Unit 22

HETEROTROPHIC NUTRITION

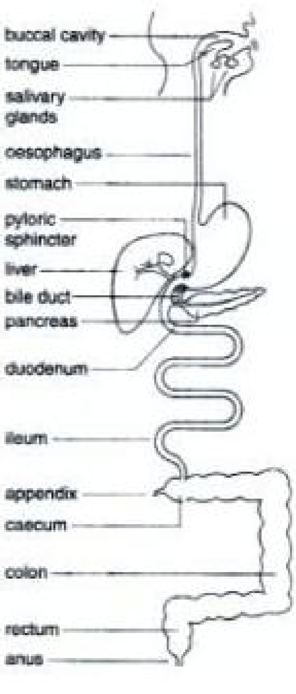
- **Heterotrophs** are organisms that, unlike plants, cannot manufacture their own organic molecules from simple inorganic ones. Instead, to obtain the organic molecules they need, they must feed on other organisms. They are, in effect, nutritional thieves, stealing the components of other creatures' bodies in order to construct their own.

- Human beings are **omnivores**, a type of heterotroph that preys on a wide range of other organisms, including both plants and animals. A balanced human diet must contain all the major types of organic molecule. **Carbohydrates** (see unit 2) can be obtained from foods such as bread, rice, and potatoes. **Lipids** (see unit 2) are found in fatty or oily foods. **Proteins** (see unit 3) are present in meat, eggs, and vegetables such as the soya bean.

- **Vitamins** are organic molecules which, though they are only needed in small quantities, are also a necessary part of the human diet. An example of a vitamin is **nicotinic acid**, or $\mathbf{B_3}$. This can be obtained from wholemeal bread, yeast extract, and meat, particularly liver. It is used in the construction of **NAD**, a hydrogen-carrying molecule which plays a vital role in respiration (see unit 8). A person whose diet is lacking in nicotinic acid is likely to suffer from skin rashes and lesions, a condition known as **pellagra**.

- As well as all these organic nutrients, a balanced diet must also contain a range of simple inorganic molecules, or **mineral ions**. Examples include **calcium**, which is needed for the construction of bones, **iron**, which forms a vital part of haemoglobin (see unit 20), and **phosphate**, which is needed in the manufacture of a whole range of molecules, from phospholipids (see unit 6) to ATP (see unit 8).

- All heterotrophs, whatever their dietary requirements, suffer a common problem. Most molecules of food are too big to pass easily across an organism's surface, from the world outside to the cells inside its body. The solution to this problem is **digestion**, a process in which food molecules are broken down into small, soluble sub-components. Once food has been digested, the soluble molecules that result can diffuse across the organism's surface and into its body, a process known as **absorption**.



- In humans, as in most animals, the site of digestion and absorption is the **gut**, or **alimentary canal**. A diagram of the human alimentary canal is shown on the left.

- Food begins its journey in the mouth, where chewing, or **mastication**, occurs. This process breaks the food up into small, manageable pieces, which not only makes swallowing easier, but also increases the surface area of the food. This increase in surface area means that a digestive enzyme, called **amylase**, which is present in saliva, can work on the food more effectively.

- Like all the digestive enzymes in the gut, amylase is a **hydrolytic** enzyme. It catalyses a reaction in which water is added to split apart bonds formed by condensation (see unit 1). Different hydrolytic enzymes are needed to break bonds in different types of food molecule. Amylase is used to break **starch** down into **maltose** (see unit 2).

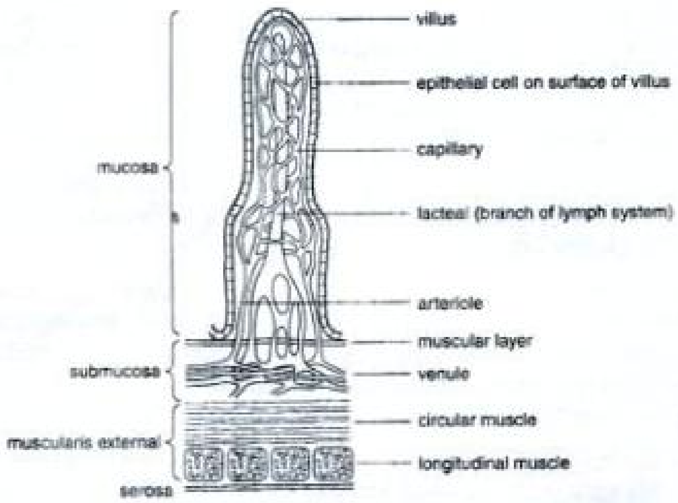
- After chewing, the food is swallowed and passed into the **oesophagus**, a long, muscular tube which runs down to the stomach. Waves of muscular contraction, in the walls of the oesophagus, squeeze the food along in a process known as **peristalsis**.

- Food may remain in the stomach for up to four hours, while the enzymes contained in the acidic **gastric juice** break its components down. After this it is released into the **duodenum**, where yet more enzymes get to work on it. Some of these enzymes are attached to the duodenal lining, and some arrive down the **pancreatic duct**, in **pancreatic juice**. A summary of all these enzymes is given above right.

Site of production	Enzyme	Site of action	Substrate	Product
salivary glands	amylase	mouth	starch	maltose
stomach lining	pepsin	stomach	proteins	peptides
pancreas	amylase trypsin lipase	duodenum duodenum duodenum	starch proteins lipids	maltose peptides fatty acids + glycerol
lining of duodenum	disaccharidases exopeptidases	duodenum duodenum	disaccharides peptides	monosaccharides amino acids
liver	bile salts (not an enzyme)	duodenum	lipids	lipid droplets

Protein-digesting enzymes, such as **pepsin**, are released in an inactive form. This is to prevent them from breaking down the cells where they are made. Once released, they can be activated. The only substance on the list which isn't an enzyme is **bile**. This doesn't actually hydrolyse fats, it just **emulsifies** them, causing them to break up into little droplets, which increases their surface area and allows enzymes to work on them more effectively.

- After digestion in the duodenum, food is passed on to the **ileum**, where it is absorbed. A diagram of the ileum lining is shown below.



As you can see in the diagram, the ileum lining is folded to form finger-like processes called **villi**. The cell membranes of the **epithelial cells**, which are found on the surface of these villi, are also folded, to form **microvilli**. All this folding dramatically increases the total surface area available for absorption.

- Almost all of absorption is due to **diffusion**, though a little **active transport** may be involved as well (see unit 6). Sugars and amino acids diffuse into the blood capillaries in each villus. Fatty acids and glycerol enter the **lacteals**, which are branches of the **lymph system**, from where they will, eventually, make it into the blood.
- All the indigestible components of the food, which are too large to be diffuse through the gut wall, carry on into the **colon,** where water is reabsorbed, and then out of the **rectum** as **faeces**.