

ANIMAL NUTRITION

All animals need to eat food to give them nutrients that they will use every day. An animal's digestive system is designed to break down and absorb these nutrients. These nutrients are used in the body to provide energy, repair damaged tissue and to regulate bodily processes.

Animals are unable to produce their own organic food. All animals are heterotrophic organisms that are dependent on other organisms for their nutrients.

Animals usually obtain their organic food in a complex, insoluble form. Before the animal tissues can use this food, it must first be broken down into simpler, soluble nutrients.

Five main processes in nutrition

INGESTION – the food is taken in and enters the alimentary canal.

DIGESTION – food is exposed to mechanical and chemical processes that change solid, insoluble food to simpler, soluble substances.

ABSORPTION – the end products of digestion are absorbed into the bloodstream.

ASSIMILATION – the cells absorb the nutrients from the blood and use it to build new cell structures and compounds.

EGESTION – the process through which undigested remains are removed from the body in the form of faeces.

Necessity for food

- Provides energy – most of the energy is provided through the ingestion of carbohydrates and fats.
- Growth and repair of damaged tissues – this requires ingestion of proteins
- Regulation of body processes (e.g. cellular respiration and excretion) – this requires ingestion of vitamins, water and mineral salts.

There are four main types of teeth found in animals namely incisors, canines, premolars and molars. (Table 1; Figure 1).

Table 1: Different types of teeth found in animals (including humans)

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

Human nutrition

The digestive system – The human digestive system consists of the **alimentary canal** and **accessory organs**.

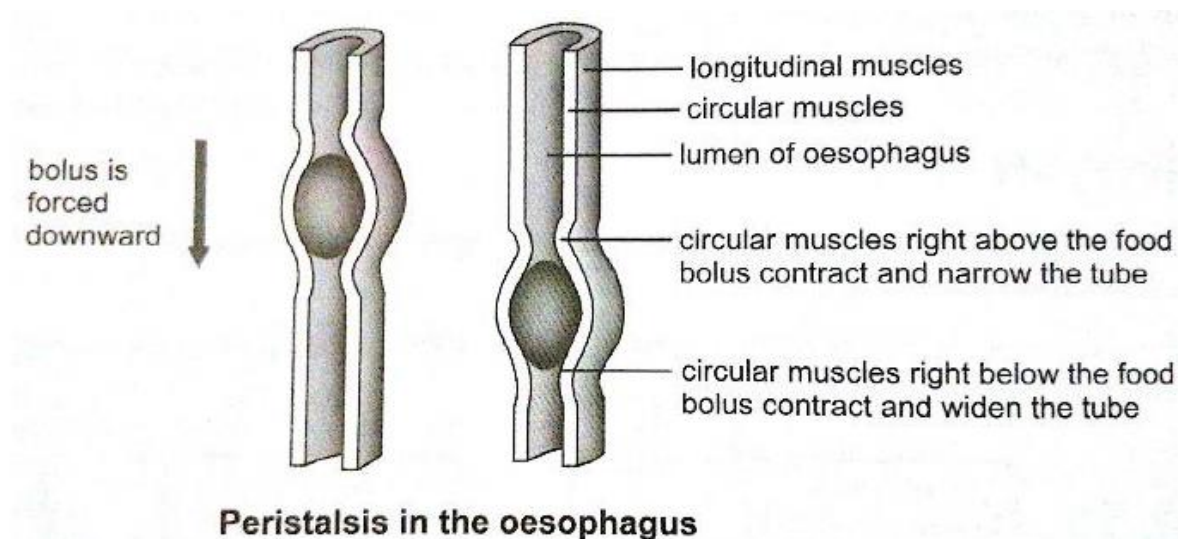
Alimentary canal – a long tubular structure that extends throughout the body. It consists of the mouth and mouth cavity, pharynx, oesophagus, stomach, small intestine, large intestine and anus.

Accessory organs – it includes the tongue, salivary glands, pancreas, liver, gall bladder.

