

# The Digestive System

## Foodstuffs and Vitamins

## The Digestive System

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The *digestive system* [Figure 9 - 1] is based around the *alimentary canal*, a long muscular tube which extends through the body between the mouth and the anus. Glands lying outside the alimentary canal produce enzymes which are used in the digestive process.

These glands produce many litres of secretions in a day, but most of this volume is re-absorbed.

Apart from the acts of eating and defaecation, the digestive process is not under the control of the conscious will; the movement of foods through the digestive system is effected by smooth muscle.

The digestive system is divided into four main areas following the passage of food: the mouth and oesophagus, the stomach, the small intestine, and the large intestine.

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### Alimentary Canal

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With the exception of the mouth and pharynx, the alimentary canal [Figure 9 - 2] is formed from four layers of tissue:

**Adventitia.** (outer covering) This consists of loose fibrous tissue in the thoracic region, and peritoneum in the abdominal regions. (peritoneum is described separately).

**Muscle layer.** In most areas, this is smooth muscle, arranged in two layers enclosing blood vessels and nerve fibres.

**Submucous layer.** This is composed of loose connective tissue, together with blood vessels and nerve fibres.

**Mucous membrane.** (inner layer) This layer varies in nature along the alimentary canal. In areas where food has already been softened, the membrane is composed of columnar epithelium with glands which secrete digestive juices.

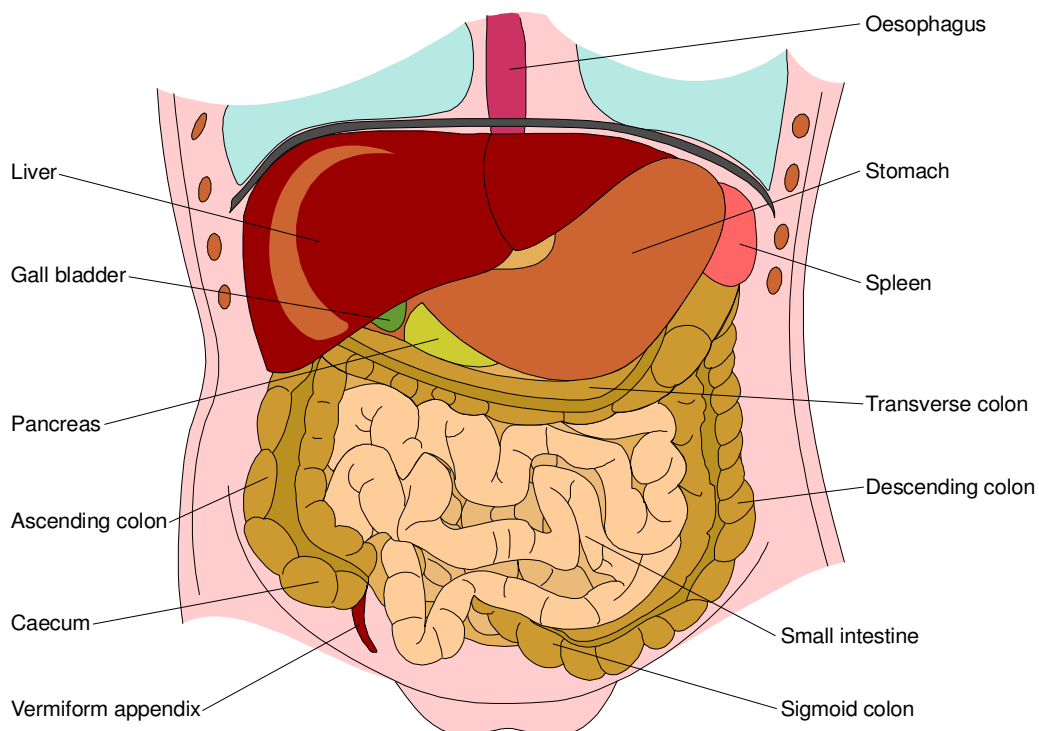
Although it mainly follows this same basic structure, the exact formation of the alimentary canal varies along its length.

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**Figure 9 - 1** the digestive system

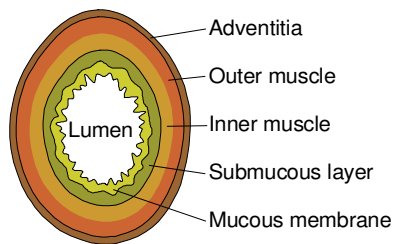
Frontal section showing the main organs of the digestive system

The heart is not shown



**Figure 9 - 2** the alimentary canal

The basic formation of the alimentary canal



## Peritoneum

The *peritoneum* [Figure 9 - 3] forms a lining for the abdominal cavity. It consists of two layers of serous membrane:

**Parietal layer.** This lines the abdominal wall.

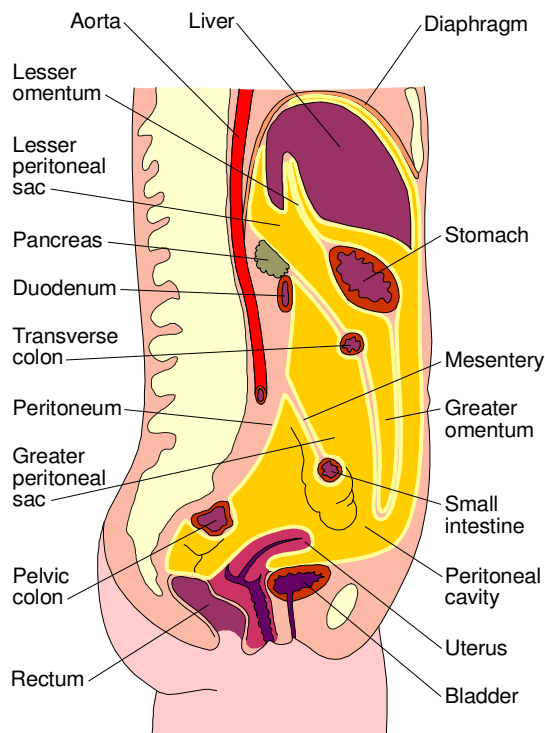
**Visceral layer.** This covers the abdominal organs.

The potential space between the two layers is occupied by serous fluid to allow ease of movement.

**Figure 9 - 3** the peritoneum

A sagittal section through the female abdomen, indicating the abdominal organs and the peritoneum

Potential spaces have been much exaggerated for clarity



The peritoneum forms a closed sac, the abdominal organs being invaginated from 'outside'. Some organs such as the stomach, spleen, liver, and intestines, are completely covered by double folds of peritoneum; other organs such as the pancreas and kidneys are only partially covered.

