9.1 Digestive System

STRUCTURE OF THE HUMAN DIGESTIVE SYSTEM

- The human digestive system is made up of a long and muscular alimentary canal that starts from the mouth to the anus

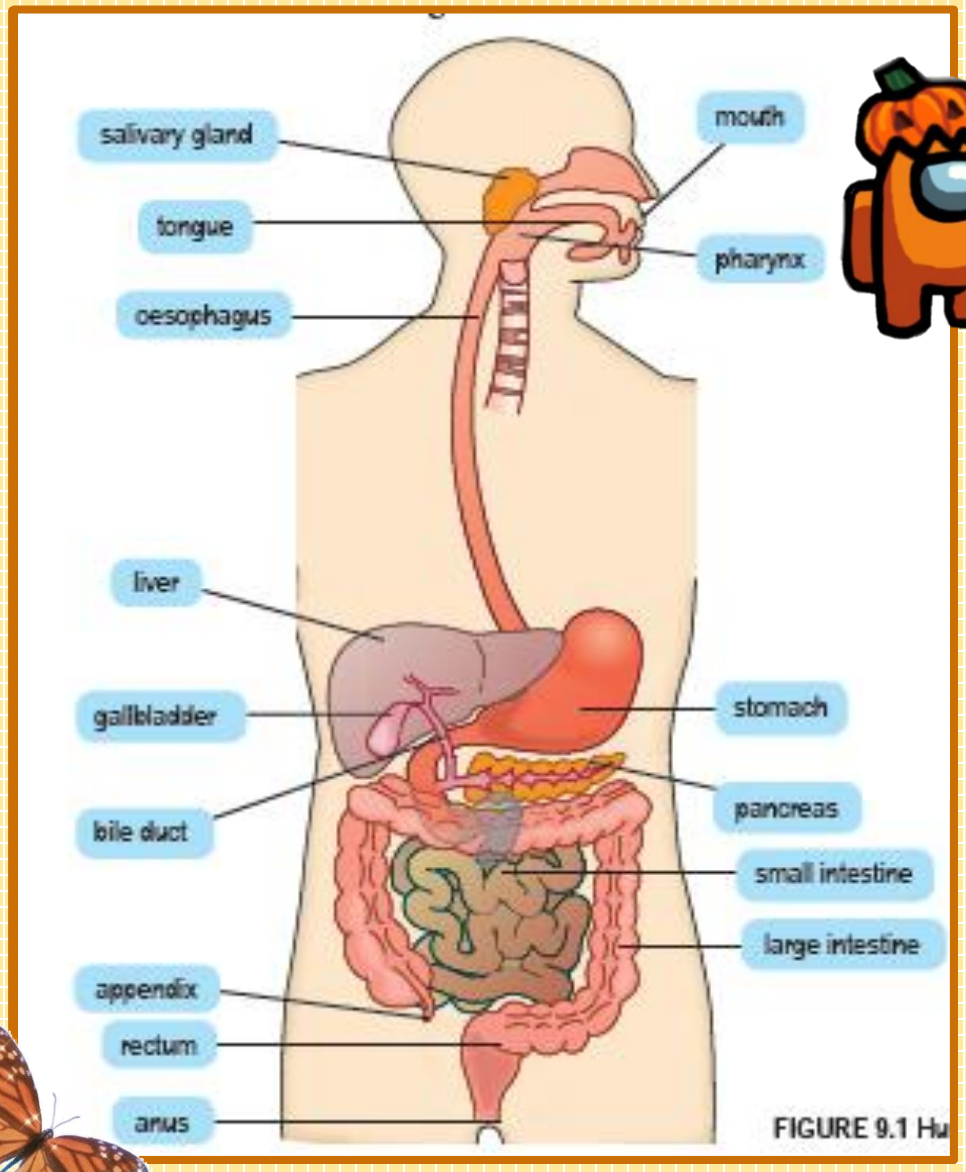


FIGURE 9.1 Hu

- The parts of the alimentary canal include the mouth, oesophagus, stomach, small intestine, large intestine and anus.
- The other organs in the digestive system are liver, gallbladder and pancreas. Salivary, gastric and intestinal glands secrete digestive juices into the alimentary canal