DIGESTION

1. Mechanical digestion

- During mechanical digestion food is broken down into smaller particles.
- Mechanical digestion includes:
 - The **chewing** process (mastication) – food is broken down by the teeth and tongue
 - **Bolus** formation – chewed food is mixed with saliva and rolled into a ball by the tongue. The tongue pushes the bolus down to the oesophagus
 - **Churning** movements – this takes place by the contraction and relaxation of the muscles of the stomach wall. Food is broken down further and mixed with gastric juice
 - **Peristaltic** movements – rhythmic contraction and relaxation of the muscles in the wall of the alimentary canal. It helps to move food particles forward.



2. Chemical digestion

- Chemical digestion is the breaking down of large, insoluble molecules in food into smaller, soluble molecules by the addition of water. The reaction is known as **hydrolysis**.

Table 4: Enzymes involved in chemical digestion

Substrate	Enzymes	End product of digestion
Carbohydrates	Carbohydrases e.g. salivary amilase (produced in mouth), Pancreatic amylase (produced in pancreas), Maltase, Sucrase, Lactase (produced in small intestine)	Glucose
Proteins	Proteases e.g. pepsin and renin (produced in stomach) and trypsin (in pancreas)	Amino acids
Lipids	Lipase (produced in pancreas and small intestine)	Glycerol and fatty acids

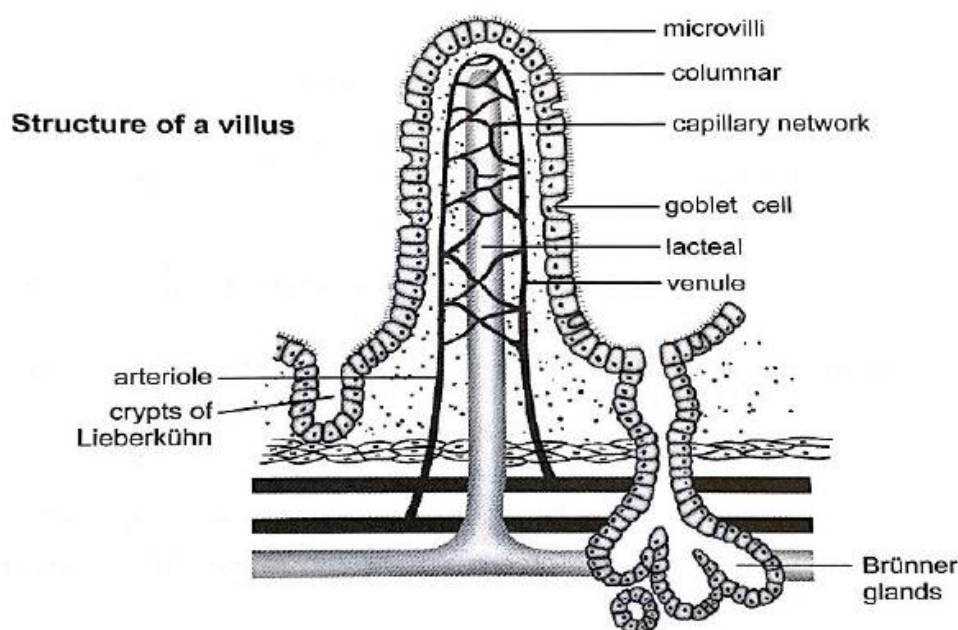
ABSORPTION

- The end products of digestion i.e. glucose, amino acids, fatty acids and glycerol as well as vitamins, mineral salts and water are absorbed by the **villi** in the small intestine.

SMALL INTESTINE – long, muscular tube of approximately 5m to 6m in length. It consists of three parts which are **duodenum**, **jejunum** and **ileum**.

Functions

- The layer of muscles in the wall of the small intestine causes peristaltic movements, which moves the chyme (semi-solid food) forward and ensures that it becomes thoroughly mixed with the digestive juices.
- Glands in the duodenal wall (crypts of Lieberkuhn and Brunner glands) secrete digestive juices (intestinal juice), which play a role in digestion.
- The small intestine has millions of villi to increase the surface area for the absorption of digested nutrients.