A fold of peritoneum attaching an organ to the abdominal wall is termed a *mesentery*. Mesenteries not only support abdominal organs, they provide a route for blood vessels, lymph vessels, and nerves.

## Omenta

An *omentum* is a loose fold of peritoneum. The *lesser omentum* extends from the liver to the stomach. The *greater omentum* is a large folded, fatty membrane which starts at the stomach and hangs like an apron over the anterior of the abdominal organs, ending at the level of the transverse colon.

## Mouth

The *mouth* is the orifice by which food enters the alimentary canal.

The mouth is bounded by muscles and bones, and is lined with mucous membrane. It contains the tongue and the teeth, which assist in the initial processing of food.

The digestive process begins as soon as food is placed in the mouth, although no nutrients are actually absorbed.

## Tongue

The *tongue* is a muscular structure attached to the floor of the mouth.

The tongue is involved in the actions of chewing and swallowing, and holds the majority of nerve endings associated with the sense of taste.

## Teeth

The teeth serve the functions of cutting, tearing, and grinding food during the eating process.

A *tooth* [Figure 9 - 4] is formed mainly from an ivory-like substance named *dentine*, in the centre of which is the pulp cavity. The *pulp cavity* contains nerves and blood vessels. *Enamel*, which is extremely hard, protects the outer surface.

The teeth are set into the frontal opposing margins of the maxilla and mandible, and are arranged in a symmetrical layout.

[Figure 9 - 5]

There are 32 teeth in a full set for an adult:

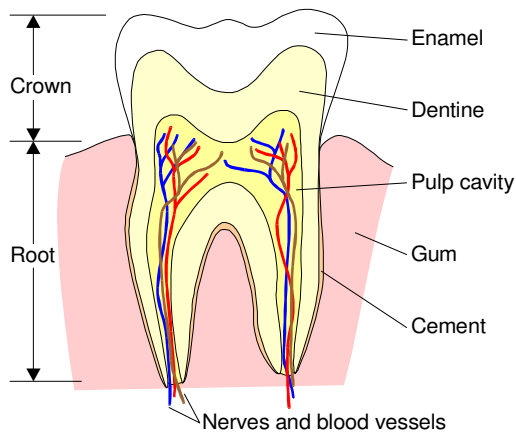
**Incisors.** (8) These are the frontal cutting teeth.

**Canines.** (4) These slightly pointed teeth are used for tearing food.

**Premolars (8) and molars. (12)** These irregular shaped teeth are used for grinding food during chewing.

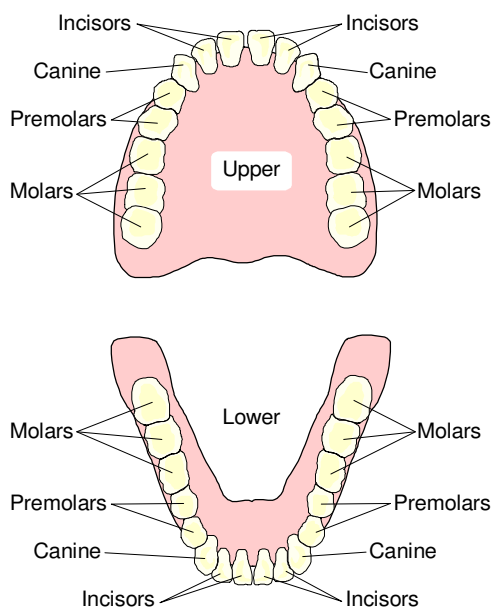
**Figure 9 - 4** a tooth

A section through a tooth showing the structure



**Figure 9 - 5** the teeth

The arrangement of the teeth



### Chewing and swallowing

The act of *chewing* breaks up the food, and mixes it with saliva. The tongue then pushes small pieces of food (*boluses*) into the pharynx for swallowing.

The start of a swallowing action is controlled by the conscious will, but the continuation of the action is involuntary.

During the swallowing action, the soft palate prevents the food entering the nasal pharynx, and the epiglottis moves to prevent the entry of the food into the trachea.

### Saliva

The presence (or anticipation) of food stimulates a reflex action secretion of saliva from three pairs of glands: the *parotid* in the cheeks, the *submandibular* below the angle of the jaw, and the *sublingual* beneath the tongue.

*Saliva* is a mixture of secretions, containing *mucin* to ease the act of swallowing, *ptyalin* which breaks down starch into maltose (a sugar), *amylase* - a digestive enzyme which initiates the breakdown of carbohydrates, and minerals. Calcium phosphate in saliva is deposited onto the teeth as tartar.

### Oesophagus

The *oesophagus* is a muscular tube linking the lower part of the laryngopharynx to the stomach, via an opening in the diaphragm. The formation of the oesophagus follows the general structure of the alimentary canal.

Food is propelled down the oesophagus by *peristalsis*, waves of muscular contraction, controlled by the autonomic nervous system.

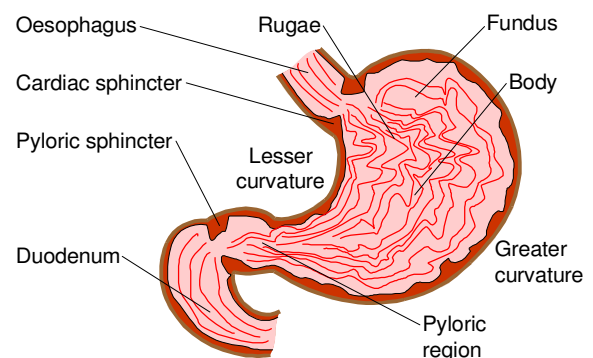
Sphincter muscles at the top and bottom of the oesophagus prevent unwanted flows: the *cricopharyngeal sphincter* protects against air passing into the oesophagus during respiration, and the *cardiac sphincter* guards the entry into the stomach against regurgitation.

### Stomach

The *stomach* [Figure 9 - 6] is a hollow organ, with muscular walls, situated in the epigastric, umbilical, and left hypochondriac regions of the abdominal cavity.

**Figure 9 - 6** the stomach

The main areas of the stomach



The composition of the stomach follows the general structure of the alimentary canal, but with some modifications:

The folds of the peritoneum enclosing the stomach continue to form the greater omentum.

The muscle layer is formed from three complementary layers of muscle fibre which allow for a churning movement of stomach contents, as well as peristalsis.

The mucous membrane contains numerous *gastric glands* which secrete gastric juice.

Very little actual digestion takes place in the stomach; it acts more as a reservoir for ingested food, releasing it gradually into the small intestine.

