Animal nutrition

Scope

Topic	Topic Breakdown
Animal nutrition	Review of the biological importance of organic and inorganic compounds Definition of dentition Differences in dentition in terms of nutritional requirements of the following: - Herbivores – Carnivores – Omnivores Structure and functions of the alimentary canal and associated organs • **Parts of the alimentary canal**: - Mouth (tongue and teeth) – Pharynx – Oesophagus – Stomach - — Small intestines and large intestine - Rectum and - Anus • **Associated organs:** - Salivary glands – Liver - Gall bladder and - Pancreas Process of digestion • **Definitions**: - Ingestion – Digestion – Absorption – Assimilation – Egestion • **Mechanical digestion** - Role of different type of teeth and tongue - Chewing process/ mastication - Bolus formation- role of saliva and swallowing of food - Peristalsis – definition and significance in the alimentary canal • **Chemical digestion** Role of the following groups of enzymes - site of production, substrate, pH and end products (specific names of enzymes need not be mentioned) - Carbohydrates – Proteases – Lipases Process of absorption • **Description of absorption** • **Structural adaptations in facilitating absorption**: - Small intestines and Villi Importance of hepatic portal system in transport of absorbed food Role of the liver in: - Glucose metabolism - Deamination - Breaking down of alcohol, drugs and hormones Homeostasis • **Definitions**: - Homeostasis - Negative feedback mechanism • **Homeostatic control** of glucose levels – Insulin and glucagon

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An animal's **digestive system** is designed to break down and absorb these nutrients.

Dentition

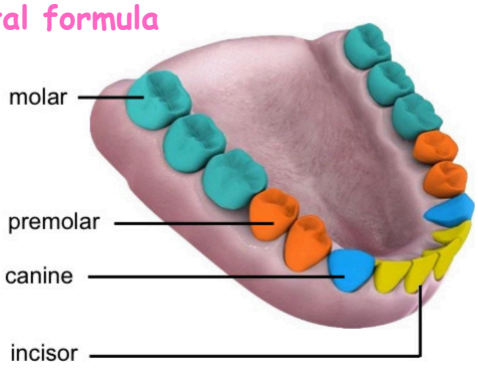
refers to the development, arrangement, and types of teeth in an animal's mouth

Types of teeth	Structure and function
incisors	• chisel-shaped • used for biting or cutting of food
canines	• pointed • used for catching, holding, tearing and/or killing prey
premolars	• flat and uneven • used for grinding and crushing food
molars	• flat and uneven • used for grinding and crushing food
carnassial teeth	• specialised molars and pre-molars with jagged, triangular edges • used for cutting meat

The arrangement of teeth in a human is represented as a dental formula

Human dental formula: $\frac{2.1.2.3}{2.1.2.3}$

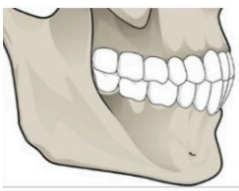
2 incisors, 1 canine, 2 premolars and 3 molars in the upper half



The shape and type of teeth that an animal has, gives a good indication of the type of food that the animal consumes

Type of nutrition	Types of teeth
herbivores	• use incisors to cut the plant material • usually lack canines • use molars and premolars to grind food
carnivores	• use incisors to slice or shred meat • large, well-developed canines used for catching, holding and tearing meat • molars and premolars are modified to form carnassial teeth (see Figure 2 below)
omnivores	• have teeth that are modified for eating both plant material and meat similar to those in humans


Herbivore (sheep)


Omnivore (human)


Carnivore (leopard)