The villi that are responsible for nutrient absorption are adapted for absorption in the following ways:

- 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.

Absorption Process

Glucose, the end product of carbohydrate digestion, is actively absorbed, against the concentration gradient, into the blood capillaries of the villi.

Amino acids, the end product of protein digestion, are also actively absorbed, against the concentration gradient, into the blood capillaries.

Glycerol and fatty acids, the end products of lipid digestion, are absorbed by diffusion.

Vitamins – fat soluble vitamins A, D, E and K are passively absorbed into the blood capillaries, while water soluble vitamins B and C are passively absorbed or aided by carrier molecules.

Mineral salts are both passively and actively absorbed into the capillaries.

Water is absorbed into the capillaries by osmosis.

Large amounts of water, certain vitamins and mineral salts are also absorbed in the colon.

Table 5: A summary of how and where the end products of digestion are absorbed

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

Active absorption requires energy for the nutrient to be absorbed against a concentration gradient (low to high). Passive absorption does not require energy because it moves with the concentration gradient (high to low).

TRANSPORT AND ASSIMILATION OF ABSORBED NUTRIENTS

Glucose, amino acids, vitamins, mineral salts and water are absorbed through the blood capillaries in the villi.

The capillaries join to form large veins that eventually open into the **hepatic portal vein**

The hepatic portal vein transports the absorbed nutrients to the liver where most of the glucose is converted into glycogen and stored.

Excess amino acids undergo **deamination** in the liver to form **urea** and **glucose**.

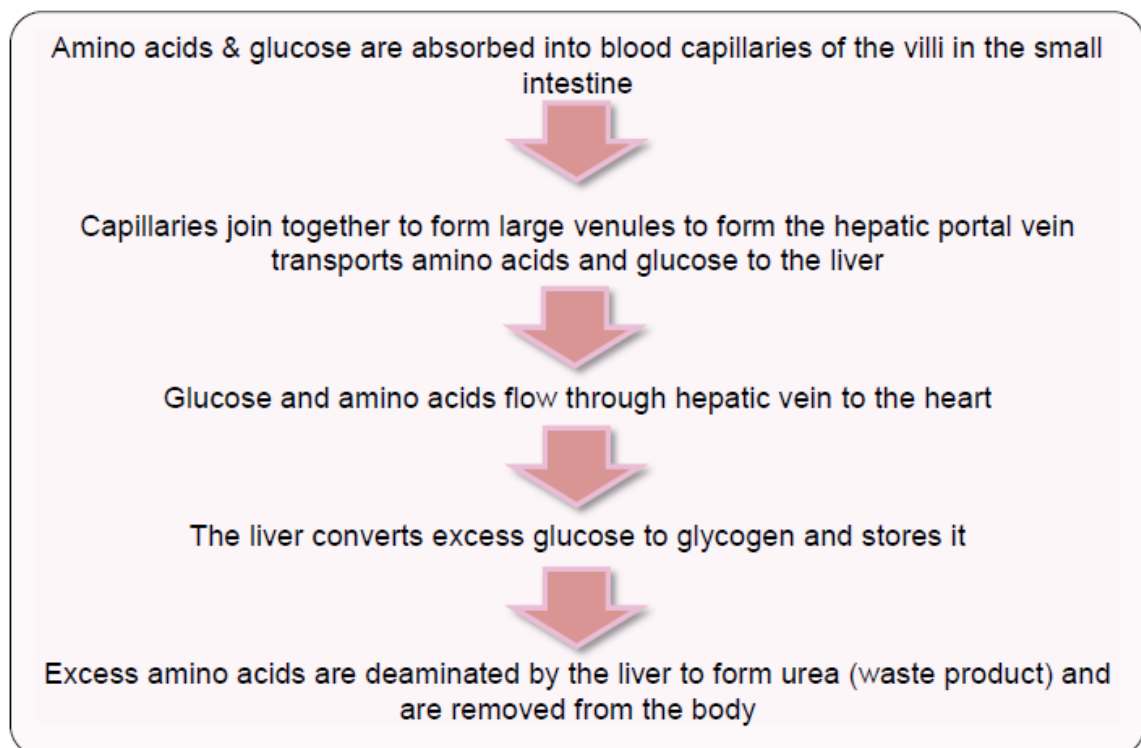
The urea is transported to the kidneys and excreted as part of urine

The remaining glucose and amino acids leave the liver through the **hepatic veins** and are transported to the heart and to the rest of the body.