Within the stomach, food and gastric juice mix to form *chyme*. This then passes from the stomach into the duodenum via the *pyloric sphincter*.

### Gastric Juice

*Gastric juice* is secreted by the mucous lining of the stomach in response to the release of the hormone gastrin, secretion of which is stimulated by the presence of food in the stomach.

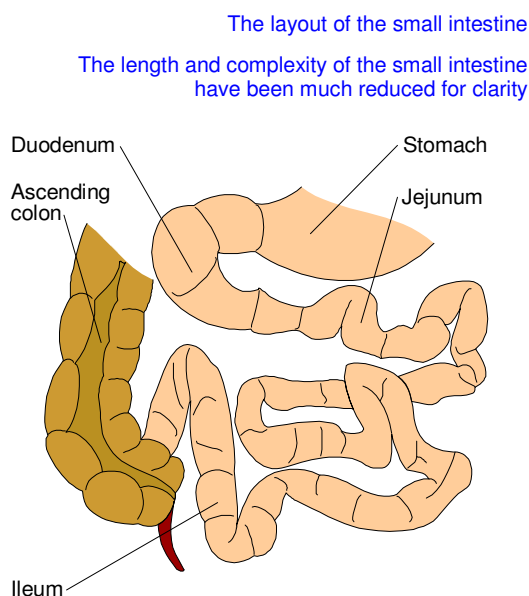
Gastric juice contains around 0.5% Hydrochloric acid, and is thus strongly acidic. The enzymes pepsin and rennin are also present.

Gastric juice serves the purposes of initiating the breakdown of proteins, and of destroying bacteria in food.

### Small Intestine

The *small intestine* [Figure 9 - 7] is a thin tube, approximately 5m in length, irregularly coiled in the abdomen.

**Figure 9 - 7** the small intestine



The small intestine is described in three parts - each continuous with the next:

**Duodenum.** This is the first 250mm, connecting to the stomach.

**Jejunum.** This is the central part, and is approximately 2m long.

**Ileum.** This is the final, largest part, and is about 3m long. It connects into the large intestine.

The walls of the small intestine follow the general structure of the alimentary canal, but with some modifications:

A mesentery attaches the majority of the small intestine to the posterior abdominal wall.

The mucous membrane of the small intestine contains small projections, approximately 0.5mm - 1mm long, called *villi*.

The villi serve the double purpose of increasing the absorbent surface area of the intestines, and of accommodating intestinal glands and lymph vessels. The surfaces of the villi are covered with additional microscopic hair like projections known as *microvilli*.

The main digestive processes take place within the small intestine, aided by intestinal juice, secreted from the villi. *Intestinal juice* is a mixture of the enzyme enteropeptidase, water and mucus. *Enteropeptidase* assists in the final digestion of most foodstuffs.

Additional substances from external glands assist the digestive processes:

**Bile.** This is secreted by the liver. It emulsifies fats.

**Pancreatic juice.** This is secreted by the pancreas. It assists in the breakdown of fats, carbohydrates, and proteins.

### Digestive Glands

#### Pancreas

The *pancreas* is a pale grey coloured gland, situated in the epigastric and left hypochondriac regions of the abdominal cavity. It secretes pancreatic juice into the duodenum. Secretion is controlled partly by reflex nervous action, but more by a stimulating agent, *secretin*, which is released into the circulation whenever acidic stomach contents enter the duodenum.

*Pancreatic juice* is alkaline, to the extent that it neutralises the acidity from the stomach. It also contains three enzymes:

**Trypsin.** This assists in the digestion of proteins into amino acids.

**Amylase.** This breaks down carbohydrates into sugars.

**Lipase.** This breaks down fats into fatty acids and other simpler compounds.

The pancreas has a second function, as an endocrine gland; this is considered as part of the endocrine system.

## Liver

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The *liver* [Figure 9 - 8] is the largest gland in the body, occupying the majority of the right hypochondriac region of the abdominal cavity, and spreading across the epigastric region into the left hypochondriac region. It is composed of many small lobules, each receiving blood from both the systemic and portal circulations. The liver is thus an initial recipient of substances absorbed from food.

The liver is covered by a thin capsule, and partially by a layer of peritoneum, which acts as a main support.

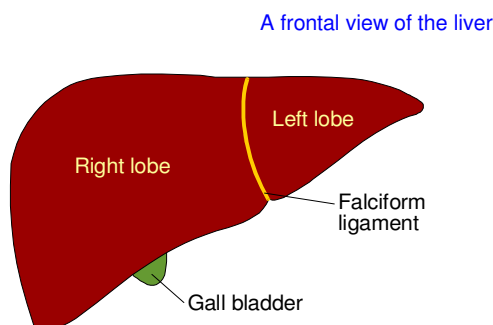
The liver is formed in four lobes:

The large *right lobe* and smaller *left lobe* form the majority, with the *caudate* and *quadrate lobes* as small areas on the posterior surface of the right lobe.

Blood vessels, lymph vessels, and nerve fibres, together with the hepatic ducts, join the liver at the *portal fissure* (or *porta hepatis*) on the posterior surface.

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**Figure 9 - 8** the liver



The liver has a variety of functions:

**Chemical breakdown.** Amino acids, old tissue cells, alcohol, and hormones are broken down, mainly for later excretion.

**Storage.** Excess fats, glucose (as glycogen), vitamins, iron compounds, and copper compounds are stored, for release when intake does not meet the requirements of the body.

**Synthesis.** Vitamin A is synthesised from carotene. Some amino acids, plasma protein, and blood clotting factors are synthesised from amino acids available in the bloodstream.

**Conversion.** Glucose is converted into glycogen in the presence of insulin. Glycogen is conversely converted to glucose by glucagon.

Stored fats are converted into glucose.

**Heat production.** The liver is the main heat producing organ in the body because of its considerable chemical activity.

**Secretion.** The liver secretes bile, which is used in the digestive process.

*Bile* is a slightly alkaline, greenish, viscous fluid. Bile contains complex salts, the pigment *bilirubin* as a by-product of old cell breakdown, as well as water, mucus, and cholesterol.

## Bile Ducts and Gall Bladder

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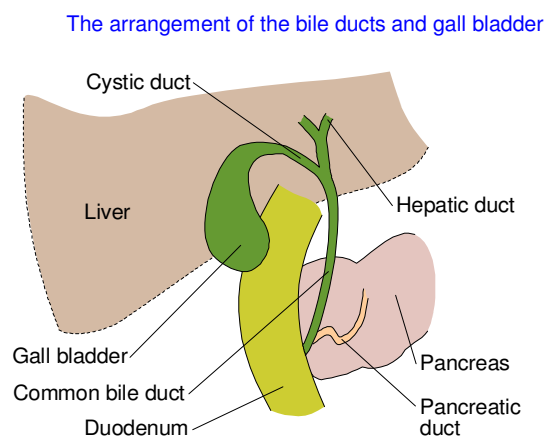
The liver produces bile continuously. As bile is only required during digestion, that produced at other times is stored in the gall bladder.