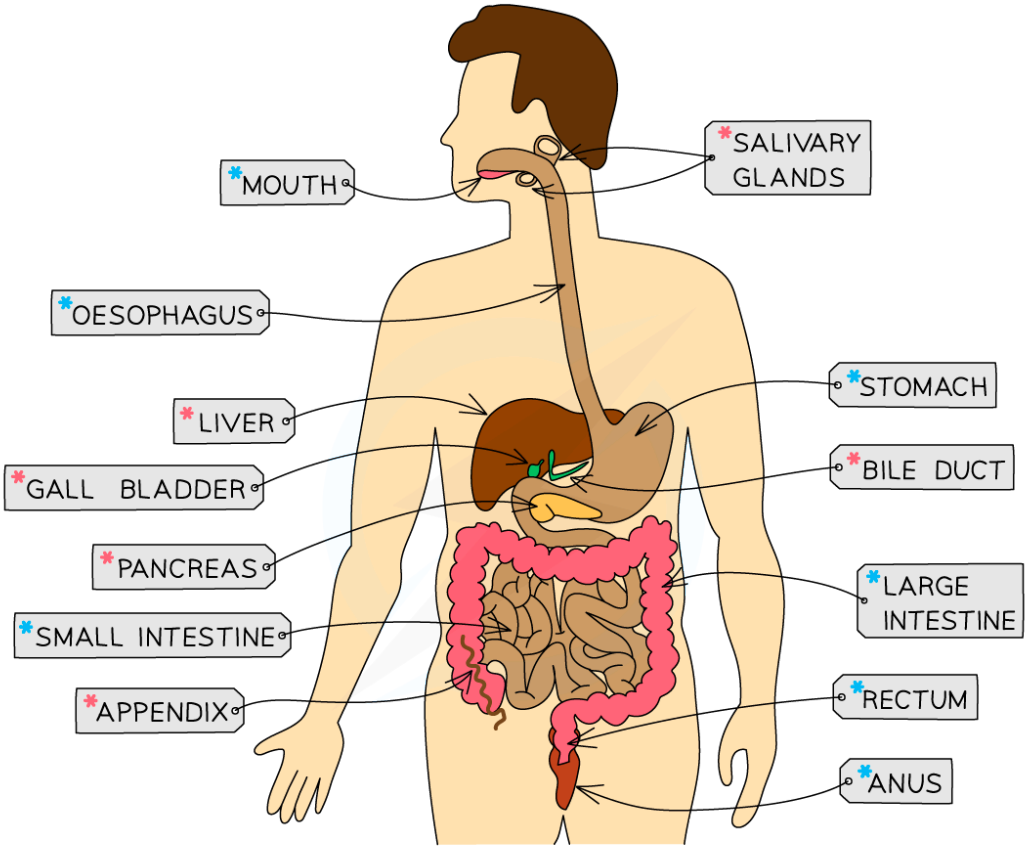
Animal nutrition

Human nutrition

Digestive system

The **digestive system** is responsible for breaking down complex molecules into their simplest forms to be absorbed into the body to sustain life.

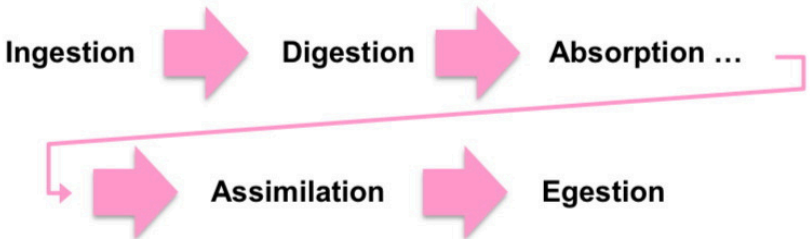
The human digestive system is made up of an alimentary canal (tube from mouth to anus) and accessory organs (e.g. liver, pancreas) that aid in the digestive process



* = PART OF ALIMENTARY CANAL, THE PASSAGE ALONG WHICH FOOD PASSES THROUGH THE BODY

* = ACCESSORY DIGESTIVE STRUCTURES

There are **five** steps in the **digestive process** as shown:



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Digestive system

Parts and functions

Structure	Function
mouth cavity	The mouth cavity consists of many parts: • Teeth which break down and grind food • **Tongue** which mixes food and is used for swallowing of food • Hard and soft palate which forms the roof of the mouth • **Salivary glands** release saliva which contains enzymes (called carbohydrases) to chemically break down carbohydrates
pharynx & oesophagus	• After food is swallowed (now called the **bolus**), it moves into the pharynx which is the tube used to take in food and air • The food moves down to the larynx where the epiglottis (a cartilage flap) stops food from going into the trachea • Food goes down the oesophagus • The oesophagus pushes food down to the stomach by **peristalsis**
stomach	• The stomach is a muscular sac with thick walls • It churns the food and mixes it with gastric juice (hydrochloric acid – HCl) and enzymes (this mixture is called **chyme**) • The stomach has two **sphincters** (a ring of muscles to close a tube) to keep both openings to the stomach closed while food is being digested

