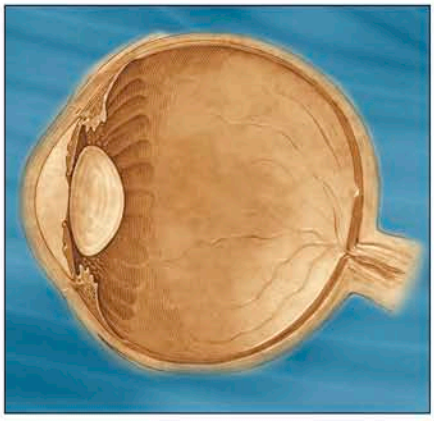
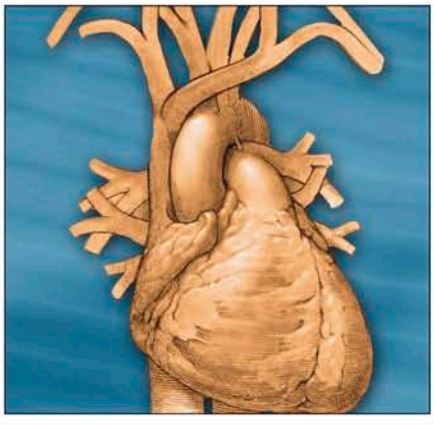
The Facts On File Illustrated Guide *to the* Human Body





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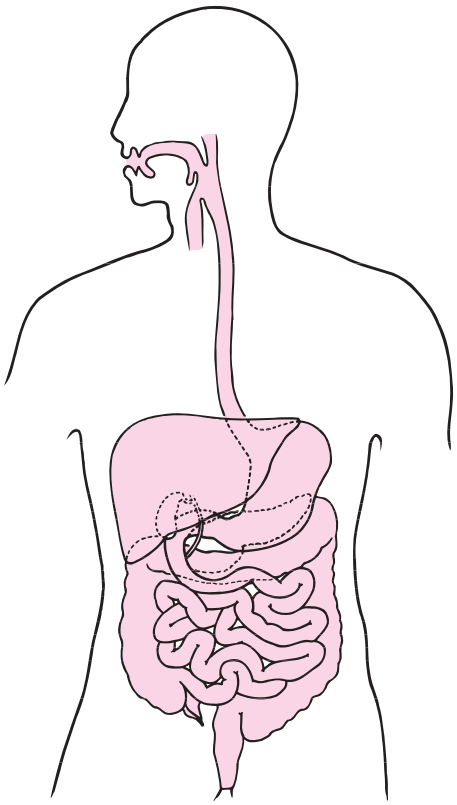
THE FACTS ON FILE
ILLUSTRATED GUIDE TO
THE HUMAN BODY

DIGESTIVE SYSTEM



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This book is not intended to serve as a medical textbook for either physicians or patients. The information and advice it contains should not be used or relied upon without consulting the advice of a qualified physician. The publishers disclaim any responsibility for the accuracy of the information or advice that this book contains and any responsibility for any consequences that may result from any use or reliance thereon by the reader.

Contents

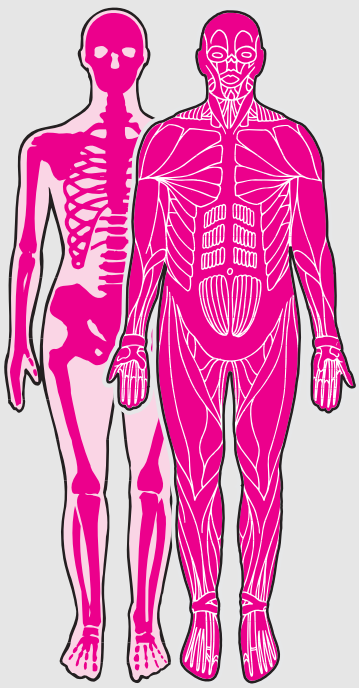
Introduction

This book is a concise, illustrated guide to the anatomy, physiology, well-being, and disorders of the human digestive system. It has been written and illustrated specially for students and laypeople interested in medicine, health, fitness, and first aid. The subject is dealt with in clear steps, so that the reader can steadily acquire a good overall understanding. Explanatory texts, diagrams, illustrations, captions, and fact boxes are combined to help readers grasp important information at a glance. A glossary of scientific and jargon words defines medical terms in everyday language. A list of Web sites provides links to other relevant sources of information, and the index enables quick access to articles.

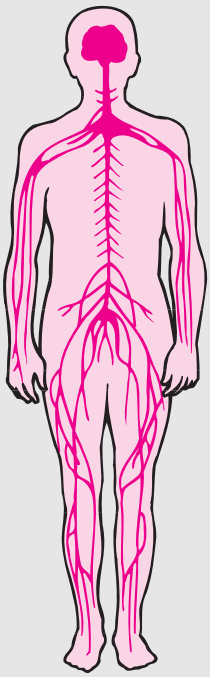
There are six sections within the book. The first section surveys the digestive system and outlines the process of digestion. The second section looks at food and the body's needs for nutrients. Sections 3 and 4 focus on the components of the digestive tract, and section 5 deals with organs linked with digestion. The last section describes the urinary system, which works in conjunction with the digestive system. Within each section, discussion and illustration of the structure and function of the anatomical parts are followed by principles of healthcare, fitness, and exercise. These are followed by a survey of the main disorders and diseases affecting the region. Information is presented as double-page topics arranged in subsections.

Human body systems

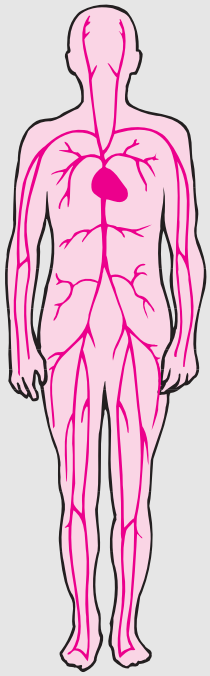
This book is one of eight titles in THE FACTS ON FILE ILLUSTRATED GUIDE TO THE HUMAN BODY series, which looks at each of the major body systems in turn. Some of the titles in the series include more than one system. The skeletal and muscular systems, and the blood and lymphatic systems, for example, work in conjunction and so are treated together. There is a separate title for human cells and genetics, which are the building blocks and underlying chemistry of all body systems.



Skeletal and Muscular Systems



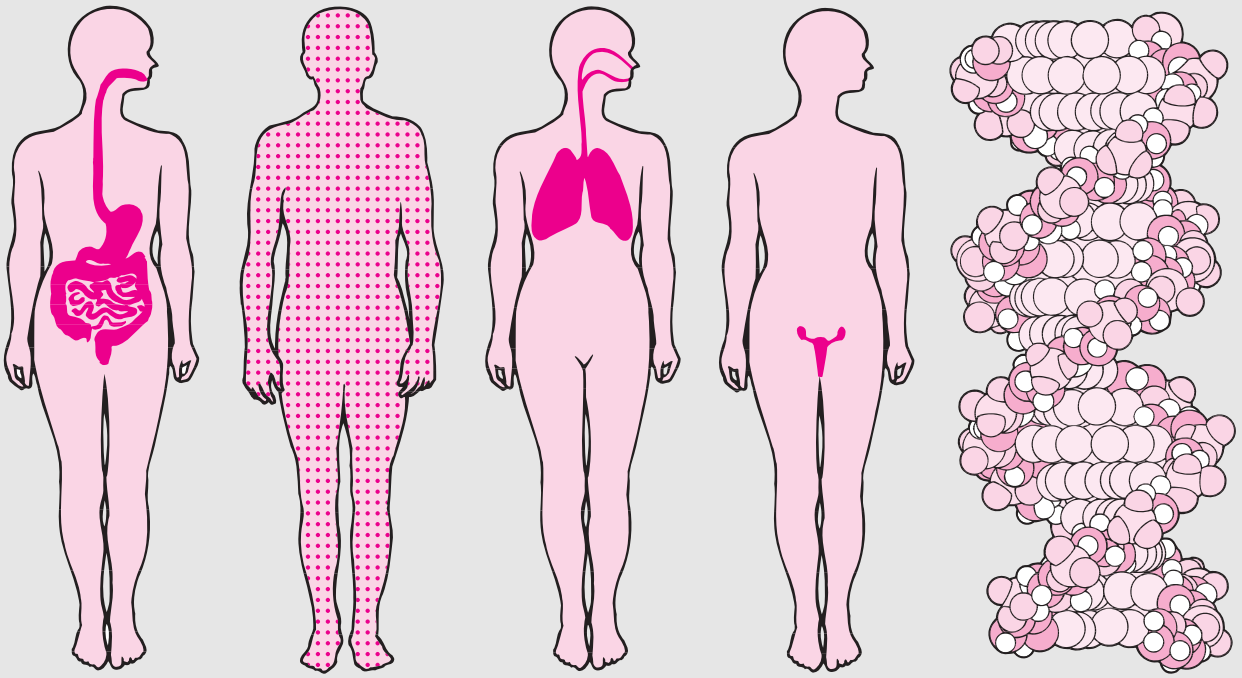
Brain and Nervous System



Heart and Circulatory System

Section 1: DIGESTIVE SYSTEM follows the passage of food from the mouth to the anus, and shows how foodstuffs are broken down.
Section 2: NUTRIENTS & DIET analyzes the calorific and nutrient content of foods and gives guidelines on a balanced diet.
Section 3: MOUTH & GULLET focuses on the mechanical and early chemical breakdown of foods.
Section 4: STOMACH & GUT features the major chemical processes of digestion and the absorption of essential nutrients.
Section 5: LIVER & PANCREAS looks at how organs linked to the digestive tract aid digestion and how the products of digestion are processed and utilized.
Section 6: URINARY SYSTEM examines how the waste products of chemical processes in the body are filtered from the blood, collected, then eliminated.

This book has been written by anatomy, physiology, and health experts for non-specialists. It can be used:
• as a general guide to the way the human body functions
• as a reference resource of images and text for use in schools, libraries, or in the home
• as a basis for examination preparation for students of human biology, medicine, nursing, physiotherapy, and general healthcare.

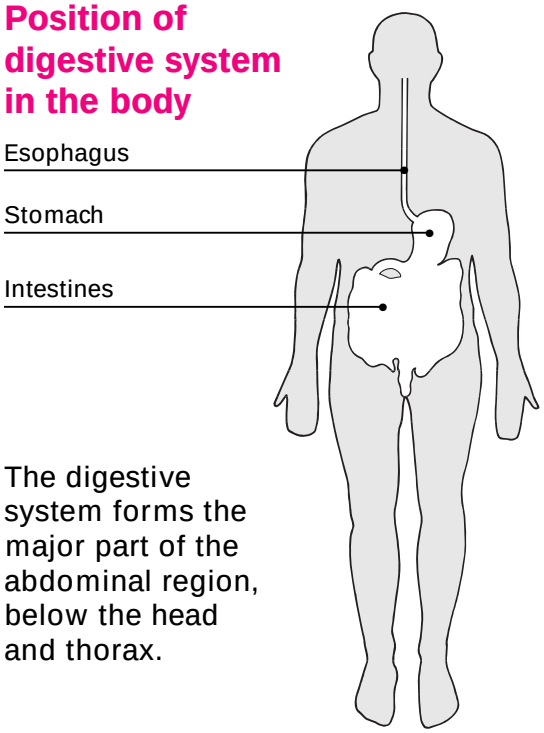


Digestive System | The Senses | Respiratory System | Reproductive System | Cells and Genetics

Introduction

The digestive system is basically a long tube that breaks down food so it can be absorbed into the body. Its main feature is the alimentary canal, which measures about 30 feet (9 m) from mouth to anus and includes the esophagus, stomach, small and large intestines, and rectum. Also contributing to the digestive process are various accessory digestive organs: the teeth, tongue, salivary glands, liver, gallbladder, and pancreas.

Position of digestive system in the body



The digestive system forms the major part of the abdominal region, below the head and thorax.

Digestive system parts

Mouth cavity Here the teeth, tongue, and salivary glands process food for swallowing.

Esophagus This is the alimentary canal between the lower pharynx (throat) and the stomach. Swallowed food is moved through it by rhythmic muscular contractions known as peristalsis.

Stomach This enlarged section of the alimentary canal churns, disinfects, and starts digesting food, producing chyme, a semifluid mixture.

Sphincters These are rings of smooth muscle that contract to close an orifice. They include the pyloric sphincter (between the stomach and duodenum) and two anal sphincters.

Digestive juices Saliva and juices secreted in the stomach, small intestine, and pancreas contain enzymes for digesting specific food substances.

Small intestine This convoluted tube, about 21 feet (6.5 m) long, connects the stomach and the large intestine. It is subdivided into the duodenum, jejunum, and ileum. The small intestine is the part of the alimentary canal where most digestion occurs.

Large intestine Also called the colon, this is a broad tube about 5 feet (1.5 m) long, extending from the ileum to the rectum. It is subdivided into the cecum (from which the appendix projects), and the ascending, transverse, descending, and sigmoid colons.

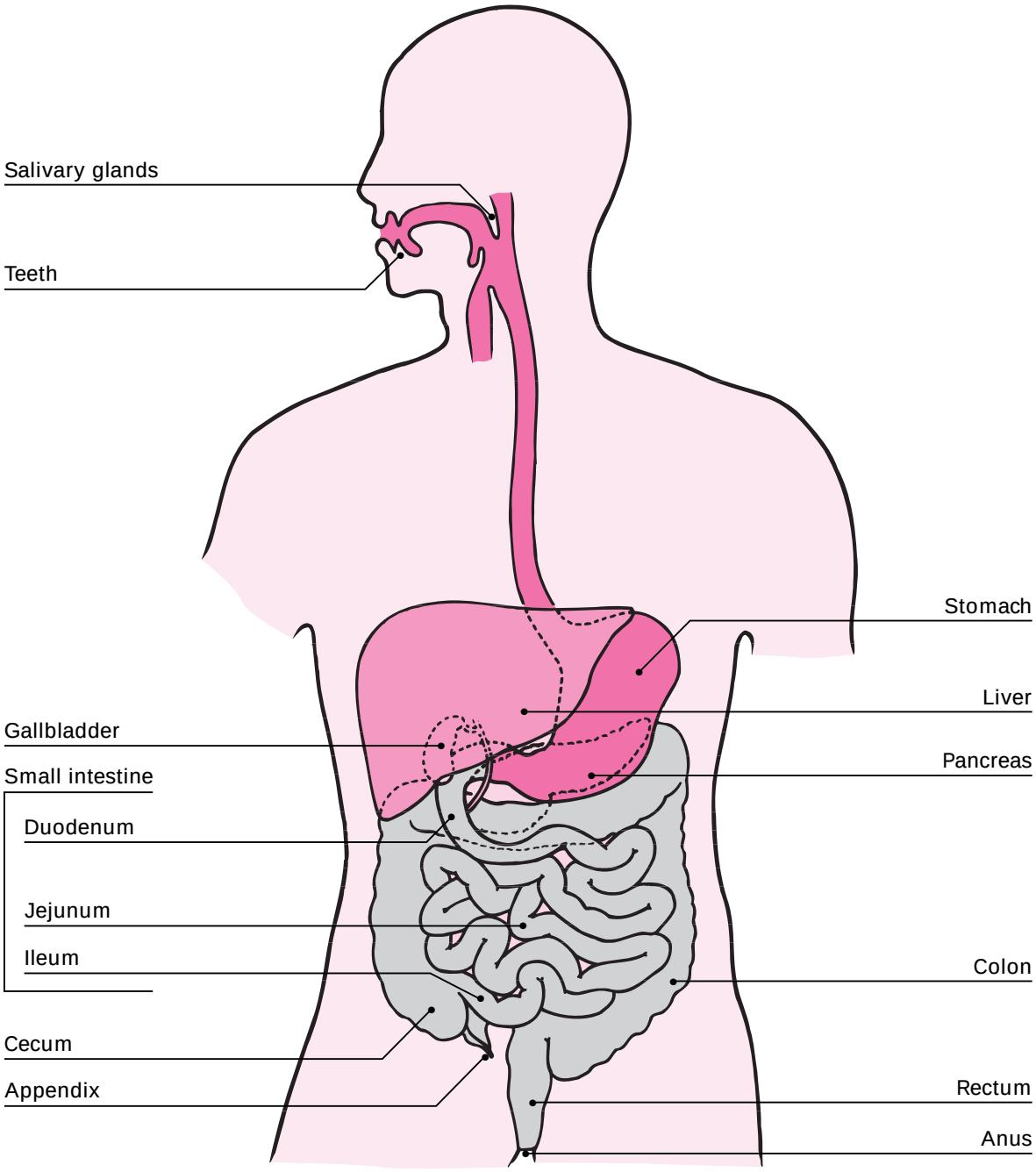
Rectum This tube extends from the sigmoid colon, and ends at a narrow orifice, the anus.

Liver The body's largest solid organ, the liver lies in the upper right part of the abdomen. Its complex chemical activities include secreting the emulsifying substance bile, and storing vitamins and glycogen (a carbohydrate produced from glucose).

Gallbladder This sac stores bile, releasing it via the cystic duct and common bile duct into the duodenum.

Pancreas This endocrine gland secretes insulin and pancreatic juice into the duodenum.

Digestive system



Digestive organs

The digestive system

The digestive system consists of the group of organs involved in the processes by which food is digested (broken down into simpler substances) and absorbed (taken up by the blood or lymph vessels). The digested and absorbed substances are then transported around the body to be used for energy and for rebuilding and repairing cells and tissues.

Alimentary canal organs

The alimentary canal—or gastrointestinal (GI) tract—consists of several organs.

Mouth
Here, food is chewed into smaller pieces, mixed with saliva, and formed into a rounded ball, or "bolus."

Pharynx (throat)
Propels the bolus of food from the mouth to the esophagus.

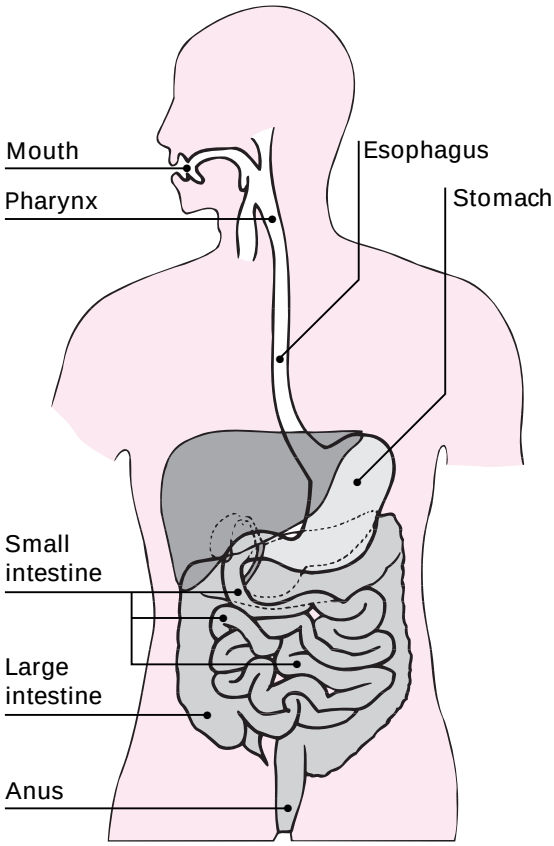
Esophagus (gullet)
Pushes food down to the stomach by means of waves of muscular contraction.

Stomach
Churns food into even smaller pieces, mixes the food with gastric juices to digest food (especially protein), and regulates an even flow of food into the small intestine. Acid in the stomach kills bacteria.

Small intestine
Made up of the duodenum, jejunum, and ileum. Part of the system where most digestion takes place and water and nutrients are absorbed into the blood and lymph systems.

Large intestine
Removes salt and water from undigested food and turns the remaining waste into a soft solid (feces), which is a mixture of indigestible remnants, unabsorbed water, and millions of bacteria.

Anus
Opening for feces to exit the body.



Accessory organs

The teeth and the tongue physically break the food up into smaller pieces. As food is chewed, it is mixed with saliva from the salivary glands. These make the digestive juice saliva. The liver, the pancreas, and the gallbladder also produce digestive juices that chemically break down food. The liver is the largest gland in the body, and weighs 3–4 pounds (1.4–1.8 kg).

Accessory digestive organs

The accessory digestive organs aid digestion in various ways.

Teeth

These chop up food, making it easier to digest by exposing more surface area of the food for digestive enzymes to act on.

Tongue

Helps the teeth to chew food and shape it into the bolus, ready to be swallowed.

Salivary glands

Produce saliva, which lubricates food, making it easier to swallow. Saliva begins converting starch to sugar.

Liver

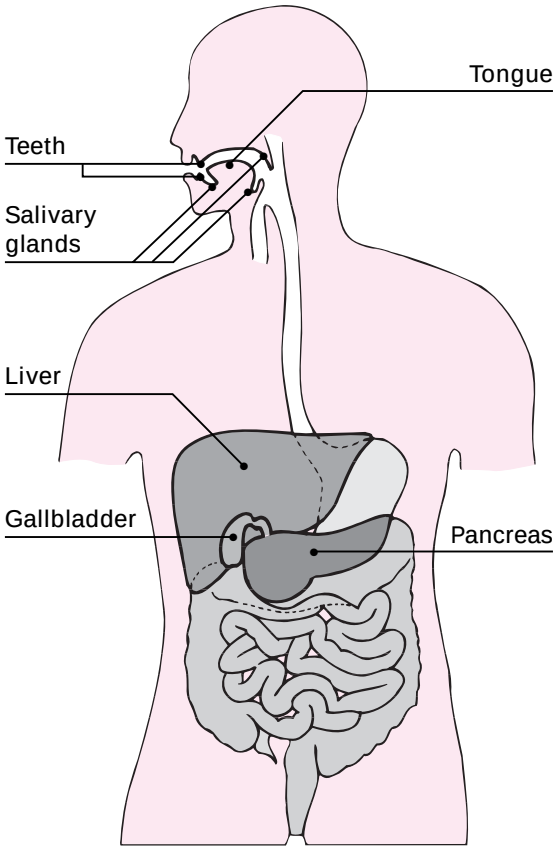
Converts nutrients from food into usable substances and stores them until they are needed.

Gallbladder

Stores and concentrates bile from the liver and releases it when needed to help with fat digestion.

Pancreas

Secretes many digestive enzymes into the small intestine and neutralizes stomach acid. Insulin, which helps the body to utilize sugar, is passed directly into the bloodstream from the pancreas.



Digestion fact

- The salivary glands produce up to 3 pints (1,600 ml) of saliva every day.

Digestion key words and facts

Digestive system: key words

Appendix (*or* Vermiform appendix) A short, wormlike tube opening into the cecum, which is closed at the other end. It contains tissues involved in immunity.

Bowel *See* **Large intestine**.

Cecum The first part of the large intestine, forming a blind pouch.

Colon The part of the large intestine between the cecum and rectum. It consists of the ascending, transverse, and descending colons, and the rectum.

Duodenum The upper part of the small intestine, where most chemical digestion takes place.

Esophagus (*or* Gullet) The muscular tube through which food travels between the pharynx and stomach.

Gallbladder A pear-shaped bag where bile is stored, below the liver.

Gastric Relating to the stomach.

Hepatic Relating to the liver.

Ileum The last part of the small intestine.

Jejunum The middle part of the small intestine.

Large intestine (*or* Bowel) The lower part of the alimentary canal, comprising the cecum, colon, and rectum. It absorbs water, and expels wastes as feces.

Liver Divided into four lobes, its many functions include the manufacture of bile, a digestive juice.

Pancreas A tongue-shaped gland located in the abdomen that produces glucagon, insulin, and pancreatic juice.

Palate The roof of the mouth.

Pancreatic islets (*or* Islets of Langerhans) Scattered areas of the pancreas that produce glucagon and insulin.

Parotid glands *See* **Salivary glands**.

Peristalsis Waves of muscular contractions that force substances, such as food, through internal passageways.

Pharynx The throat.

Pylorus The narrow exit from the stomach into the duodenum, closed by a sphincter.

Rectum The last part of the colon, where feces collect before leaving the body.

Salivary glands The lingual, parotid, sublingual, and submandibular glands that produce saliva.

Sigmoid colon The S-shaped part of the colon.

Small intestine The alimentary canal between the stomach and large intestine, comprising the duodenum, jejunum, and ileum. Most digestion occurs here.

Sphincter A ring-shaped muscle that contracts to close an orifice, such as the pyloric sphincter and the anal sphincters.

Stomach A muscular, baglike part of the alimentary canal between the esophagus and small intestine. It stores, churns, and partially digests food.

Taste buds Tiny sensory organs (circumvallate papillae, filiform papillae, fungiform papillae) on the tongue and palate.

Teeth Bonelike structures in the jaws. Different types (incisors, canines, premolars, molars) are specialized to pierce, tear, crush, and/or grind food.

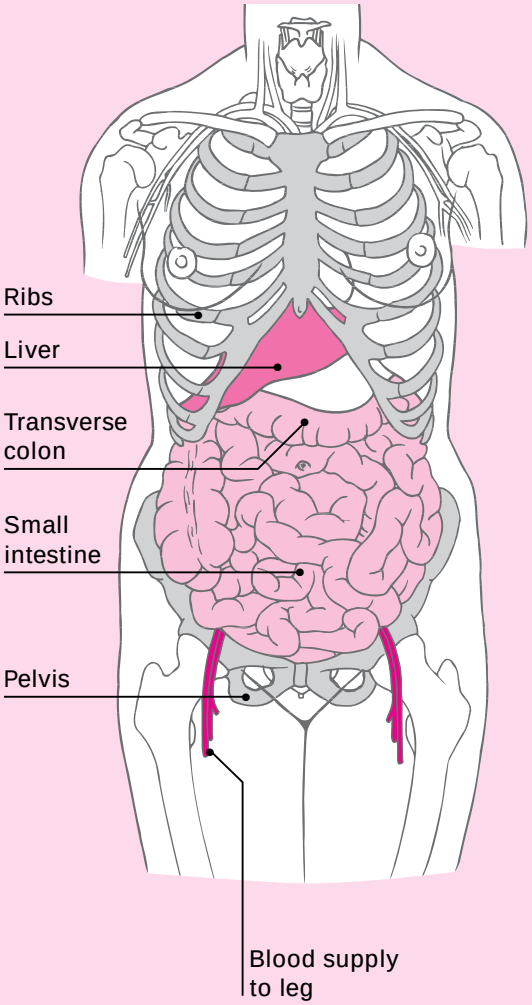
Tongue A muscular organ in the mouth, involved in tasting, chewing, swallowing, and speech.

Villus A minute fingerlike projection. Huge numbers line the small intestine, increasing its surface area (plural: villi).

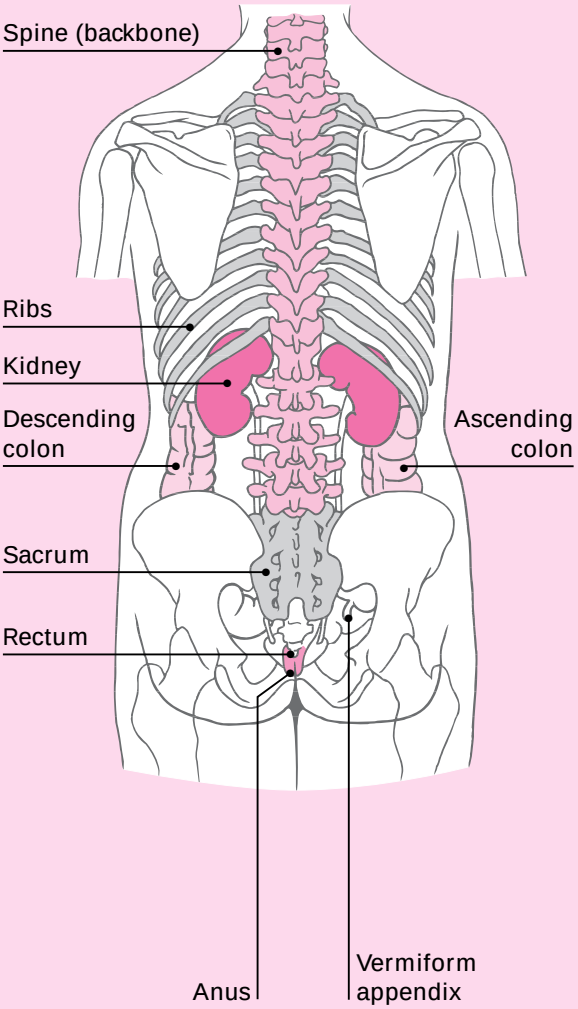
Location of organs

The two diagrams below show the location of the major digestive organs within the body. They take up most of the space within the abdomen, with the diaphragm above them and the pelvis below. The liver is situated under the rib cage on the right side of the body, while the kidneys sit against the rear wall of the abdomen, just above the level of the waist.

Front view



Back view



Food's journey

The journey of food

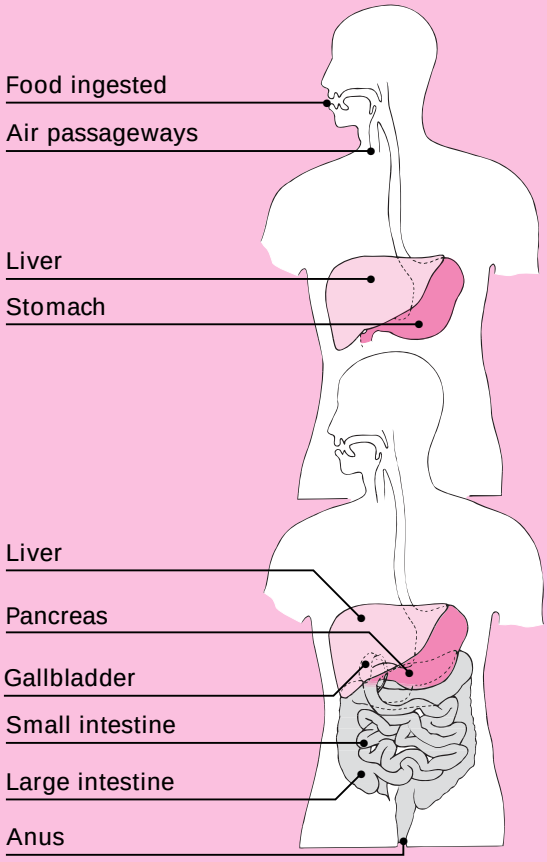
As food journeys through the body, it is first ingested, then digested, and finally absorbed into the blood or lymph.

Food is ingested and swallowed

Ingestion is the process of taking food into the body by way of the digestive system. The mouth is the doorway into this system. Teeth in the mouth break down the food by mastication (chewing). Taste buds on the tongue send nerve impulses to the brain to stimulate the release of saliva from the salivary glands. Saliva is mixed with the food by the actions of the teeth and the tongue. Saliva moistens the food, and begins the process of chemical breakdown. The tongue rolls the food into a chewed mass of food (bolus), ready to be swallowed. The throat (pharynx) automatically continues the swallowing process. While food is being swallowed, the air passageways are closed to prevent choking.