The body cells absorb the required nutrients. This process is known as **assimilation**.

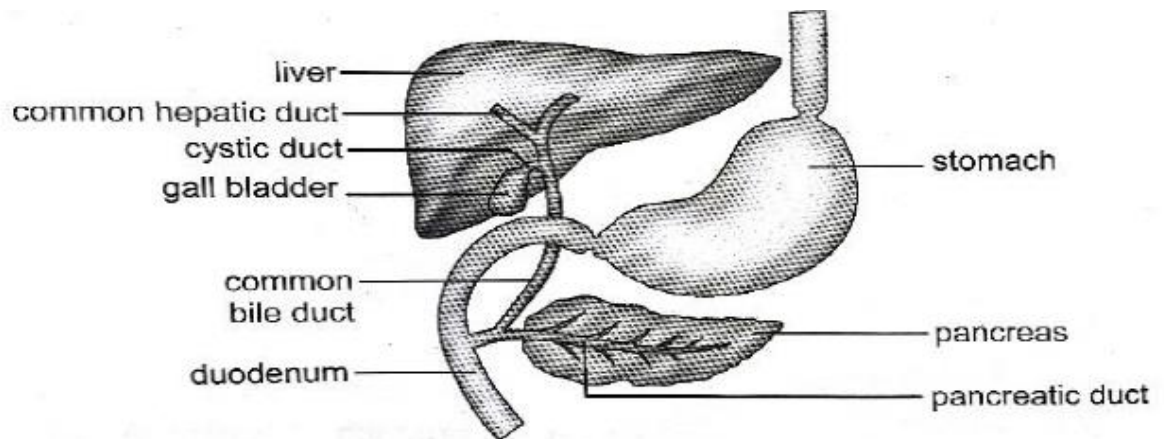
Transport of amino acids and glucose

Glucose and amino acids are absorbed from the small intestine and transported in the blood circulatory system as shown in the flow diagram (Figure 8).



ASSIMILATION

- Assimilation is the incorporation of absorbed nutrients into the cells of the body. The body cells absorb the required nutrients which are necessary for the building and maintenance of compounds.
- For example, 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.



LIVER – the largest gland in the body and is located just below the diaphragm. It consists of two lobes, a large right lobe and a smaller left lobe. Each lobe is made up of tiny lobules that in turn consist of liver cells. The liver cells produce bile that is transported away from the liver to the gall bladder for storage via the common hepatic duct.

Function

- The liver produces bile, which is stored in the gall bladder.
- Glucose is converted into glycogen for storage in the liver.
- Any excess glucose is converted into fat and stored.
- Excess amino acids are broken down to form urea and glucose in the liver by a process called deamination.
- The liver is a detoxifying organ that absorbs and neutralises certain toxins such as alcohol.
- Vitamins A, D, E, K and B12 are stored in the liver.
- The liver synthesises heparin which prevents blood clotting.

GALL BLADDER – a muscular sac located between liver lobes. It contracts to release bile when it is stimulated.

Function

- The gall bladder stores and releases bile that is produced in the liver. Bile contains bile acid, which are critical for digestion and absorption of fats and fat-soluble vitamins in the small intestine.

PANCREAS – a tongue-shaped gland located just below the stomach. The pancreas is both an exocrine and endocrine gland. It is composed of two types of cell:

- Normal pancreatic cells
- Islets of Langerhans

Functions

- Normal pancreatic cells secrete pancreatic juice with enzymes which play a role in digestion.
- The islets of Langerhans secrete two hormones (insulin and glucagon) which control the blood glucose levels in the body.