Bile from the liver passes via the *hepatic ducts* which link with the *cystic duct* from the gall bladder to form the *common bile duct*. When bile is not required for digestive purposes, it flows through the cystic duct into the gall bladder.

The *gall bladder* [Figure 9 - 9] is a hollow organ, formed from the same four layers of tissue as the alimentary canal, situated beneath the right lobe of the liver. Its muscular layer allows it to contract and empty its contents into the duodenum, via the cystic duct and common bile duct.

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**Figure 9 - 9** the gall bladder



The common bile duct links with the pancreatic duct just outside the duodenum, the connection to which is controlled by the *sphincter of Oddi*.

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## Large Intestine

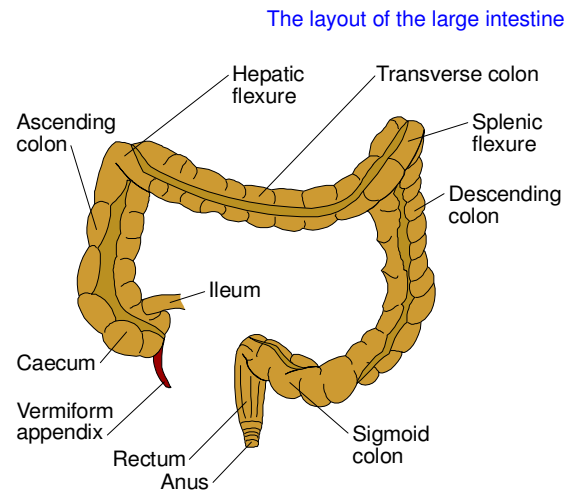
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The *large intestine* forms the final sections of the alimentary canal. It is much larger in section than the small intestine. [Figure 9 - 10]

The large intestine is formed from the same four layers of tissue as the main alimentary canal. The muscle layer is formed in bands, to give the large intestine a slightly bulging appearance.

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**Figure 9 - 10** the large intestine



The large intestine is described in seven parts, each continuous with the next:

**Caecum.** This is the first part, connecting to the end of the ileum at the ileocaecal valve.

The *vermiform appendix* is small closed tube leading from the inferior closed end of the caecum.

**Ascending colon.** This leads from the caecum, vertically up the right side of the abdomen to the *right colic flexure* or *hepatic flexure*, situated under the right lobe of the liver.

**Transverse colon.** This starts at the hepatic flexure, and leads across the abdominal cavity, in front of the stomach, to the *left colic flexure* or *splenic flexure*, anterior to the spleen.

**Descending colon.** This starts at the splenic flexure, and leads down the left side of the abdominal cavity.

**Sigmoid colon.** This is the continuation of the descending colon into the pelvic area.

**Rectum.** This is a slightly dilated section of the large intestine, and forms the end of the digestive areas.

**Anal canal.** This is the final part of the alimentary canal, leading to outside the body at the anus.

The main functions of the large intestine are those of absorbing water, minerals, and vitamins, and temporarily storing waste matter prior to excretion.

The chyme which passes into the caecum is liquid, although some water has been absorbed in the small intestine. The majority of water will have been absorbed by the time this chyme reaches the descending colon.

The absorption of water (particularly the reabsorption of most digestive enzymes) is an important factor in preventing the body becoming dehydrated. The residue remaining after final absorption has occurred is excreted as *faeces*.

The movement of matter along the large intestine takes place at infrequent intervals (not regular peristalsis). This is known as *mass movement*, and is often caused by ingesting food.

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## Defaecation

When mass movement forces faeces into the rectum, the desire to defaecate is triggered.

The opening of the anus is controlled by two sphincter muscles. The *internal anal sphincter* is composed of smooth muscle and is under autonomic control. The *external anal sphincter* is composed of striated muscle and is under conscious control.

When a decision is made to *defaecate*, the external anal sphincter is relaxed. Abdominal pressure is raised by a lowering of the diaphragm, a contraction of abdominal muscles, and by trying to force air out of the lungs against a closed epiglottis.

This forces faeces from the rectum out of the anus; a continuation of pressure then forces expulsion of faeces from the descending and sigmoid colons.

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## Digestive Process

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The *digestive process* is a series of complex biochemical reactions which differ slightly between carbohydrates, proteins, and fats.

**Table 9 - 1** digestion of carbohydrates

The main biochemical activities involved in the digestion of carbohydrates

Organ	Digestive enzymes and activity
Mouth	Salivary amylase begins the conversion of carbohydrates to sugars
Stomach	No action - as Hydrochloric acid in gastric juice stops the action of salivary amylase
Small intestine	Amylase from pancreatic juice converts all starches to sugars Sucrase, maltase and lactase from the intestinal glands convert all sugars to glucose
<b>Absorption</b>	Glucose is absorbed into capillaries in the villi, and is carried to the liver via the portal circulation
<b>Utilisation</b>	Glucose provides energy for all cells when broken down in the presence of Oxygen Excess glucose is stored, partly as glycogen in the liver and muscles, and partly as fat in adipose tissue

**Table 9 - 2** digestion of proteins

The main biochemical activities involved in the digestion of proteins

Organ	Digestive enzymes and activity
Mouth	No action
Stomach	Hydrochloric acid in gastric juice converts pepsinogen to pepsin, which then converts proteins to less complex polypeptides
Small intestine	Enteropeptidase from intestinal juice converts inactive enzymes in pancreatic juice to those which then convert polypeptides to di- and tripeptides Peptidase from intestinal glands breaks peptides into amino acids
<b>Absorption</b>	Amino acids are absorbed into capillaries in the villi, and are carried to the liver via the portal circulation
<b>Utilisation</b>	Amino acids are widely used throughout the body for cell repair and replacement, the production of secretions, and in producing substances such as blood clotting agents Excess amino acids are either broken down in the liver and excreted as urea, used to provide heat and energy, or are stored as fat in adipose tissue

**Table 9 - 3** digestion of fats

The main biochemical activities involved in the digestion of fats

Organ	Digestive enzymes and activity
Mouth	No action
Stomach	No action
Small intestine	Bile emulsifies fats Lipase from pancreatic juice converts fats to fatty acids and glycerol
<b>Absorption</b>	Fatty acids and glycerol are absorbed via the villi into lymph vessels, from where they pass into the thoracic duct, left subclavian artery, and into the circulating blood. From this they reach the liver for reorganisation and recombination
<b>Utilisation</b>	Fats are used to provide heat and energy in the presence of Oxygen Excess fats are stored in adipose tissue

### Appendicitis

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*Appendicitis* is an inflammation of the vermiform appendix.