Food passes to the stomach

The opening to the esophagus widens, and waves of rhythmic muscular contractions called peristalsis force food into the stomach. The walls of the stomach distend as it fills up with food. The muscular walls of the stomach churn the food, breaking it down, and mixing it with gastric juices to produce chyme (a semifluid mixture). The gastric juices continue the process of chemical digestion that began in the mouth. Peristaltic movements eventually force chyme into the small intestine.

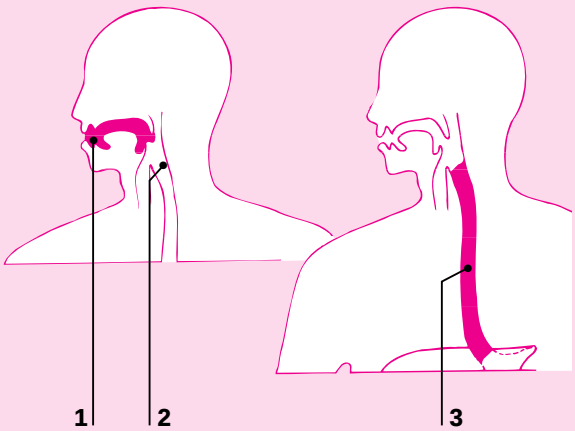


Food is digested and absorbed

In the small intestine, enzymes from the pancreas, and bile from the liver and gallbladder, almost complete the digestion of food. The products of digested food are absorbed through the lining of the small intestine into blood or lymph vessels. Remaining undigested food passes to the large intestine, where bacteria complete the digestion process, and water is absorbed. Feces (dead bacteria and cells, mucus, bile, and indigestible food) are excreted by muscular action via the rectum and anus.

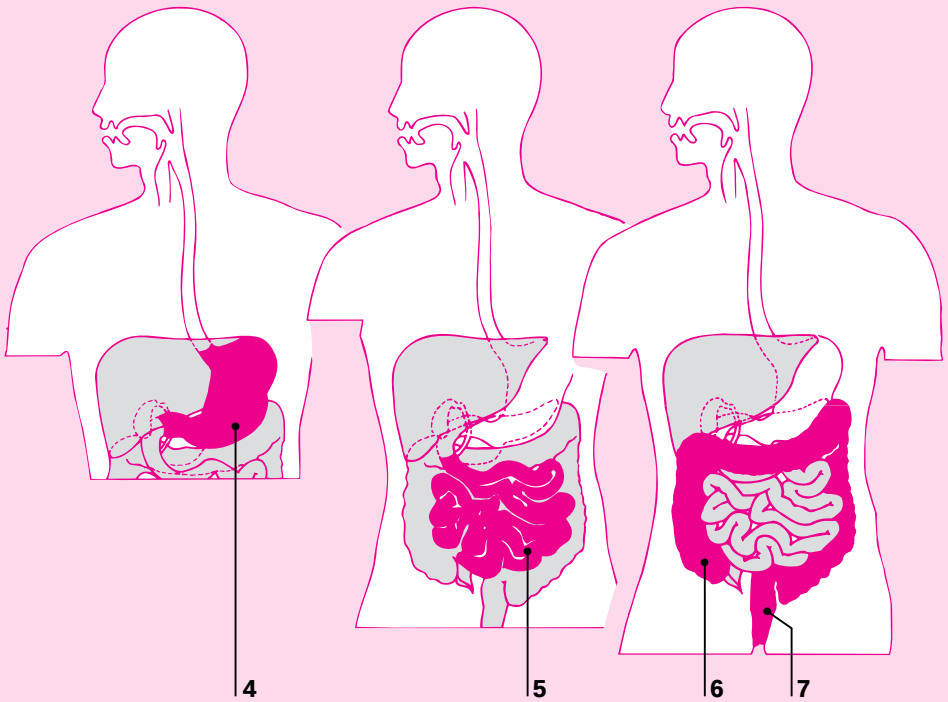
Journey time

It takes most food a total of about 24 hours to pass through the digestive system. Some foods, especially liquids, move faster, and others more slowly.



How long food takes to pass through the system

Organ	Time taken
1 Mouth	under voluntary control (usually minutes)
2 Pharynx	1–2 seconds
3 Esophagus	5–10 seconds (solids) 1 second (liquid)
4 Stomach	2–6 hours
5 Small intestine	1–6 hours
6 Large intestine	10–24 hours
7 Rectum	under voluntary control

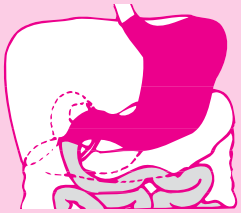
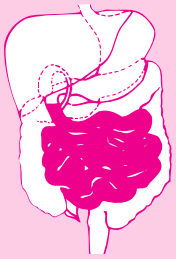
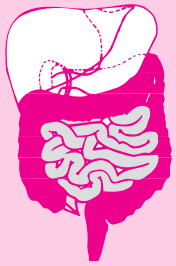


Digestive processes

In order to digest and absorb food, the digestive system relies on six essential processes and mechanisms. These are: ingestion, mechanical digestion, propulsion, chemical digestion, absorption, and elimination.

Activity	How it is achieved
Ingestion Process of taking food into the alimentary canal.	Food is placed voluntarily into mouth.
Mechanical digestion Physical breakdown of food into smaller fragments, enabling digestion.	Physical breakdown is achieved by: • mastication (chewing); • churning; • mixing; and • segmentation.
Propulsion Process that moves food through the alimentary canal.	Food movement is achieved by: • peristalsis (wavelike contractions of walls of alimentary canal); • swallowing; and • segmentation (rhythmic local constrictions of walls of alimentary canal).
Chemical digestion Chemical breakdown of food into simpler substances, enabling digestion and absorption.	Chemical breakdown is achieved by: • hydrolysis (using water to break down complex molecules); • digestive enzymes (proteins that act as biological catalysts) breaking down food molecules; and • bile (watery, alkaline solution), which breaks large fat globules down into smaller droplets.
Absorption Passage of digested food products from alimentary canal to blood or lymph vessels.	• Simple molecules produced by food digestion are absorbed through the cell membranes of the alimentary canal lining into blood and lymph vessels.
Elimination Process that expels indigestible substances from body.	• Defecation occurs; feces (dead bacteria and cells, mucus, bile, and indigestible food) are expelled by muscular action.

The location of digestive processes

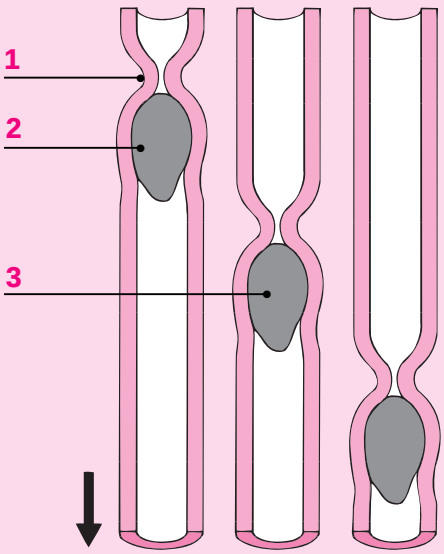
	Organ
	The **mouth** is involved in: • ingestion; • propulsion; • mechanical digestion (mastication and mixing); and • chemical digestion (saliva).
	The **pharynx and esophagus** are involved in: • propulsion (peristalsis).
	The **stomach** is involved in: • propulsion (peristalsis); • mechanical digestion (churning and mixing); • chemical digestion (gastric juices); and • absorption.
	The **small intestine** is involved in: • propulsion (peristalsis and segmentation); • mechanical digestion (segmentation and mixing); • chemical digestion (pancreatic juices, digestive enzymes, and bile); and • absorption.
	The **large intestine** is involved in: • propulsion (peristalsis); • mechanical digestion (mixing and segmentation); • chemical digestion (bacterial); • absorption (mainly water); and • elimination (defecation).

Movement of food

Peristalsis

This is an involuntary process that propels food through the alimentary canal.
Adjacent muscle fibers contract and relax in sequence.
1 As a group of muscle fibers contracts, that part of the passage becomes narrower.
2 This action squeezes the food bolus into the next section, where the muscle fibers are relaxed.
3 This area then contracts, squeezing the bolus further down the length of the alimentary canal.
Within the digestive system peristaltic action occurs in the:

- pharynx and esophagus (as part of the swallowing process);
- stomach;
- small intestine; and
- large intestine.

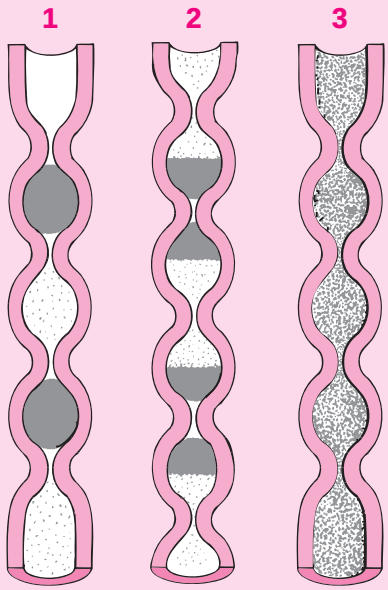


Segmentation

This is an involuntary process that occurs mainly in the small intestine, and has three functions:

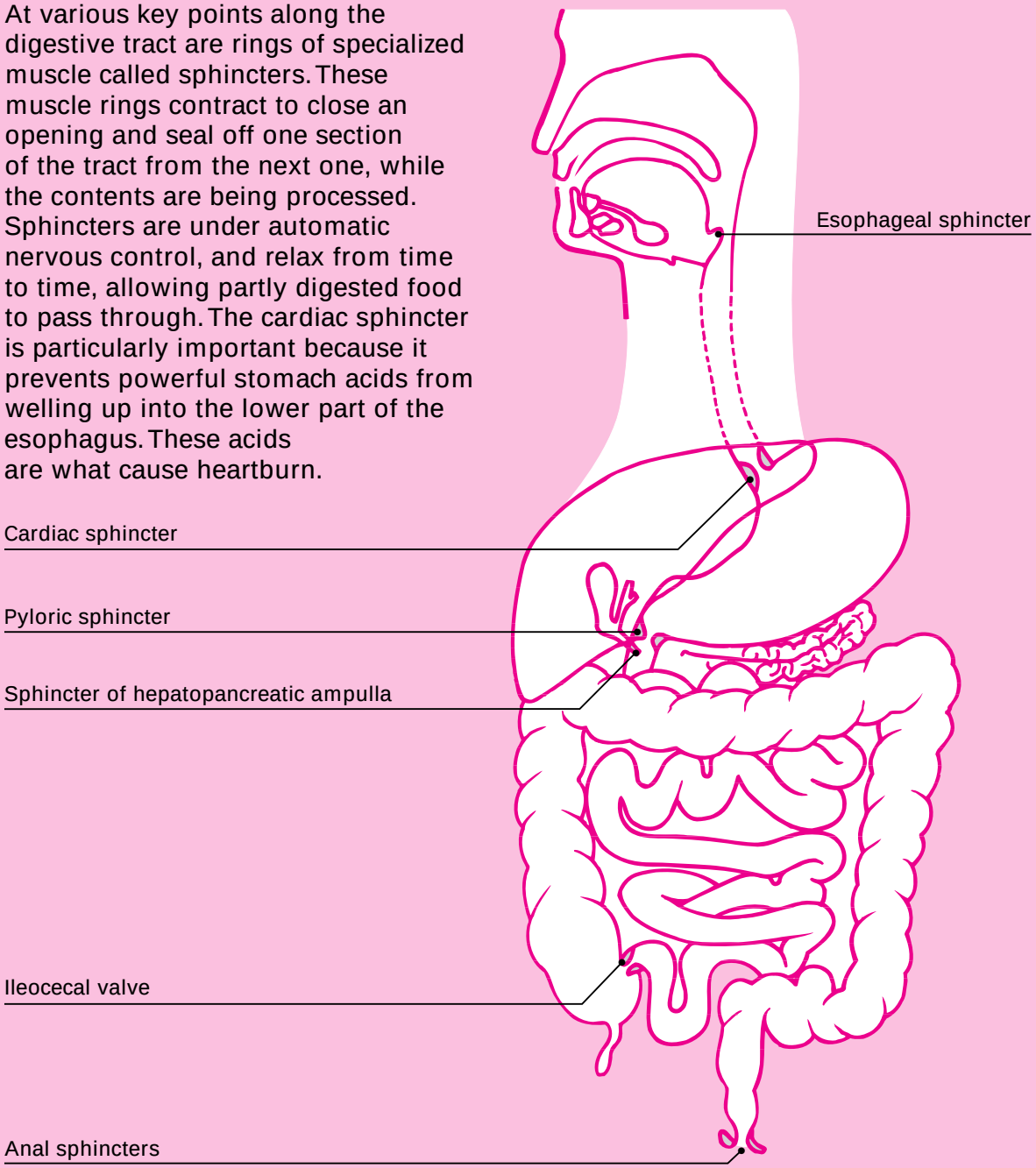
- mixing food with digestive juices;
- increasing the absorption rate; and
- helping to propel food through the alimentary canal.

1 Nonadjacent sections of the intestinal wall alternately contract and relax.
2 As inactive segments exist between the active ones, the food bolus is moved back and forth across the alimentary canal and mixed with digestive juices.
3 The digestive juices break down the bolus, and the contraction and relaxation of the intestinal wall help move the bolus down the canal.



Muscle sphincters

At various key points along the digestive tract are rings of specialized muscle called sphincters. These muscle rings contract to close an opening and seal off one section of the tract from the next one, while the contents are being processed. Sphincters are under automatic nervous control, and relax from time to time, allowing partly digested food to pass through. The cardiac sphincter is particularly important because it prevents powerful stomach acids from welling up into the lower part of the esophagus. These acids are what cause heartburn.

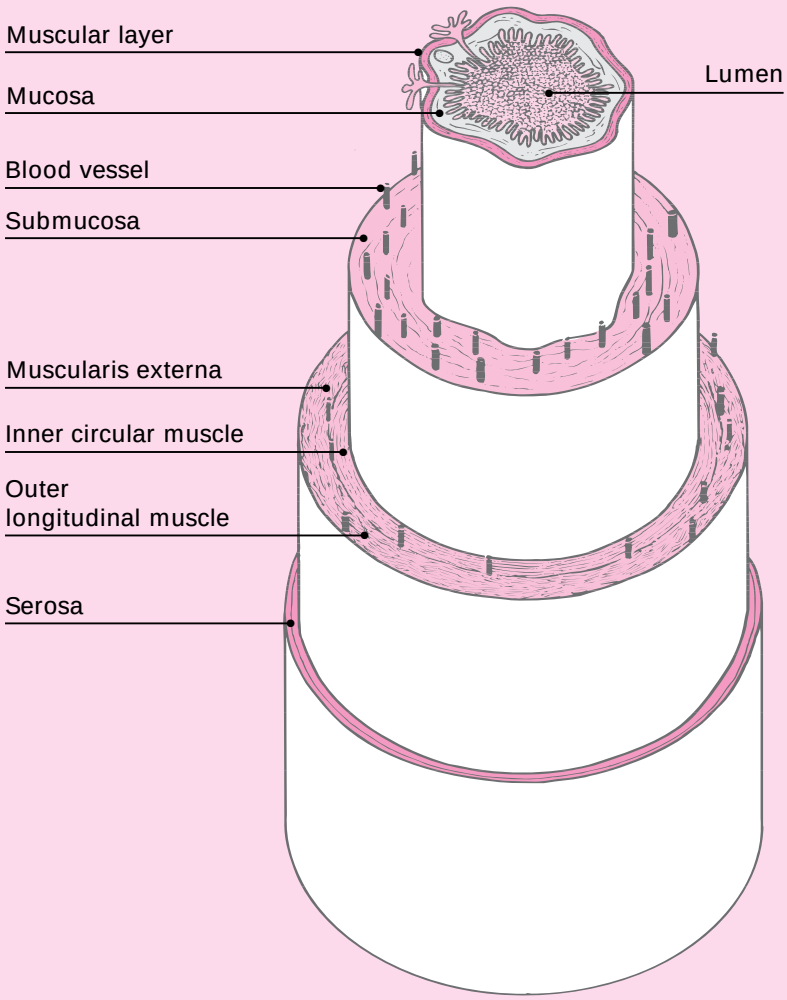


Alimentary canal wall

Structure of the alimentary canal

The walls of the alimentary canal, from esophagus to anus, are made up of four basic tunics (layers):

- mucosa;
- submucosa;
- muscularis externa; and
- serosa.



Mucosa

The mucosa, or mucous membrane, is the innermost layer that lines the lumen (cavities) of the alimentary canal. It is made up of surface epithelium, lamina propria (connective tissue), and a muscular layer. The mucosa contains goblet cells that secrete mucus (thick, slimy fluid which lines the gut), lymph nodules, and muscles.

Submucosa

This is a connective tissue layer of loose, spongy tissue, which cushions the layers on either side. It contains blood vessels, lymph vessels, and nerve endings.

Muscularis externa

This muscular layer thickens at certain points to form sphincters (rings of muscle). It normally has two sublayers, an inner circular muscle layer, and an outer longitudinal muscle layer.

Serosa

The serosa is connective tissue that covers the external surfaces of most digestive organs. In the esophagus, the serosa is replaced by an adventitia (fibrous connective tissue).

Functions of the alimentary canal's layers

Each of the tunics (layers) of the alimentary canal lining has a distinct function. These include secretion and absorption on the inside, propulsion in the middle, and containment on the outside.

Mucosa

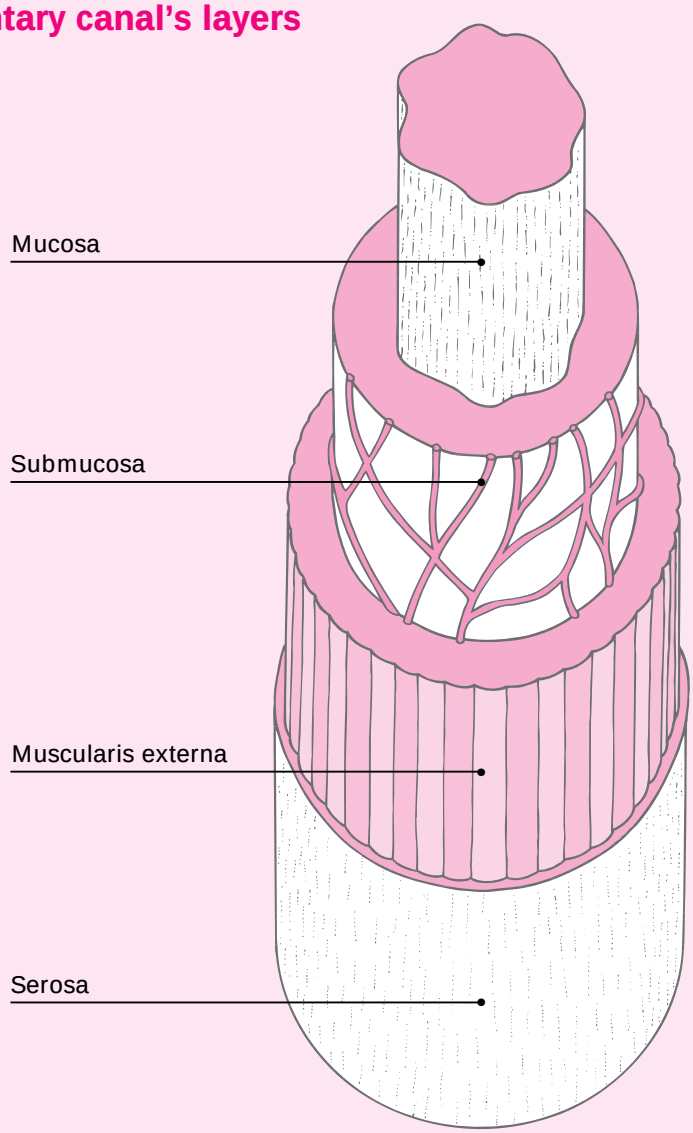
Secretes mucus to moisten food, and lubricate and protect the lining of the alimentary canal. The mucosa also secretes digestive enzymes and hormones, contains lymph nodules that protect against infectious diseases, and absorbs the end products of digestion into blood and lymph vessels.

Submucosa

Supplies surrounding tissues of alimentary canal wall with blood and lymph.

Muscularis externa

Performs peristalsis and segmentation, which mix and propel food through the canal, and has muscle sphincters that act as valves to regulate the passage of food from one section of the canal to the next.



Serosa

Secretes fluid that lubricates the peritoneal cavity (space between the membranes covering abdominal organs) allowing the organs to glide across one another. It also stores fat, holds organs in place, and provides routes (the mesenteries) for blood, lymph, and nerves.

The urinary system

Although the intestines remove undigested leftovers from food, chemical reactions in the body produce many other waste products, which build up in the blood. These wastes are dealt with by the urinary system, which consists of the kidneys, ureters, bladder, and urethra. The kidneys remove waste products from the blood and also help to regulate the amount of water in the body. Wastes and excess water, in the form of urine, are excreted via the ureters, bladder, and urethra.

Kidneys

The kidneys are two bean-shaped organs located to the rear of the abdominal cavity, just above the waist, on either side of the spinal column. Each kidney is about 5 inches (12.5 cm) long and weighs about 6 ounces (170 g). Blood enters the kidney in the renal artery to pass through tiny filter units called nephrons. The cortex (outer part) of each kidney contains about one million nephrons, made up of a Bowman's capsule, a glomerulus (knot of capillaries), and a tubule. Filtered blood leaves the kidney in the renal vein. Urine leaves via the ureter.

Ureters

These two tubes drain urine from the kidneys to the bladder. Each ureter is a muscular tube 10 inches (25 cm) long.

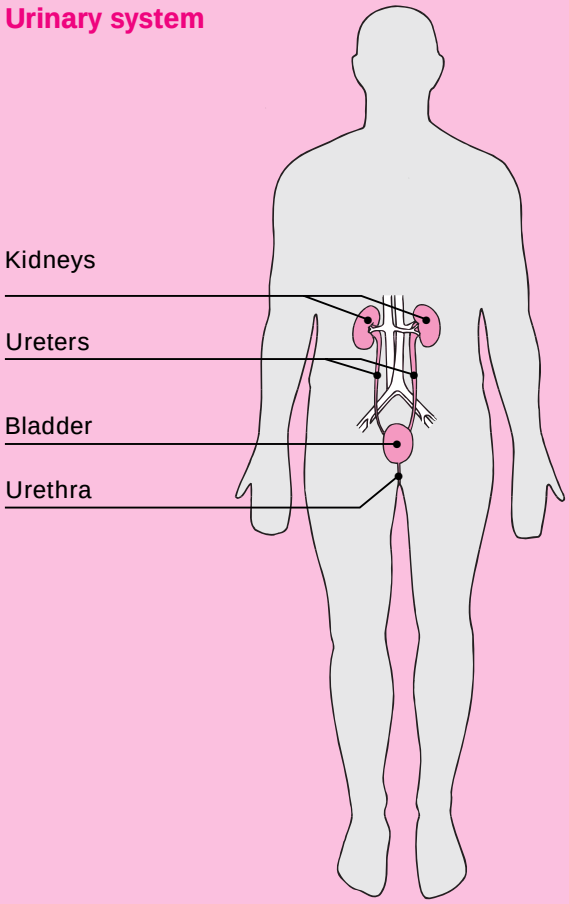
Bladder

Situated in the lower abdomen, this hollow, muscular organ acts as a reservoir for urine. It varies in size depending on the amount of urine it contains. The two ureters enter the bladder from behind. The urethra leaves from the bladder's lowest point, known as the neck. A man's bladder may hold as much as 1.2 pints (56 cl) when full.

Urethra

This muscular tube connects the bladder with the outside of the body. It measures about 1.5 inches (3.8 cm) in a woman but up to 8 inches (20 cm) in a man. Micturition (urination) occurs when the sphincter (muscular ring) between the bladder and the urethra is relaxed. This sphincter is under voluntary control.

Urinary system



Kidney function

As blood flows through the kidneys, it is filtered, purified, cleaned, and adjusted. The kidneys keep the body balanced by adjusting their output of urine to equal the intake of substances into the body. They balance the fluid levels of the body as well as balancing its acid/alkaline nature (pH). The kidneys also balance concentrations of salts, minerals, and other substances, and eliminate foreign substances, such as drugs.

Fluid regulation

Most fluid is taken into the body in the form of drinks and food. Fluid intake is regulated by the feeling of thirst (a dry mouth and throat). Fluid is lost through urination, the lungs (as water vapor), the skin (as sweat), and the gut (in feces). Fluid output is adjusted by ADH (antidiuretic hormone), a hormone secreted from the pituitary gland, and by aldosterone, a hormone secreted by the adrenals (near the kidneys).

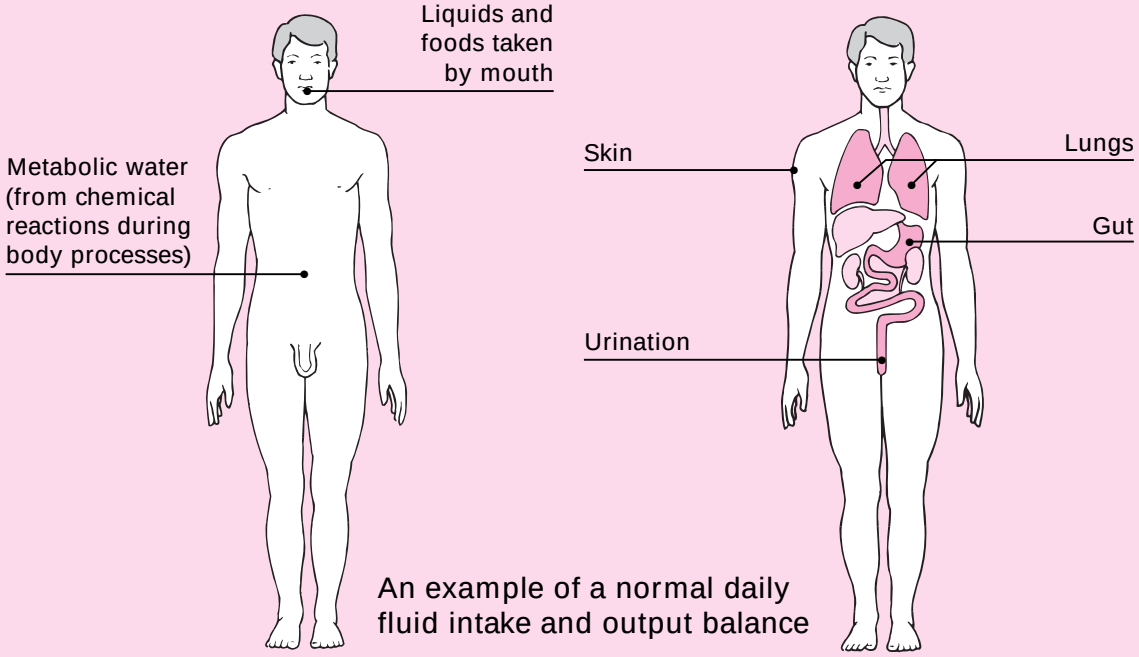
Fluid intake and output

Daily input

- Mouth—54 fluid ounces (1600 ml)
- Foods—24 fluid ounces (700 ml)
- Body processes—7 fluid ounces (200 ml)

Daily output

- Urination—51 fluid ounces (1500 ml)
- Skin—17 fluid ounces (500 ml)
- Lungs—10 fluid ounces (300 ml)
- Gut—7 fluid ounces (200 ml)



An example of a normal daily fluid intake and output balance

The human body needs food to maintain life processes and promote healthy cell growth. The substances required by the body in the form of food are proteins, carbohydrates, fats, vitamins, and minerals. The body also requires about 84.5 fluid ounces (2500 ml) of water daily—some of which will be found in food—since roughly 75 percent of the body is water. The food is broken down and resynthesized in a form that the body can use. A wide variety of foods is more likely to provide all the essential nutrients than a limited diet. It is perfectly possible to be healthy on a balanced vegetarian diet, but some extreme diets can cause malnutrition because of nutrient deficiencies.

Proteins

Proteins are complex organic compounds containing nitrogen. Dietary protein is broken down by the body to liberate amino acids that pass into the blood and are used for building and repairing body tissues. Excess protein can be used for energy or turned into fat. The diet should contain about 15 percent protein. The need for protein varies with age, body weight, and amount of physical activity. Men usually need more protein than women because they are heavier. Young children need proportionately more protein than adults because they use a great deal of their protein for the rapid growth of body tissue.

Carbohydrates

Carbohydrates—chemical compounds of carbon, hydrogen, and oxygen—should ideally make up 50–60 percent of the diet. After digestion and absorption as glucose into the bloodstream, carbohydrates may be used directly, temporarily stored in the muscles and liver as glycogen (the only carbohydrate the body makes), or converted into fat and deposited in the adipose tissues of the body. Carbohydrates provide the most readily available energy source for the body.

Fats

Fats are energy sources and should make up about 30–35 percent of the diet. They also help to prevent heat loss from the body, and to protect the body's structures. Fats are major contributors to obesity, and have been implicated in heart disease.

Vitamins

Vitamins act together with enzymes to increase the rate of chemical reactions that occur in the body. There are about 40 vitamins, of which 12 are essential in the diet. They can be divided into two groups: those that are soluble in fat (vitamins A, D, E, and K), and those that are soluble in water (vitamin C and the B complex). Fat-soluble vitamins are absorbed by the intestine, with fats, and are stored in fatty tissue. Overingestion of fat-soluble vitamins can cause dangerously high levels of these vitamins to accumulate within the body. A varied diet is necessary to provide the essential vitamins. Cooking vegetables in the minimum amount of water for only a short time will help to preserve the vitamins.

Minerals

Minerals play a vital role in the regulation of body fluids and the balance of chemicals. Some are needed in comparatively large amounts; these are calcium, phosphorus, potassium, sodium, chlorine, sulfur, and magnesium. Those that are needed in smaller quantities are iron, iodine, and fluorine. Deficiencies in these minerals can cause serious illnesses such as anemia and goiter (enlargement of the thyroid gland).

Food nutrients

The digestive system is designed to extract from food the nutrients (useful substances) that we need for growth, repair, and energy. There are six groups of essential nutrients: proteins, vitamins, fats, minerals, carbohydrates, and water.