9.2 DIGESTION

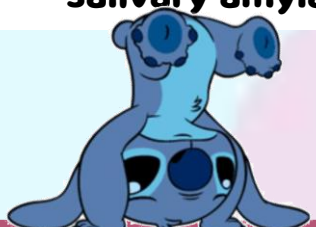
TYPES OF DIGESTION

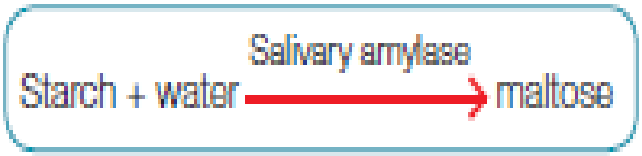
- Digestion is the process that breaks down large and complex pieces of food into smaller and simple pieces that can be dissolved for easy absorption.
- Digestion is made up of two parts, that is, physical digestion and chemical digestion.

PHYSICAL DIGESTION	CHEMICAL DIGESTION
The mechanical breakdown of food to form small Particles	The decomposition process of complex molecules into simple molecules
Involves chewing and peristalsis	Involves enzymes reaction

DIGESTION OF CARBOHYDRATES IN THE MOUTH

- The digestive process begins in the mouth The presence of food in the mouth stimulates the secretion of saliva from the salivary glands.
- Saliva contains salivary amylase that hydrolyses starch to maltose.
- The pH of the saliva ranges between 6.5–7.5, which is suitable for salivary amylase to act at its optimum.