liver & gall bladder	• Liver cells produce **bile** which is stored in the gall bladder until being released into the duodenum of the small intestine
	• Bile has a number of functions in digestion:
	  ○ Bile emulsifies large fat globules into small fat droplets which aids digestion
	  ○ It neutralises the acidic fluid (chyme) which comes from the stomach
	  ○ It promotes peristalsis in the small intestine
	  ○ It acts as an antiseptic which prevents decay of food particles in the small intestine

pancreas	• Secretes pancreatic juices which digest carbohydrates, proteins and lipids in the small intestine (exocrine gland). • Also neutralises chyme from the stomach • Controls blood glucose levels in the body (endocrine gland)
small intestine	• The small intestine in humans is 6 m long and divided into three regions: duodenum; jejunum and ileum • **Duodenum** is the first portion which receives bile from the liver and pancreatic juices from the pancreas • **Jejunum** is the middle portion which secretes intestinal juices • **Duodenum** is the final portion which is the region of most absorption in the small intestine
	• The small intestine has transverse folds and microscopic **villi** which greatly increases the surface area for absorption
colon	• The colon (also called the large intestine) is divided into three regions: ascending colon, transverse colon and descending colon • **Most water and mineral salts** are absorbed in the colon • The descending colon leads to the rectum followed by the anus where undigested food is **egested**

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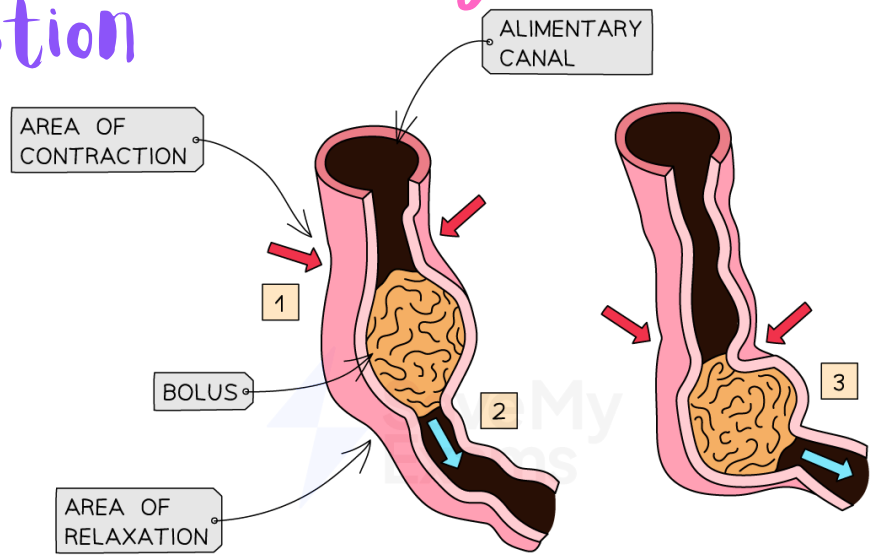
Digestion

The breakdown of food. Can be **mechanical** or **chemical**

Mechanical Digestion

Mechanical digestion is the physical breakdown of large food particles into smaller particles.

- It does not alter the chemical structure of the compounds.
- occurs during **mastication**, churning in the stomach and during peristalsis.
- Food is moved through the digestive system by the *rhythmic contraction and relaxation of circular muscles along the alimentary canal* by peristalsis.
- **Peristalsis** is a reflex action and is triggered by the presence of the food in the alimentary canal.