The initial cause may not be identifiable - bacterial infection, together with a blockage of the appendix, perhaps by solid food matter, are likely contributors.

Initial inflammation causes swelling and ulceration of the inner mucous membranes. This leads to pain - first in the centre of the abdomen, and then in the area around the appendix.

If the inflammation does not subside (with or without treatment), it will soon block the small lumen of the appendix and lead to an abscess. As this continues, the blood vessels associated with the appendix become occluded, the appendix begins to atrophy, and may well rupture - with serious consequences.

### Cholera

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*Cholera* is a totally debilitating infection by the vibrio cholerae bacterium. It spreads through faeces into water and food.

The disease has a sudden onset and causes serious diarrhoea, stomach and leg cramps, violent vomiting, and exhaustion. Hypovolaemic shock can result if lost fluids are not replaced.

Cholera can be fatal, especially if not treated.

### Cirrhosis

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*Cirrhosis* is a condition which affects the liver. Cirrhosis occurs when liver cells have become damaged by some other condition - chronic alcohol abuse, hepatitis, or other liver disease - and fibrous tissue begins to grow in a mesh between areas of regenerating liver cells.

The condition leads to a failure of normal liver function, which in turn causes a general degeneration in health, weight loss, vomiting, jaundice, a build-up of fluid in the abdomen, and oedema of the legs.

Cirrhosis is incurable and may eventually prove fatal.

### Coeliac Disease

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*Coeliac disease* is an inherited condition in which the small intestine develops an abnormal sensitivity to gluten and other proteins found in grain foodstuffs. The problem may develop at any time of life.

The villi in the small intestine become damaged and are then unable to absorb nutrients properly.

As a result, there is a risk of malnutrition.

Indications of coeliac disease vary widely from person to person, but will probably include abdominal distension and pain, nausea and vomiting, diarrhoea, an unexplained weight loss, and a general falling in the level of overall health.

### Crohn's Disease

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*Crohn's disease* most commonly affects the ileum, although it may affect any part of the alimentary canal.

It is a chronic condition, causing thickening and inflammation to the walls of the digestive tract, which may then become deeply ulcerated. This then leads to abdominal pain and diarrhoea, with a reduced ability to digest food.

The condition may be complicated by intestinal obstruction, and the creation of holes - *fistulae* - between the intestine and other organs or tissues.

The cause is unknown, although infection may contribute, as may genetic factors.

### Dental Problems

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#### Apical abscess

An *apical abscess* occurs following decay of a tooth, with that decay extending through the pulp and into the root area. Infection, usually bacterial, reaches the tooth socket and sets up inflammation and an accumulation of pus.

An apical abscess is usually extremely painful, but if a chronic abscess forms, this may be painless.

#### Dental caries

*Dental caries* is the decay and degeneration of teeth. *Plaque* - a mixture of food debris, bacteria, and saliva - forms a sticky coating over teeth. The bacteria then act on sugars in food and form acids which attack the tooth enamel. Small cavities form, allowing the acids then to destroy the structure of the dentine.

Initially, this decay is painless, but if it reaches the nerve in a tooth, toothache will be triggered.

Decayed tooth structure is not regenerated, so must be removed and replaced with artificial filling material if eventual complete destruction of a decayed tooth is to be prevented.

#### Gingivitis

*Gingivitis* is an inflammation of gum tissue, causing swollen gums which are prone to bleeding.

The cause of gingivitis is almost always a build-up of plaque, particularly in the areas of the teeth nearest the gums.

### *Knocked out tooth*

A tooth which has been knocked out of its socket may be replaced, and may well re-connect to the gum tissue as long as certain conditions are met:

Replacement is within 24 hours, and preferably within one hour.

The tooth has not been contaminated, or more important, cleaned and disinfected.

The severed root structures have not dried out or been further damaged, and have not been contaminated by touching or cleaning them.

### *Diverticular Disease*

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*Diverticula* are small protrusions from the colon, sometimes caused by the pressure of chronic constipation resulting from a low fibre diet. In the majority of cases, diverticula do not cause problems or symptoms.

*Diverticulosis* or *uncomplicated diverticular disease* is the term applied to relatively mild and intermittent symptoms of the presence of diverticula.

*Diverticulitis* is a potentially serious condition which results from faeces being trapped in a diverticulum. Bacteria multiply around the blockage causing inflammation and infection.

Symptoms of severe abdominal pain, fever, diarrhoea (or occasionally constipation), nausea and vomiting often start suddenly, without warning. There may also be a palpable lump in the abdomen, or rectal bleeding - originating from weakened blood vessels passing through the diverticulum.

There is a risk that diverticula may perforate or rupture and lead on to further infection and peritonitis.

### *Gallstones*

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*Gallstones* are hard lumps of material which build up in the gall bladder or bile duct.

Most gallstones are around 6mm in diameter, although the size may vary from small sand-like grains to up to 25mm in diameter - or more.

Gallstones tend to occur if the composition of the bile is abnormal, if the flow of bile is blocked, or if a local infection occurs. A susceptibility to developing gallstones may be inherited.

Gallstones form when substances - often involving calcium compounds - precipitate out of the bile.

In the majority of cases, gallstones are asymptomatic. However, their existence may cause *cholecystitis* - inflammation of the gall bladder, with pain in the right hypochondriac region, and possibly fever, nausea, and vomiting.

If gallstones block the bile duct, *obstructive jaundice* may result, with yellowing of the skin and whites of the eyes, darkening of the urine, and pale coloured faeces. A gallstone passing through the bile duct into the duodenum causes intense pain (known as *biliary colic*) in the upper abdominal areas.

### *Gastritis*

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*Gastritis* is an inflammation of the mucous membrane in the stomach. This results in a sensation of indigestion and nausea. Bleeding into the stomach may also cause vomiting of blood or blood stained faeces.

Gastritis has a variety of causes, including repeated use of medications such as Ibuprofen, swallowing of corrosive poisons, over-use of alcohol, infections, and extreme stress. Other contributory factors include trauma, and failure of kidneys, or the liver.

### *Gastroenteritis*

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*Gastroenteritis* is an inflammation of the stomach and the intestines.