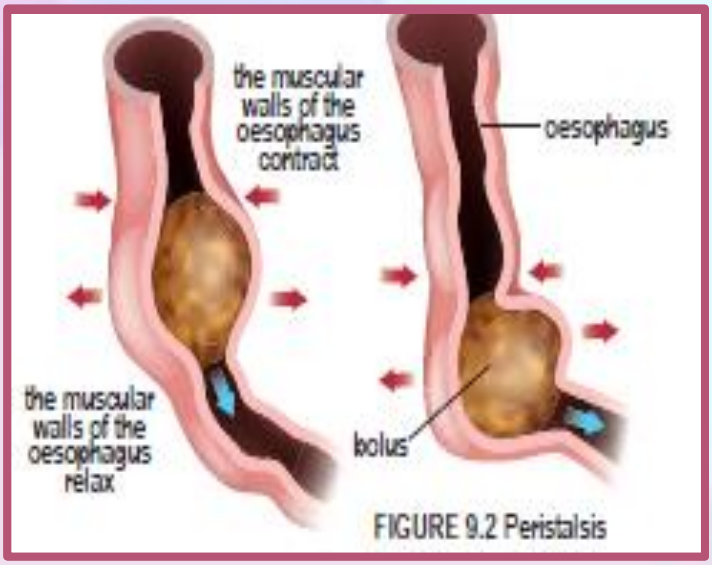


FIGURE 9.2 Peristalsis

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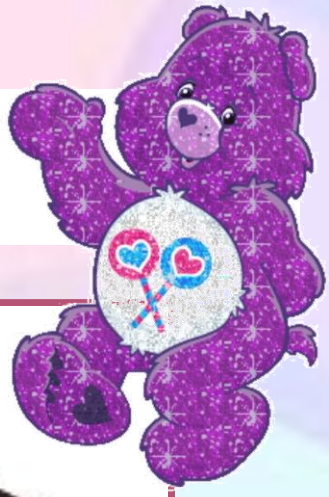
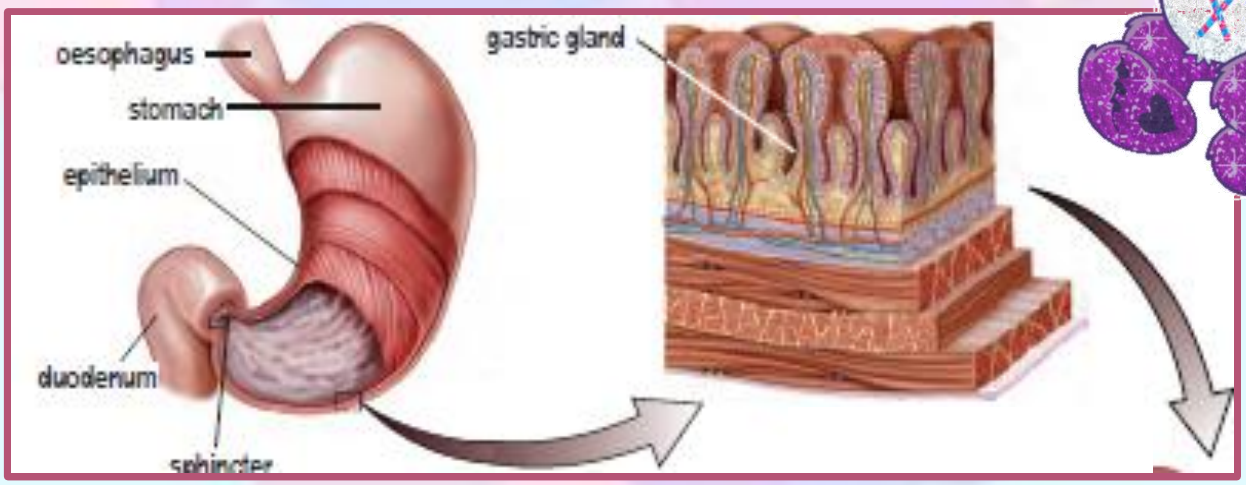
- Saliva helps food to form bolus and makes it easier to be swallowed.
- When swallowing, the epiglottis will close the trachea opening to prevent food from entering the trachea.
- In the oesophagus, the food bolus is moved by peristalsis.
- Peristalsis is the rhythmic contraction and relaxation of muscles along the alimentary canal.
- Peristalsis pushes the bolus through the oesophagus until it enters the stomach

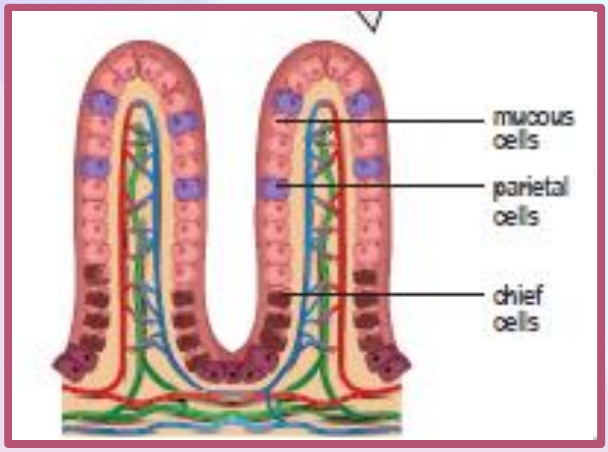
DIGESTION OF PROTEIN IN THE STOMACH

- The surface of the stomach wall is lined with epithelial cells that have undergone adaptations in structure and function to form gastric glands
- These epithelial cells are chief cells, parietal cells and mucous cells



- Chief cells secrete pepsinogen.
- Parietal cells secrete hydrochloric acid.
- Mucous cells secrete mucus





Protein + water —pepsin→ polypeptides

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The functions of hydrochloric acid are to:

- prepare a medium with a suitable pH (Ph 1.5–2.0) for pepsin to act
- stop the enzymatic action of salivary amylase
- kill bacteria in food

- The function of mucus is to protect the stomach wall from the reaction of hydrochloric acid and digestive enzymes
- The food in the stomach is mixed with gastric juice made up of hydrochloric acid and pepsin.
- Food is churned by the peristaltic action of the stomach wall muscles for a few hours.
- The contents in the stomach finally change to a semifluid called chyme. Chyme enters the duodenum slowly when the sphincter muscle relaxes.

