaemia (fatigue, pale skin, breathlessness)

Fibre, Water

Fibre (mainly cellulose from plant material) cannot be digested, but it adds bulk to food, stimulates peristalsis, prevents constipation, and may reduce the risk of bowel cancer. Sources: vegetables, whole grains, fruits.

Water is a solvent for reactions, transports substances in blood, regulates temperature through sweating, and is needed for all metabolic processes. It is continuously lost through urine, sweat, breathing, and faeces.

Food Tests

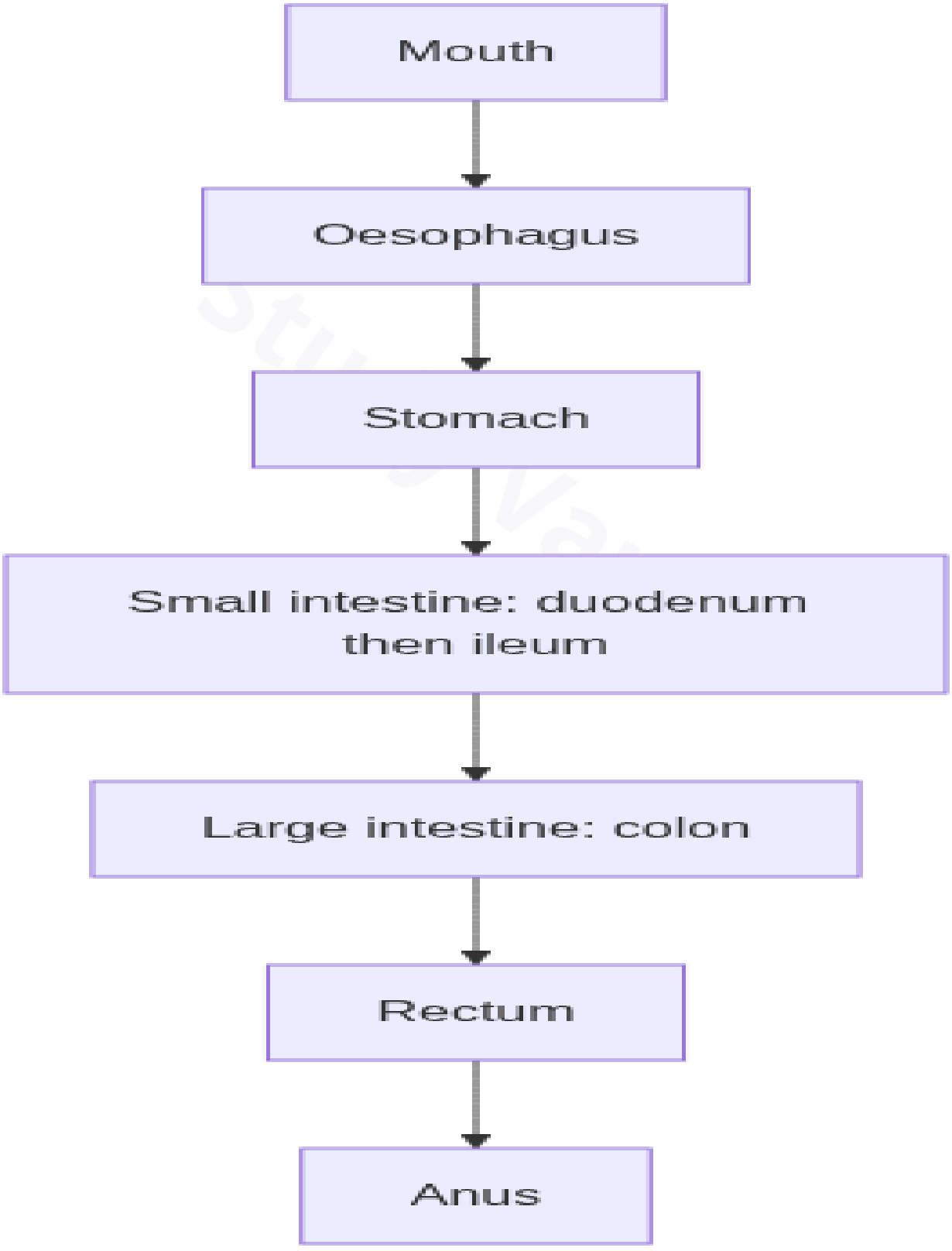
These tests identify which food substances are present in a sample.