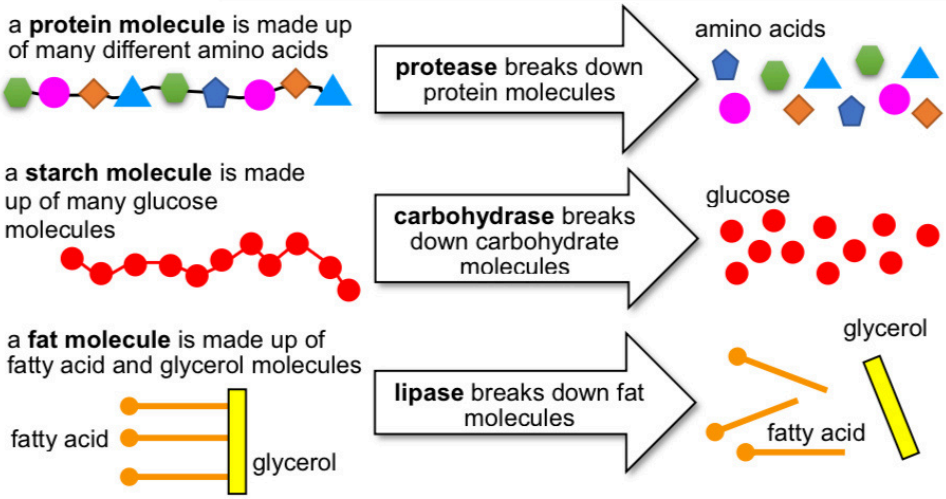


The **bolus** reaches the stomach, and is physically broken down further by the contractions of the stomach muscles. The bolus is also mixed with stomach acid and digestive enzymes which forms a mixture called chyme.

Chemical Digestion

Chemical digestion is the breaking down of large food compounds into smaller food compounds using digestive enzymes.

Group of enzymes	Carbohydrases	Proteases	Lipases
Where they are produced	Saliva, pancreatic juices, intestinal juices	Stomach, pancreatic juices intestinal juices	Pancreatic juices, intestinal Juices
Substrate	Carbohydrates (starch)	Proteins	Lipids (fats and oils)
Preferred pH	Slightly alkaline	Acidic in stomach, Alkaline in small intestine	Slightly alkaline
End product of digestion	Glucose	Amino acids	Glycerol & fatty acids



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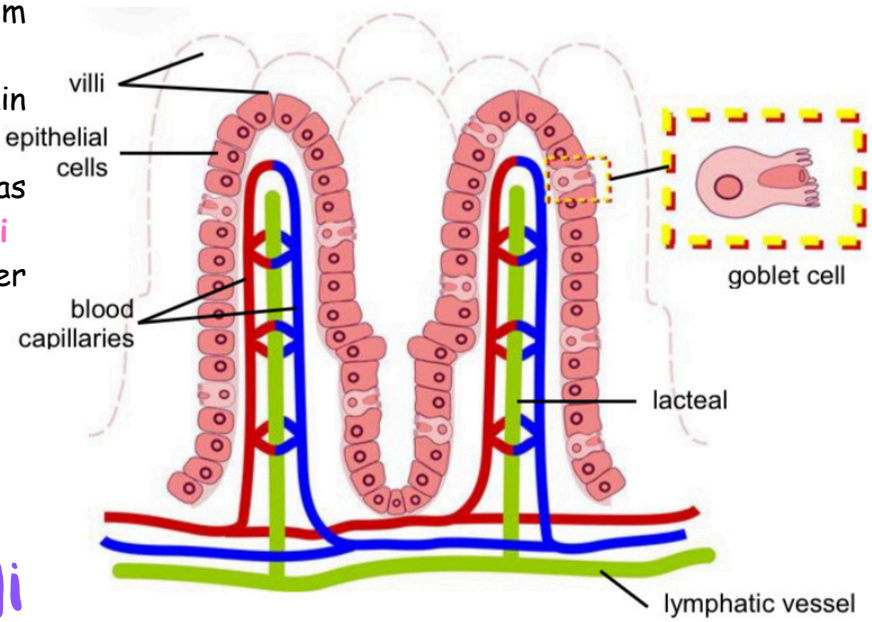
Absorption

Most **absorption** takes place in the small intestine because most of the digestion has taken place by the time the food reaches the small intestine.

Surface area of small intestine

- The small intestine is approximately 6 m long.
- The walls of the small intestine contain transverse folds.
- The inner wall of the small intestine has millions of finger-like projections called **villi**
- Each villus contains **microvilli** to further increase the surface area



Adaptations of villi

- The **epithelium** is only one-cell layer thick allowing nutrients to pass through quickly.
- **Goblet cells** secrete mucus to ensure the absorptive surface is moist and to allow nutrients to be dissolved and then to be absorbed.
- The epithelium contains **many mitochondria** to supply energy for active absorption of nutrients.
- **Microvilli** further increase the surface area.
- There is a **lymph vessel** called a **lacteal** in each villus which absorbs and transports lipids.
- The **villus** is richly supplied with blood capillaries to transport glucose and amino acids.