DIGESTIONS OF CARBOHYDRATES, PROTEINS AND LIPIDS IN THE SMALL INTESTINE

- The small intestine consists of duodenum, jejunum and ileum.
- Duodenum is the first part of the small intestine which receives chyme from the stomach.
- Duodenum also receives bile produced by the liver and pancreatic juice secreted by the pancreas

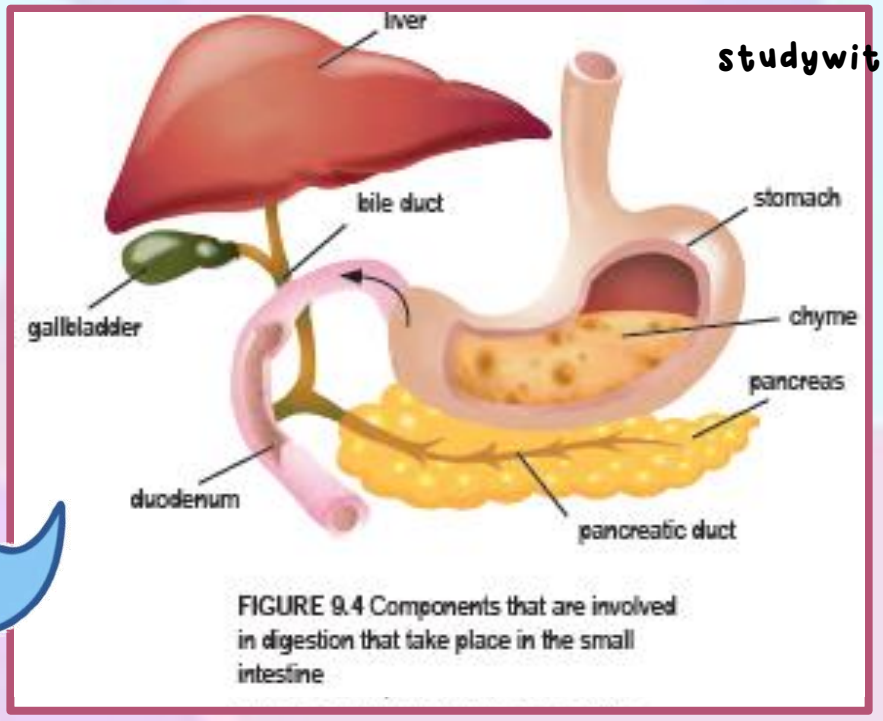

FIGURE 9.4 Components that are involved in digestion that take place in the small intestine

PANCREAS

The pancreas secretes **pancreatic amylase**, **trypsin** and **lipase** into the duodenum through the pancreatic duct.

LIVER

- Produces bile
- The gallbladder stores bile.
- The bile flows into the duodenum through the bile duct.
- Functions of bile
  - neutralise the acidic chyme
  - prepare an **alkali condition** (pH 7.6–8.6) for enzyme action in the duodenum
  - emulsify lipids by breaking down lipids into tiny droplets to increase surface area for lipase activity.

DUODENUM

- Pancreatic amylase hydrolyses starch to maltose
  Starch + water $\xrightarrow{\text{pancreatic amylase}}$ maltose
- Trypsin hydrolyses polypeptides into shorter peptides.
  Polypeptide + water $\xrightarrow{\text{trypsin}}$ peptides
- Lipase hydrolyses lipids into fatty acids and glycerols.
  Lipid + water $\xrightarrow{\text{lipase}}$ fatty acid and glycerol

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- **Glands on the ileum wall secrete mucus and intestinal juice that contains maltase, sucrase, lactase, lipase and erepsin.**
- **The alkali medium in the ileum allows enzymes to act at its optimum**

CARBOHYDRATE DIGESTION

- **Maltase** hydrolyses **maltose** into glucose.

  Maltose + water $\xrightarrow{\text{maltase}}$ glucose

- **Sucrase** hydrolyses **sucrose** into glucose and fructose.

  Sucrose + water $\xrightarrow{\text{sucrase}}$ glucose + fructose

- **Lactase** hydrolyses **lactose** into glucose and galactose.

  Lactose + water $\xrightarrow{\text{lactase}}$ glucose + galactose

LIPID DIGESTION

Lipase hydrolyses lipids into **fatty acids** and **glycerols**.

Lipid + water $\xrightarrow{\text{lipase}}$ Fatty acids + glycerol

PROTEIN DIGESTION

Erepsin hydrolyses peptides into **amino acids**.

Peptides + water $\xrightarrow{\text{erepsin}}$ amino acids

9.3 Absorption

The adaptations of ileum and villus in the absorption of digested food

Simple molecules produced from the digested food are absorbed in the ileum of the small intestine.