Nutrient	Major sources	Major functions
Proteins (large molecules made up of many amino acids)	• Dairy products • Meat, fish, eggs • Legumes (peas and beans) • Bread and cereals	Provide structure for body tissues; are essential for growth and repair of cells; and as hormones, enzymes, and carrier molecules, help regulate body processes.
Carbohydrates (sugars, starches, and fiber—e.g. cellulose)	• Bread and cereals • Vegetables • Fruit	Are a major energy source; fiber provides bulk and absorbs water from digested foods; make fats and amino acids.
Fats (lipids) (combinations of fatty acids and glycerol)	• Dairy products • Meat and eggs • Vegetable oils	Are a major energy source; are the structural component of cells; transport and absorb fat-soluble vitamins; and when stored, provide energy reserves, protection for organs, and insulation.
Vitamins (chemicals the body needs for biochemical processes)	• Dairy products • Meat, fish, eggs • Fruit • Vegetables • Bread and cereals	Regulate metabolism (chemical processes within cells); maintain healthy brain, nerves, muscles, skin, and bone; enable release of energy from food.
Minerals (chemicals needed to maintain health)	• Vegetables • Legumes • Dairy products • Meat, fish, eggs	Control cell metabolism; prevent anemia (lack of iron); maintain fluid balance and healthy teeth and bones.
Water	• All groups • Water	Maintains metabolism; is essential for normal bowel functioning; and determines volume of blood in circulation.

Calories and diets

Counting calories

The measure used in talking about food and human energy needs is the kilocalorie (kcal), or calorie.
A typical number of calories for a woman to use up in a day is 2000. So this is the amount of energy her food must supply, unless she is to run down her stored reserves. Protein, fat, and carbohydrates are all sources of energy (though protein is more vital as a source of other things). One ounce (28 g) of protein or carbohydrate produces over 113 calories in the human body, and one ounce (28 g) of fat produces 225 calories. One ounce (28 g) of alcohol—rich in the carbohydrates we call sugars—produces 180 calories.

Western and Eastern diets

The West offers the most varied, cleanest, and most readily available supply of food in the history of the world. However, despite the opportunities for eating well, major nutritional problems including obesity, diabetes (associated in some cases with excessive carbohydrate intake), and digestive diseases associated with a lack of fiber, often occur. Also, food additives may be over-used in the West. Seventy-five percent of the world's people live on a diet based on just one food, usually a cereal (such as rice). Deficiency diseases and lack of food because of crop failure are common in the East. But in times of plenty, these diets often provide more nutrients than the average Western diet.

Vegetarian diets

Strict vegetarians eat only plant products—fruit, vegetables, and cereals. They do not eat any meat, poultry, fish, eggs, dairy produce, or, in some cases, honey. Their main sources of nutrients are nuts, wholewheat flour, legumes, pasta, brown rice, unrefined sugars, fruit, and vegetables (ideally eaten raw for maximum nutritional value), and unrefined vegetable oils. Soy-based milk can be substituted for cow's milk, and seaweed agar for gelatin. Strict vegetarians may need supplements of vitamin B_{12}, which can be taken in tablet form or added to food.

Lacto-ovo-vegetarian diets

Lacto-ovo-vegetarians are those who eat all foods that come from plants, and also dairy foods and eggs. This kind of diet is nutritionally sound as long as the ingredients are selected carefully. Eggs are an even better source of protein than meat, and also contain a complete protein rarely found in vegetables or fruit. Some people become vegetarians for their health. Other reasons are ethical (usually based on a belief in animal rights), religious (based on the sanctity of life), or economic (it is more economical to use land for growing crops than for feeding cattle).

Omnivorous diets

Omnivores eat food from all available sources, including meat, fish, poultry, eggs, vegetables, fruit, and cereals. Most people in the Western world are omnivores, and in theory this should be the most nutritious diet possible because all types of food are available. In practice, however, many omnivores do not plan a healthy diet because food is so readily available, and convenience foods are often easier to get than fresh foods.

Macrobiotic diets

Foods in a macrobiotic diet are labelled either yin or yang, based on their acid and alkali levels. For example, fruits and sugar are yin, meat and eggs are yang. The ratio in which these foods are eaten is supposed to be 5:1, yin to yang. Almost all foods may be eaten but there is a strong emphasis on grains, particularly brown rice.

Adolescents

The nutritional requirements of adolescents are decided mostly by the growth spurt at puberty. In boys, this is responsible for a gain in height of about 8 inches (20 cm), and in weight of about 40 pounds (18 kg). In girls, the gains are usually less. If the extra requirements are not provided at mealtimes, adolescents may have sweet snacks between meals. These may lead to obesity and dental problems, or an imbalance in the diet.

Adults

Childhood eating habits tend to continue in adult life. With freedom to choose, an adult may tend to eat what he or she finds satisfying (such as sweet things), rather than what is nutritionally worthwhile. Lifestyle may decide much of the daily food intake. People who are busy at work or in the home, may feel too rushed or tired to prepare or eat proper meals. Social events may encourage people to eat rich, fatty foods and drink alcohol.

Older people

Many elderly people remain active, and so their diet is similar to that of other adults. But as activity declines, the need for food is also less. If a person's intake is less than 2000 calories per day, the diet may be deficient in minerals and vitamins. They may need vitamin D if they do not get enough sunlight. The diet should include fresh fruit, vegetables, milk, eggs, and meat, but not too much bread or candy. Fiber is important to prevent constipation.

Eating problems

Overeating

Children who do not get enough affection or attention often turn to food for comfort, and this may lead to a dependence on food in all future times of stress. Parents should never feel that a child is rejecting them by rejecting their cooking, otherwise they can easily force the child into eating too much and suppress the body's signals of fullness.

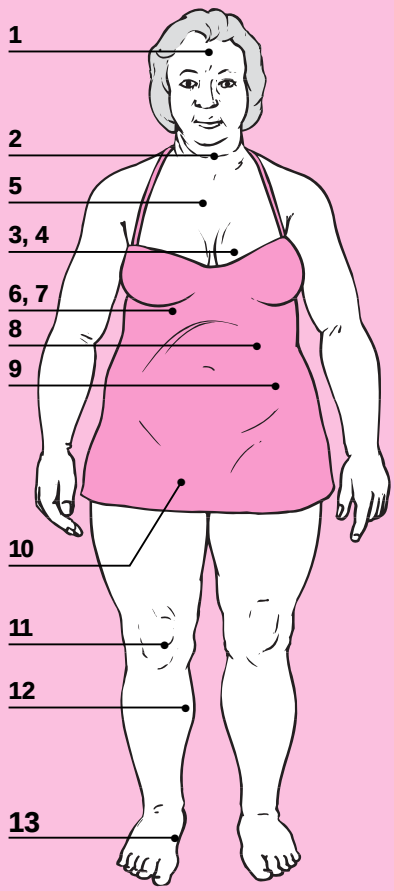
In adulthood, there are many danger situations likely to lead to overeating. Activity often declines during adulthood, but is not usually followed by a corresponding decrease in the amount of food eaten. Family difficulties, a death in the family, or work problems may all lead to the kind of stress that encourages overeating for comfort.

Effects of being overweight

Overweight people have a shorter life expectancy, and the greater their excess weight, the more their life expectancy decreases.

If the onset of obesity begins before the age of 35, life expectancy is even lower, and if it begins in childhood, the statistics are worse still. Overweight people are more accident-prone than those of normal weight, mainly because weight limits mobility so danger is more difficult to escape. Being overweight may disguise symptoms of serious diseases and make it difficult for a doctor to make a diagnosis. It also makes surgery more dangerous.

1 Strokes are more likely.
2 A double chin forms.
3 Hypertension, or high blood pressure, is more common.
4 Heart disease, heart palpitations, and poor circulation are more common.
5 Breathlessness and respiratory disease are more likely.
6 Gallbladder diseases occur more often.
7 Cirrhosis (scarring) of the liver is more common.
8 Diabetes is more common.
9 Kidney diseases of all types are more common.
10 Hernias are more frequent, especially among men.
11 Arthritis, especially of the hips and knee joints, is more common.
12 Varicose veins are more common.



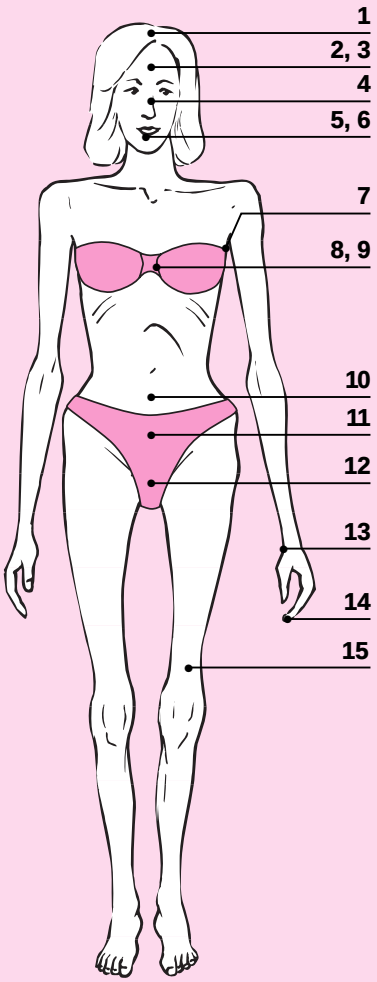
Undereating

Occasionally the normal body cycle of hunger, eating, and fullness is changed, perhaps by physical disturbances, such as illness, or by psychological disturbances, for example stress or depression. The hunger pangs that the body produces may be ignored, in an overenthusiastic attempt to lose weight or because of a psychological disturbance, and the condition known as anorexia nervosa may set in. This usually affects females between the ages of 14 and 18. Males are rarely affected. The sufferer either becomes physically incapable of eating, or vomits the food after meals (bulimia). Once anorexia is established, drastic and potentially fatal weight loss occurs. Medical help must always be sought.

Effects of anorexia

People who develop anorexia almost always say that there is nothing wrong with them; they may explain away their weight loss, or even fool themselves into thinking that they are fat. It may therefore be very hard to obtain successful treatment, since the cooperation of the anorexic is required. If left untreated, however, the condition can easily lead to death.

1 The hair changes texture, and sometimes color, because it lacks nourishment.
2 Dizziness and excessive fatigue may be felt as the muscles have no energy reserves.
3 Sleep disturbance often occurs.
4 Hormone imbalance arises.
5 Bad breath occurs because of the constantly empty stomach.
6 Decayed teeth occur if the tooth enamel is destroyed by stomach acids in vomit.
7 Hypothermia, or low body temperature, occurs as the body tries to conserve energy.
8 The electrolyte balance of the body is altered.
9 Respiration slows.
10 An excess of fine hair begins to grow on the body.
11 Chronic constipation may occur.
12 Menstrual periods often cease.
13 The pulse slows, and the blood pressure drops.
14 The fingernails become more brittle because they are not receiving nutrients.
15 Severe emaciation is one of the most obvious signs of the condition.



Reducing weight

Reducing weight requires commitment and planning. The only way to achieve a genuine weight loss is to use up more calories of energy than you take in by eating. A cut of about 3,500 calories is needed to lose one pound (0.45 kg) of body weight, so a person who would normally use 2,000 calories per day should lose about two pounds (0.9 kg) per week on a 1,000 calorie diet. This is the ideal rate of weight loss; if you lose weight more slowly you may become discouraged, and if you try to lose weight more quickly, you will damage the body tissues by breaking them down instead of your body fat.

Optimum weight

Men		Women	
Height (ft:in/m)	Weight (lb/kg)	Height (ft:in/m)	Weight (lb/kg)
5:2/1.57	119–136/54–62	4:10/1.47	100–117/45–53
5:3/1.60	122–140/55–64	4:11/1.50	103–120/47–54
5:4/1.63	125–143/57–65	5:0/1.52	106–123/48–56
5:5/1.65	128–147/58–67	5:1/1.54	109–126/49–57
5:6/1.68	132–151/60–68	5:2/1.57	112–130/51–59
5:7/1.70	136–156/62–71	5:3/1.60	115–134/52–61
5:8/1.73	140–160/64–73	5:4/1.62	119–138/54–63
5:9/1.75	145–164/66–74	5:5/1.65	123–142/56–64
5:10/1.78	149–169/67–77	5:6/1.68	127–146/58–66
5:11/1.80	153–174/69–79	5:7/1.70	131–150/59–68
6:0/1.83	157–178/71–81	5:8/1.73	135–154/61–70
6:1/1.85	161–183/73–83	5:9/1.75	139–159/63–72
6:2/1.88	165–188/75–85	5:10/1.78	143–164/65–74

Measuring weight

The chart above shows desirable weights for men and women by height. Always check with your doctor before going on a diet. Weigh yourself on the same scales, in the same room, at the same time of day, so that you have an accurate record of your weight loss. Measure your height without shoes, and weigh yourself without clothes. During middle and old age people tend to put on about 10–20 pounds (4.5–9 kg) in weight, but this is not necessary; older people will find that they stay healthier if they maintain about the same weight as they had in their 20s.

Testing for obesity

Weight is not the only measure of whether you need to go on a reducing diet. Body shape and condition will tell you a lot too. If you examine yourself honestly, you may have to admit that you could do with losing some weight. If you stand relaxed, without pulling in your muscles, does your abdomen sag? Does your stomach bulge over a tight waistband? Can you pinch a roll of flesh on your midriff, upper arm, or thigh? Do you deliberately wear loose clothes so that your real shape is hidden? Are your body measurements larger than they used to be? If so, it is a good idea to think seriously about losing weight for the sake of your health and appearance.

Food groups

The no-counting method of dieting is basically a calorie-controlled diet, but one in which you do not need to weigh all your portions of food. The foods are divided into three groups, by high, medium, and low calorific value, and the aim is to eat as much as you please of the lower group, and to avoid the foods in the high group. Foods in the middle group should be eaten only in moderation.

a This is the group of forbidden foods, such as: cakes, cookies, candy, pastries, chocolate, nuts, cream, sugar, fried foods, sausages, salami and bologna, avocado, puddings, sauces, jellies, honey, mayonnaise, and oily salad dressings.

b This is the group of medium calorific value, with foods such as: lean meat, mackerel, herring, anchovies, bananas, crackers, bread, rice, pasta, whole milk, eggs, cheese, duck, and goose.

c This is the group of very low calorie foods, such as: onions, peppers, tomatoes, mushrooms, lettuce and other salad greens, beets, apples, oranges, lemons, grapefruit, tangerines, melon, strawberries, raspberries, blackberries, peaches, nectarines, loganberries, sugar substitutes, diet soda, skim milk, black tea and coffee, unsweetened fruit juice, and water.

a High calories

b Medium calories

c Low calories

Attitude to eating

If you are trying to lose weight, and then to maintain that weight loss afterward, it will probably be necessary to alter the role that food plays in your life. Studies of overweight people show that they generally do not eat to satisfy hunger, but rather because they have uncontrolled urges for a particular food, or because food is too easily available. An overeater will not stop when his or her body has had enough, but will continue until the food is finished. Your body will need gradual re-education until you eat only when hungry, and stop eating when your hunger has been satisfied.

Eating patterns

Overweight people are open to temptation from snacks, candy stores, takeout foods, leftovers on plates, and eating while preparing food. One of the keys to successful dieting is to remove sources of temptation or to learn to overcome them. Help yourself to stop snacking by removing all tempting food from the kitchen; have only low-calorie foods available. Never buy food when you are hungry; go shopping after a meal so that your appetite will not be stimulated.

Nutritional needs

Malnutrition should not be a problem in the West, but ignorance of the body's nutritional needs may put some people at risk. Age, sex, body size, activity level, pregnancy, and illness are all factors that influence these needs. Protein intake can be between 1–3 ounces (35–85 g) per day, fat no more than 2 ounces (65 g) per day, and carbohydrates between 9–20 ounces (250–560 g) per day. The average person will be able to get all the nutrients they need from a daily diet that includes two servings (5–6 ounces/142–170 g) of meat, fish, poultry, eggs, beans, peas, or nuts; two to three cups of milk or the equivalent in cheese or yogurt (preferably fat-free or low fat); five to seven servings of fruit or vegetables (to include both); and six to nine servings of cereal, bread, pasta, or rice (a serving is a slice of bread or a cup of cereal). Foods high in fat or sugars are best avoided.

Pregnancy

During pregnancy, a well-balanced diet is essential for the development of the fetus. A pregnant woman needs about 15 percent more calories, and may need extra folic acid (the need doubles at this time), iron, and calcium. Weight gain should be about 20–25 pounds (9–11 kg).

Indigestion

Dyspepsia or indigestion is one of the most common digestive problems. Symptoms are nausea, heartburn, abdominal pain, discomfort or distension. Causes may be psychological, or be due to food intolerance or disease. A bland diet and regular meals may help.

Hypertension

Two dietary factors may predispose a person to high blood pressure (hypertension)—obesity and a diet high in salt. Weight loss and a low sodium diet are usually recommended to reduce blood pressure. Foods to be avoided include butter, bacon, and canned fish.

Illness and convalescence

People who are ill or recovering from illness may have little appetite and low food tolerance. Ample protein and energy foods are needed to repair the drain on the body's reserves and to restore the person's strength. Immobilization in bed may have caused demineralization of the bones. Milk is a good source of calcium to correct this.

Effects of inadequate nutrition

There are many theories and much research into the link between diet and disease. Here are some of the most commonly known effects of malnutrition.

1 The hair may become dull and brittle, or it may fall out or change color.

2 Headaches may be related to vitamin deficiency.

3 Nightblindness may arise from a lack of vitamin A.

4 The tongue may become inflamed as a result of a number of vitamin deficiencies.

5 Bleeding gums may be a sign of scurvy (vitamin C deficiency).

6 Enlargement of the thyroid gland (goiter) may be linked to iodine deficiency.

7 Rashes, itching, soreness, scaliness, and cracking of the skin may be the sign of a number of vitamin deficiencies.

8 Softening of the bones may be a sign of rickets (lack of vitamin D).

9 Loss of motor function in the legs may be sign of beriberi (lack of vitamin B_1, or thiamine).

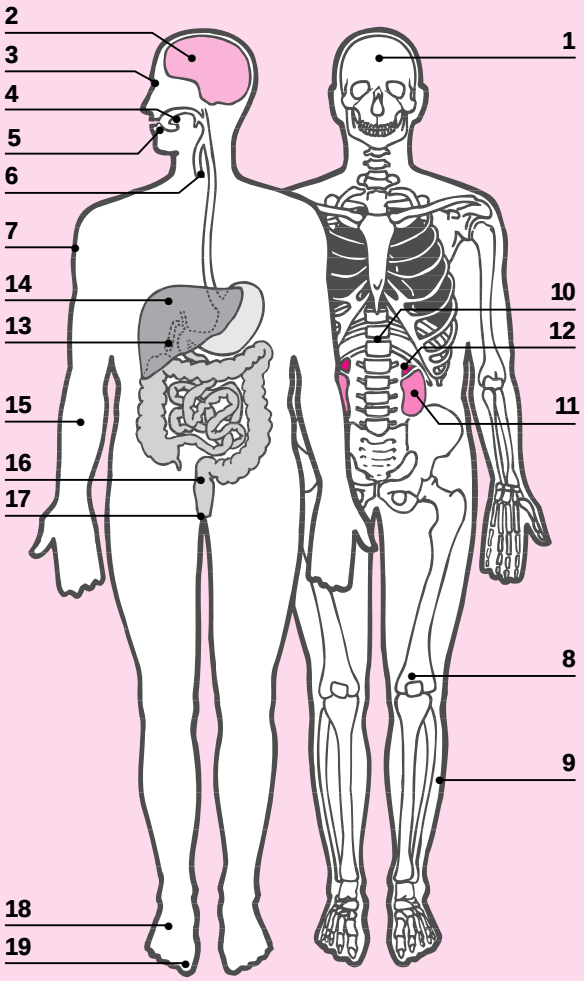
10 Lesions in the spinal cord may be a sign of vitamin B_{12} deficiency.

11 Stones may form in the kidneys as a result of insufficient fluid; obese people may be prone to kidney failure.

12 Adrenal glands may enlarge as a result of salt deficiency (related to the B vitamins).

13 The formation of gallstones is associated with a fatty diet.

14 Too much alcohol may cause cirrhosis (scarring) of the liver.



15 Insufficient iron will cause anemia.

16 Constipation can be caused by lack of fiber in the diet.

17 Piles (hemorrhoids) may also be a result of lack of fiber.

18 Swelling and painful feet may be a sign of vitamin B_{12} deficiency.

19 Numbness in the toes may be a sign of vitamin deficiency. Attacks of gout are connected with overindulgence in rich food and alcohol.

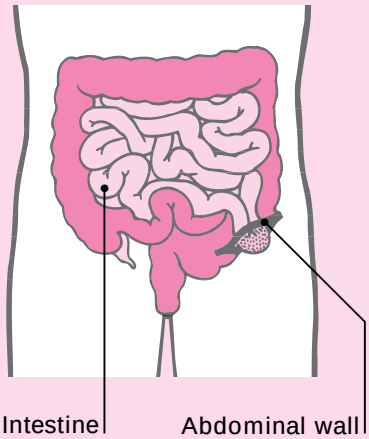
Digestive disorders

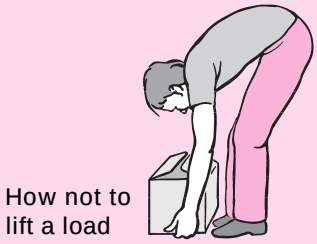
Almost all general digestive disorders, such as indigestion, gastroenteritis, and constipation, respond to self-help that can be given in your own home or workplace. For instance, drinking plenty of fluids is a commonsense way of restoring body fluids lost through vomiting or diarrhea, and by taking care about what, when, and how you eat, you may be able to heal a peptic ulcer. Modifying your daily pattern of activity also helps with the pain and discomfort of some digestive ailments. People with esophagitis (inflammation of the esophagus) benefit from lying down after eating, while hiatus hernia sufferers are better if they stand after meals. Care with lifting heavy loads may prevent a hernia, and will certainly reduce the risk of worsening an existing one. Of course, medical help is needed to establish diagnosis and treatment of serious conditions.

Types of hernia

Hernias (ruptures) occur where part of the intestine pokes through a weak part of the abdominal wall. Inguinal hernia occurs in males of all ages where the thigh meets the abdomen. Femoral hernias (commonest in women) occur at the top of the thigh. Umbilical hernias (often seen in infants) protrude from the navel. Some hernias regress naturally, and others can be pushed back into place. But if a hernia gets nipped at its entrance, the resulting strangulated hernia causes pain and vomiting, and needs urgent medical aid. In hiatus hernia, the upper stomach bulges up where the esophagus passes through the diaphragm.

Hernia

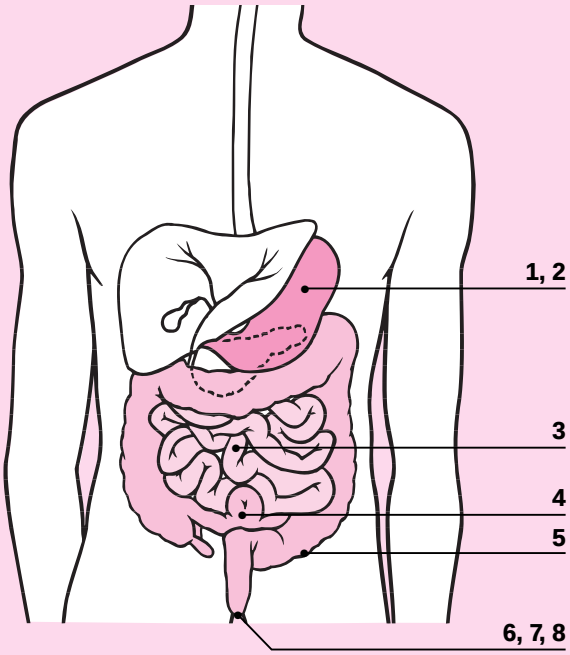




Avoiding hernias

Some hernias occur because channels fail to close properly during pre-birth development, but most hernias develop when muscular exertion forces the abdomen through a weak part of the abdominal wall. To avoid this kind of hernia, do not exert unusually sudden muscular force that raises pressure within the abdomen. Do not cough violently or strain the bowels. Raise any heavy weight from a squatting position rather than bending and lifting from a standing position. Using the correct lifting posture helps to prevent back strain as well as hernias.

Digestive tract troubles



1 Dyspepsia, or indigestion, usually results from excess acid secreted in the stomach. Eating too quickly, or taking too much food in one meal, may also cause indigestion.

2 Gastroenteritis is inflammation of the stomach, and possibly the entire digestive tract. Food poisoning, allergy, irritant foods, or chemicals may be to blame.

3 Umbilical hernia is a navel swollen by a protruding piece of intestine. Common in babies, this usually needs no treatment and regresses by age two.

4 Inguinal hernia of the groin may get pinched, causing acute pain, vomiting, and swelling in the groin. If left untreated, peritonitis (inflammation of abdominal membranes) may result.

5 Femoral hernia, occurring at the top of the thigh, may also get strangulated.

6 Diarrhea happens when the bowels try to purge themselves of some irritant or poison. The bowels respond to irritation by producing extra mucus and speeding up the rate at which waves of muscular contraction force feces through the bowel. This means there is less time than usual for the intestines to absorb water. This usually results in colicky pain, and an irresistible urge to open the bowels frequently, passing movements that are thin and watery. Seek medical advice if diarrhea is severe or persistent, or if it alternates with constipation.

7 Constipation is likely to happen to anyone who eats little food, takes little fluid, has a diet low in fiber, takes no exercise, or persistently ignores the need to open the bowels. Habits such as hurrying to work straight after breakfast, or rising late in the morning, may be to blame. Other possible causes of constipation include depression, some medicines, and certain physical diseases. All basically healthy people can cure constipation by taking exercise, drinking plenty of fluid, and including sufficient fiber in the diet.

8 Food poisoning almost always occurs as a result of poor food hygiene. Symptoms typically include vomiting, diarrhea and abdominal pain; they may start up to 24 hours after eating food contaminated with bacteria, but within an hour if the poisoning is caused by bacterial toxins. Take plenty of fluids, and call a doctor if the symptoms are severe or last for over 24 hours.

Introduction

The digestive journey begins in the mouth. The main process at this stage of the journey is mechanical digestion, which involves the physical breakdown of food by chewing with the teeth and tongue, and the passing of food to the stomach by muscular contractions called peristalsis. There is also some chemical digestion, which occurs as a result of saliva being mixed with the food in the mouth. Saliva contains enzymes that break down carbohydrates.

Digestive system key words

Adenoids Tonsils (lymphoid tissues that protect against bacteria) located at the back of the nose cavity.

Epiglottis A flap of cartilage behind the tongue that is closed during swallowing to help stop food from entering the larynx and windpipe.

Esophagus (or gullet) The muscular tube through which food travels between the pharynx and the stomach.

Larynx The voice box, located just below the pharynx.

Nasopharynx The part of the pharynx above the soft palate.

Palate The roof of the mouth, divided into the anterior hard palate at the front, and the posterior soft palate at the back.

Pharynx The throat.

Salivary glands The lingual, parotid, sublingual, and submandibular glands, which produce saliva.

Taste buds Tiny sensory organs (circumvallate papillae, filiform papillae, fungiform papillae) on the tongue and palate.

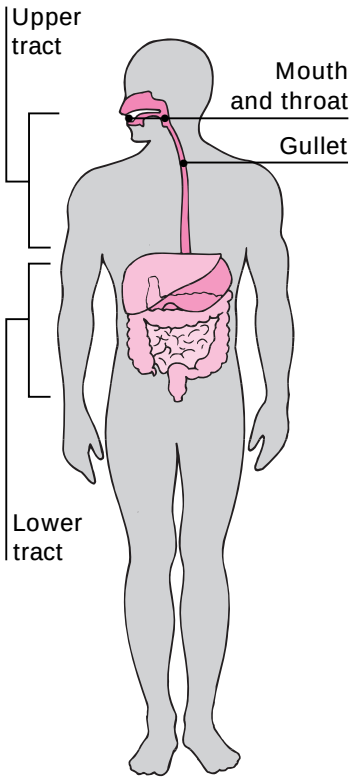
Teeth Bonelike structures in the jaws. Different types (incisors, canines, premolars, molars) are specialized to pierce, tear, crush, and/or grind food.

Tongue A mobile, muscular organ in the mouth, involved in tasting, chewing, swallowing, and speech.

Trachea (or windpipe) An air passage leading from the base of the larynx to the top of the lungs.

Uvula Conical flap of soft tissue hanging down from the soft palate, which helps to stop food and liquid from entering the nose.

Upper & lower tract



The upper digestive tract is the place where food first enters the digestive system. It consists of the mouth, throat, and gullet, or esophagus. The throat and esophagus connect the mouth with the stomach. Once food reaches the stomach, it enters the lower digestive tract (see Section 4).

Structure and functions of the mouth

The mouth, or oral cavity, is a mucosa-lined cavity housing the teeth and tongue (accessory digestive organs). It is made up of the lips, cheeks, and palate.

Lips

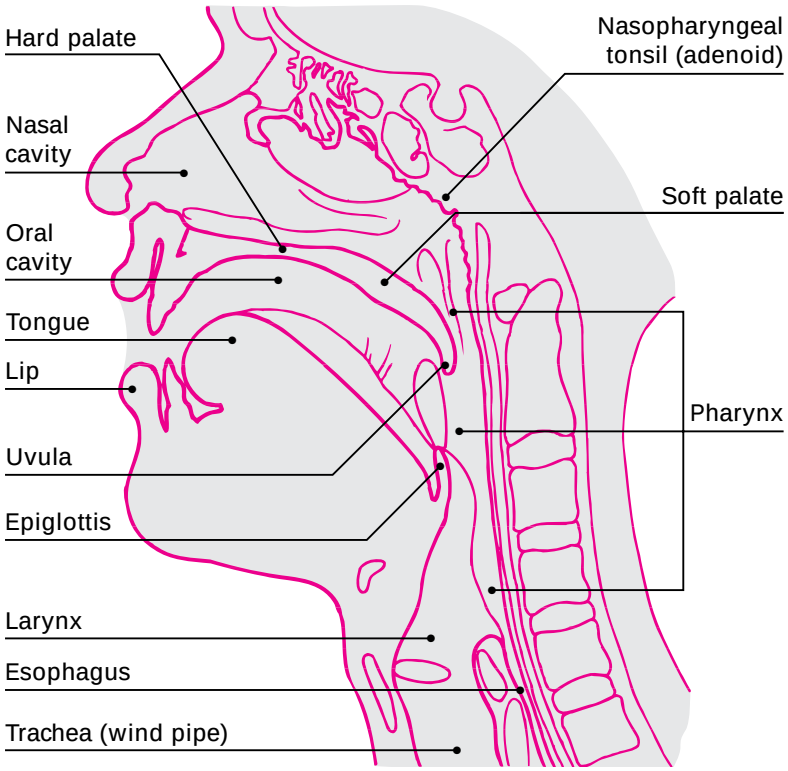
The lips, or labia, are folds of skeletal muscle with a thin covering of epithelium (layer of cellular lining tissue). The functions of the lips are:

- To hold food in the mouth and keep it in place for chewing;
- to protect the anterior (front) opening of the mouth; and
- to judge the texture and temperature of foods.

Cheeks

The main components of the cheeks are the buccinator (cheek) muscles. The cheeks are lined with cellular tissue, which protects against abrasion from food particles. The main function of the cheeks is to keep food between the teeth during chewing.