Absorption	Glucose	Amino acids	Glycerol and fatty acids	Vitamins	Minerals	Water
Active/Passive absorption	Active	Active	Passive (diffusion)	Active & passive	Active & passive	Passive (osmosis)
Structure where absorption takes place	Blood capillary	Blood capillary	Lacteal	Blood capillary	Blood capillary	Blood capillary

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Absorption

Glucose and **amino acids** are absorbed from the small intestine and transported in the blood circulatory system as shown in the flow diagram

Amino acids & glucose are absorbed into blood capillaries of the villi in the small intestine

↓

Capillaries join together to form large venules to form the hepatic portal vein transports amino acids and glucose to the liver

↓

Glucose and amino acids flow through hepatic vein to the heart

↓

The liver converts excess glucose to glycogen and stores it

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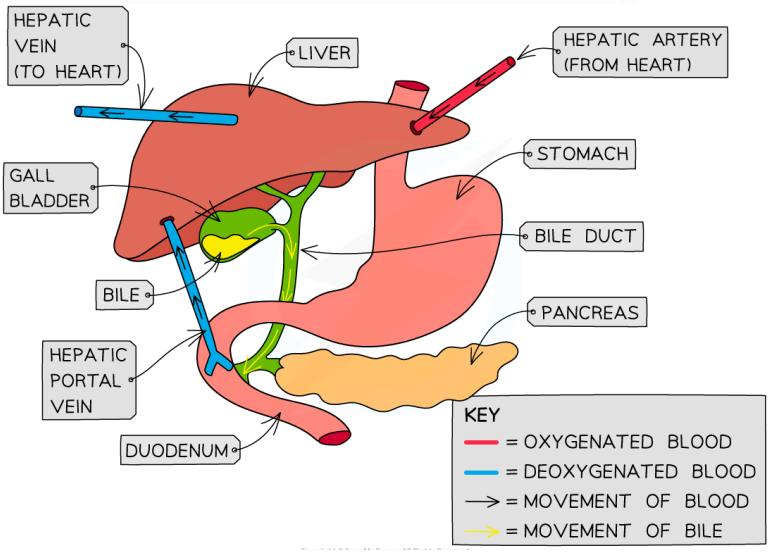
Excess amino acids are deaminated by the liver to form urea (waste product) and are removed from the body



Assimilation

Assimilation is the incorporation of absorbed nutrients into the cells of the body.

- muscle cells will absorb amino acids to be converted to proteins and glucose will be absorbed by cells to provide energy.
- The liver plays a vital role in the assimilation of nutrients.
- The liver is responsible for the metabolism of glucose, deamination of amino acids, the breakdown of alcohol, drugs and hormones.

Egestion

Egestion is the removal of undigested material

- undigested materials are transported through the **colon** where most water and mineral salts are absorbed.
- The undigested material is temporarily stored in the **rectum** until it is excreted through the **anus**. The undigested waste is then referred to as **faeces**.

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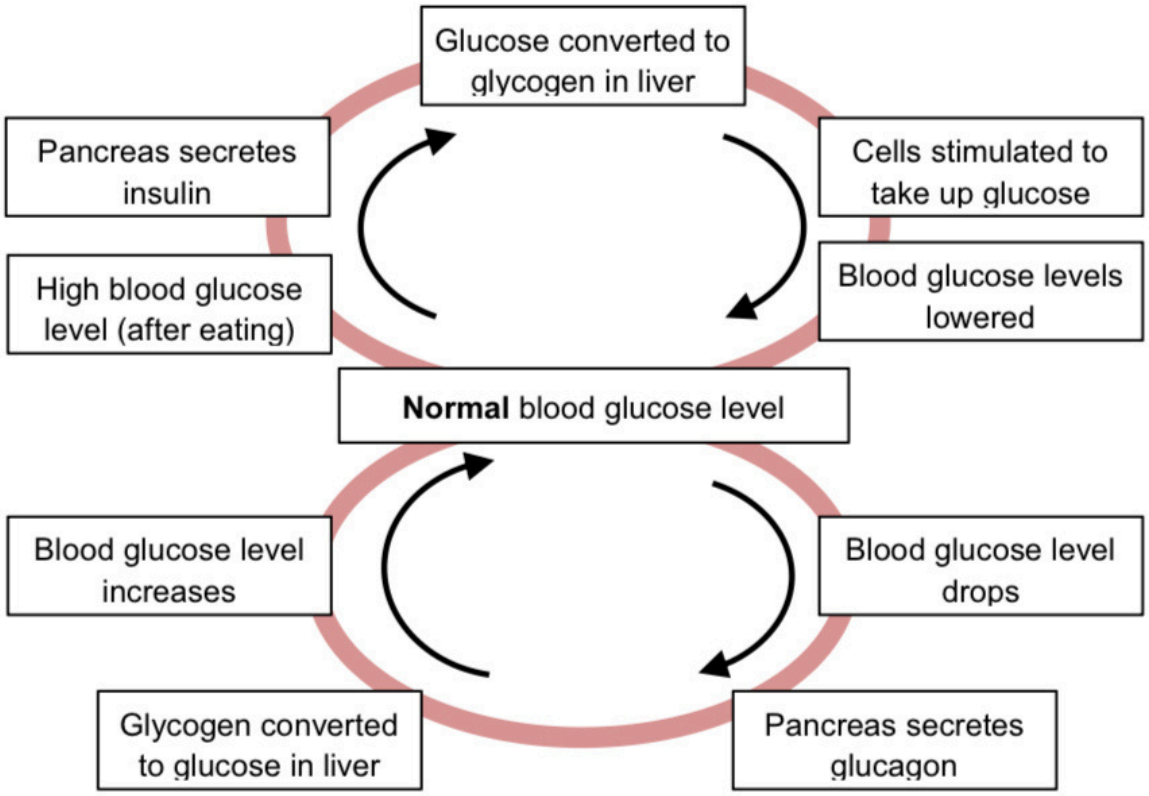
After a meal, blood glucose levels will **increase** because more glucose is absorbed from the small intestine into the blood. The pancreas detects an increase in blood glucose and releases the hormone **insulin** which causes the glucose to be converted into **glycogen**. Glycogen is stored in the liver and skeletal muscles in the body. The body cells are also stimulated to take up glucose. This lowers the blood glucose level and returns it to normal.