A common cause is infection by either the rotavirus or the Norwalk virus. Alternative causes are infection by bacteria or other organisms.

Gastroenteritis causes abdominal pain, fever, diarrhoea and vomiting.

The condition usually passes quickly, but a prolonged or severe attack may lead to dehydration and hypovolaemic shock.

### *Food poisoning*

*Food poisoning* is a specific cause of gastroenteritis, associated with the ingestion of contaminated or inherently poisonous food or water.

Examples of causative agents include: poisonous materials such as Lead or Mercury, residues from insecticides and other chemicals, poisons in certain fungi or plants, bacteria such as salmonella, and campylobacter, toxins produced by bacteria such as *Escherichia coli* (E-coli), variants of staphylococcus, *clostridium per fringens*, and *clostridium botulinum* - which causes the very dangerous condition of *botulism*.

## Heartburn

*Heartburn* is a symptom of *oesophageal reflux* - a gentle regurgitation of stomach contents into the oesophagus.

This occurs because of relaxation of the cardiac sphincter. There are many reasons for this, including poor posture and dietary habits. Fatty foods, caffeine, chocolate, and alcohol may also encourage reflux.

The acid in the regurgitated material irritates the inner lining of the oesophagus, producing discomfort and a burning sensation in the central thoracic area.

Severe heartburn may mimic the pain of cardiac problems.

## Hepatitis

*Hepatitis* is an inflammation of the liver, through bacteria, toxic substances, or viruses.

Overdoes of some medications, such as Paracetamol, may also cause hepatitis-like conditions.

The viral types exist in several forms: A, B, C, D, E, F, and G have been identified to date.

The most common forms are hepatitis A - spread from faeces into food and water, hepatitis B and hepatitis C - both spread in the blood and by sexual contact.

Exact signs and symptoms vary with the type, but hepatitis usually causes abdominal pain, with nausea, diarrhoea and vomiting. The skin will probably be jaundiced.

If not treated, there is a risk that hepatitis will become chronic and lead to cirrhosis, eventually proving fatal.

## Hernia

A *hernia* occurs when part of an organ - usually abdominal - protrudes through a tear or hole in the muscular tissue which normally holds it in place.

Hernias often occur spontaneously, and may be present at birth, but may occur through muscular strain associated with heavy lifting, a chronic cough, or persistent straining against chronic constipation.

**Hiatus hernia.** This is a breakthrough of part of the stomach into the thoracic cavity - through an enlargement of the opening in the diaphragm through which the oesophagus passes.

The hernia itself rarely leads to symptoms, but it will tend to lead to oesophageal reflux and heartburn. Chest pain and difficulty in swallowing may also occur.

**Inguinal hernia.** This is more common in males. It appears as a swelling in the groin area or scrotum, and occurs when a portion of the peritoneum or the large intestine breaks through the lower wall of the abdomen.

**Femoral hernia.** This is similar to an inguinal hernia, but is more common in females. It occurs when part of the intestine breaks through the abdominal wall via the opening taken by the femoral artery, appearing as a swelling in the upper thigh.

**Umbilical hernia.** This is caused by a weakness in the muscles around the navel, allowing protrusion of the intestine.

**Incisional hernia.** This occurs when a wound or operation incision has not healed fully and a weakness in the containing tissues has resulted.

Hernias are generally relatively minor problems, leading often to no more than a slight compressible bulge under the skin. They are, however, susceptible to the complication of *strangulation*. This occurs when the herniated tissue becomes constricted and cannot be pushed back into the abdominal cavity. The blood supply to the strangulated portion is cut off by the pressure of the surrounding tissue, leading to gangrene.

## Irritable Bowel Syndrome

*Irritable bowel syndrome* is a term used for a series of symptoms which occur in the digestive system, but without identifiable cause.

Symptoms are mainly caused by abnormal muscular contractions in the intestinal walls, sometimes brought on by external factors.

Previous intestinal infection, stress, low-fibre diets, and use of laxatives may contribute to the problem.

Symptoms include alternating diarrhoea and constipation, vomiting, abdominal pain and tenderness, with abdominal bloating and a sense of internal gas.

## Mumps

*Mumps (epidemic parotitis)* is a droplet spread viral infection which affects the parotid gland.

Mumps may affect people of all ages, although children are most vulnerable.

Mumps brings fever, swelling of the parotid glands, a dry mouth with a 'furred tongue', and swollen lymph nodes in the neck. There may also be difficulty in swallowing and earache.

The condition may lead to encephalitis and *orchitis* (swollen testicles) - more commonly in adults.

## Pancreatitis

*Pancreatitis* is a potentially fatal inflammation of the pancreas.

*Acute pancreatitis* is usually caused by gall bladder problems, such as gallstones blocking the pancreatic duct, or by chronic alcohol abuse. The exact mechanism of pancreatitis is not known, but it is believed that trapped digestive enzymes become active inside the pancreas and begin to digest the gland itself. Haemorrhage, oedema, and tissue damage result. The enzyme damage may spread to surrounding tissues, and may be distributed via the circulation to cause more widespread damage.

The condition is marked by severe pain in the upper abdomen, often occurring within twelve hours of a heavy meal with alcohol. This pain may extend to all abdominal areas, the back, and the shoulders, with nausea and vomiting - maybe leading to hypovolaemic shock. Complications may include bowel obstruction, bleeding into the bowel, and jaundice resulting from bile duct obstruction.

*Chronic pancreatitis* is often associated with alcohol abuse or chronic pancreatic duct obstruction, although a cause may not be identifiable.

The condition may follow attacks of acute pancreatitis and usually begins with severe high abdominal pain - extending through to the back.

Attacks often last for 24 hours or more and tend to recur. Inflammation and fibrosis slowly destroy the glandular tissue with knock-on effects on the effectiveness of the overall digestive process.

## Peptic Ulcer

A *peptic ulcer* is a breakdown in the mucous membrane lining the alimentary canal. The basic cause is that this mucous membrane is damaged by the action of gastric acid or pepsin, either because these are present in abnormally high concentration, or because the normal protective mechanisms have broken down.

Common ulcer sites are the stomach and duodenum.

**Gastric ulcer.** This occurs in the stomach. The main causes are the over-use of medications such as Aspirin or Ibuprofen, and infection by helicobacter pylori bacteria.

The ulcer may well produce no symptoms, but abdominal pain - increased after eating - and vomiting are likely.

**Duodenal ulcer.** This occurs in the duodenum. It is usually caused by over-production of gastric acid, and infection by helicobacter pylori bacteria is very common.