ILEUM

The long ileum is adapted to absorb nutrients because its internal layer is folded and covered by tiny projections called villi

VILUS

Villus has the following adaptations to absorb nutrients :

- **The epithelial layer of the villus is one cell thick. This helps accelerate nutrient absorption.**
- **Goblet cells secrete mucus to aid digestion.**
- **The network of blood capillaries helps to transport digestive products to the whole body.**
- **Lacteal carries droplets of fatty acids and glycerol.**
- **The intestinal glands secrete intestinal juices that have digestive enzymes.**

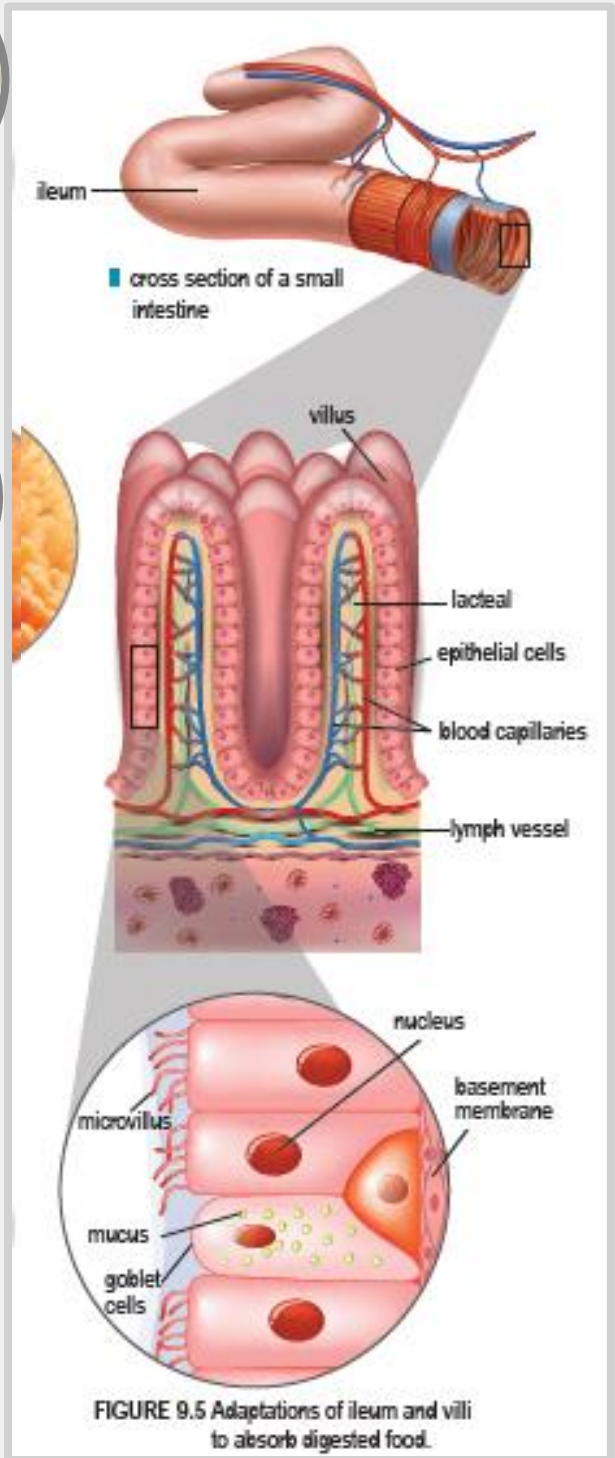

FIGURE 9.5 Adaptations of ileum and villi to absorb digested food.