Section of the head



Palate

This is the roof of the oral cavity. The front part, the hard palate, is supported by bone. The rear part, the soft palate, is made up of skeletal muscle and connective tissue. The soft palate ends in a projection called the uvula. The main function of the palate is to prevent food from entering the nasal cavity during swallowing. This is achieved by the soft palate and uvula rising to cover the nasopharynx (entrance to the nasal cavity). The palatine tonsils (paired masses of lymphoid tissue) are at the rear of the oral cavity. The tonsils have no digestive function but defend against bacteria that enter the mouth.

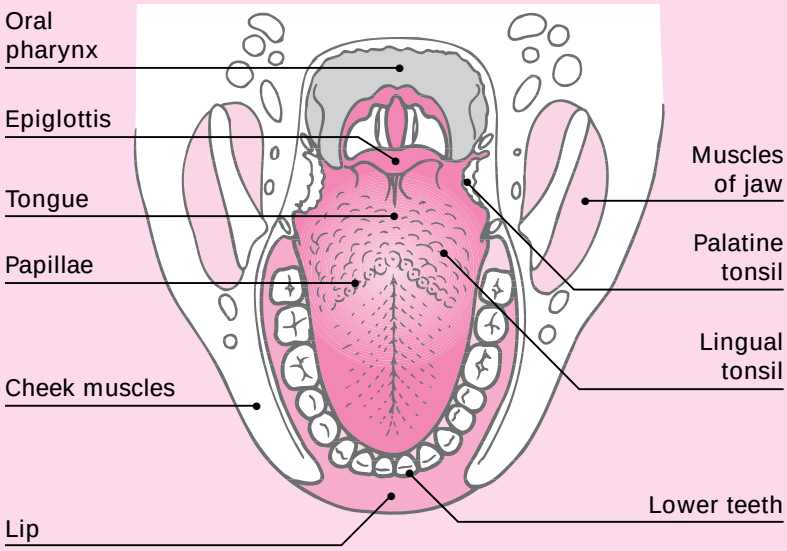
The tongue

Tongue

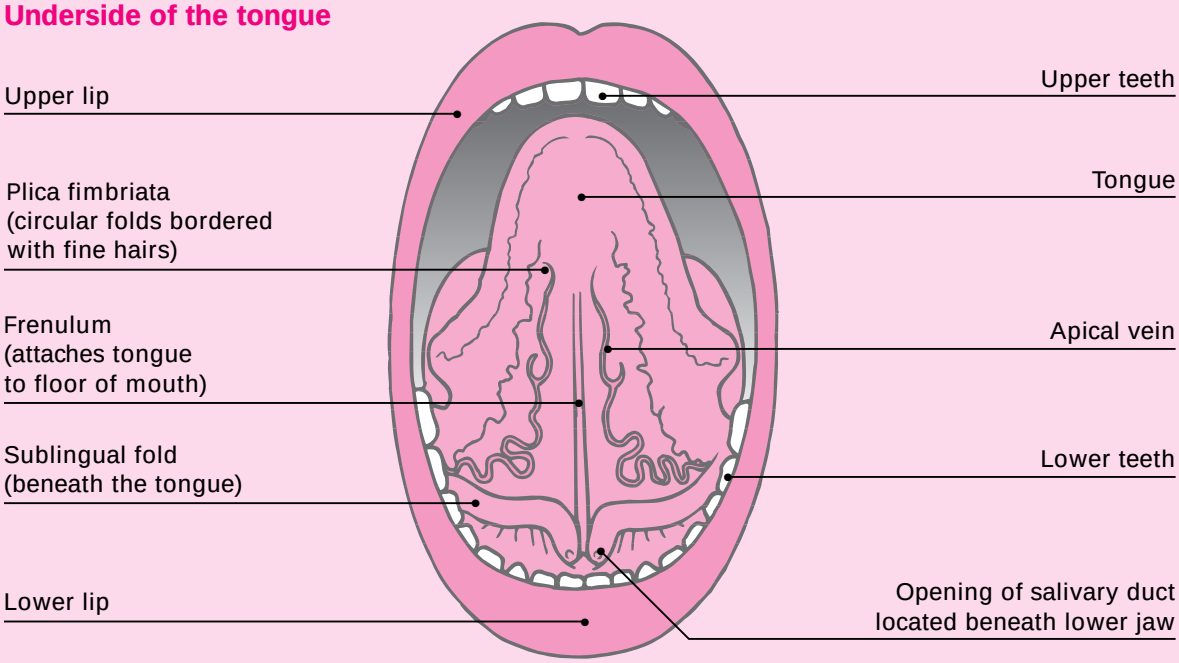
The tongue is made mainly of skeletal muscle covered with a mucous membrane. A thin membrane called the frenulum anchors the tongue to the floor of the mouth.

The top surface of the tongue contains papillae, taste buds, and other structures associated with sensing different tastes. The front of the tongue manipulates food during chewing, and the base helps in shaping the food for swallowing.

Cross section through the mouth

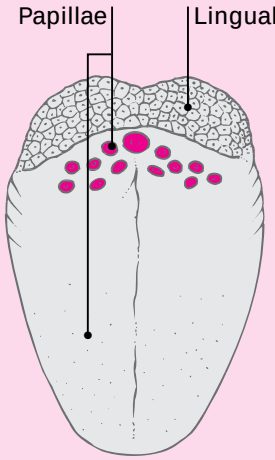


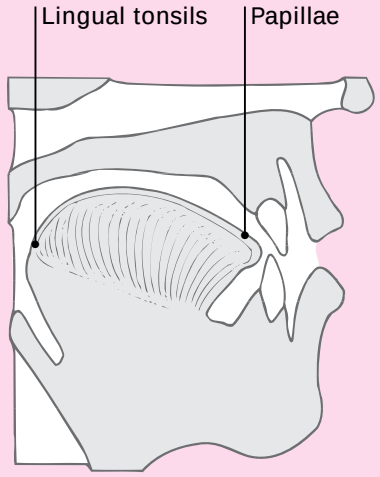
Underside of the tongue



Structure and functions of the tongue

Intrinsic muscles within the tongue allow it to alter its shape. Extrinsic tongue muscles are attached to the skull bones and soft palate, and allow the tongue to alter its position. Various types of papillae (small bumps) project from the tongue's upper surface. Embedded in the rear surface of the tongue are the lingual tonsils. The main functions of the tongue are:

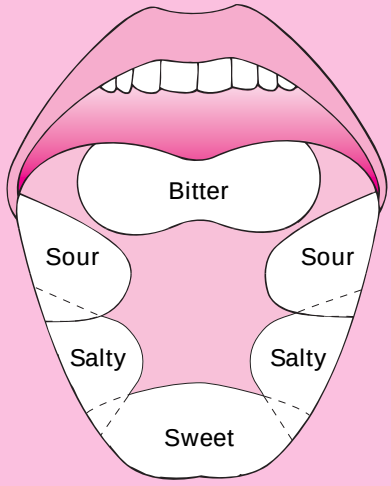




- manipulating food for chewing;
- mixing the food with saliva, shaping it into a bolus and directing it toward the pharynx for swallowing;
- stimulating saliva secretion;
- providing friction for manipulating foods via the papillae (which help the tongue to grip food); and
- defending against bacteria with the lingual tonsils.

Taste regions

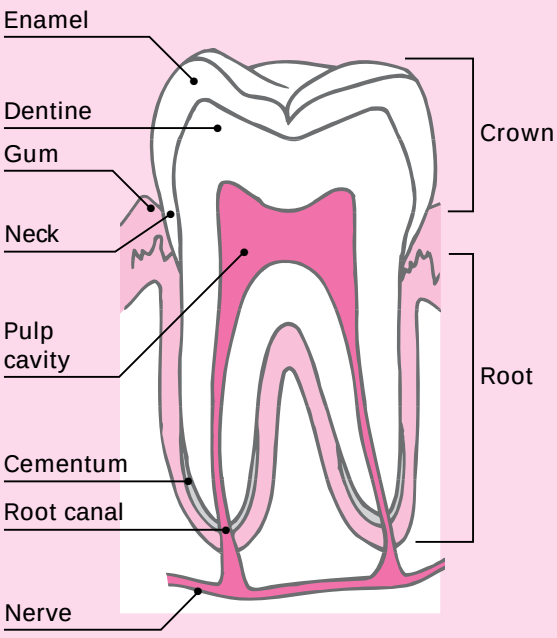
In the skin around the base of the papillae (small bumps) are tiny sensory structures called taste buds, which are connected to a main nerve by a bundle of nerve fibers. Taste buds on different parts of the tongue are sensitive to different tastes—bitter at the back, sweet at the front, and sour or salty at the sides.



Structure of teeth

A typical tooth consists of three main parts: the crown, the neck, and the root. The crown is the part that projects upward from the gum. It is covered in enamel—the hardest substance in the body. The root fits into a socket in the upper or lower jaw. The neck joins the crown to the root.
It is a narrow part of the tooth, which is surrounded by the gum. In the center of a tooth is a pulp cavity, which is a soft core of connective tissue that contains nerves and blood vessels.

Structure of a permanent molar tooth

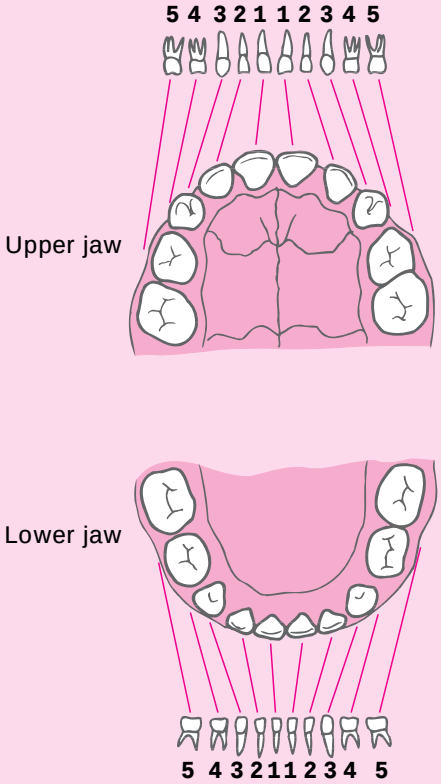


Deciduous dentition

Six months or so after birth, the first deciduous (milk or baby) teeth push through the gums. By the age of two, a child usually has 20 baby teeth.
At about six years of age, the first permanent teeth start to push out the baby teeth. By the age of 17–24 years, a full set of 32 adult teeth is usually present in the gums.

Teeth of a young jaw

1 Central incisor (6–8 months)
2 Lateral incisor (8–12 months)
3 Canine (15–20 months)
4 First molar (12–16 months)
5 Second molar (20–40 months)



Function of teeth

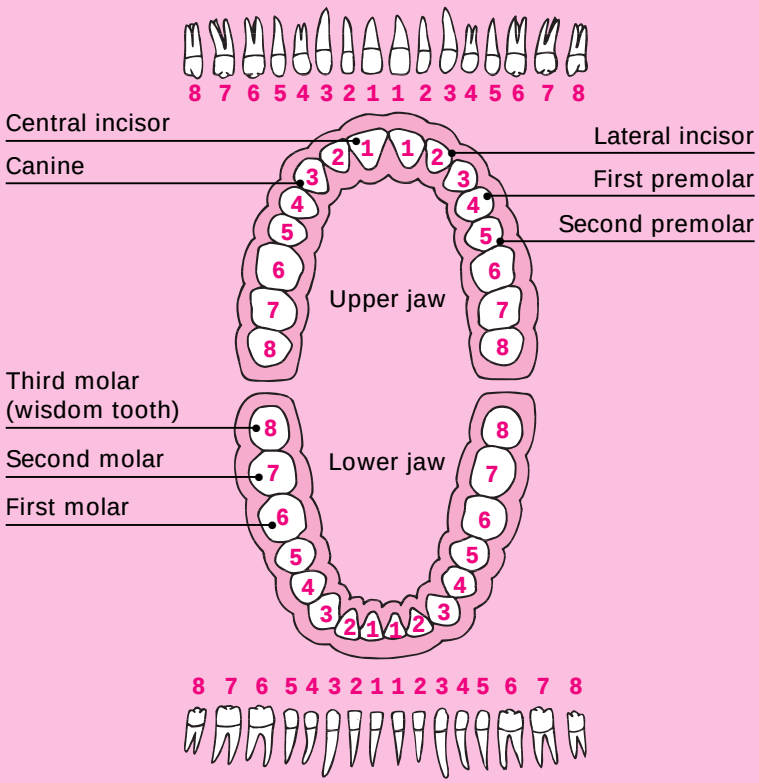
Teeth are hard structures set in the jaw. There are four types, each with a different shape and function. All teeth are involved in the process of mastication (chewing). This is a form of mechanical digestion involving the mouth, the teeth, and the tongue. The purpose of mastication is to reduce the food to a soft, flexible mass that is easily swallowed.

Mastication occurs in two stages:

1 incisors and canines shear the food;

2 as the jaws open and close, the tongue pushes food between premolars and molars, which grind the food.

Individual teeth of the jaw



Tooth	Shape	Function
Incisor	• chisel-shaped with sharp edges	• biting into and cutting food
Canine (cuspid or eyetooth)	• conical with cusps (points)	• grasping, shredding, and tearing food
Premolar (bicuspid)	• flat surfaces with two distinct edges	• grinding food
Molar	• large with flat surfaces and rounded edges	• crushing and grinding food

Dental hygiene

Dental cavities are one of the most common medical problems in many Western countries. Cavities occur mainly because of the high sugar content of the Western diet, made worse by poor personal dental hygiene. Some people have a full set of dentures by middle age, but this can be avoided if the teeth and gums are adequately cared for through childhood and adulthood. Dental problems can be minimized by brushing and flossing the teeth regularly, visiting the dentist two or three times a year, and cutting down on sweet and starchy foods, especially between meals.

Teeth facts

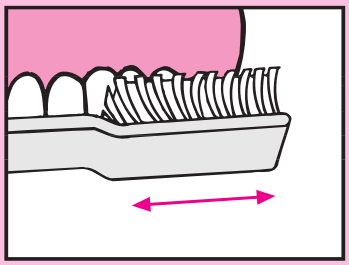
- Bacteria in the mouth feed on sweet or starchy food, producing acids, which cause cavities in the teeth.
- Dentists clean and fill tooth cavities to prevent further tooth decay.

Brushing the teeth

Brushing is one way to fight tooth decay, as it removes most of the plaque and bacteria from the surfaces of the teeth. Your toothbrush should have a small head, with medium-firm multitufted nylon bristles; it should be changed as soon as the bristles begin to spread. Teeth should be brushed after every meal, as acid begins to form immediately; plaque collects in a matter of hours. Even babies' and toddlers' teeth should be brushed.

The illustrations show brushing techniques recommended for maximum efficiency in plaque removal.

1



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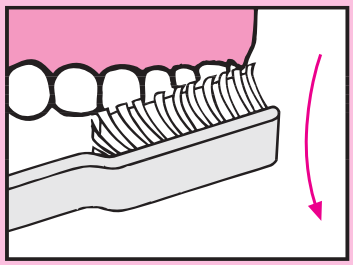

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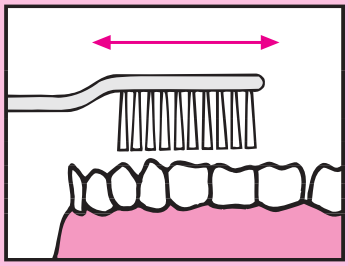

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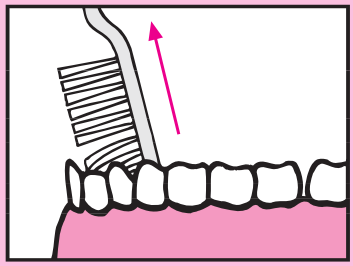


1 Place the brush against the teeth as shown, and move it slightly from side to side so that the bristles reach into the gap between the teeth and the gums.

2 When the bristles are well positioned, brush away from the gums with a slightly rocking action. Repeat steps 1 and 2 on the insides and outsides of the top and bottom teeth.

3 Brush back and forth across the top surfaces of the teeth.

4 Brush the insides of the front teeth by tilting the brush and brushing away from the gums.

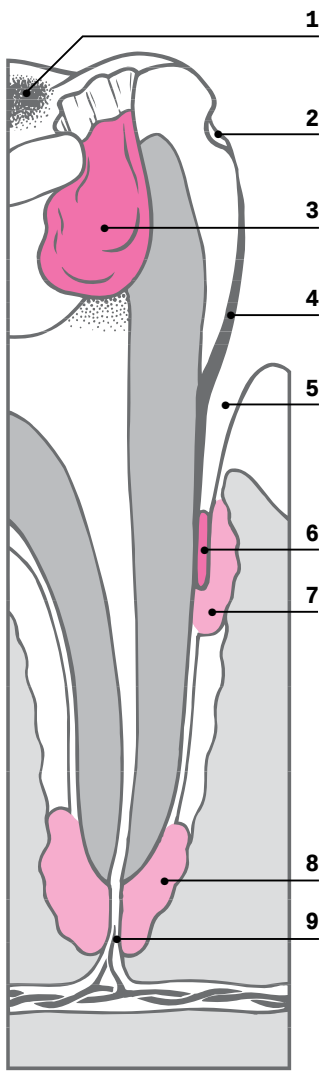
After brushing, use dental floss to remove any plaque remaining in the spaces between the teeth.

Tooth and gum problems

The illustration on the right shows some of the common problems that may arise as a result of poor dental hygiene.

1 Discoloration of the tooth; this may be a result of smoking, or excessive consumption of tea or coffee, or it may be an indication that the pulp at the center of the tooth is dead. Some drugs may cause the permanent discoloration of children's teeth.
2 Small cavity; this cavity, caused by tooth decay, is still confined to the enamel of the tooth and has not yet reached the sensitive dentine and pulp in the center of the tooth.
3 Large cavity; here the tooth has decayed right down to the central pulp where the nerves of the tooth are located. This causes pain and sensitivity at first, and eventually the death of the pulp.
4 Plaque, a sticky, bacteria-filled film that builds up on the tooth as a result of ineffective cleaning. If plaque is not removed, it hardens into a substance known as calculus or tartar.
5 Periodontal pocket caused by the breakdown of the bone and fibrous attachments holding the tooth in the gum. As more of the periodontal attachments decay, the tooth loosens and finally drops out.
6 Debris, plaque, and tartar, collected in the periodontal pocket. Even meticulous cleaning cannot remove debris that is located so far under the gum, and once pockets are formed, debris and plaque build up rapidly, leading to foul breath and infection.
7 Gumboil or periodontal abscess caused by the decay of debris in the periodontal pocket and subsequent infection.
8 Abscess at the base of the tooth, caused by bacteria in the decaying tooth pulp. Since the infection has no escape route, great pain is caused.
9 Loss of blood supply to the tooth causes death of the pulp, which in a healthy tooth has its own blood supply.

Section through a diseased tooth



Salivary glands

Salivary glands

Most saliva is produced by the three large pairs of extrinsic (lying outside the mouth) salivary glands. These are the parotid, sublingual, and submandibular glands. The small intrinsic (lying inside the mouth) salivary glands, or buccal glands, are located in the mucous membrane lining the mouth. They secrete small amounts of saliva.

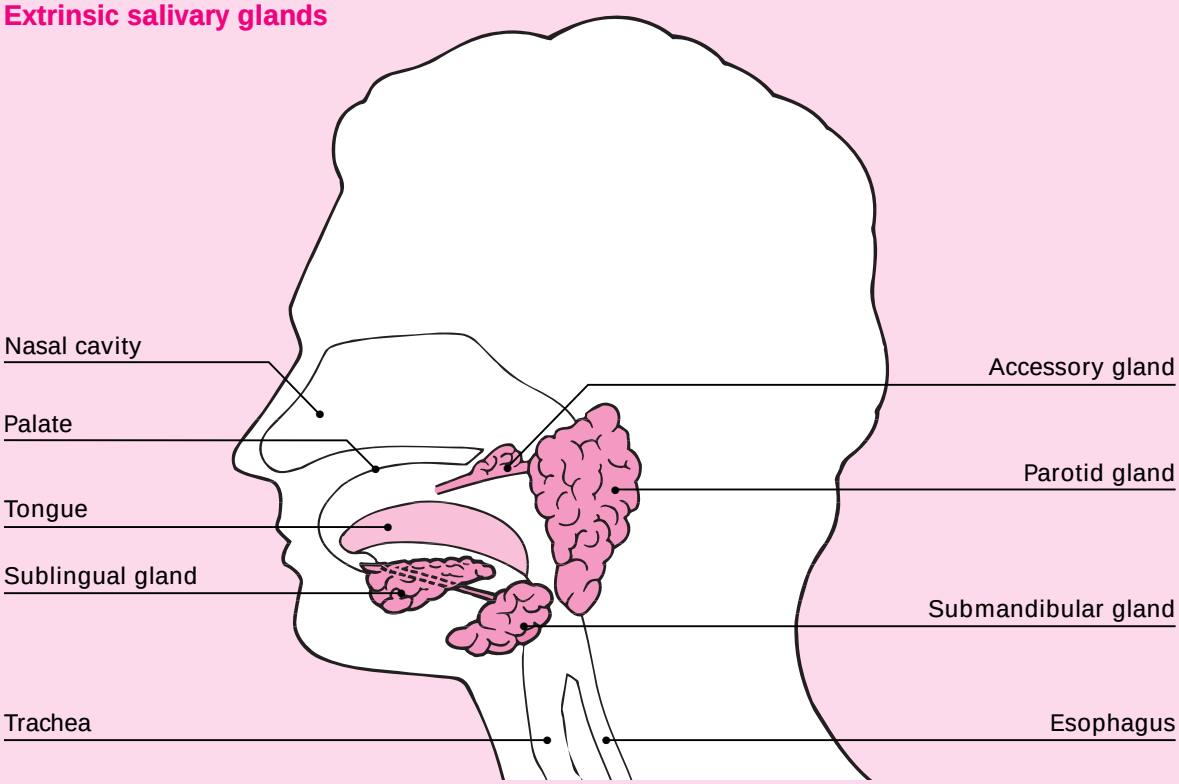
Digestive enzyme

Extrinsic salivary glands produce saliva from a mixture of cells secreting mucus and serous (thin, watery) fluid. Serous fluid contains the enzyme salivary amylase. This enzyme immediately begins the digestion of carbohydrates, breaking them down into maltose and dextrin.

Saliva facts

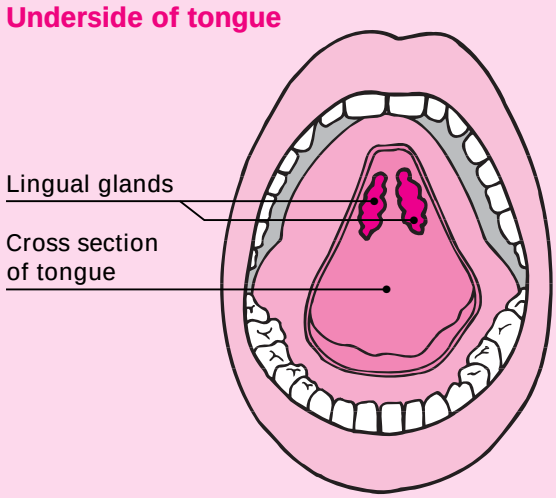
- The salivary glands secrete more than 36 fluid ounces (one liter) of saliva every day.
- Stomach acids inactivate salivary amylase minutes after it is secreted.
- Saliva is secreted upon smelling food and drink, before anything enters the mouth. A meal is said to be "mouthwatering" if it prompts this reaction.

Extrinsic salivary glands



Sublingual glands

These are the smallest salivary glands, which are located at the front of the mouth just under the tongue. (Sublingual means "under the tongue.") The secretion of the sublingual glands is high in mucus and low in salivary amylase. Tiny ducts leading from these glands carry their salivary secretions into the floor of the mouth.



Saliva

Saliva is more than 95 percent water. The rest is composed of various solutes (dissolved substances), chemicals, mucus (thick, slimy fluid), and waste materials.

In addition to starting the chemical breakdown of carbohydrates, saliva has a number of different functions. It moistens food with water, and lubricates it with mucus to help it slide easily down the throat during swallowing. It also moistens and lubricates the mouth and the tongue, and dissolves solid substances, enabling food to be tasted with the taste buds. Saliva cleanses the mouth and the teeth, and inhibits the growth of bacteria. The high bicarbonate concentration of saliva helps to reduce tooth cavities by neutralizing the acidity of food in the mouth.

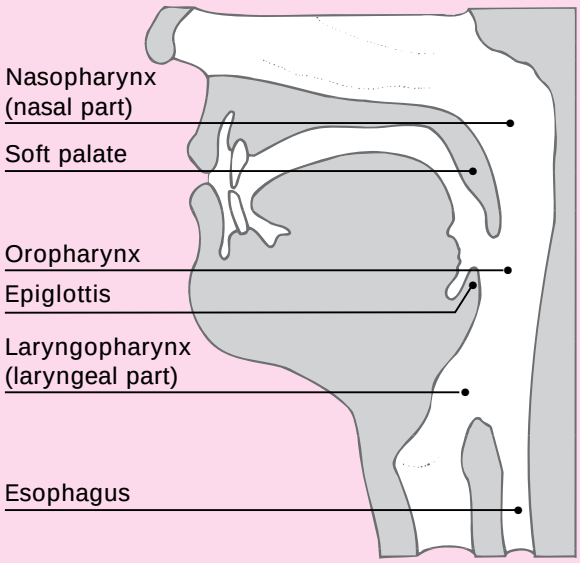
Salivation

The salivary glands are constantly secreting low levels of saliva to keep the mouth and throat moist. This process is known as salivation. The ingestion of food, however, stimulates the glands to secrete heavily. Increased secretion is activated both psychologically and physiologically. In psychological activation, the smell, sight, and touch of food, or the sound of food preparation, can stimulate increased salivation. In physiological activation, the taste buds are stimulated by dissolved substances in ingested food.

Pharynx and esophagus

Pharynx structure and function

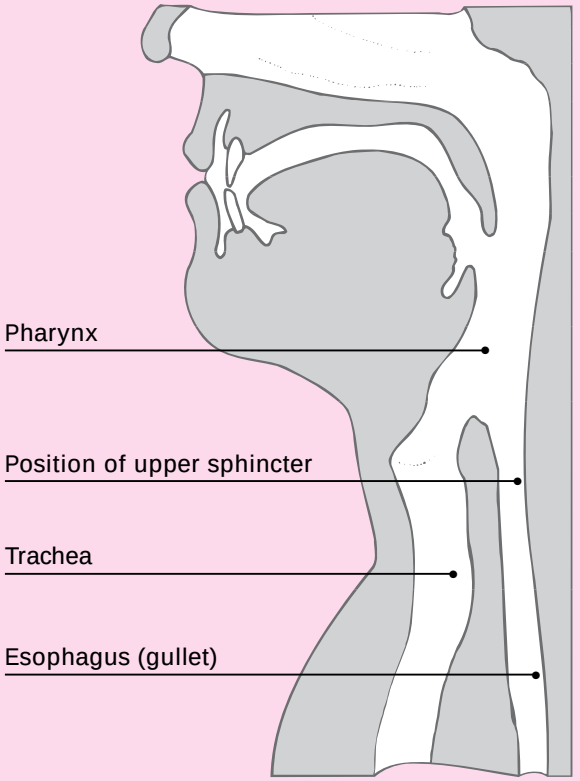
The pharynx (throat) is a tubelike structure made of muscle and lined with mucous membrane. It connects the back of the nose and mouth with the esophagus. The pharynx acts as an air passage during breathing and a food passage during swallowing. It propels food into the esophagus by means of peristalsis (wavelike contractions of its muscular walls). The pharynx can be divided into three parts: the nasopharynx (above the soft palate), the oropharynx (from the soft palate to the epiglottis), and the laryngopharynx (from the epiglottis to the esophagus).



Esophagus structure and function

The esophagus, or gullet, is a collapsible muscular tube through which food passes from the pharynx to the stomach. The passage of food in and out of the esophagus is controlled by upper and lower esophageal sphincters. These rings of muscle relax occasionally, allowing the contents of the digestive tract to pass through.

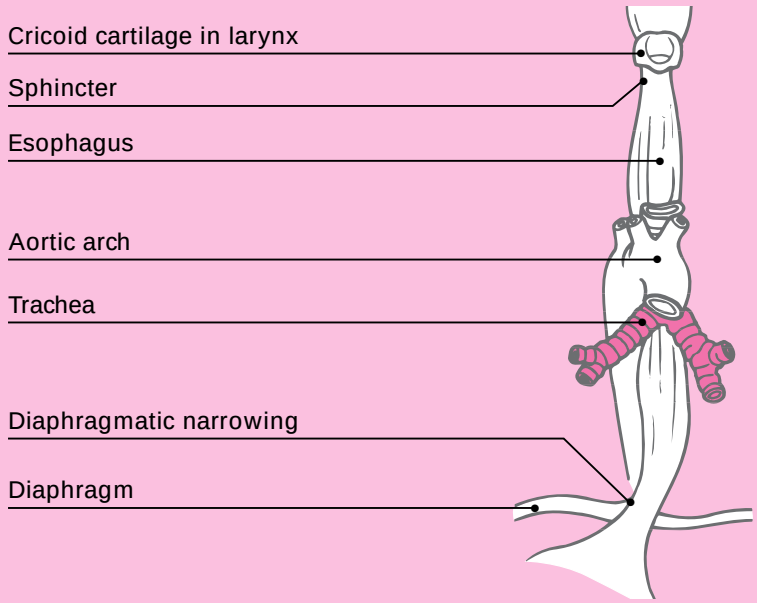
The upper sphincter links the pharynx to the esophagus. The cardiac (lower) sphincter links the esophagus to the stomach. The esophagus secretes mucus (thick, slimy fluid) to help the passage of food, and propels food along using peristalsis. Peristaltic waves are able to squeeze food from the throat down to the stomach in approximately one or two seconds.



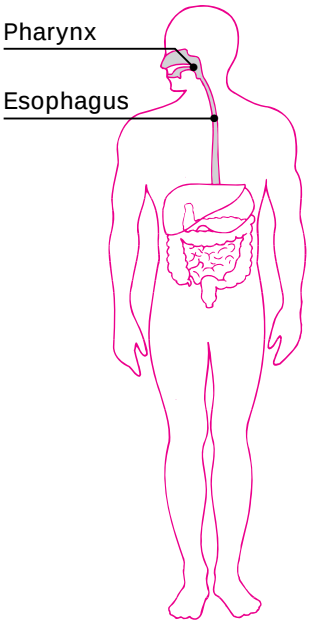
Esophagus

The esophagus is about ten inches (25 cm) long. It is positioned just in front of the spine and behind the trachea, or windpipe. After passing through the lower neck and thorax, the esophagus passes through the diaphragm and joins the stomach in the abdominal cavity. The diaphragm is a sheet of muscle separating the chest cavity from the abdominal cavity.