Abdominal pain - increased when the stomach is empty - and vomiting are the most likely indications.

All gastric ulcers are at risk of haemorrhage, which will lead to vomiting of blood (*haematemesis*), or perforation, which will allow gastric contents into the abdominal cavity and potentially lead to peritonitis.

## Peritonitis

*Peritonitis* is an inflammation of the peritoneum. This generally occurs as a result of some other condition, although a blood borne bacterial infection may be the cause.

Liver or kidney failure may cause peritonitis through a build-up of fluid in the abdominal cavity.

Bacteria may infect the peritoneum from the digestive system via a perforated ulcer, a ruptured appendix, from an inflamed pancreas, or because of a penetrating abdominal wound.

Peritonitis is indicated by abdominal pain (often severe and acute) and distension, a fever, and reduced urine production. There may also be signs of shock or an inability to pass faeces.

## Typhoid

*Typhoid* is a bacterial infection of the intestines by the salmonella typhi bacillus. It is spread in excrement, by insects, and via food and water.

The bacteria enter the lymphoid tissue of the intestines. They then spread to the liver, spleen, and gall bladder via the circulation. Inflammation results, together with damage to the intestinal lymphoid tissue which leads to ulcers forming in the mucous membrane.

Initially, typhoid manifests itself with a high fever and headache.

As the condition worsens, it brings nosebleeds, spots on the thorax and abdomen, a distended abdomen, and constipation which then possibly changes to diarrhoea, and finally delirium.

Intestinal haemorrhage and peritonitis may lead on to intestinal perforation which may be fatal.

## *Vomiting*

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*Vomiting* is the body's way of removing a possibly dangerous substance from the stomach, or simply removing stomach contents in reaction to some other problem.

There are many potential causes of vomiting, including: viral infection, reactions to medications, poisons, motion sickness, migraine, hormonal changes (such as during pregnancy), food allergies, and visual stimulus such as witnessing an unpleasant or horrific situation.

The action is controlled from the vomiting reflex centre in the medulla oblongata. The mechanism involves a sharp downward contraction of the diaphragm, a pulling in of the abdominal muscles, a relaxation of the stomach itself and an opening of the cardiac sphincter.

## Foodstuffs and Vitamins

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In order to survive, the human body must receive a balanced diet of foods. This balanced diet must include appropriate proportions of: carbohydrates, proteins, fats, mineral salts, fibre, and water, together with vitamins.

Failure to receive any of the constituents of a balanced diet can result in malnutrition.

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### Foodstuffs

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#### Carbohydrates

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*Carbohydrates* are formed from the elements Carbon, Hydrogen, and Oxygen. They vary in chemical complexity from simple sugars to complex cellulose:

**Monosaccharides.** These are simple sugars, which are readily absorbed by the body. eg. glucose, fructose.

**Disaccharides.** These, in molecular terms, are combinations of two monosaccharides. eg. sucrose, lactose.

**Polysaccharides.** These are complex molecular combinations of many monosaccharides. eg. starches, cellulose.

Not all polysaccharides can be digested by the human body; cellulose and other similar vegetable fibres pass through the alimentary canal virtually unchanged.

Carbohydrates provide energy for heat and movement. Excess carbohydrate is converted to fat and stored.

#### Proteins

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*Proteins* are combinations of *amino acids*, which are formed from the elements Carbon, Hydrogen, Oxygen, Nitrogen, Sulphur, and Phosphorus.

Proteins are split into their constituent amino acids during the digestive process, and absorbed through the intestinal wall.

Amino acids are classed as either 'essential' or 'non-essential'.

*Essential amino acids* cannot be synthesised in the body, and must be available from the diet.

*Non-essential amino acids* can be synthesised in the body from other amino acids, in a process called *transamination*.

Depending on their amino acid content, proteins are graded as either 'first class' - those which contain all the essential amino acids - and 'second class' - those which do not.

*First class proteins* are derived from animal products and soya beans. *Second class proteins* are mainly of vegetable origin.

Amino acids from proteins are used for:

Growth and repair of body cell tissues,  
Production of hormones, enzymes, and antibodies,  
Production of energy (only when insufficient is available from carbohydrates).

Amino acids provide the only usable source of Nitrogen to the body.

Excess protein is broken down; the nitrogenous part is excreted via the kidneys as urea, and the remainder is stored as fat.

#### Fats

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*Fats* are complex compounds formed from the elements Carbon, Hydrogen, and Oxygen. (although these are the same elements which form carbohydrates, the chemical composition is different).

Fats are considered in two groups according to their source:

**Animal fats.** These are derived from meat, oily fish, and dairy products. All animal protein sources also contain some fat. Animal fats are mainly 'saturated'. ie. their molecular bonding structure is fully utilised.

**Vegetable fats.** These are found in vegetable oils. Vegetable fats are mainly 'polyunsaturated'. ie. their molecular bonding structure is not fully utilised.

Vegetable fats are essential in the diet, and assist in the formation of prostaglandins and blood clotting factors.

Fats, in general, provide energy to the body. They also serve the purposes of:

Transporting the fat soluble vitamins,  
Contributing to the secretions from sebaceous glands,  
Assisting in the formation of cholesterol, and steroid hormones.

Excess fats are stored in the body's fat depots - under the skin, and in the mesentery.

#### Mineral Salts

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*Mineral salts* are inorganic compounds which are essential for all body processes. Many mineral salts are required, although usually only in small quantities.

[Table 9 - 4]

**Table 9 - 4** essential minerals

The more common mineral elements, together with their sources and uses

Mineral	Source	Main Functions
Calcium	Dairy products, green vegetables, some fish	Hardening of teeth and bones, mechanism of muscle contractions, mechanism of blood clotting
Iodine	Some fish, some vegetables, a common artificial additive to table salt	Formation of thyroid hormones
Iron	Liver, kidney, beef, eggs, grain, green vegetables	Formation of haemoglobin
Magnesium	Green vegetables, milk, meat, nuts	Formation of bone structure, regulation of muscular and nervous activity
Phosphorus	Cheese, liver, kidney	Hardening of teeth and bones, regulation of body fluids
Potassium	Almost all foods	Many cellular activities, mechanism of muscle contractions, transmission of nerve impulses, maintenance of body electrolyte levels
Sodium	Most foods, table salt	Mechanism of muscle contractions, transmission of nerve impulses, maintenance of body electrolyte levels

### ***Fibre***

*Fibre*, or *roughage*, consists of indigestible vegetable substances, in the form of complex polysaccharides and cellulose.

It is found in 'whole meal' grain products, bran, and many vegetables.