MICROVILLUS

On the surface of the villus epithelium, there are many tiny p called microvillus. Microvillus provides a large surface area to increase the rate of nutrient absorption

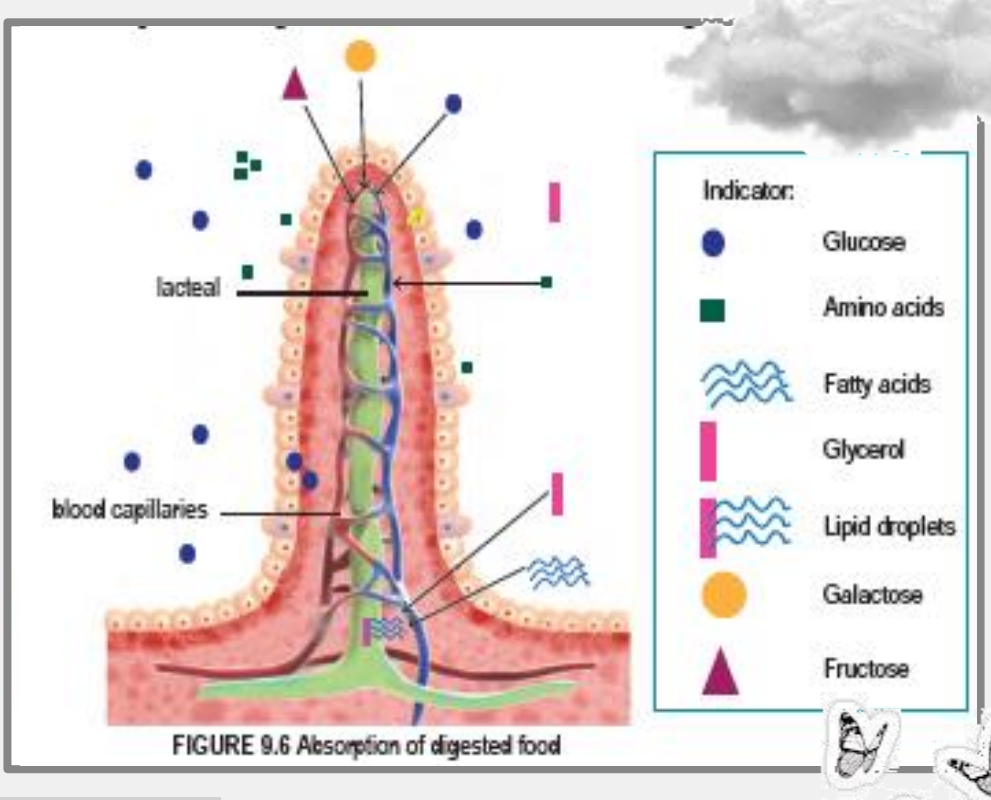

FIGURE 9.6 Absorption of digested food

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Method of food absorption in the ileum

DIGESTED FOOD	ABSORBED THROUGH	METHODS OF ABSORPTION
Fructose	Epithelial cells into blood Capillaries	Facilitated diffusion
Glucose and galactose		Active transport
Amino acids		Active transport
Vitamins b and c		Absorbed with water
water		Osmosis
Fatty acids and glycerols recombine through the condensation process to form tiny droplets of lipids in the epithelial cells	Epithelial cells into lacteal 	Simple diffusion
Vitamins A, D, E, K dissolve in the lipid		Simple diffusion

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9.4 Assimilation

The ROLE OF the CIRCULATORY SYSTEM

- The human circulatory system consists of the blood circulation system and the lymphatic system to help transport nutrients to be assimilated.
- In the assimilation process that occurs in cells, nutrients are used to form complex compounds or structures of components.
- The blood capillaries in the small intestine combine to form the hepatic portal vein that transports blood to the liver.
- Lacteals combine to form bigger lymph vessels in the lymphatic system.
- Then, the contents of the lymph vessels enter the thoracic duct that flows into the left subclavian vein. This lipid is then transported by blood throughout the body

FUNCTIONS OF LIVER IN THE ASSIMILATION OF DIGESTED FOOD

Metabolism of digested food

Detoxification

Storage of nutrients

ASSIMILATION PROCESS IN THE LIVER

AMINO ACIDS

- The liver synthesises **plasma protein** and **enzymes** from amino acids.
- Excess amino acids cannot be stored in the body and are broken down through the **deamination** process to form urea which is then expelled.
- When the glucose supply is insufficient, the liver converts amino acids into glucose.

GLUCOSE

- Glucose in the liver is used for cellular respiration when required by the body and the excess is converted to glycogen and stored in the liver.
- When the glucose level in the blood decreases and the body needs energy, glycogen is converted to glucose.
- When the glycogen supply reaches a maximum level, the excess glucose is converted to fats.