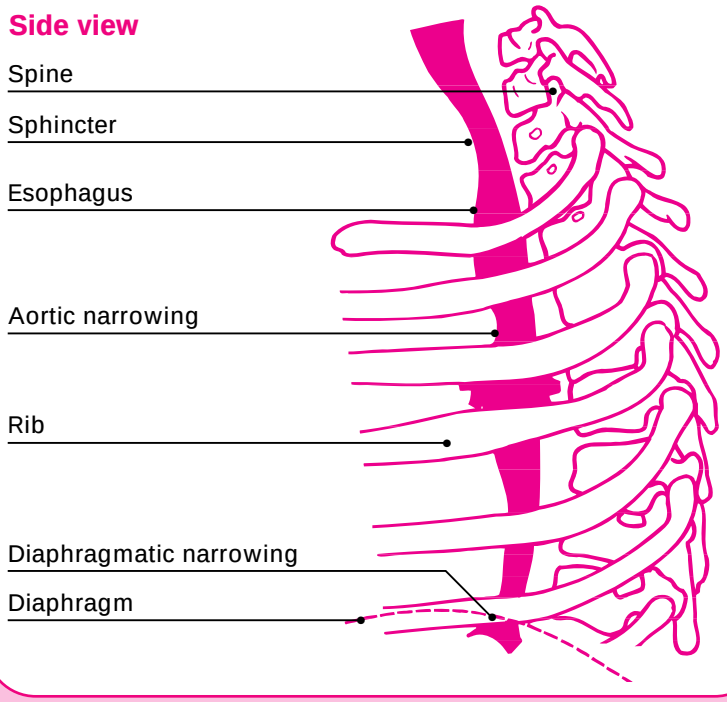
Front view showing relative position



Position guide



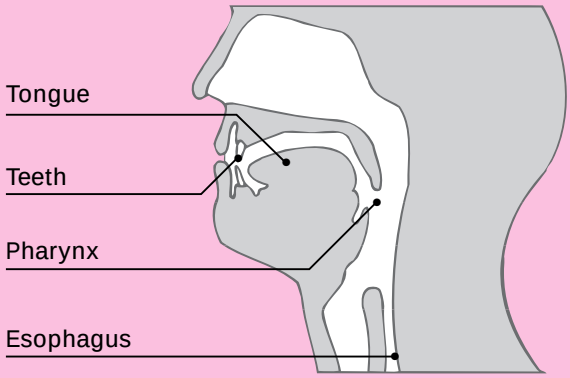
Side view



Swallowing

Swallowing

Swallowing, or deglutition, is the process that propels food from the mouth to the stomach. It involves the mouth, teeth, tongue, pharynx, and esophagus. The process involves two phases—the buccal phase and the pharyngeal-esophageal phase. Food does not normally enter the larynx during swallowing, but if food does go down the wrong way, the coughing reflex helps to prevent choking.

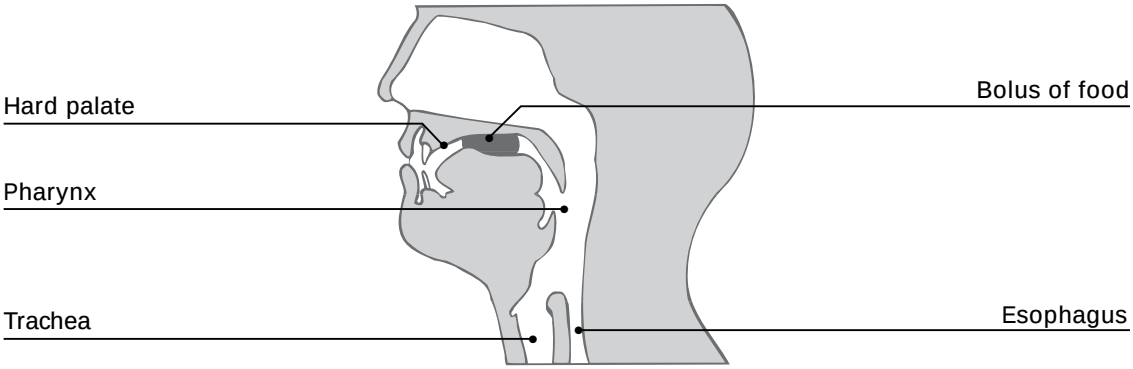


Buccal phase

Steps **1** through **2** are called the buccal (oral) phase. This stage is voluntary (under conscious control).

1 Food is prepared for swallowing in the mouth. This involves chewing the food and mixing it with saliva to form a bolus (ball-like mass).

2 The tongue rises and presses against the hard palate. This forces the bolus of food into the pharynx.



Swallowing fact

- "Deglutition" comes from the Latin word *deglutire*, meaning "to swallow down."

Choking fact

- A bolus of food entering the trachea, rather than the esophagus, causes choking.

Pharyngeal-esophageal phase

Steps **3** through **9** are known as the pharyngeal-esophageal phase. This stage is involuntary. It is a reflex (automatic) action triggered by food stimulating receptors in the pharynx.

3 The soft palate rises to cover the nasal cavity to stop food from entering.

4 The larynx (voice box) rises so that the epiglottis (flap of cartilage) covers its opening. This prevents food from entering the air passages to the lungs.

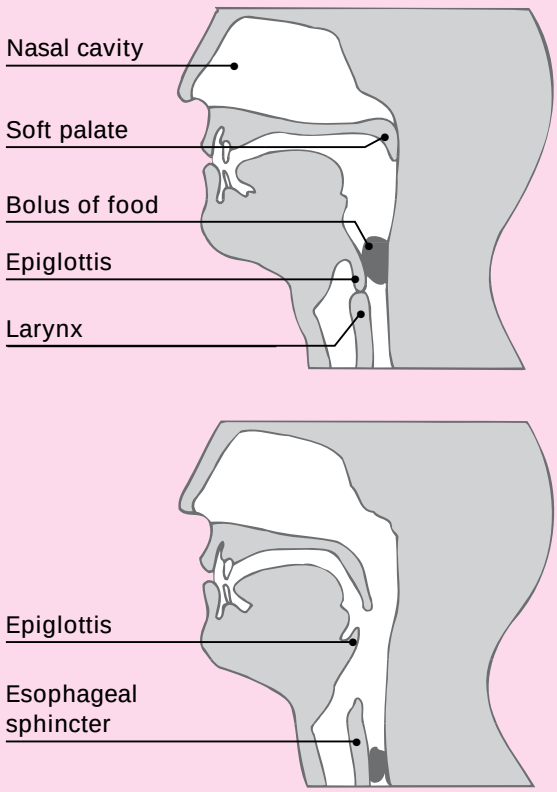
5 The upper esophageal sphincter relaxes.

6 Peristalsis (wavelike contractions of the muscular walls) force the bolus into the esophagus.

7 The upper esophageal sphincter contracts after food entry.

8 Peristalsis propels food down the esophagus.

9 The lower esophageal sphincter relaxes, allowing food into the stomach.



Choking and obstructions

Food, vomit, or other objects lodged in the windpipe may cause choking, unconsciousness, and death unless quick action is taken. Different techniques are applicable for children and adults. None should be attempted without training.

If the person choking is an infant, grasp them by the legs and hold them upside down. Smack them sharply several times between the shoulder blades. If the child is very small, make sure the head is supported as you turn them upside down to avoid injury to the neck. Lay an older child across your knee, head hanging down, and use the same technique as for infants.

For adults, strike several sharp blows between the shoulder blades. If the smacking method is not effective with an adult, stand behind the person with your fists clasped against their upper abdomen, then push them up hard toward you. This is called the Heimlich maneuver. It is best not to try to remove an obstruction with a hooked finger or tweezers, since this almost always forces the obstruction farther down the windpipe.

If the victim fails to breathe after you have shifted the obstruction, give mouth-to-mouth or mouth-to-nose artificial respiration. Detailed instructions for this can be found in first-aid manuals.

Upper digestive tract disorders

From the mouth to the esophagus, the upper digestive tract can be affected by a number of disorders that cause pain or discomfort, and prevent this part of the digestive system from working normally. Most of the disorders of the upper digestive tract are not serious, and will clear up with very simple treatment. Medical advice should be sought, however, if a condition persists for more than three weeks. Many symptoms are common to different ailments, and medical help is also necessary to establish accurate diagnosis and treatment. Disorders that may occur in the mouth include bad breath, gum infections, salivary gland infections, and mouth ulcers. A mouth ulcer is a break in the lining of the mouth that uncovers sensitive tissue underneath. Good oral hygiene minimizes mouth disorders, which are often caused by bacterial infections.

Digestive tract troubles

Esophagitis (inflammation of the esophagus) occurs through irritation due to factors such as hot or abrasive foods, smoking, and infections. Swallowing is difficult and there is burning chest pain. Bland foods, plenty of liquids, and lying down after meals may ease the condition.

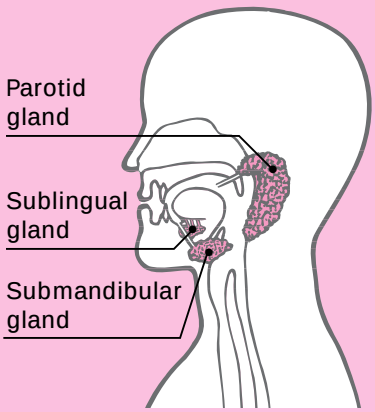
Halitosis, or bad breath, is most often caused by neglecting dental hygiene. Sore throats, sinus problems, and digestive troubles can also lead to severe halitosis. A dentist will help to clear up any problems originating from the teeth or gums; other causes may require medical assistance.

Mouth ulcers can be caused by various problems, such as stress, illness, or an injury to the mouth lining caused by a chipped tooth, a ragged filling, an illfitting denture, hot food, or biting the mouth or the tongue. Most ulcers heal up by themselves or with self-help, but persistent ulcers may be the first signs of cancer.

Gingivitis is an infection of the gums caused by their constant contact with plaque that has collected where the teeth meet the gums. Brushing the gums as well as the teeth will keep them healthy, and help to stimulate their blood supply.

Salivary gland infections may be caused by bacterial infections, while the parotid gland may become swollen and infected as a result of mumps, which is the result of a viral infection.

Stones sometimes block the ducts of salivary glands (such as the submandibular glands) when chemicals in the saliva encrust minute particles. These stones can be removed, or an opening can be made near the duct to allow the saliva to bypass the duct.

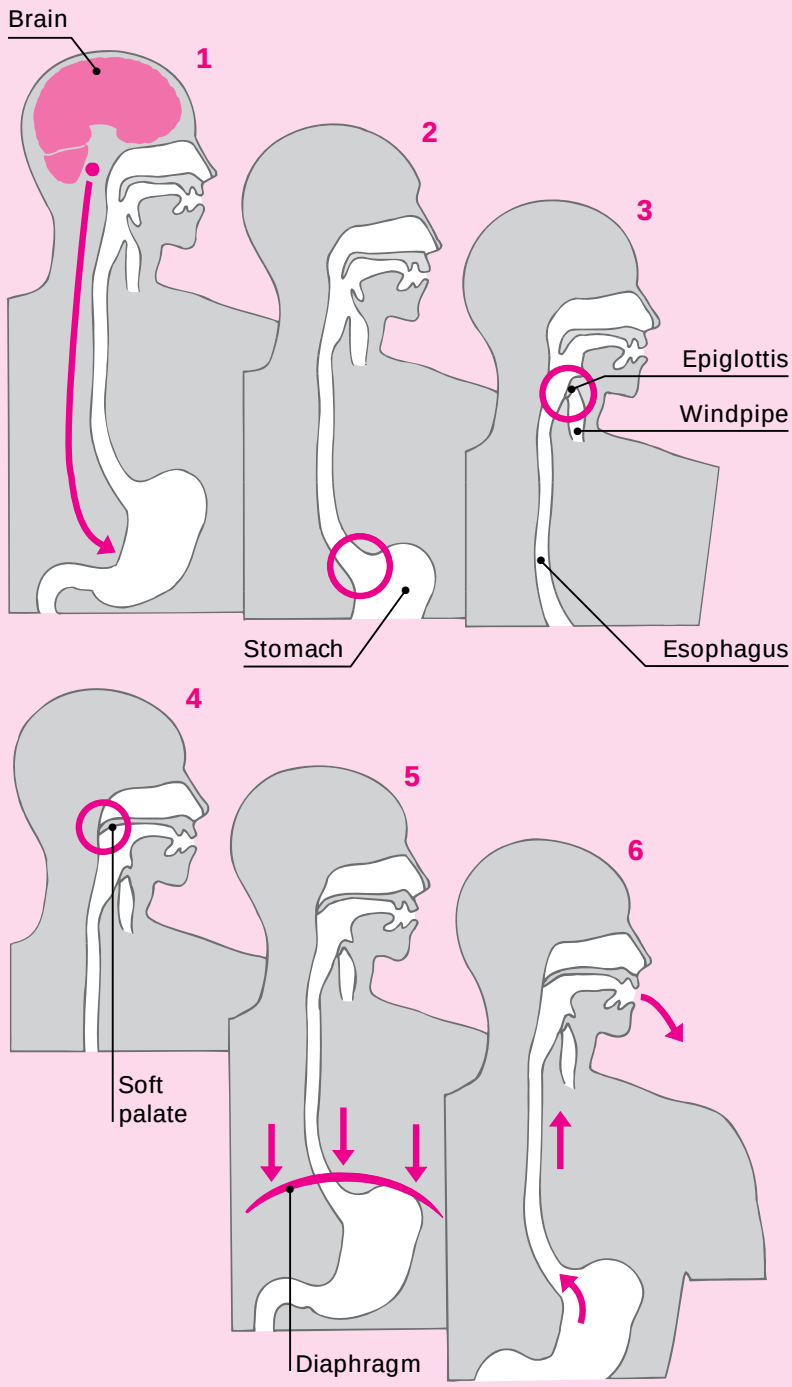


Vomiting

Vomiting, or emesis, is the involuntary expulsion of the stomach contents through the mouth. Many factors can trigger vomiting, such as: irritants in the stomach, high levels of some substances (such as alcohol) in the blood, pressure within the skull, disturbances of balance (such as motion sickness), overeating, or an emotional problem.

Emetic process

1 The emetic (vomiting) center in the brain is activated. Nerve messages sent to the abdomen trigger the vomiting reflex.
2 The lower esophageal sphincter relaxes.
3 The epiglottis closes the entrance to the larynx to prevent choking.
4 The nasal passages are sealed by the soft palate.
5 The diaphragm and abdominal wall muscles contract.
6 This contraction causes the contents of the stomach to be propelled upward by the pressure, through the esophagus, and out of the mouth.



As food journeys through the stomach and intestines, it is gradually broken down into a form that can be absorbed and used by body cells. The stomach stores food, and breaks it down with stomach acids and some enzymes. In the small intestine, enzymes complete the chemical breakdown of food, and nutrients are absorbed. The large intestine changes digested wastes into feces, which are excreted via the rectum and anus.

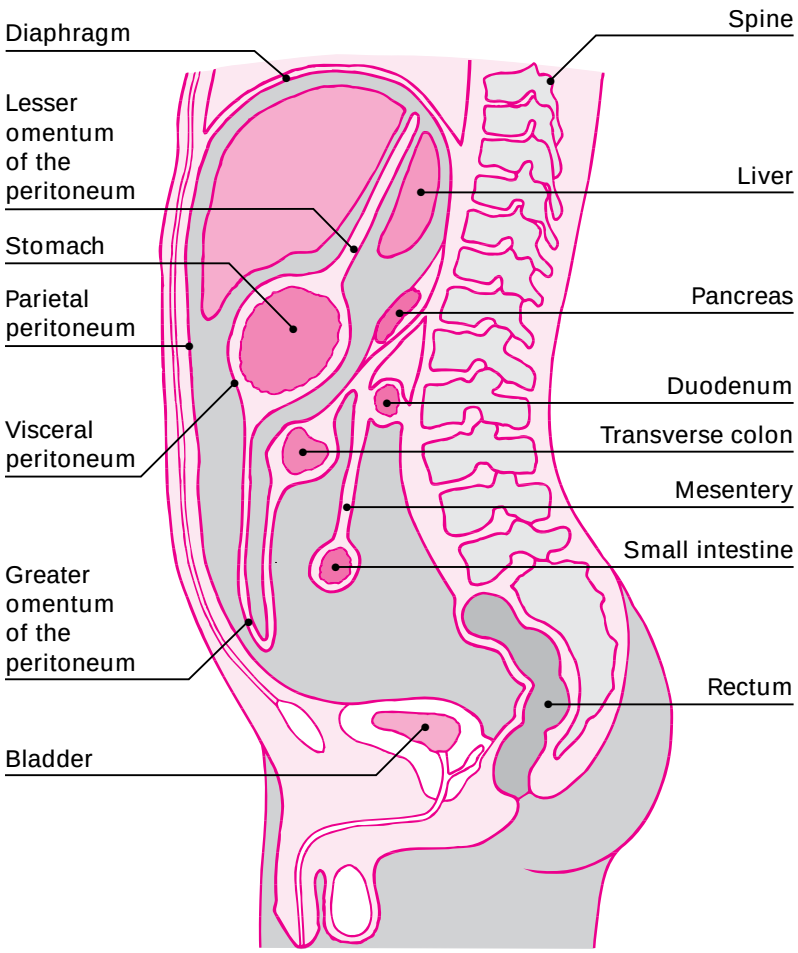
Digestion facts

- The stomach can hold about 54 fluid ounces (1.6 l) of fluid.
- *Omentum* is a Latin word meaning "fat skin." The plural is *omenta*.

Peritoneum

A thin membrane of connective tissue—serous membrane—lines the closed abdominal cavity and covers the organs within it. This is called the peritoneum. The parietal peritoneum lines the abdominal cavity and the visceral peritoneum covers most of the organs. Between the parietal and visceral peritoneum is a space called the peritoneal cavity. Two extensions of the peritoneum are the mesentery and the greater omentum, which contains large amounts of fat. The greater omentum hangs down over the intestines like a large apron, protecting and insulating them. The lesser omentum extends from the liver to the stomach.

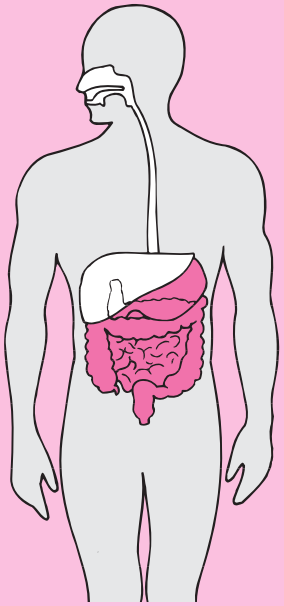
Side view of digestive organs in abdomen



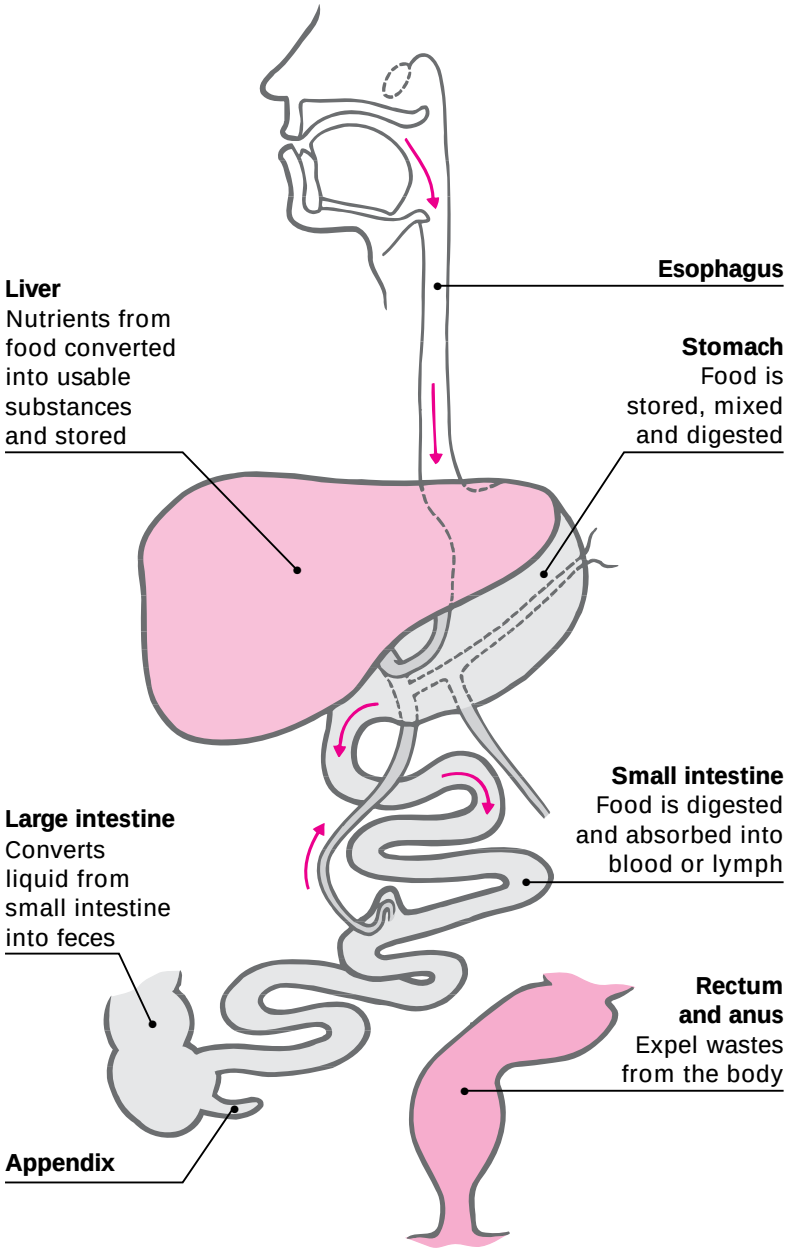
Lower tract

A bolus of food from the esophagus is propelled into the stomach, which is the widest and most expandable part of the digestive tract. When food reaches a muscular ring called the pyloric sphincter, it passes into the small intestine. This has a smaller diameter than the large intestine, even though it is four times longer. The large intestine is the final section of the digestive tract.

Locator



Route of food through lower tract



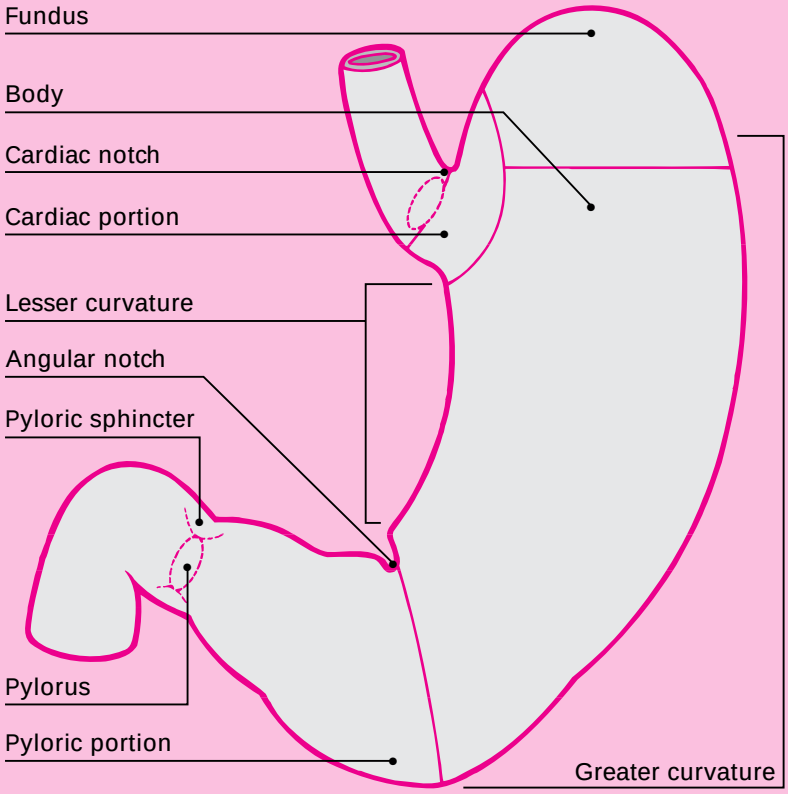
Stomach structure

Parts of the stomach

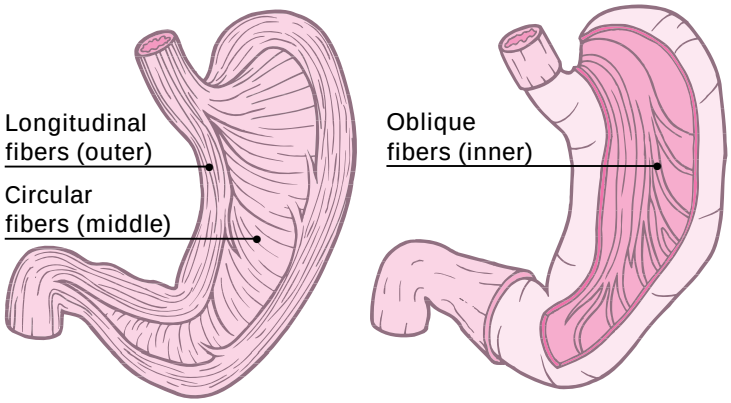
The stomach is a hollow muscular organ that connects the esophagus with the duodenum (the uppermost part of the small intestine). It has a greater curvature toward the left side of the body and a lesser curvature on the right.

At the entrance to the stomach is the lower esophageal sphincter. At the exit to the stomach is the pyloric sphincter. The pyloric sphincter is more powerful than the lower esophageal sphincter, and surrounds an opening called the pyloric orifice, or pylorus. The stomach itself is divided into four major portions: the cardiac portion, the fundus, the body (large central area), and the pyloric portion. The fundus usually contains some swallowed air.

The stomach wall is made up of three layers of smooth muscle—circular and longitudinal layers, and also an oblique (crosswise) layer. This makes the stomach strong and allows a great range of movements.



Muscles of the stomach wall



Stomach lining

The stomach is lined with glandular cells that secrete gastric juice (digestive fluid), and goblet cells that secrete mucus (thick, slimy fluid). Mucus lubricates and protects the stomach lining, and moistens food. Rugae (wrinkles and folds) in the stomach lining greatly increase its surface area. The rugae flatten as the stomach fills, allowing it to distend (expand).

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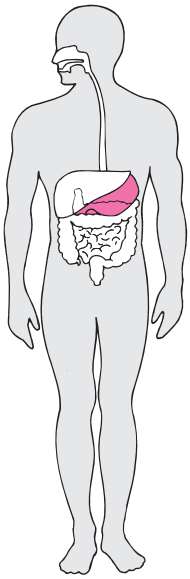
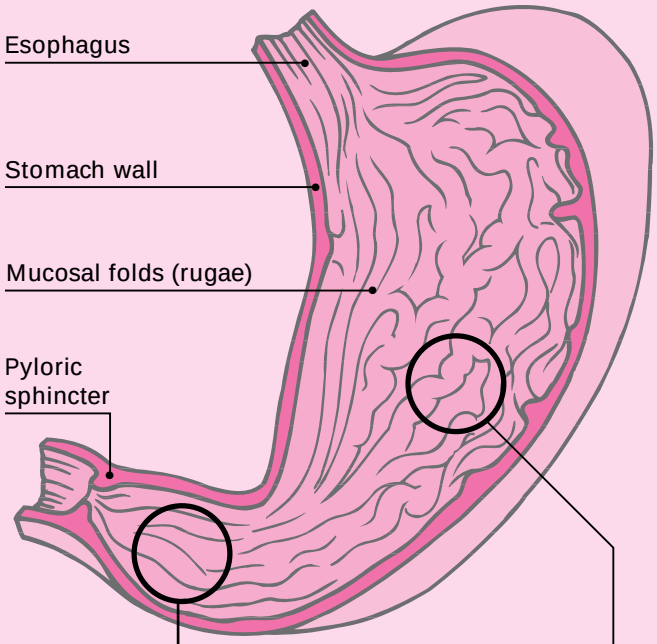
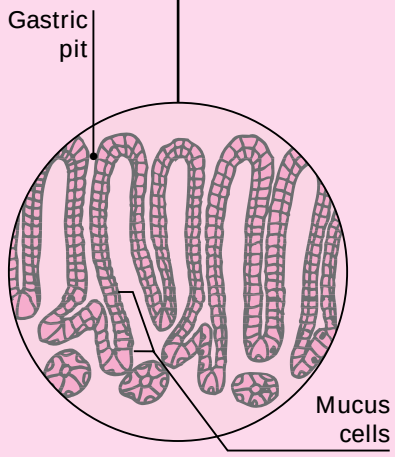
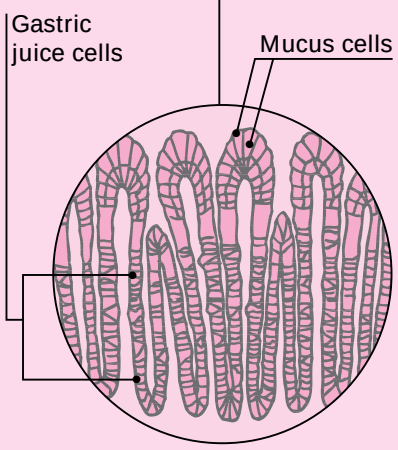


Cross section of stomach





Magnified section of mucus membrane of pyloric region



Magnified section of mucus membrane of body of stomach

How the stomach works

Functions of the stomach

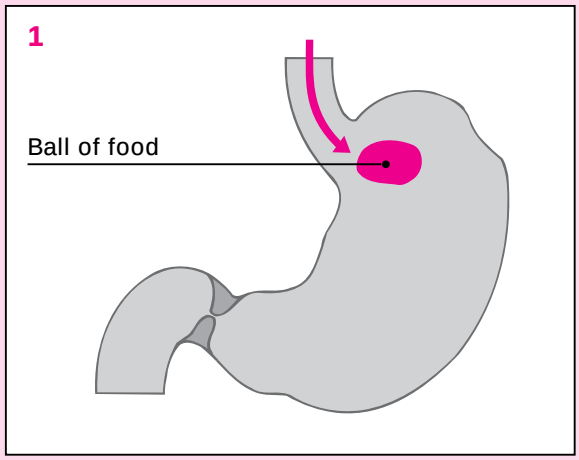
The stomach has four main functions: digestion (both mechanical and chemical), absorption, propulsion, and storage. The muscular action of the stomach walls churns, mixes, and pummels the food. This physically breaks down the food (mechanical digestion) and mixes it with mucus and gastric juice to form chyme (semifluid mixture). Enzymes (proteins that act as biological catalysts) in the gastric juice begin the breakdown of proteins (chemical digestion). Some water, salts, alcohol, and certain drugs (for example, aspirin) are absorbed in small quantities through the stomach lining into blood vessels. Peristalsis (wavelike contractions of stomach walls) propels food through the stomach and forces chyme through the pyloric sphincter. The stomach acts as a storage tank, reducing the need for frequent meals.