Some fibre is partially digested by microbes in the large intestine to form gaseous products, or *flatus*.

Fibre is necessary in the diet as it stimulates peristalsis and bowel movement. It may also contribute in the prevention of some gastrointestinal disorders.

### ***Water***

*Water* is essential to continuing life. Approximately 60% of the total body weight is water. Unlike other foods, considerable quantities of water are lost through evaporation from the skin and the lungs.

Water is taken into the body either as a liquid, or as a constituent of other foods. A small amount is produced within the body as the result of Hydrogen from foods reacting with Oxygen.

Water provides a moist environment for living cells. It participates in, and facilitates, all biochemical reactions in the body.

Water is a major constituent of blood, and acts as a transport medium for both benevolent and malevolent substances.

Some water is excreted with faeces, but the majority of excess water is excreted as urine.

### ***Vitamins***

A *vitamin* is an organic substance, found in minute quantities in specific foods, and which is essential for healthy survival, but which provides no actual energy or physical contribution to the body. Vitamin deprivation causes specific disease depending on the vitamin involved.

Vitamins A, D, E, and K are fat soluble and excess amounts are stored in adipose tissue, mainly the liver. [Table 9 - 6]

The remaining vitamins are water soluble and are not stored; the effects of a reduced intake are therefore much more rapid. [Table 9 - 5]

**Table 9 - 5** water soluble vitamins

The main water soluble vitamins

Figures given as daily need are approximate upper limits

Vitamin	Main sources	Main functions	Consequence of deficiency	Daily need
B1 (thiamine)	Cereal roughage, yeast, milk, meat, yeast	Catalyses oxidation of carbohydrates in cells	General fatigue, loss of muscle tone, nerve changes, beriberi	1.5mg
B2 (riboflavin)	Milk, eggs, beef, cereals, nuts, yeast	Assists cellular respiration	Eye problems, skin disorders, digestive problems	2mg
B3 (niacin, nicotinic acid)	Whole grain, liver, sea food, beans	Assists carbohydrate metabolism, assists production of sex hormones, reduces cholesterol	Pellagra	20mg
B5 (pantothenic acid)	Most foods	Promotes growth, assists utilisation of other vitamins and energy	Fatigue, sleep disorders, cardiovascular and neurone problems, eczema	not known
B6 (pyridoxine)	Cereals, liver, milk, green vegetables	Assists in metabolism of amino acids	Skin and nervous disorders, learning disabilities, anaemia	2.5mg
B12 (cyano- cobalamin)	Meat, dairy products, synthesised in the body	Assists red blood cell production	Anaemia, nervous disorders, general weakness	2µg
B (biotin)	Liver, vegetables, eggs, synthesised in the body	Assists cell growth, and synthesis of non-essential amino acids	Dermatitis, muscle pains, weakness, insomnia	100µg
B (folic acid, folacin)	Meat, eggs, milk, green vegetables, synthesised in the body	Assists red blood cell production and DNA formation	Anaemia, gastro-intestinal problems	200µg
C (ascorbic acid)	Fruit and vegetables (destroyed by cooking)	Assists oxidation reactions, assists formation of collagen, teeth, and bones, assists healing	Scurvy, low infection resistance, anaemia, poor connective tissue formation	60mg

**Table 9 - 6** fat soluble vitamins

The main fat soluble vitamins

Figures given as daily need are approximate upper limits

<b>Vitamin</b>	<b>Main sources</b>	<b>Main functions</b>	<b>Consequence of deficiency</b>	<b>Daily need</b>
A (retinol)	Dairy produce, liver, fish liver oils	Maintains epithelial tissues, corneas of eyes, assists formation of rhodopsin	Stunting, low disease resistance, poor healing, night blindness	2mg
D (calciferol)	Dairy produce, eggs, liver, formed in skin by sunlight	Promotes Calcium and Phosphorus absorption from food, and bone and tooth formation	Rickets, dental caries, osteomalacia, diarrhoea, insomnia	10µg
E (tocopherols)	Eggs, dairy produce, green vegetables, nuts	Strengthens red blood cells, assists muscle and nerve maintenance	Anaemia	15mg
K (phylloquinone)	Synthesised in the body, fruit, vegetables	Enables clotting function of blood	Poor blood clotting actions	10µg

### *Malnutrition*

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*Malnutrition* is the result of a failure to maintain a balance between the intake of foods required for health and foods actually taken.

The condition is usually associated with a much reduced and poor diet as a result of poverty or deprivation. However, it may also result from a straightforward imbalance in the intake of basic foods - perhaps through personal desire - or from a metabolic disorder which prevents the proper uptake of nutritional essentials.

The signs and symptoms vary widely, although weakness, a susceptibility to other diseases, and eventual death are common factors.

#### *Anorexia nervosa*

*Anorexia nervosa* is a psychological condition, which causes either a direct refusal to take food, or the use of laxatives or emetics to prevent the uptake of food.

The causes of the condition are complex, with factors such as emotional rejection being contributory, and are usually based around a desire to lose and control body weight with an assumption that low body weight is desirable. Delusions of being overweight are often prevalent.

### *Vitamin Deficiencies*

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Deficiencies of individual vitamins in the diet will lead to various different general problems, as indicated in Table 9 - 5 and Table 9 - 6.

Some vitamin deficiencies lead to specific conditions.

#### *Beriberi*

*Beriberi* is the result of a deficiency of vitamin B1. It is most common amongst those whose principal diet is based on rice.

*Wet beriberi* leads to excessive tissue fluid.

*Dry beriberi* lead to extreme wasting.

Degeneration of nervous tissue is a feature of both forms of the condition, with a common outcome of heart failure and death.

#### *Pellagra*

*Pellagra* is a result of a deficiency of vitamin B3. It is most common amongst those whose principal diet is maize.

Pellagra leads to skin disease, diarrhoea, and depression.

#### *Rickets*

*Rickets* is a result of a deficiency of vitamin D. It is primarily a childhood condition. The lack of vitamin D causes there to be insufficient Calcium salts in the bones, which are then soft and slightly pliable. They thus tend to deform. This shows mainly in the long bones, particularly in the legs, which curve unnaturally.

*Osteomalacia* is a softening of the bones occurring in adulthood through a lack of vitamin D.

Bone pain is the main symptom.

#### *Scurvy*

*Scurvy* is a result of a deficiency of vitamin C. It may occur in alcoholics, or in those who eat very few fresh vegetables or fruit.

Initial indications are swollen and bleeding gums, followed by a rash of fine bleeding spots.

Subcutaneous bleeding is a late sign.