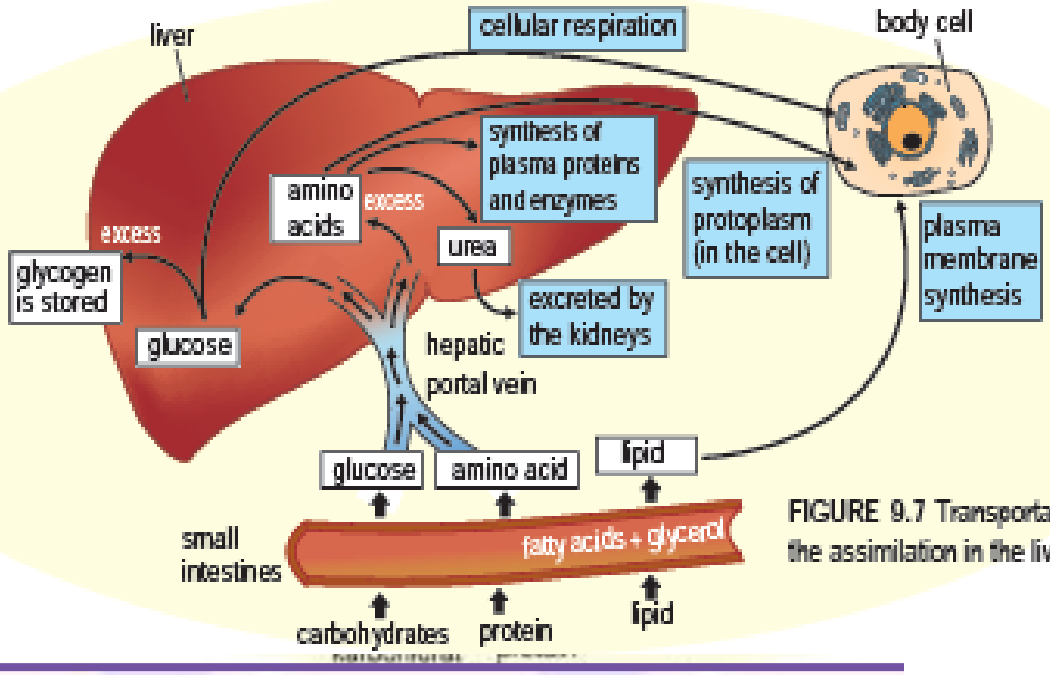

FIGURE 9.7 Transportation of nutrients and the assimilation in the liver and cells

ASSIMILATION PROCESS IN CELLS

AMINO ACIDS

- Amino acids are used to synthesise new **protoplasm** and also **repair damaged tissues**.
- Amino acids are used to synthesise **hormones** and **enzymes**.

GLUCOSE

- Glucose is oxidised through **cellular respiration** to release energy, water and carbon dioxide.
- Excess glucose is kept as **glycogen** in muscles.
- Energy is used for cell processes such as protein synthesis.

LIPIDS

- Lipids such as **phospholipid** and **cholesterol** are the primary components that build the plasma membrane.
- Excess fats are kept in adipose tissues found underneath the skin as stored energy.
- Fat is oxidised to release energy when there is insufficient glucose.

9.5 Defaecation

Functions of the large intestine

Absorption of water and vitamins

Formation of faeces

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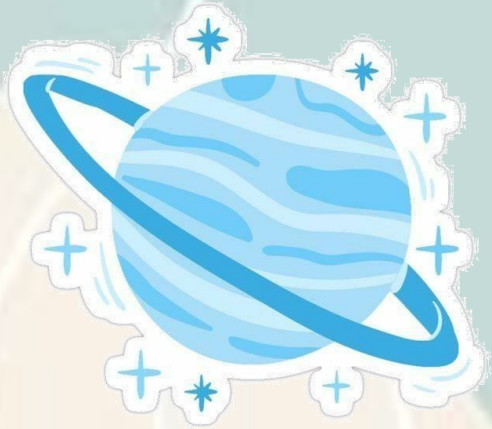

9.6 Balanced Diet

Energy value in a food sample

A balanced diet refers to a diet that consists of all seven food classes (carbohydrates, lipids, proteins, vitamins, mineral salts, fibre and water) in the correct proportion and balanced quantity according to individual needs so that optimal health can be maintained.