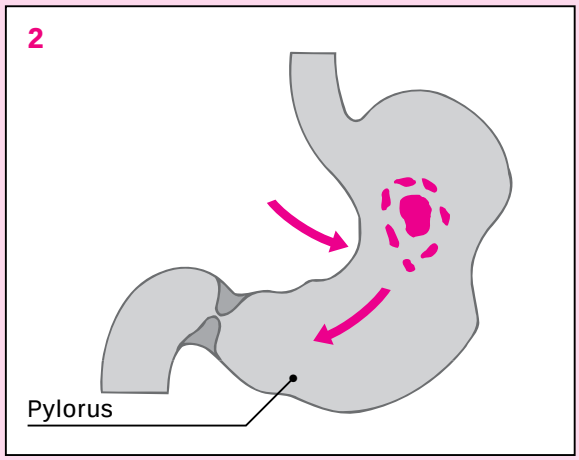
Muscular activity in the stomach

This is responsible for peristalsis, mixing actions, and the emptying of stomach contents. It is controlled by various mechanisms.

1 As the lower esophageal sphincter relaxes, food enters and distends the stomach. This expansion and gastric secretion (stimulated by contact with food) triggers gentle peristalsis.

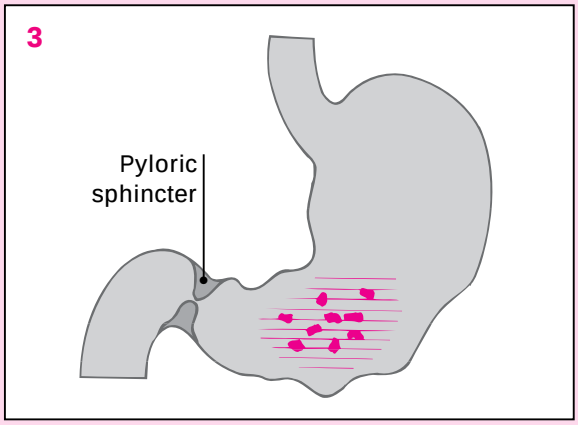
2 The food is mixed and moved toward the pylorus (lower region of the stomach). The pyloric sphincter remains closed throughout steps 1 and 2.





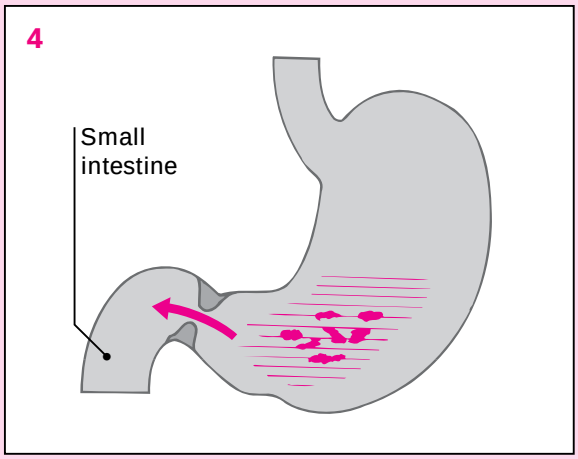
Stomach facts

- The lining of the stomach sheds about 500,000 cells per minute and is completely renewed every three days.
- The word “stomach” comes from the Greek word for “throat.”



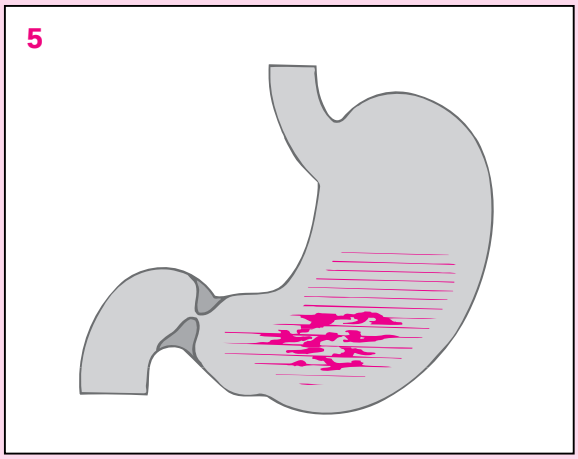
3 More vigorous peristalsis and mixing action take place near the pyloric sphincter, which relaxes. The lower esophageal sphincter remains closed (unless more food is traveling along the esophagus).

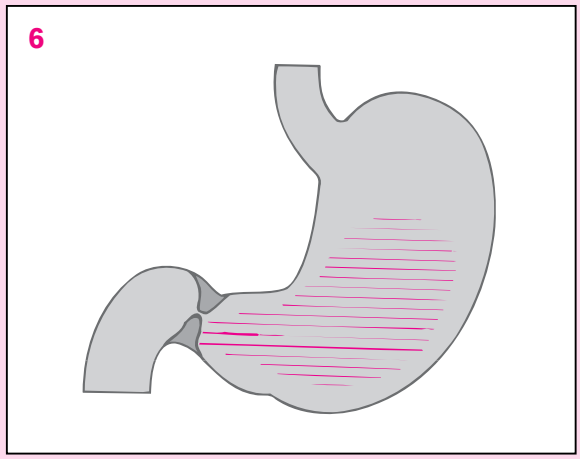
4 Peristalsis forces small amounts of chyme through the slightly open pyloric sphincter, and into the small intestine.



5 The presence of chyme stimulates receptors in the small intestine walls. These activate hormonal mechanisms to inhibit gastric secretion in the stomach. In turn, this reduces gastric activity, preventing further escape of chyme from the stomach.

6 Most material remains in the stomach for further mixing.





Stomach juices

Gastric secretion

Gastric juice is a clear, colorless fluid secreted by the stomach in response to food. There are three phases that control this secretion.

1 Cephalic phase

This begins before food reaches the stomach, and prepares the stomach for digestion. Seeing, smelling, thinking about, and tasting food stimulates the secretion of the hormone gastrin from specialized cells in the stomach. This enters the blood system, which returns it to the stomach, to trigger the secretion of more gastric juice.

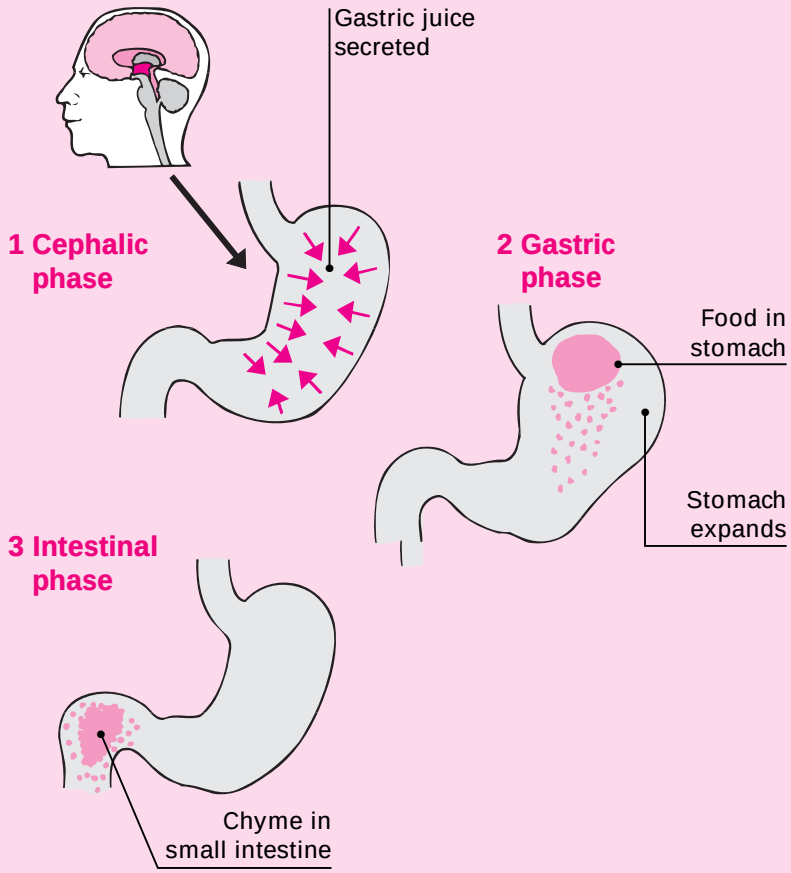
2 Gastric phase

This begins when food reaches the stomach. Secretion of gastric juice is triggered by the presence of food and the expansion of the stomach, and by the low acidity this causes.

Stomach facts

- The stomach processes about 1100 pounds (500 kg) of food in a year.
- In 24 hours, the stomach makes 40–60 fluid ounces (1.7 l) of gastric juices.

Controlling gastric secretion



3 Intestinal phase

After one to three hours, food leaves the stomach and enters the small intestine. At this point, the intestinal phase begins. Chyme (a semifluid mixture of food and digestive juices) in the small intestine triggers the secretion of hormones that stimulate gastric secretion. Hormones are released that inhibit (slow or prevent) gastric secretion, preventing more acidic chyme from entering the small intestine.

Gastric juice composition

Gastric juice (digestive fluid) contains hormones, enzymes (proteins that act as biological catalysts), hydrochloric acid, mucus (thick, slimy fluid), and the protein intrinsic factor.

Ingredient	Function
Gastrin (hormone)	• Stimulates the secretion of more gastric juice—it has a positive feedback effect • Stimulates the contraction of stomach muscles
Serotonin (neurotransmitter)	• Stimulates the contraction of stomach muscles
Rennin (enzyme only present in infants)	• Chemically breaks down milk protein
Lipase (enzyme)	• Splits fat molecules
Pepsinogen (inactive form of pepsin)	• Is activated by hydrochloric acid to form pepsin (an enzyme), which chemically breaks down proteins
Hydrochloric acid	• Activates pepsinogen into pepsin • Kills bacteria
Intrinsic factor	• Is essential for the absorption of vitamin B_{12} by the small intestine
Mucus	• Protects the stomach • Lubricates the stomach • Mixes with food to create a fluid medium for chemical reactions

Protecting the stomach

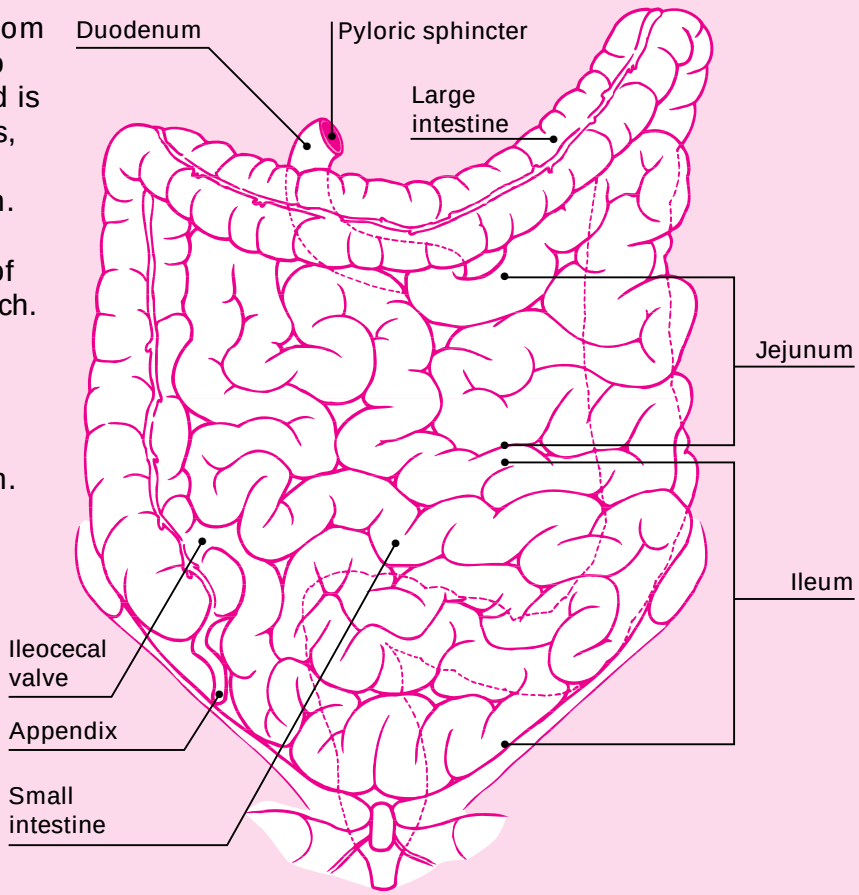
The enzymes and hydrochloric acid in gastric juice begin the digestion of large protein molecules into smaller protein molecules of peptones, proteose, and amino acids. Although the stomach walls are made mainly of protein, they are not normally digested by gastric juice. This is because they are covered with a protective coating of mucus that is secreted by the stomach lining. The enzyme pepsin is also secreted in an inactive form (pepsinogen), so it cannot digest the stomach cells that produce it.

Small intestine structure

Parts of the small intestine

The small intestine is a long, coiled, muscular tube connecting the stomach with the large intestine. It stretches from the pyloric sphincter to the ileocecal valve, and is divided into three parts, the duodenum, the jejunum, and the ileum. The pyloric sphincter controls the entrance of chyme from the stomach. The ileocecal valve regulates the flow of chyme into the large intestine and stops backflow into the ileum.

Front of the intestines



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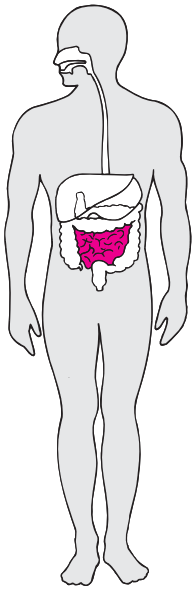


Intestine facts

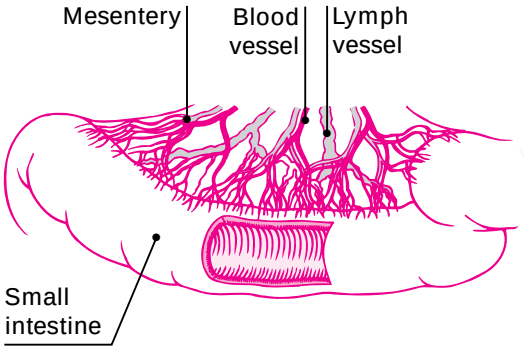
- The small intestine is about 20 feet (6 m) long and 1.6 inches (4 cm) in diameter. The large intestine is about 5 feet (1.5 m) long and 2.4 inches (6 cm) in diameter.

Area for absorption

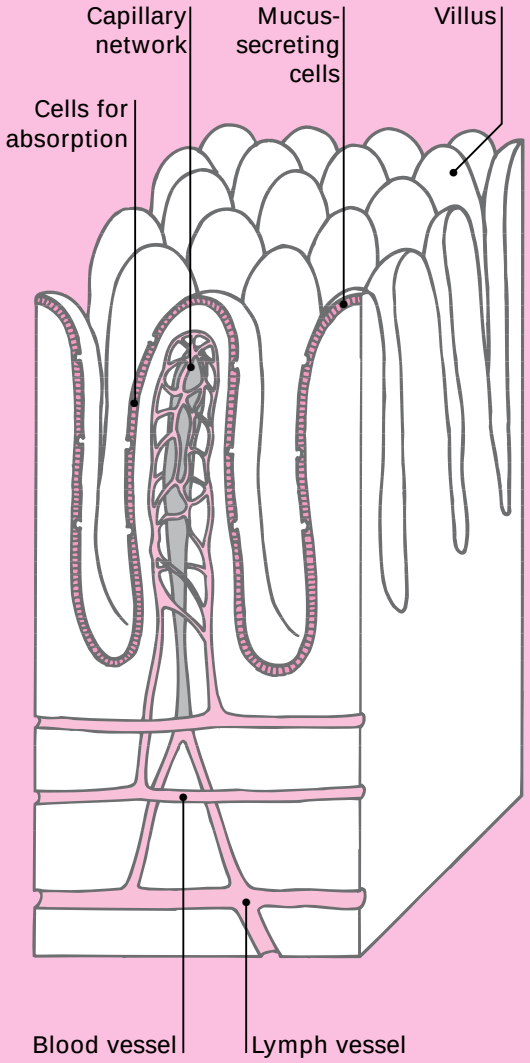
The small intestine is adapted in several ways for the absorption of nutrients from digested food. It is the longest section of the whole alimentary canal, and also has a gigantic internal surface area of about 300 square yards (250 sq m)—an area larger than a doubles tennis court. This huge surface area is achieved by means of numerous folds, which are covered with minute, fingerlike bulges called villi (singular villus). The villi are themselves covered with extensions called microvilli (or brush border), which further increases the total surface area. The folds, villi and microvilli, make the small intestine 600 times more absorptive than an intestine would be if it had a smooth lining.

Mesentery

The small intestine is anchored to the rear wall of the abdomen by a tissue structure called the mesentery. This thin, membranous sheet also carries blood to the intestine, and transports nutrients away in blood and lymph.



Section through intestine wall

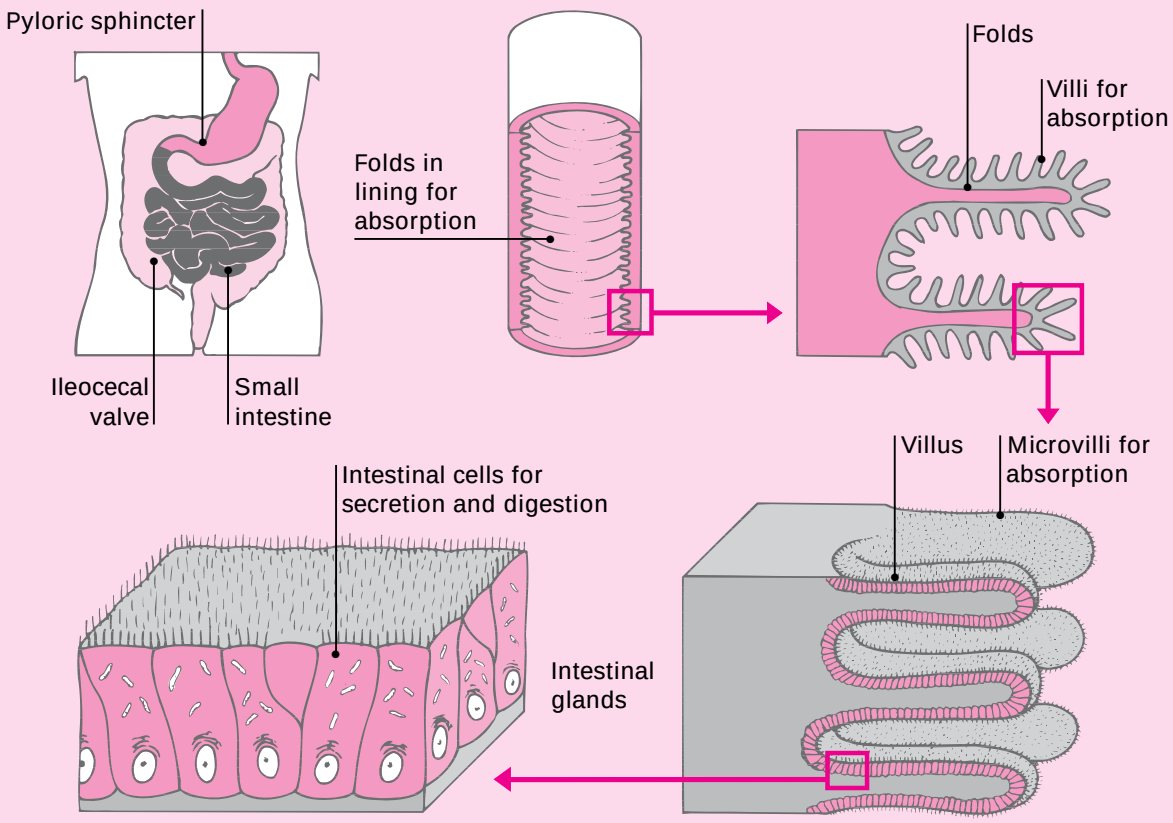


Small intestine function

Role of the small intestine

The major functions of the small intestine are digestion and absorption, which occur as a result of movements of the intestinal muscles and the chemical action of enzymes. These enzymes are secreted by the small intestine itself, and also by the liver and pancreas.
They complete the digestion of proteins and carbohydrates in the food, and break down most of the fats.
Segmentation (rhythmic constrictions of the muscular walls of the intestine) and pendular movements (lengthening and shortening motions caused by muscle contractions) mix stomach chyme with digestive juices and bring it into contact with villi in the intestinal walls for absorption. Waves of peristalsis (rhythmic muscular contractions) move chyme forward. It takes from one to six hours for chyme to move through the small intestine. Intestinal juice provides lubrication and a fluid medium for absorption and chemical digestion, neutralizes acidic chyme, and protects the intestine wall from being digested.

Small intestine



Chemical digestion in the small intestine

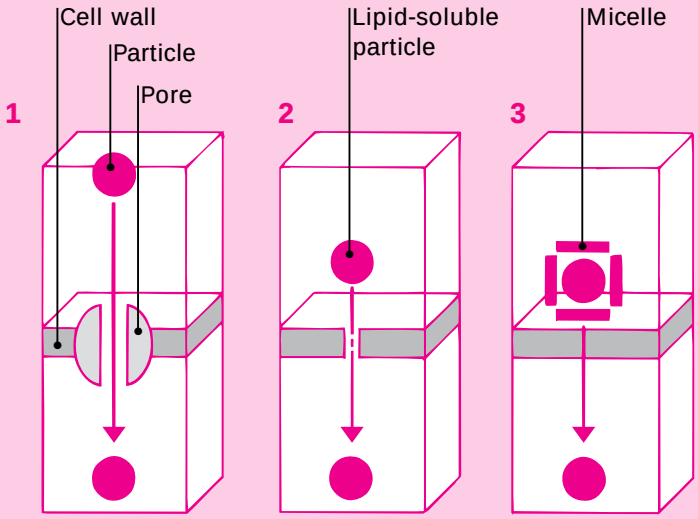
Most of the chemical digestion carried out by the digestive system occurs in the small intestine. The production and release of digestive enzymes and hormones (which control processes and mechanisms) is stimulated by ingestion of food, distension of the small intestine walls (caused by the entrance of chyme), the acidity of chyme, and the presence of partially digested foods in chyme.

Agent	Source	Functions
Peptidases (enzymes)	Small intestine/ pancreas	• Break down peptides (protein segments) into amino acids
Maltase (enzyme)	Small intestine	• Converts disaccharide (double sugar) maltose into monosaccharide (single sugar) glucose
Sucrase (enzyme)	Small intestine	• Converts disaccharide sucrose into the monosaccharides glucose and fructose
Lactase (enzyme)	Small intestine	• Converts the disaccharide lactose into the monosaccharides glucose and galactose
Lipase (enzyme)	Small intestine/ pancreas	• Breaks down fat into its components—monoglycerides and fatty acids
Enterokinase (enzyme)	Small intestine	• Activates a protein-splitting enzyme (trypsin) from the pancreas
Secretin (hormone)	Small intestine	• Stimulates the pancreas to produce juice with high bicarbonate content
Cholecystokinin (hormone)	Small intestine	• Increases the bile output of the liver • Stimulates the release of bile stored in the gallbladder
Pancreatic juice (enzymatic fluid)	Pancreas	• Breaks up protein, starch, and fats; its high bicarbonate content neutralizes acidic chyme
Bile (bile salts and cholesterol)	Liver	• Emulsifies (breaks down) fats into smaller droplets

Small intestine absorption

Methods of absorption

The simple substances produced by digestion are small enough to be absorbed across the cell walls of the intestinal lining. This happens by means of passive or active transport. Passive transport (such as diffusion) does not require the cell to use any energy. For active transport (such as solute pumping or endocytosis), a cell needs to use energy to transport a particle across its wall.



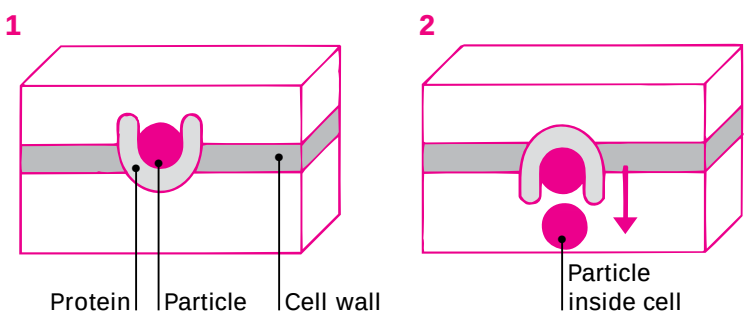
Simple diffusion

1 A particle is small enough to pass through the pores of the cell wall.
2 A particle is lipid soluble (can be dissolved in fat), and so will pass directly through the lipid layer of the cell wall.
3 A particle is coated with bile salts (secreted by the liver) to form micelles. These do not float and so sink to the cell's wall, through which they are easily diffused.

Digested substances absorbed by simple diffusion include the end products of fat digestion (glycerol, monoglycerides and fatty acids), water-soluble vitamins (B and C) and water. (The diffusion of water across the cell wall is called osmosis.)

Facilitated diffusion

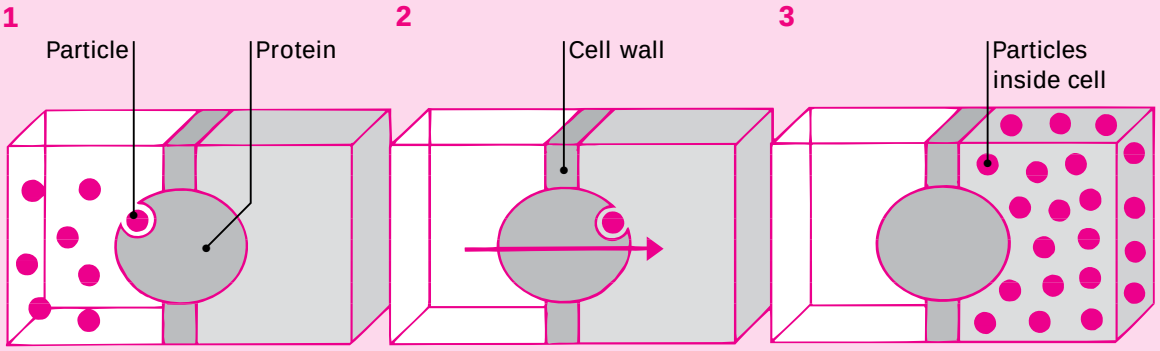
If a particle is not lipid soluble, and is too large to pass through the pores of the cell wall, then it needs the help of a carrier protein.
1 The particle binds to the protein, which straddles the cell wall.
2 The particle enters the cell through the protein.



Digested substances absorbed by facilitated diffusion include fructose (a sugar).

Solute pumping

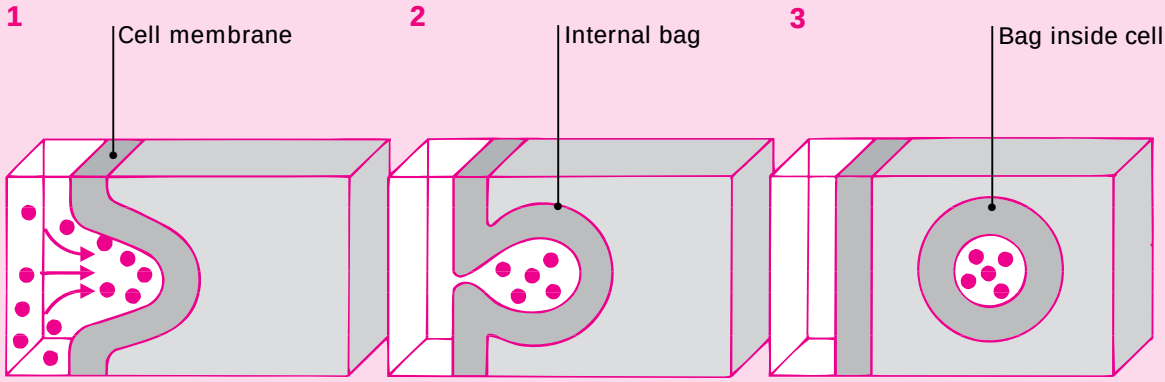
1 A carrier protein combines with a particle.
2 The protein transports the particle across the cell wall.
3 The particle is released into the cell.
The carrier is powered by ATP (adenosine triphosphate), and is called a solute pump. Substances absorbed by solute pumping include amino acids (the building blocks of proteins) and glucose/galactose (sugar).



Endocytosis

This is the process by which cells "engulf" substances.
1 The cell membrane folds inward.
2 It then closes over the gathered particles or liquid, forming an internal bag on the inside of the membrane.
3 The bag breaks away from the membrane. Its contents may be digested by cellular enzymes.

Substances absorbed by endocytosis include proteins.

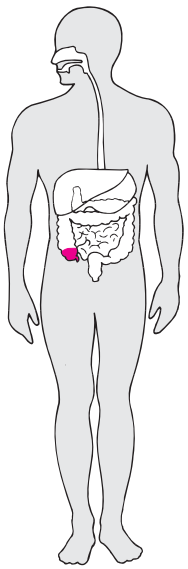


Appendix and membranes

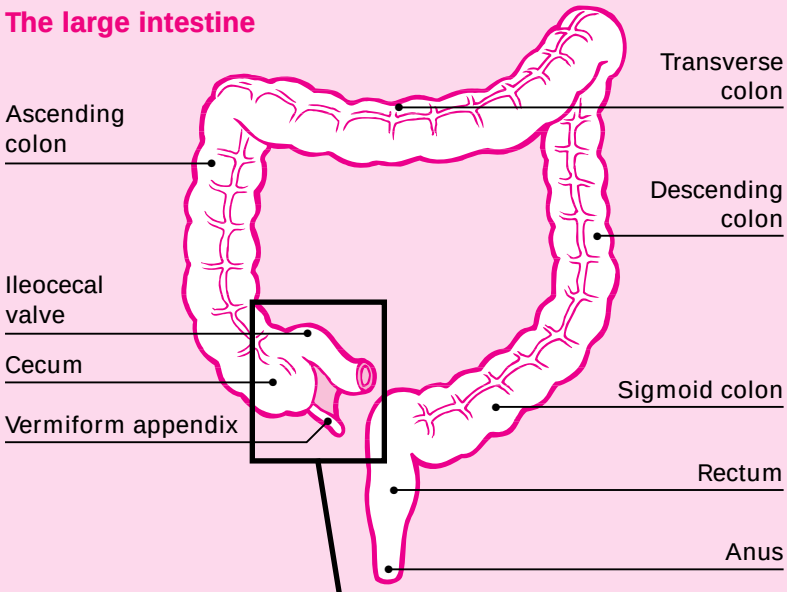
Appendix

Attached to the first part of the large intestine, just below the ileocecal valve, is a wormlike, tubular structure called the vermiform ("worm-shaped") appendix. It is made of muscle fibers sheathing a layer of lymphatic tissue, and may play a minor role in the immune system. The appendix does not seem to have a digestive function in humans. Inflammation of the appendix lining causes appendicitis.