EGESTION

All 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

HOMEOSTASIS

Homeostasis is the tendency of living organisms to maintain a constant composition of their internal environment within narrow limits, irrespective of changes in the external environment.

Internal environment – body fluid in which the cells are bathed.

For cells to function optimally, these factors must be kept constant:

- Glucose levels
- Ion/salt concentration
- Water content
- Oxygen and carbon dioxide concentration
- Body temperature
- pH/acidity
- Metabolic waste

The following is a **general sequence of events** in a negative feedback mechanism:

- Step 1: An imbalance is detected
- Step 2: A control centre is stimulated
- Step 3: Control centre responds
- Step 4: Message is sent to target organ/s
- Step 5: The target organ responds
- Step 6: It opposes / reverses the imbalance
- Step 7: Balance is restored.

Negative feedback mechanism: mechanisms in the human body that detect changes or imbalances in the internal conditions and restore homeostasis.

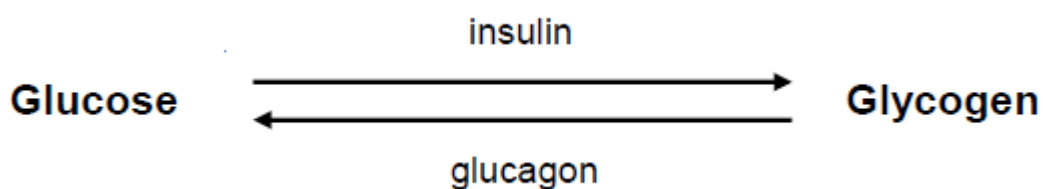
HOMEOSTATIC CONTROL - THE HORMONAL CONTROL OF BLOOD SUGAR LEVELS

The following explains the regulation of blood glucose levels:

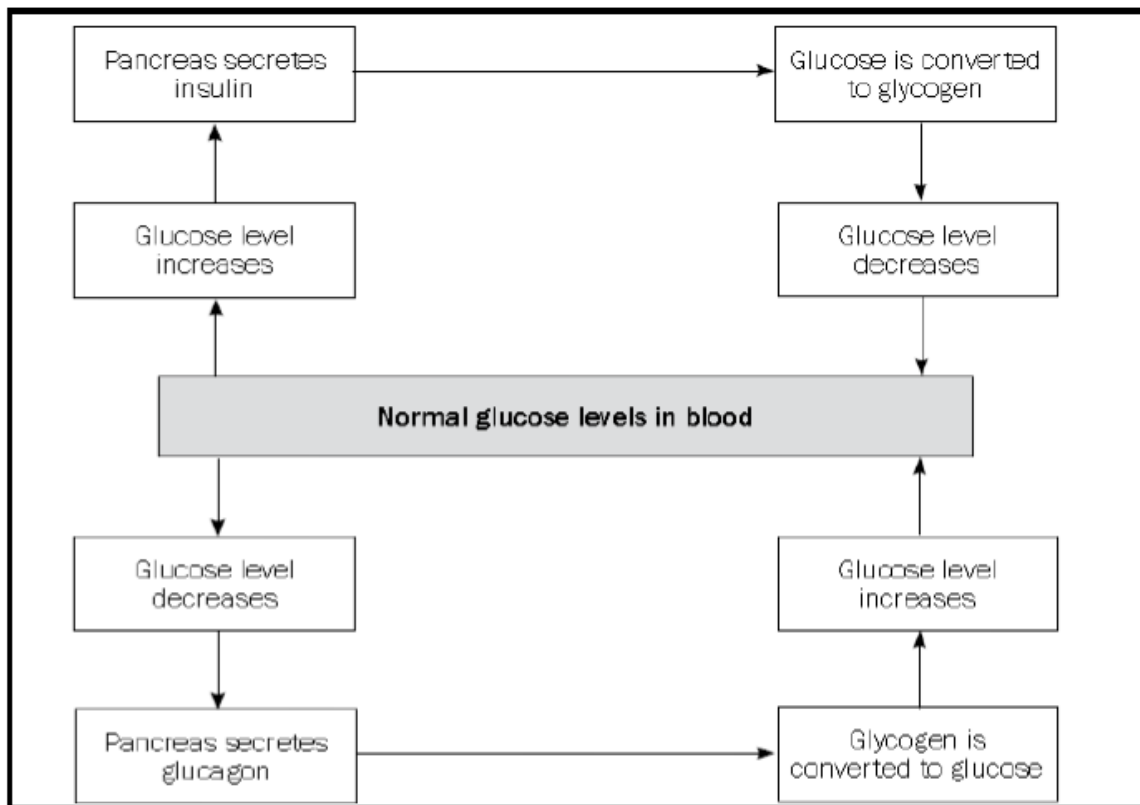
Blood glucose refers to the amount of glucose in the blood. Glucose is absorbed into the blood from the digestive system. Glucose found in the blood is taken up by the body's cells to be used for cellular respiration which releases energy. If blood glucose levels are too low, the body cells cannot release enough energy and the body cannot function at its best. If blood glucose levels are too high, water is drawn out of the cells and into the bloodstream. This results in dehydration of the cells and therefore dehydration of the body. The pancreas monitors the amount of glucose in the blood.