Substance	Reagent	Method	Positive result
Starch	Iodine solution	add iodine drops to sample	blue-black colour
Reducing sugars (e.g. glucose, maltose)	Benedict's solution	add Benedict's, heat in water bath	brick-red/orange/yellow precipitate
Non-reducing sugars (e.g. sucrose)	Benedict's after acid hydrolysis	add dilute HCl, heat; cool; neutralise with $NaHCO_3$; add Benedict's, heat	brick-red precipitate
Protein	Biuret reagent	add Biuret reagent to sample	lilac/purple colour
Lipid	Ethanol emulsion test	dissolve sample in ethanol; pour into water	milky white emulsion

> 📝 **Exam Tip**
> For the non-reducing sugar test, the acid breaks the disaccharide into monosaccharides (which are reducing sugars). The solution must be neutralised before adding Benedict's because the test only works in alkaline conditions.

The Alimentary Canal

Food travels from mouth to anus through the alimentary canal. Each region has a specialised role.



The human alimentary canal

Region	Main events
Mouth	mechanical digestion by teeth; salivary amylase begins starch digestion
Oesophagus	peristalsis moves food to stomach; no digestion
Stomach	muscular walls churn food; pepsin (in acidic conditions, pH 2) begins protein digestion; hydrochloric acid kills pathogens
Small intestine (duodenum)	bile from liver emulsifies fats; pancreatic juice (amylase, lipase, proteases) continues digestion
Small intestine (ileum)	final digestion; absorption of glucose, amino acids, fatty acids, glycerol, vitamins, minerals, and water into blood and lymph
Large intestine	water and mineral ions reabsorbed; remaining material forms faeces
Rectum / Anus	faeces stored then egested

Tooth Structure and Mastication

Teeth break food into smaller pieces — a process called **mastication** (mechanical digestion). This increases the surface area for enzymes to act on.

Part	Description
Enamel	hardest substance in the body; covers the crown; protects dentine
Dentine	hard but slightly flexible layer beneath enamel; forms the bulk of the tooth
Pulp cavity	contains nerves and blood vessels; supplies the tooth with nutrients
Cement	attaches the root to the jawbone
Root	embedded in the jawbone; holds the tooth in place
Gum (gingiva)	soft tissue surrounding the tooth at the jawline

Cross-section of a molar tooth

1. Enamel
2. Dentine
3. Gum (gingiva)
4. Pulp cavity
5. Cementum
6. Root
7. Blood vessels
8. Nerve
9. Crown (region)
10. Root (region)

Humans have different tooth types suited to different functions: **incisors** (bite and cut), **canines** (tear), **premolars and molars** (crush and grind).

> 📝 **Exam Tip**
> Exam questions often ask you to label a tooth diagram or link a tooth region to its function. Remember: enamel is the hardest layer and is on the outside (crown); the pulp cavity contains the nerve and blood supply.

Peristalsis

Food moves through the gut by **peristalsis** — wave-like contractions of circular and longitudinal muscle layers in the gut wall. This squeezes food along the tube regardless of body position.

Enzymes in Digestion

Enzymes are biological catalysts that speed up chemical reactions. They are specific — each enzyme acts on one type of substrate.

Enzyme	Produced by	Substrate	Product	pH optimum
Salivary amylase	salivary glands	starch	maltose	~7 (neutral)
Pepsin	stomach wall	proteins	peptides	~2 (acidic)
Pancreatic amylase	pancreas	starch	maltose	~7–8
Trypsin	pancreas	proteins/peptides	peptides/amino acids	~8
Lipase	pancreas	lipids	fatty acids + glycerol	~7–8
Maltase	small intestine wall	maltose	glucose	~7

Effect of temperature on enzyme activity

As temperature rises, enzyme and substrate molecules collide more often and reactions speed up. Above the optimum temperature (~37–40°C in humans), the enzyme's shape distorts — it is **denatured** — and activity falls sharply. The effect is permanent.

Effect of pH

Each enzyme has an optimum pH. Pepsin works in the acidic stomach (pH 2), while pancreatic enzymes work in the alkaline duodenum (pH 7–8). Moving away from the optimum changes the shape of the active site and reduces activity.