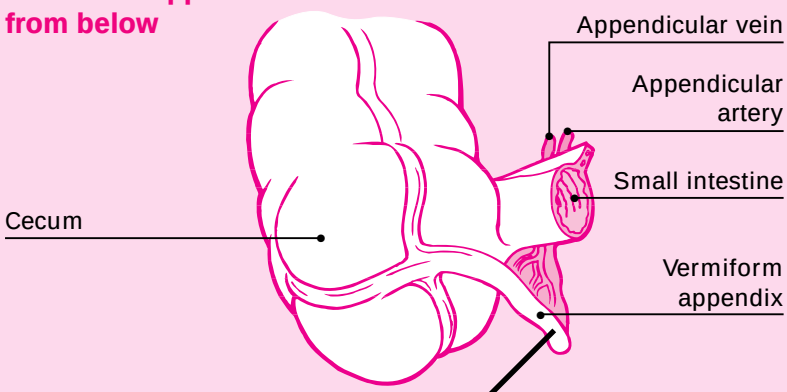
Locator



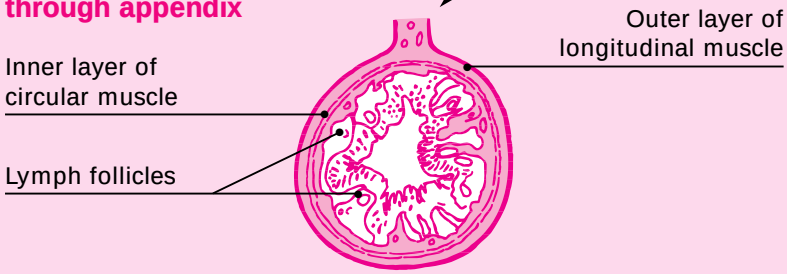
The large intestine



Cecum and vermiform appendix from below



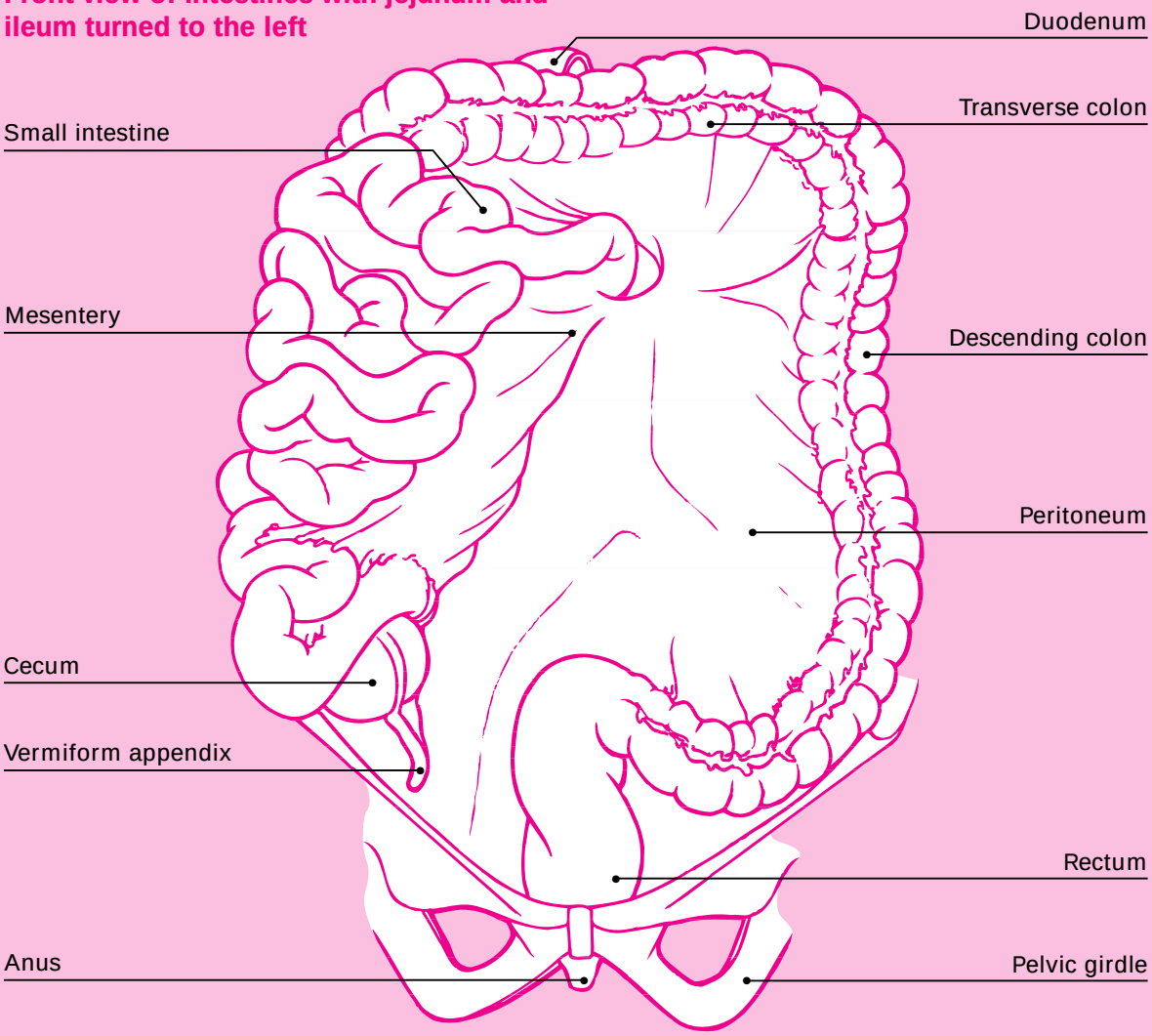
Cross section through appendix



Intestines and membranes

The two-layered abdominal membrane called the peritoneum produces a fluid that reduces friction between organs in the abdomen. Most of the duodenum, and the ascending and descending colons of the large intestine, lie behind the peritoneum, and are covered but not surrounded by it. Most of the small intestine, and the transverse colon of the large intestine, are suspended from the back wall of the abdomen by two fused layers of peritoneum, the

Front view of intestines with jejunum and ileum turned to the left



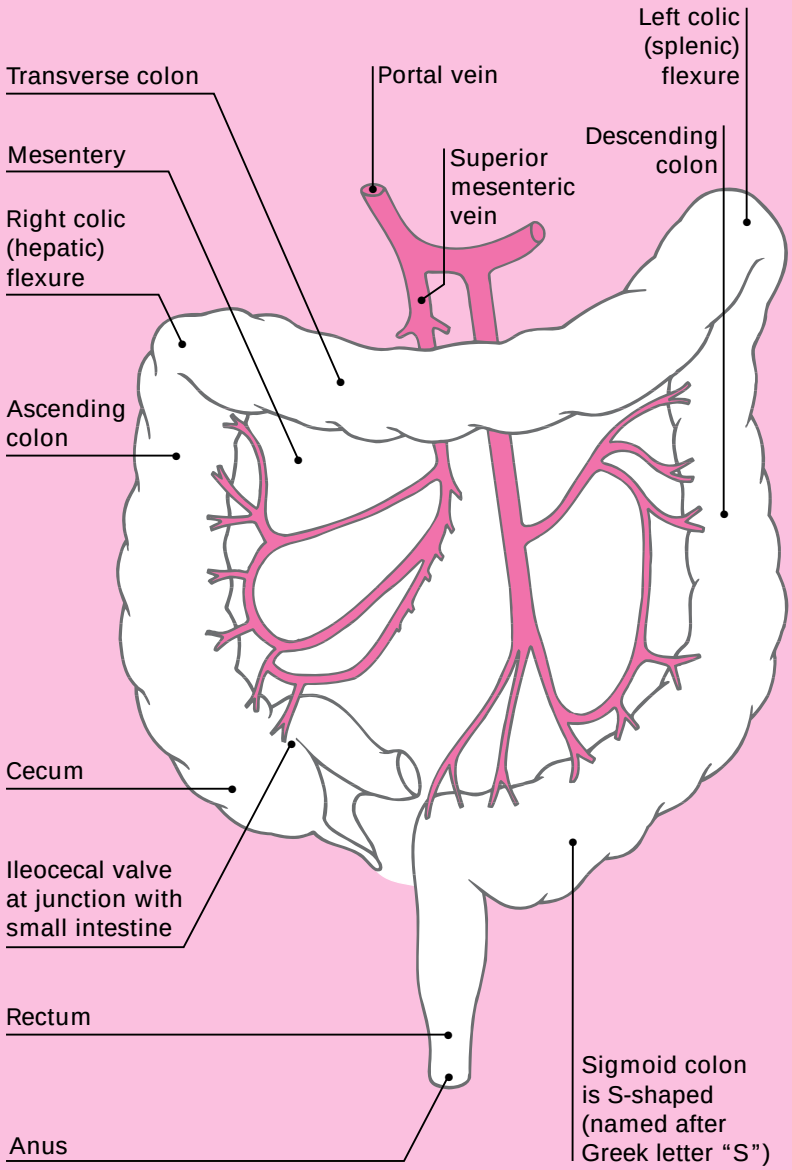
Parts of the large intestine

The large intestine is the section of the digestive system between the ileocecal valve (at the junction with the small intestine), and the anus. It starts at the cecum, ascends to the liver as the ascending colon, then crosses the abdomen, as the transverse colon, to the spleen before descending to the pelvis as the descending colon. It then narrows to become the sigmoid colon, and finally the rectum, before ending at the anus.

Functions

Material takes between about six and 18 hours to pass through the large intestine. During this time, material that escaped digestion in the small intestine is acted on by bacteria, and some water, salts, and minerals are absorbed. This converts liquid wastes into feces. Mucus secreted by the large intestine provides lubrication and holds the feces together. It also helps to neutralize acids produced by bacteria.

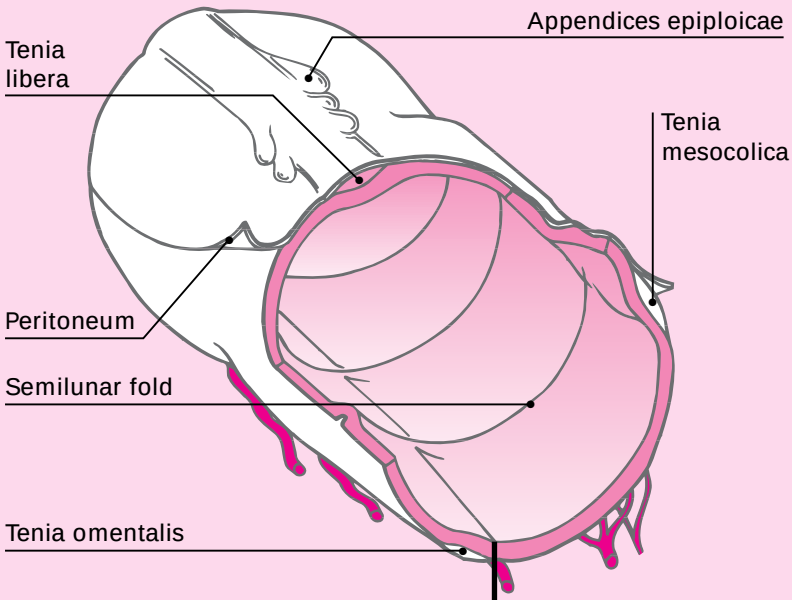
Large intestine



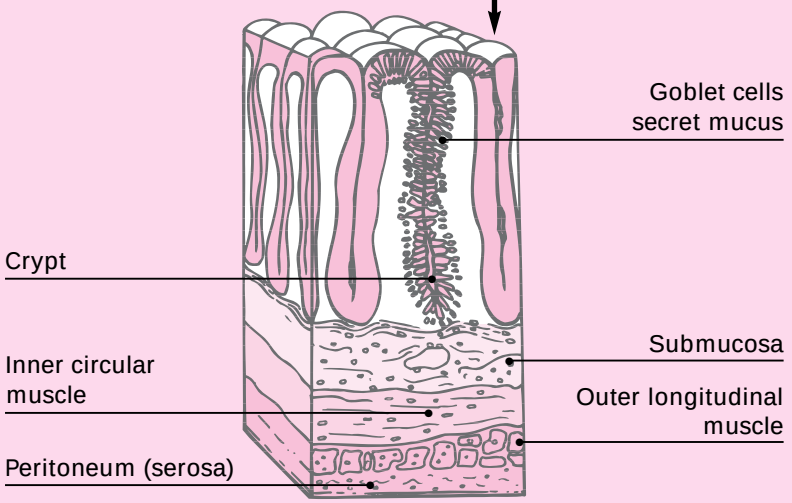
Outside and inside

The large intestine has three separate bands of longitudinal muscle running along its outer surface. These muscle bands are called "teniae," from the Latin word for ribbons. Since the teniae are not as long as the large intestine itself, the wall is puckered with bulges called haustra. The internal surface of the large intestine is smooth and has no villi because absorption is not its main function.

Ascending colon, partly cut away



Cross section of colon wall



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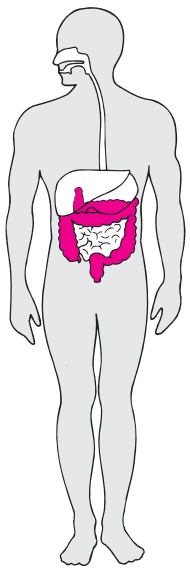
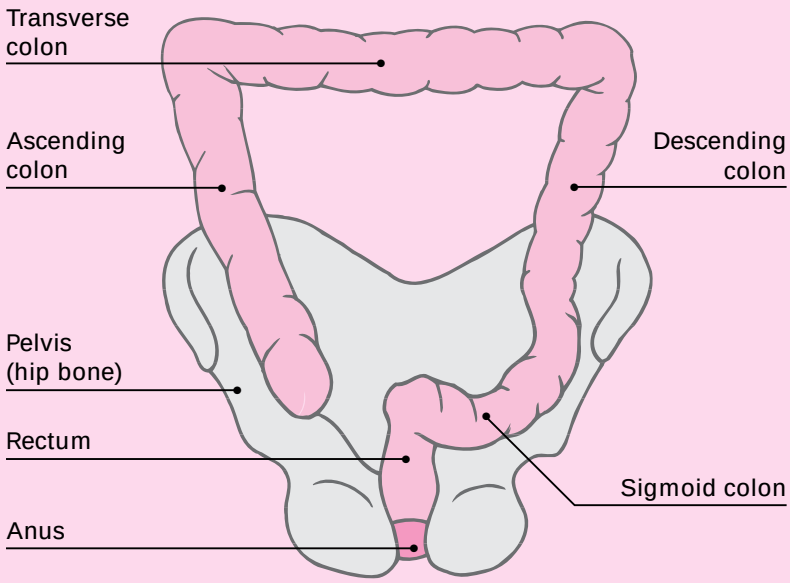


Rectum and anus

Journey's end

At the end of the large intestine is the rectum, leading to the anal canal, and the anus. The rectum extends about six inches (15 cm) from the sigmoid colon to the anus. The opening and closing of the anus is controlled by internal and external anal sphincters (rings of muscle that act as valves). The internal anal sphincter is not under voluntary (conscious) control. The external anal sphincter is under voluntary control.

Rectum and pelvis



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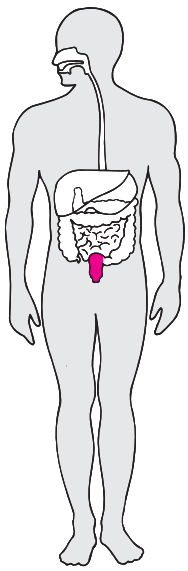
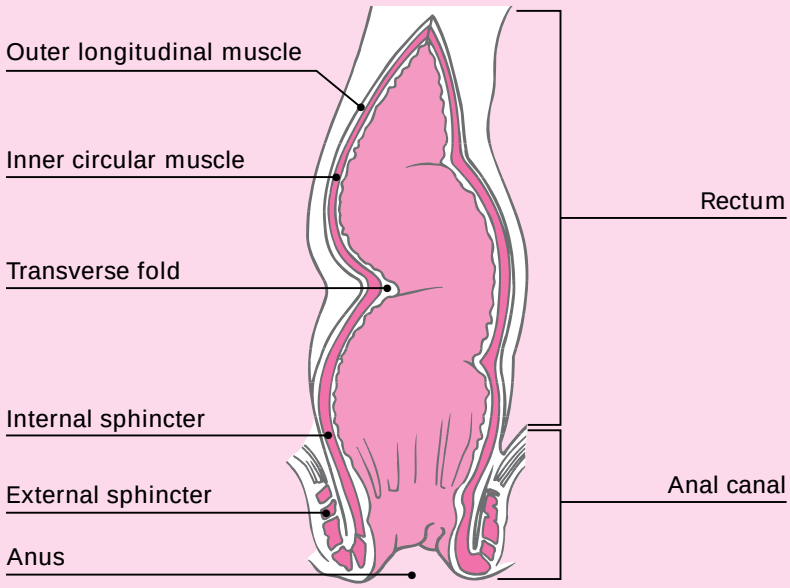


Section through the rectum



Defecation

The expulsion of feces (dead bacteria and cells, mucus, bile, and indigestible food) through the anus by muscular action is called defecation.

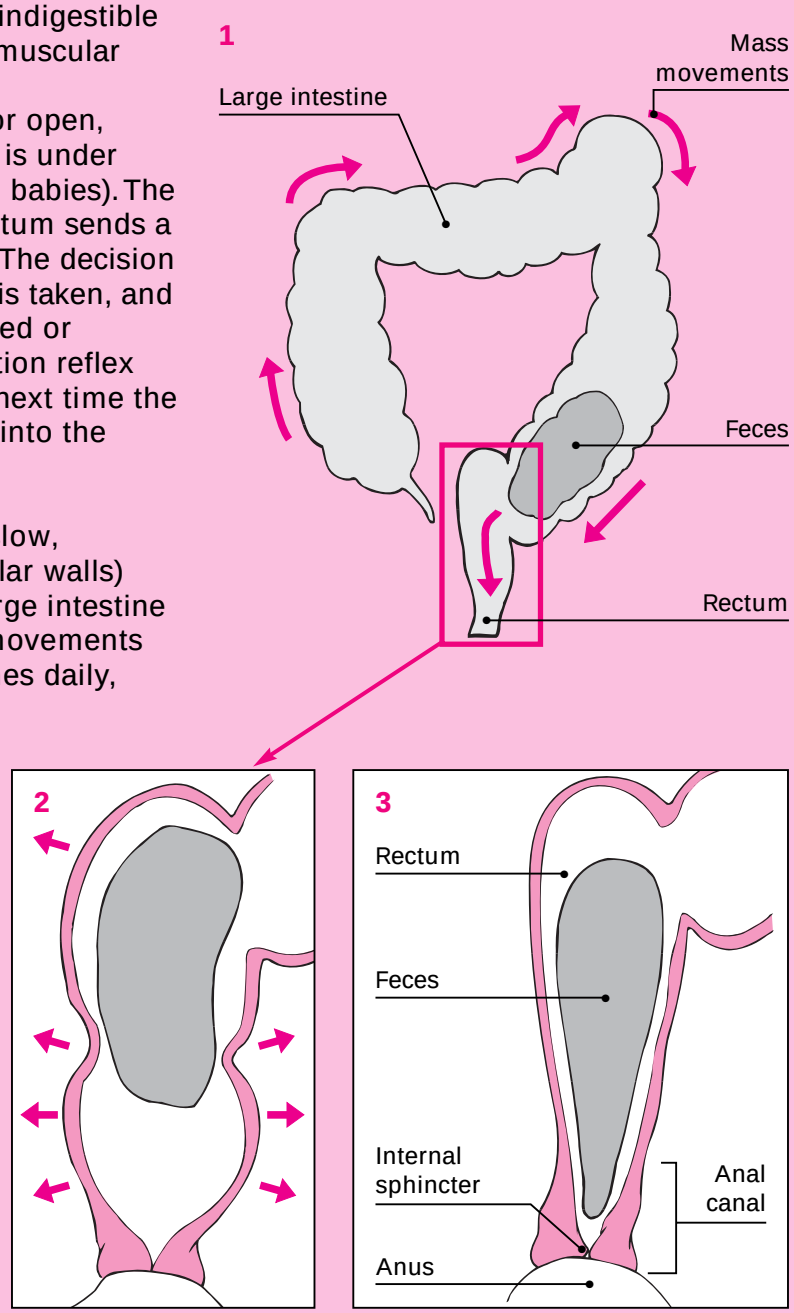
The decision to defecate, or open, the external anal sphincter, is under voluntary control (except in babies). The presence of feces in the rectum sends a nerve impulse to the brain. The decision whether or not to defecate is taken, and the sphincter is either opened or remains closed. The defecation reflex will be triggered again the next time the large intestine forces feces into the rectum.

1 Mass movements (long, slow, contractile waves of muscular walls) force the contents of the large intestine toward the rectum. These movements occur only three or four times daily, generally following meals.

2 When the contents of the large intestine enter the rectum, the walls stretch, and the defecation reflex is triggered.

3 This reflex causes the walls to contract and the internal anal sphincter to relax. The feces then enter the anal canal, and may be expelled by contractions of the intestines, abdominal muscles, and diaphragm.

The defecation reflex



Lower digestive tract disorders

Many aspects of modern life force our intestines to cope with unnatural habits, such as rushed, irregularly-spaced meals, and an excess of processed foods. In order for the intestines to work correctly, they should be treated well, particularly by following good dietary principles. The effort needed to keep the intestines healthy is minimal compared with the trouble that they can otherwise cause—especially as our bodies age. Old people are more prone to certain complaints as the large intestine deteriorates and eating habits change. Pouches called diverticula occur where the large intestine bulges through weak parts of its muscular wall. Infected pouches give rise to diverticulitis. As muscles generally lose tone, straining at stool becomes more likely to cause a hernia. If overstraining collapses the rectum wall, a fecal mass may become trapped inside the rectum and keep overflowing. Eating enough dietary fiber helps to stop this situation from developing. The human digestive system cannot digest fiber, but uses it to help retain toxic substances that would otherwise pass into the bloodstream. Fiber produces soft, bulky and easily evacuated stools, and speeds up their elimination. A fiber-rich diet can help to protect the body against disorders such as diverticulitis, colitis, and hemorrhoids.

Self-help

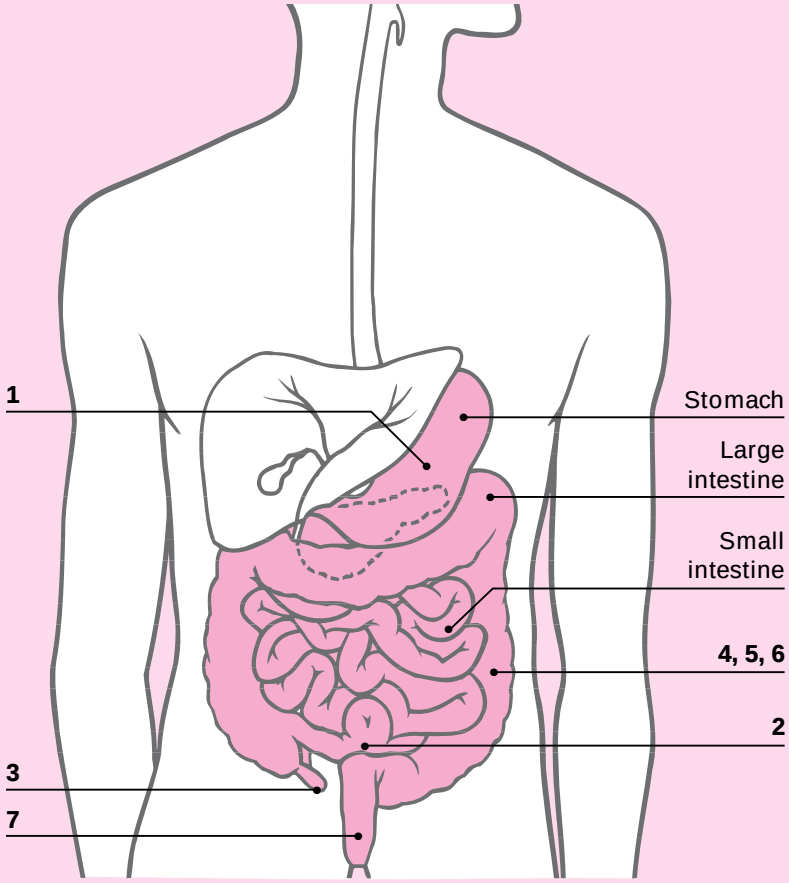
Many common digestive ailments respond to changes in diet or the introduction of an exercise regime. Make sure to include enough fiber in your diet by eating some raw cereals, fruits, and vegetables rich in fiber or roughage (indigestible cellulose). Cooking tends to break down cellulose cell walls, so most of the food taken for its fiber value should be eaten raw; cereal fiber is best. Wholewheat bread has a higher fiber content than brown or white bread, and brown rice contains more fiber than white rice.

Constipation can be prevented by eating enough fiber, together with exercising, drinking plenty of liquids, and forming regular bowel habits. This should also help to prevent straining at stool, which is very likely to produce hemorrhoids. Short term constipation and diarrhea are often linked with travel and a sudden change of diet, but do not ignore a change in bowel habit that persists for more than two or three days. See your doctor about continuing diarrhea, constipation, or alternation of the two.

Hemorrhoids (piles)

Internal hemorrhoids can occur high in the anal canal; external hemorrhoids protrude from the rectum. A greased finger can sometimes push external hemorrhoids back into place. Itching may be relieved by sitting in warm water. Various local anesthetic preparations deaden pain and relieve itching. Hemorrhoids that continue to give trouble should be seen by a doctor; if necessary the enlarged veins can be treated by injection or removed by a simple, safe operation.

Digestive tract troubles



1 Gastritis is a general term for inflammation of the stomach due to irritation from causes such as infection, stress, alcohol, spicy food, or aspirin. Often the best treatment is to rest the stomach by eating nothing and drinking plenty of bland liquids.

2 Ileitis (Crohn's disease) is inflammation of the lower small intestine producing weight loss, anemia, perhaps diarrhea, and other symptoms. Bed rest, a bland diet, vitamin-mineral supplements, and plenty of liquids help to treat it, but medical advice should be sought.

3 Appendicitis, inflammation of the appendix, can be triggered by blockage of the appendix or by ulceration of its lining. Symptoms include loss of appetite and severe pain in the lower right part of the abdomen. There may also be nausea and vomiting. The usual treatment is surgical removal of the appendix, called appendectomy. If not removed, an inflamed appendix can burst, causing peritonitis (inflammation of the abdominal lining), with potentially fatal results.

4 Colitis is inflammation of the colon, due often to mild infection producing diarrhea.

5 Irritable bowel syndrome (IBS) can involve alternate constipation and diarrhea, with bloated abdomen and discomfort. A bland, fibrous diet and bed rest help acute attacks.

6 Diverticulitis is the inflammation of pouches that may form in the colon, giving left-sided abdominal pain and fever.

7 Piles (hemorrhoids) are varicose veins of the rectum, which can be internal or external.

Lower digestive tract disorders

Further examples of lower digestive tract disorders are covered on these two pages. These disorders include ulcers, which form when the protective lining of the stomach or small intestine is eroded by irritants. The main symptom is upper abdominal pain. About 10 percent of people in developed countries may suffer from ulcers; the problem can occur at any age. If the sphincters at the entrance and exit to the stomach are not working properly, this can disrupt the passage of food through the lower digestive tract, causing disorders such as heartburn and pyloric stenosis. Other problems with the lower tract are caused by the invasion of parastic worms rather than with the tract itself. Invasion may occur through contaminated food or through the feet.

Ulcers

Ulcers are craterlike lesions that form when the walls of the digestive tract are eroded by digestive juices. The most common locations for ulcers are the walls of the stomach (gastric ulcer) and duodenum (duodenal ulcer). Most gastric and duodenal ulcers are caused by infection with the bacterium *Helicobacter pylori*. The bacterium causes inflammation and ulceration by increasing stomach acid. Other contributory factors include certain drugs (such as aspirin or ibuprofen), smoking, alcohol, coffee, diet, or stress. Some individuals have a genetic predisposition to ulcer development. Various drugs can help to treat ulcers. Antibiotics eradicate the bacteria, while other drugs block or reduce stomach acid secretion. In spite of improved drug therapy, surgery is sometimes necessary for treating hemorrhage, perforation, scarring, or other more serious complications.

Food for ulcer sufferers

Modern drugs help to make strict diets unnecessary, but small, light, frequent meals are better than large, heavy ones. Foods to avoid are those that stimulate digestive juices or irritate the inflamed lining of the stomach or duodenum.

Eat: milk, eggs, fish.
Limit: sugar, candies, chocolate.
Avoid: fatty foods, fried foods, spicy foods, pastry, strong coffee or tea, cola drinks, alcohol, pickles, fruit juices, fibrous meats, whole grain cereals.

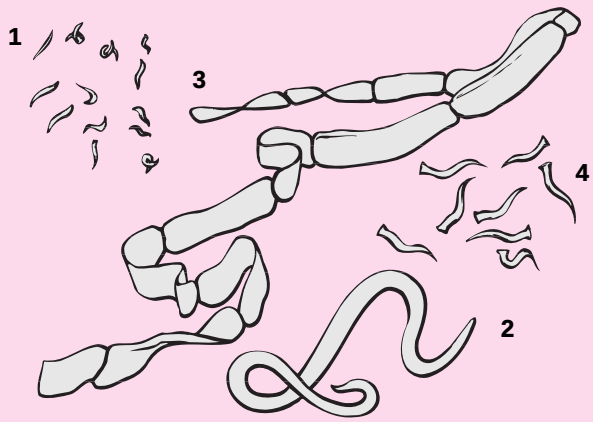
Worms

1 Threadworms or pinworms are common in children. Resembling tiny white threads ¼ inch (6 mm) long, they live in the colon, emerging at night to lay eggs around the anus. This produces itching that causes scratching, leading to reinfection via the mouth. Meanwhile, worms show up in feces. One dose of piperazine will clear an infestation; all the family should be treated.

2 Common roundworms resemble white earthworms and are up to 4 inches (10 cm) long. They invade the small intestine, and are spread via contaminated food. Treatment is the same as for threadworms.

3 Tapeworms comprise up to 30 feet (9 m) of flat, white segments. They live in the intestine and break off to leave it via the feces. Tapeworm infestation results from eating undercooked pork, beef or fish; treatment is by drugs.

4 Hookworms are about 1 inch (2.5 cm) long, and cause anemia by sucking blood from the intestine. They occur in warm climates; eggs exit via the feces, hatching into larvae that invade the skin of the feet. Patients need drugs, iron supplements, and a high protein diet. Wearing shoes, together with good sanitation and foot hygiene, prevents infestation.



Disorders

Hiatus hernia is a condition in which the top of the stomach protrudes through the diaphragm. It causes heartburn, since control is lost over the sphincter linking the esophagus to the stomach. Backward flow of stomach acids up into the esophagus causes burning, and pressure behind the breastbone.