Blood glucose levels **decrease** because the *body cells are constantly using glucose* for cellular respiration. When blood glucose levels decrease, the pancreas will release the hormone **glucagon** which converts stored glycogen (from the liver and skeletal muscles) into glucose. This increases the blood glucose level and returns it to normal

Diabetes mellitus

Diabetes mellitus is a disorder characterised by high blood glucose levels resulting in increased fatigue (tiredness), dehydration and lack of energy.

Types of diabetes mellitus	
Type 1 diabetes	**Type 2 diabetes**
Cause: Usually an inherited disorder or a loss of insulin-producing cells in the pancreas **Treatment**: Lifelong disorder that requires daily injections of insulin and specially adapted diet	**Cause**: Insulin resistance where body does not produce or react to insulin, usually as a result of poor lifestyle choices **Treatment**: Maintaining a balanced diet, regular exercise and medication

Animal Nutrition Terminology

Key terminology

herbivore	animal that eats only plants or parts of plants
carnivore	animal that eats only other animals or the remains of other animals
omnivore	animal that eats plants, animals or dead animal flesh

bolus	a ball-like mixture of food and saliva that forms in the mouth during the process of chewing
bile	is a fluid produced by the liver, and stored in the gall bladder, that aids the digestion of lipids in the small intestine
exocrine gland	a gland that uses ducts to drain and transport secretions or chemicals out of the body or onto body surfaces
endocrine gland	an organ that secretes hormones directly into the blood stream or lymphatic system instead of through ducts
peristalsis	an automatic wave of muscle contraction and relaxation that moves food in one direction through the digestive tract
chyme	a semi-liquid mass of partially digested food which has gone through mechanical and chemical digestive processes while passing through the stomach into the duodenum
villus (pl. villi)	tiny finger-like projections lining the wall of the small intestine and increasing the surface area for food absorption
ingestion	intake of food
digestion	physical and chemical breakdown of food into its simplest form
absorption	the products of digestion diffuse into the blood stream
assimilation	nutrients such as amino acids are incorporated into the cells
egestion/defecation	the removal of undigested and unabsorbed waste from the body through the anus in the form of faeces

homeostasis	the ability of an organism to maintain stability of internal conditions (e.g. temperature, chemical balance) despite changes in its environment

negative feedback mechanisms	mechanisms in the human body that detect changes or imbalances in the internal conditions and restore homeostasis
blood glucose	amount of glucose in the blood
insulin	a hormone made in the pancreas and released into the blood to help convert glucose to glycogen to reduce blood glucose
glucagon	a hormone made by the pancreas that raises blood glucose levels by converting stored glycogen to glucose
glycogen	form in which glucose is stored in the liver and cells