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.



Insulin and glucagon are **antagonistic hormones** as they have opposite effects in the body.



*The metabolic disorder, **diabetes mellitus**, occurs when insulin is not released or does not function properly resulting in high glucose levels.

Diabetes mellitus

It is a metabolic disease characterised by high glucose levels in the blood. It is a chronic, incurable disease.

It is as a result of the beta cells of islets of Langerhans not producing enough insulin or not producing at all or insulin is produced but the body cells cannot use it effectively.

- When insulin is absent or not functioning effectively, most of the glucose remains in the human body and this causes an increased blood glucose level, called **hyperglycaemia**.

Diabetes may occur:

- When the body's immune system attacks and destroys its own beta cells.
- As a result of obesity and a person being overweight.
- As a result of inactivity.
- Age.

Treatment and management:

- Daily insulin injection
- Regular exercise
- Maintaining normal body weight through a balanced diet.

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

Balanced diet

A balanced diet contains all the necessary nutrients in the correct quantities. It should include the following:

- Energy foods such as carbohydrates and lipids (fats).
- Building materials such as proteins.
- Protective nutrients such as vitamins and minerals.

Human nutritional requirements vary according to their age, gender and level of activity:

- Growing children need more protein than adults.
- Men need more food than women.
- Active people need more energy food.
- Pregnant women need more calcium.
- Older people need less food.

Energy in food – the energy value in food is measured in the units kilojoules/kilocalories (1 kJ = 4,2 kcal).

Nutritional supplement – enhances or adds to the amount of vitamins, minerals, proteins and fats in the diet. Supplements are usually taken for health, sports, beauty/anti-ageing.

Disorder	Cause	Symptom
kwashiorkor	lack of protein occurs mainly in children	swollen stomach and liver; sores on skin; stunted growth
marasmus	lack of energy foods such as carbohydrates and fats	thin muscles; no fat deposits; lack of energy; sunken eyes
anorexia nervosa	psychological condition where a person refuses to eat in fear of gaining weight	excessive weight loss; can be fatal
bulimia	psychological condition where a person regularly overeats and induces vomiting to avoid weight gain	dehydration; tooth decay; tears in the oesophagus; electrolyte imbalance
coronary heart disease	a diet too high in fats and sugars; obesity; high blood pressure; smoking; lack of exercise	plaque and cholesterol build up in blood vessels going to heart; heart failure; heart attack
diabetes	poor diet (high in sugar) and lack of exercise	tiredness; heart attack; stroke; kidney disease; blindness; numbness in fingers and toes; toe and/or leg amputations
obesity	a diet too high in energy foods such as sugars and fats	excessive deposits of body fat; increased risk of heart disease; type 2 diabetes; hypertension; arthritis