ENERGY VALUE

- **Energy value** is the total amount of energy released when one gram of food is oxidised completely.
- The energy value in food is measured in the form of heat energy, that is, in **kilojoule per gram (kJ g^{-1})**.
- Another unit of heat energy is **calorie**.
- 1 calorie or 4.2 joule is defined as the quantity of heat energy needed to raise the temperature of 1 gram water by 1 degree Celsius (°C) at a pressure of 1 standard atmosphere.
- Energy value of food (kJ g^{-1})

$$= \frac{\text{Water mass (g)} \times 4.2\ \text{J g}^{-1}\ ^\circ\text{C}^{-1} \times \text{Increase in water temperature (°C)}}{\text{Mass of food sample (g)} \times 1000}$$

Diet modifications for specific individuals

THE CAUSE OF OBESITY

- Obesity is caused by the storage of excess fats as a result of imbalanced food intake and use of energy.

EFFECTS OF OBESITY

- Individuals who are obese need to reduce the intake of carbohydrates and fats as well as increase the intake of vegetables and fruits.
- Otherwise, a diet with excessive saturated fats and high cholesterol may cause diabetes mellitus and various cardiovascular diseases such as atherosclerosis and hypertension which may result in heart attacks (myocardial infarction) or stroke if not treated

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9.7 Health Issues Related to the Digestive System and Eating Habits

Adaptation of digestive organs

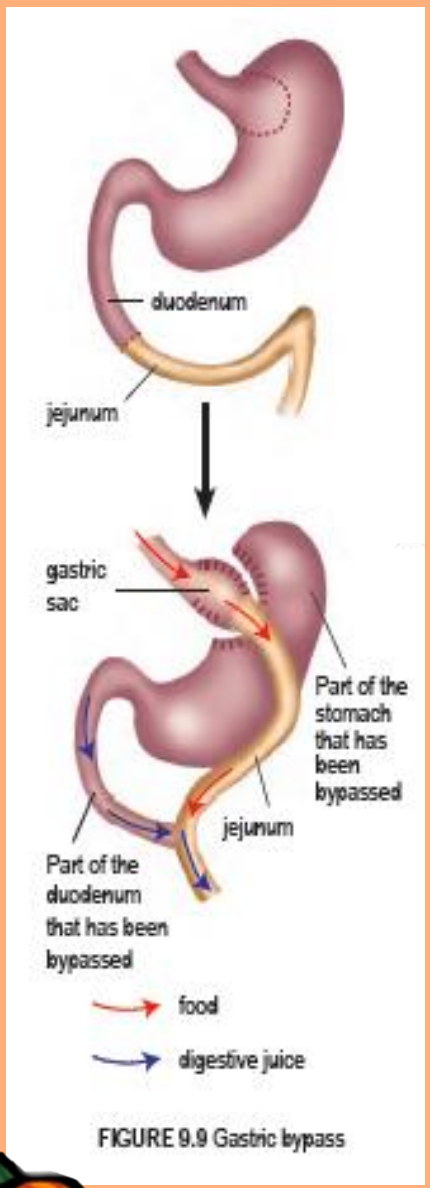

FIGURE 9.9 Gastric bypass

Health issues related to defaecation

- The food class that is most important in the defaecation process is fibre.
- Intake of diet that is high in fibre such as fruits and vegetables can smoothen bowel movements.
- This can prevent health problems such as constipation, colon cancer, rectum cancer and haemorrhoid.

Functions of fibre are to:

- stimulate peristalsis
- absorb and expel toxic substances
- regulate the absorption of glucose especially for diabetes mellitus patients
- increase the population of beneficial bacteria in the large intestine

- Besides, the intake of a large amount of water can ensure that the faeces stay soft and move easily along the large intestine to aid th process of defaecation

Health issues related to eating habits

GASTRITIS

ANOREXIA NERVOSA

BULIMIA NERVOSA

MUSCLE DYSMORPHIA