Enzyme Investigation Skills

Past papers often ask about enzyme experiments using potato catalase or protease. For a temperature investigation:

- use equal amounts or sizes of enzyme source, such as the same mass of crushed potato
- use the same volume and concentration of substrate in each tube
- place tubes in water baths at different temperatures
- measure the reaction rate using a consistent method, such as bubbles per minute or time taken for a product to appear
- repeat readings and calculate a mean if possible

The graph usually rises as temperature increases because molecules have more kinetic energy and collide more often. Activity falls after the optimum because the enzyme denatures and its active site changes shape.

To test pH instead, keep temperature constant and use buffer solutions of different pH values. The best pH is the one with the fastest reaction rate.

Role of bile

Bile is produced in the **liver**, stored in the **gall bladder**, and released into the duodenum. It contains bile salts that **emulsify** fats — breaking large fat droplets into tiny ones. This greatly increases the surface area available for lipase to act on.

Absorption in the Small Intestine

Absorption happens mainly in the **ileum**. The inner wall is folded into finger-like projections called **villi**, which are further folded at the microscopic level into **microvilli** (the brush border). This massively increases surface area.

Labelled diagram of a villus showing capillaries, lacteal, epithelial cells, and microvilli

Adaptation of villi	Benefit

Large number of villi and microvilli	greatly increases surface area for absorption
Single layer of epithelial cells	very short diffusion distance
Rich capillary network	carries absorbed glucose and amino acids away quickly, maintaining concentration gradient
Lacteal (lymph vessel)	absorbs fatty acids and glycerol (as chylomicrons) into the lymph system

After absorption:

- Glucose and amino acids pass into capillaries ’hepatic portal vein ’liver
- Fatty acids and glycerol are reassembled into fats ’enter lacteals ’lymph system ’ bloodstream

Assimilation of Glucose

Assimilation means using absorbed nutrients in body cells. After glucose is absorbed into the blood, it may be:

- respired by cells to release energy
- stored as **glycogen** in the liver and muscles
- converted to fat if there is more than the body needs

Insulin helps a non-diabetic person remove excess glucose from the blood by increasing uptake into cells and conversion to glycogen. In diabetes, insulin is absent or ineffective, so blood glucose remains too high unless managed by diet, exercise, medication, or insulin injections.

Balanced Diet and Malnutrition

A **balanced diet** contains all necessary nutrients in proportions that maintain health — it is not just about eating all nutrient types, but getting the right amounts.

Different individuals need different amounts based on age, sex, activity level, pregnancy, and growth stage.

Group	Why requirements differ
Children and teenagers	high protein and calcium needs; rapid growth
Pregnant women	extra iron, calcium, and protein for foetal development
Manual workers / athletes	higher energy (carbohydrate and fat) intake

Elderly	may need more calcium and vitamin D; lower total energy

Malnutrition is poor nutrition caused by deficiency, excess, or imbalance of nutrients — not just starvation.

- **Undernutrition** — too little energy or nutrients: leads to wasting, kwashiorkor (protein deficiency), or specific deficiency diseases
- **Overnutrition** — excess energy intake: leads to obesity, increased risk of heart disease, type 2 diabetes, and hypertension

PRACTICE — HUMAN NUTRITION AND DIGESTION

Egestion
Removal of undigested food from the body as faeces; not the same as excretion.

Peristalsis
Wave-like muscle contractions that move food along the alimentary canal.

Amylase
An enzyme that digests starch into maltose; produced in salivary glands and pancreas.

Pepsin
A protease enzyme that works in the acidic stomach to begin protein digestion.

Bile
A substance produced by the liver that emulsifies fats, increasing surface area for lipase.

Emulsification
Breaking large fat droplets into smaller ones; carried out by bile salts in the duodenum.

Villi
Finger-like projections lining the small intestine that greatly increase surface area for absorption.

Benedict's test
A food test for reducing sugars; a positive result gives a brick-red precipitate on heating.

Biuret test
A food test for protein; a positive result gives a lilac or purple colour.

Balanced diet
A diet containing all nutrients in the correct proportions to maintain health.

Malnutrition
Poor nutrition caused by deficiency, excess, or imbalance of nutrients.

Denaturation
Permanent change in enzyme shape caused by high temperature or extreme pH, destroying activity.

Mastication
Mechanical breakdown of food by teeth; increases surface area for enzyme action.

Enamel
The hardest substance in the body; forms the outer protective layer of the tooth crown.