Peritonitis is caused by inflammation of the peritoneum (the membrane lining the abdomen). It results from bacterial infection within the abdomen, caused by perforation of the stomach or intestine. It causes severe pain, muscle spasms, fever, vomiting, and sometimes shock.

Pyloric stenosis occurs when the pylorus (valve between the stomach and the small intestine) is narrowed, obstructing the passage of food. It can be caused by thickening of the muscle at the pylorus (in infants especially), by scarring, or the presence of a tumor.

Introduction

The liver and pancreas are closely connected with the digestive tract, and secrete digestive juices into the small intestine. The liver produces bile, which is stored and concentrated in the gallbladder. Bile helps with the digestion of fats. The pancreas secretes pancreatic enzymes that break down fats, proteins, and carbohydrates. It also makes two hormones, called insulin and glucagon, which control carbohydrate metabolism (the way the body uses energy).

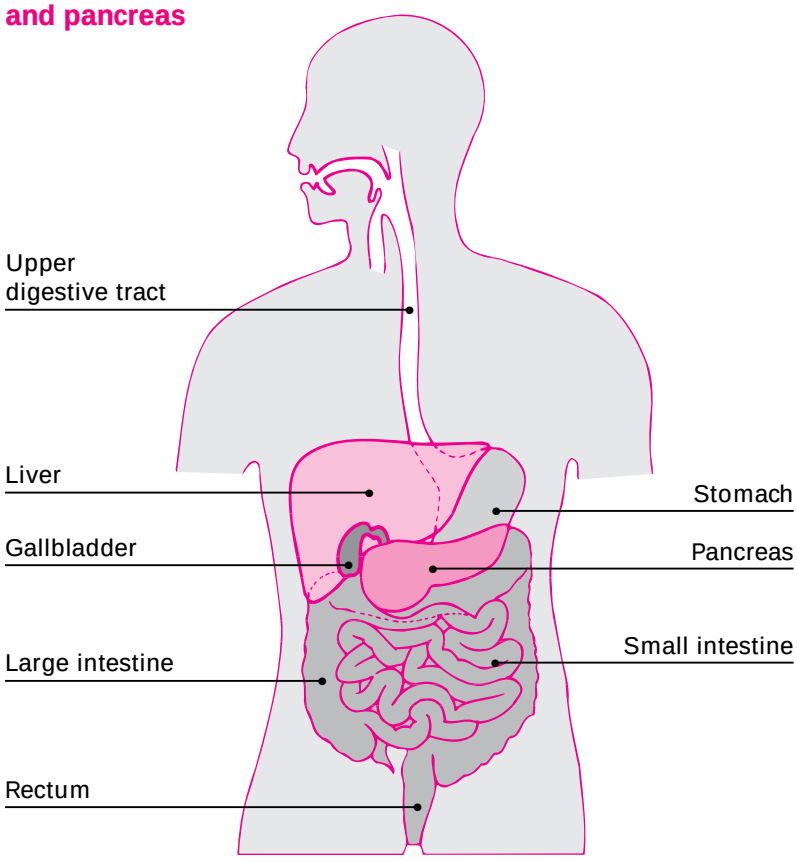
Liver and pancreas facts

- The liver weighs about 3.3 pounds (1.5 kg).
- The pancreas makes more than 36 fluid ounces (1 l) of digestive juices daily.
- The liver makes 36 fluid ounces (1 l) of bile daily.

In the abdomen

The liver is a wedge-shaped organ located mainly on the right side of the upper abdomen under the diaphragm and ribs. The underside faces the stomach, the first part of the duodenum, and the right side of the large intestine. In a hollow under the right lobe of the liver is the pear-shaped gallbladder. It is about 4 inches (10 cm) long. The pancreas is a long, soft organ, tucked behind the stomach on the left side of the body. The wider head and body portions of the pancreas (on the right side) fit into the loop of the duodenum; the tail stretches across to the spleen.

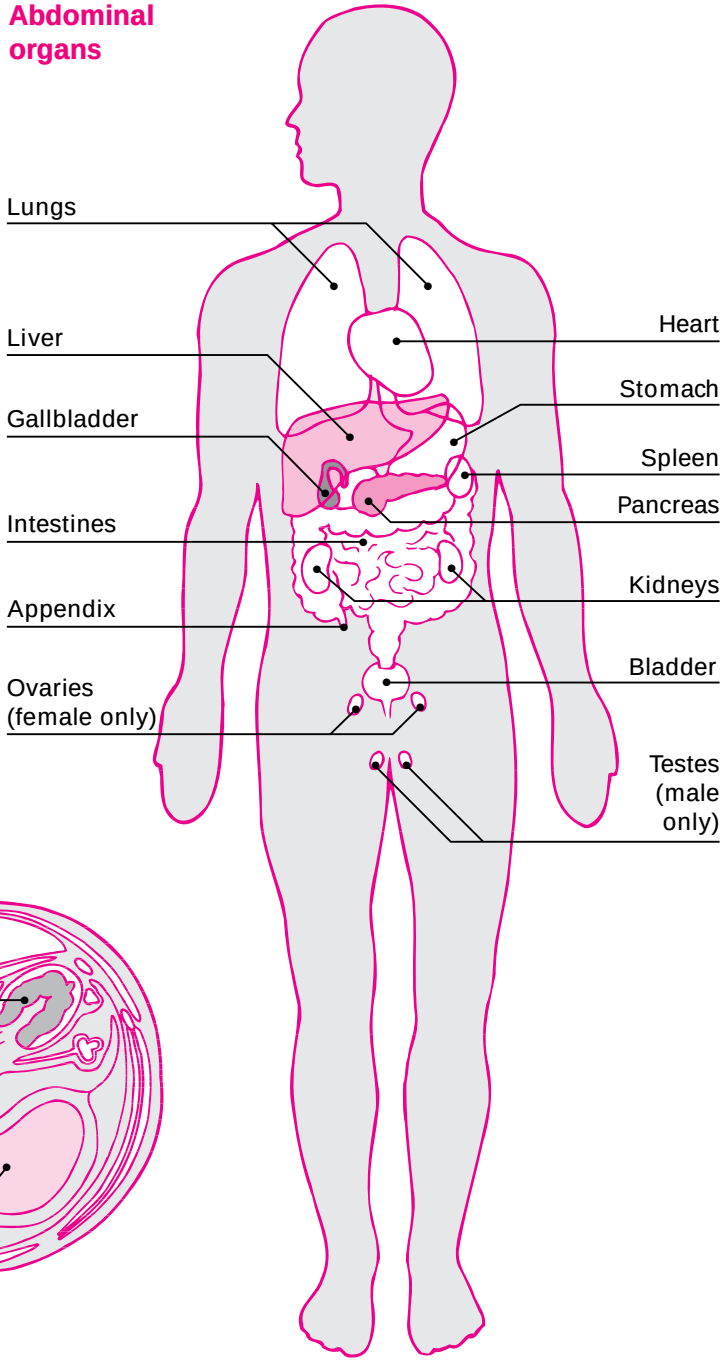
Position of liver and pancreas



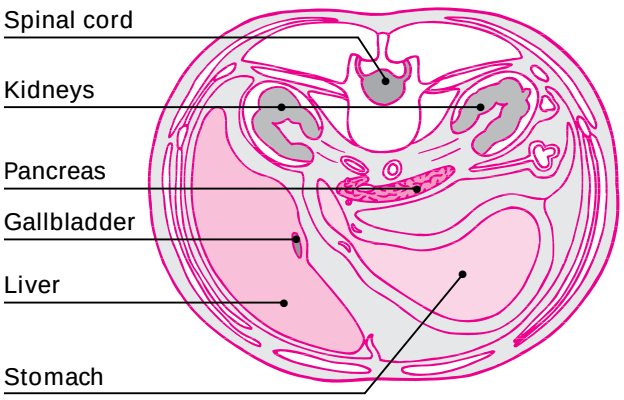
Body organs

The diagram to the right shows the relationship of the liver and pancreas to other organs in the body. They are below the heart and lungs in the thorax, but at the top of the abdomen, above the intestines and reproductive organs. The stomach lies close to the same level in the body as the liver and pancreas.
Digestive juices from the liver and pancreas pour into ducts that merge as they enter the first part of the small intestine, the duodenum. The liver, pancreas and gallbladder are not actually part of the digestive tract, but are considered to be accessory digestive organs.
The liver is the body's largest internal organ.

Abdominal organs



Cross section through the abdomen

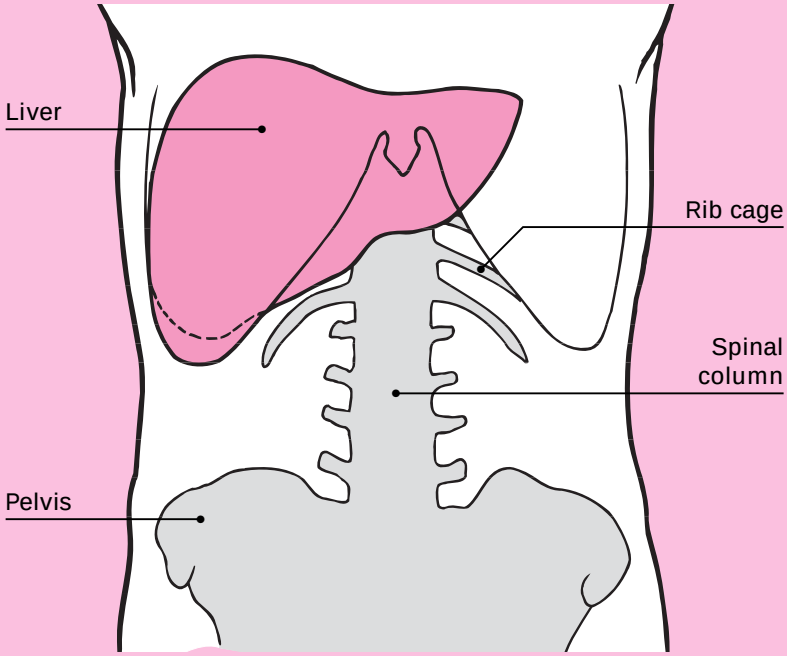


Liver structure

Lobes of the liver

The liver is divided into two main lobes, a right lobe and a smaller left lobe, which lies over the stomach. The right lobe is about six times larger than the left lobe. It is further subdivided into a quadrate lobe and a caudate lobe on its underside. The quadrate lobe partially surrounds and cushions the gallbladder. The caudate lobe is next to the inferior vena cava, which is the largest vein in the body.

Position of liver



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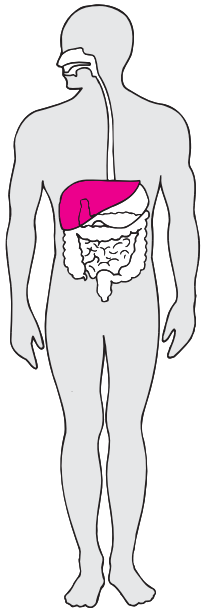
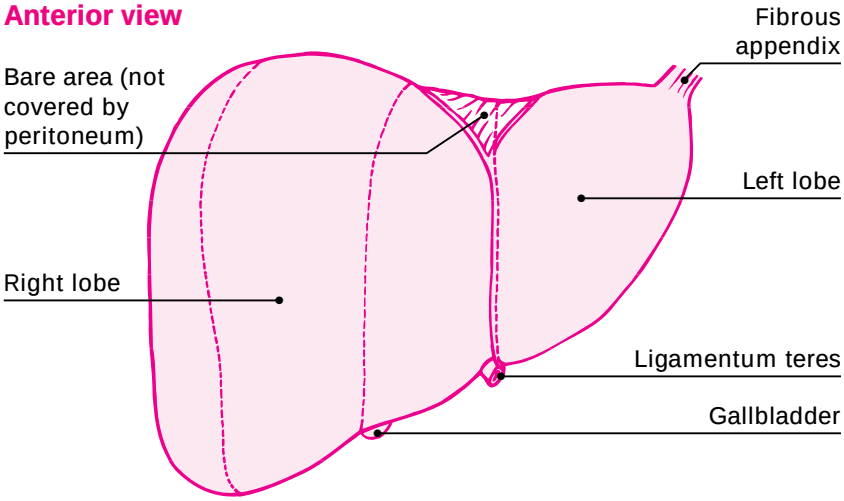


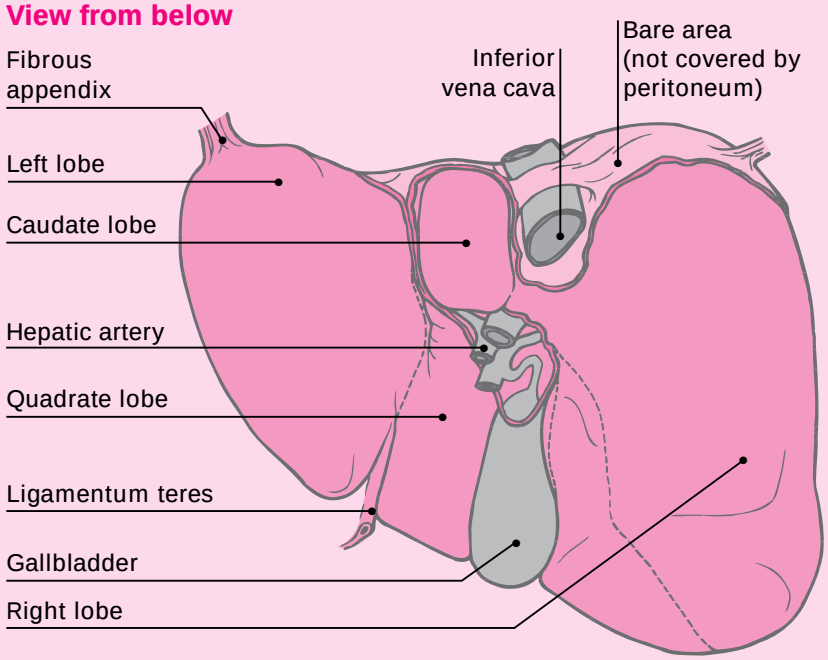
Anterior view



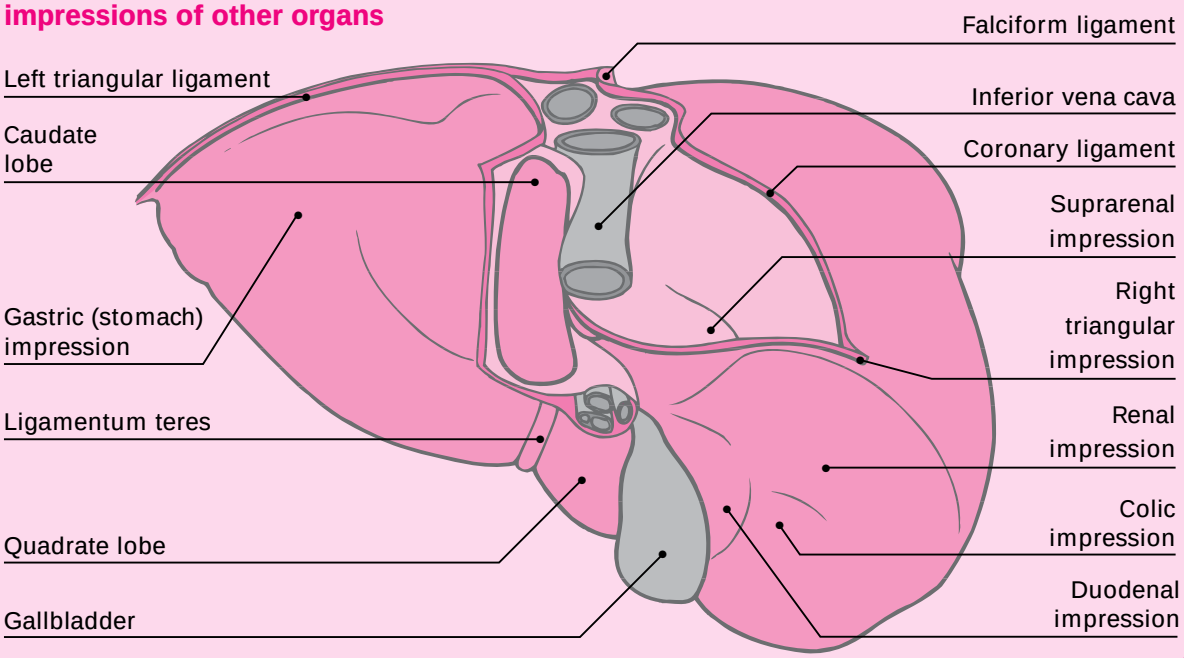
Ligaments

A mesentery attached to the front of the abdominal wall, the falciform ligament, divides the liver into its two main lobes. In the free border of the falciform ligament is the ligamentum teres (round ligament), which is a remnant of the left fetal umbilical vein. The ligamentum teres extends from the liver to the umbilicus.

View from below



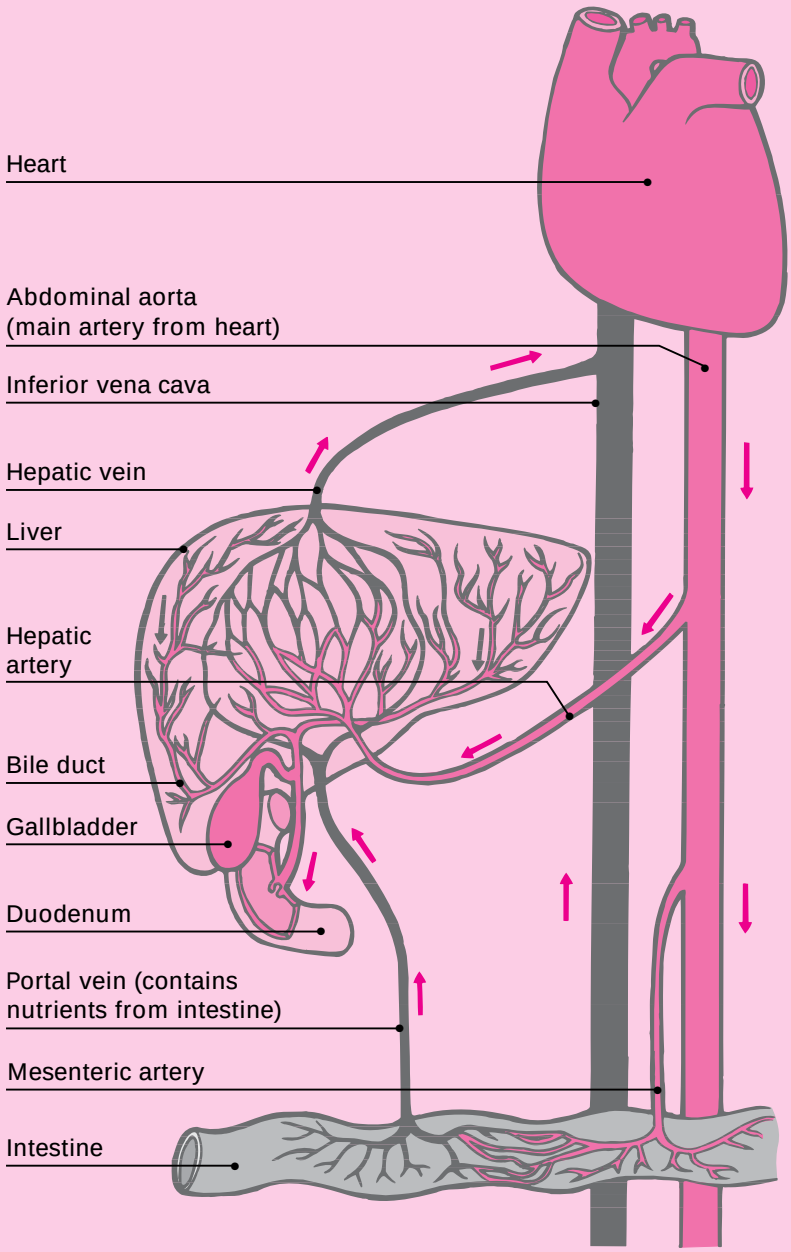
Visceral surface, showing ligaments and impressions of other organs



Roles of the liver

The liver is the largest gland in the body, and performs many functions. It converts the nutrients from food into usable substances, and stores them until they are needed. The liver is the body's main storage center. It stores vitamins and minerals, and glucose in the form of glycogen. Another important role of the liver is detoxification, turning dangerous chemicals into harmless substances. Within the digestive system, the liver is important for the production of bile (a greenish-yellow fluid). This trickles into the small intestine, or is stored in the gallbladder.

Hepatic circulation and bile ducts

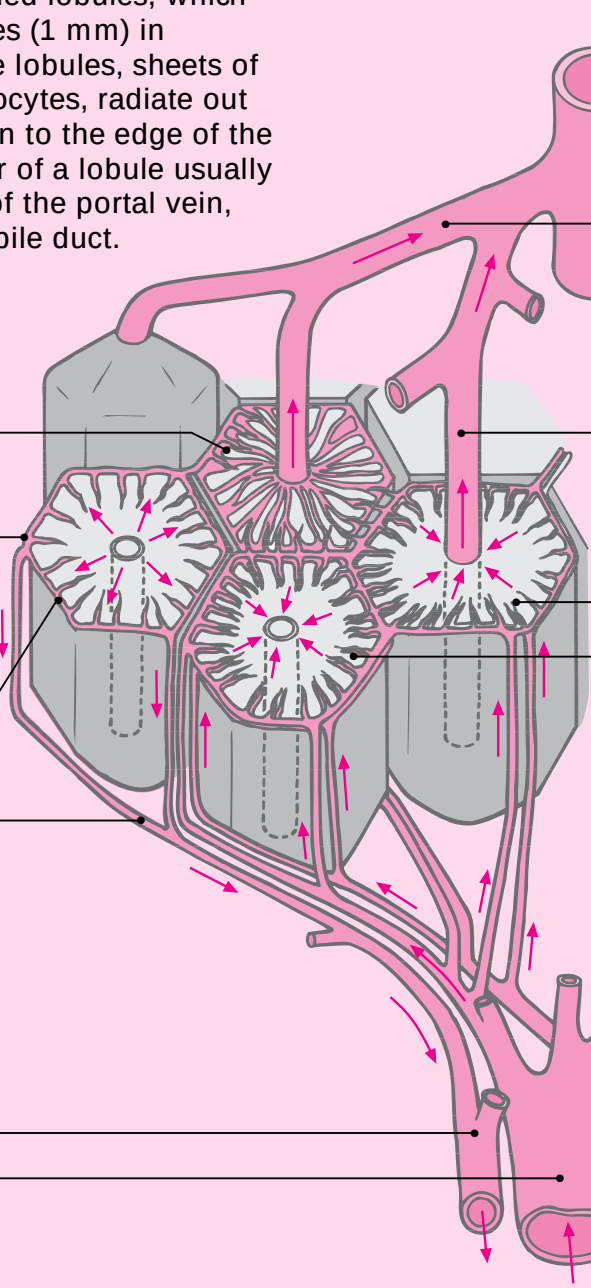


Liver facts

- The liver contains 50,000–100,000 lobules.
- Over 36 fluid ounces (1 l) of blood passes through the liver every minute.
- "Hepatic" comes from the Greek word for liver.

Liver lobules

The lobes of the liver are made up of thousands of six-sided lobules, which are about 0.04 inches (1 mm) in diameter. Within the lobules, sheets of liver cells, or hepatocytes, radiate out from the central vein to the edge of the lobules. Each corner of a lobule usually contains branches of the portal vein, hepatic artery, and bile duct.

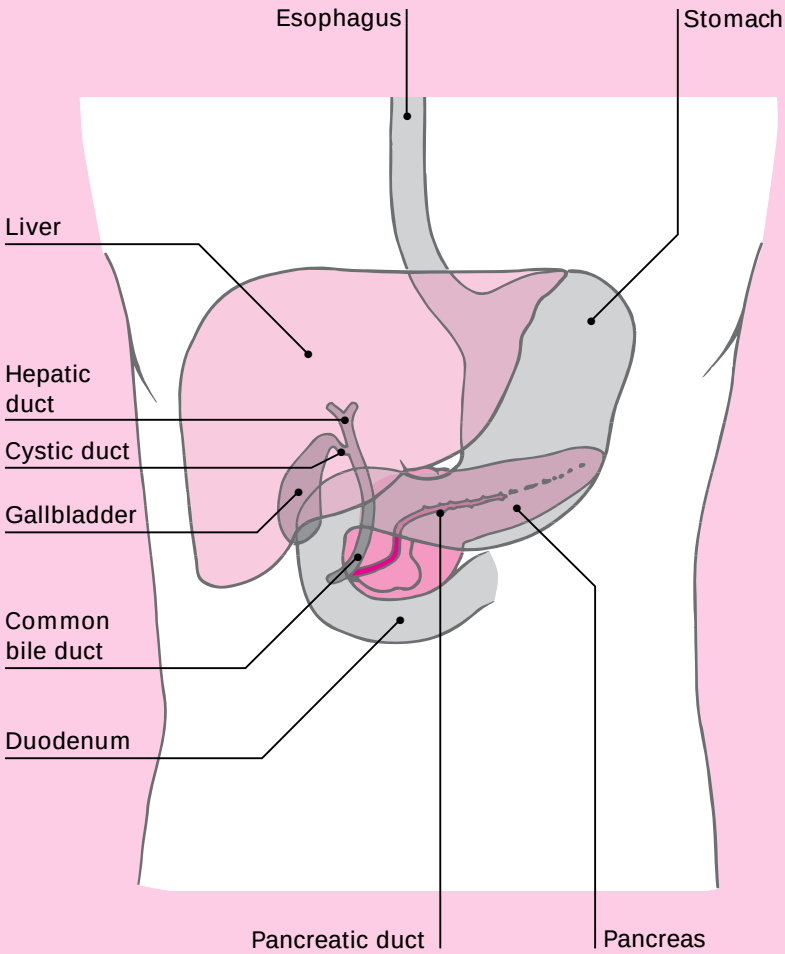


Gallbladder and bile

Functions

The functions of the gallbladder are to store bile, concentrate bile (by absorbing its water), and release bile into the small intestine. Bile helps to break down, or emulsify, large fat globules into smaller fat droplets. This increases the surface area for digestion. Loss of bile in the feces also serves to excrete cholesterol, bile pigments, hormones, and drugs from the body.

Upper abdominal digestive organs



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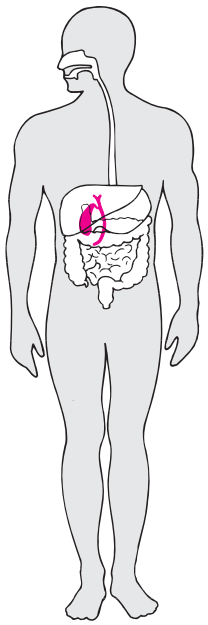


Bile

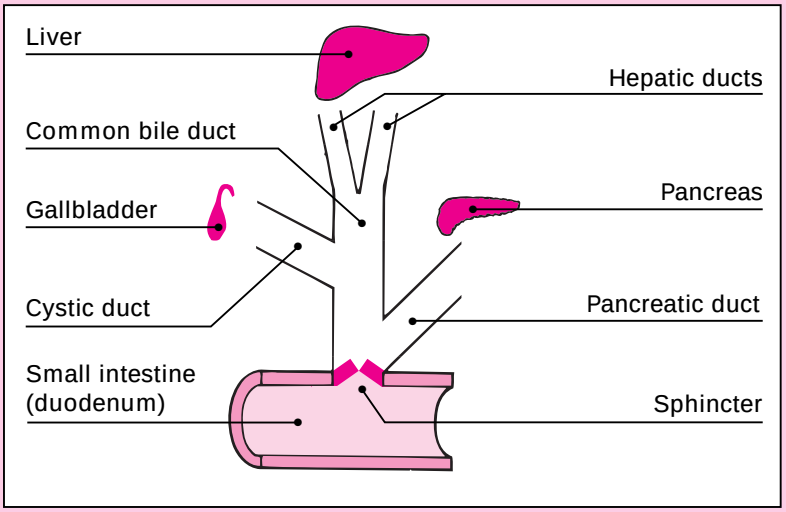
Bile is mainly made up of water. The other two major ingredients are bile salts (formed by the liver from cholesterol), and bile pigments (waste products from the destruction of red blood cells).

Gallbladder facts

- The gallbladder has a capacity of 1.5 fluid ounces (44 ml).
- The common bile duct is 3 inches (7.6 cm) long.

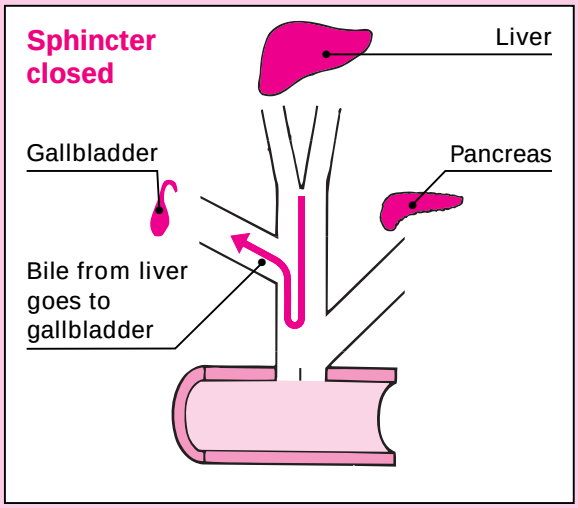
Bile ducts

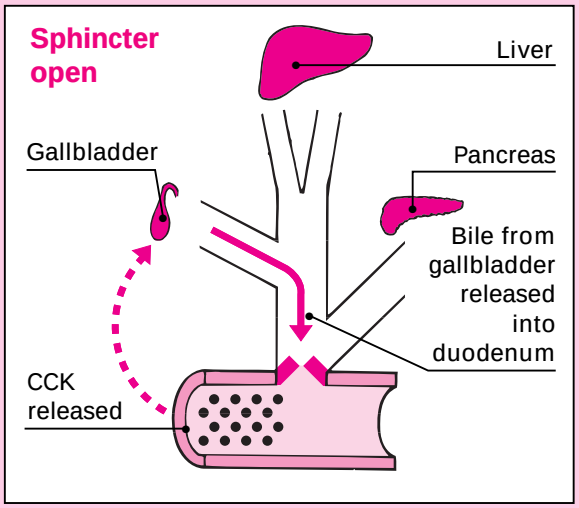
The liver continuously secretes bile, which drains out of the liver through the hepatic ducts. These join to form the common bile duct, which is linked to the gallbladder by the cystic duct. Just before it enters the duodenum, the common bile duct is joined by the pancreatic duct carrying pancreatic juices from the pancreas.



Bile storage and secretion

Where the common bile duct joins the duodenum, a sphincter controls the flow of bile and pancreatic juices into the duodenum. When the sphincter is closed, bile goes back up the ducts and is stored and concentrated by the gallbladder. The presence of fat in the small intestine triggers the release of the hormone cholecystokinin (CCK), which causes the gallbladder to contract and the sphincter to relax and open. Bile is then squirted into the duodenum.



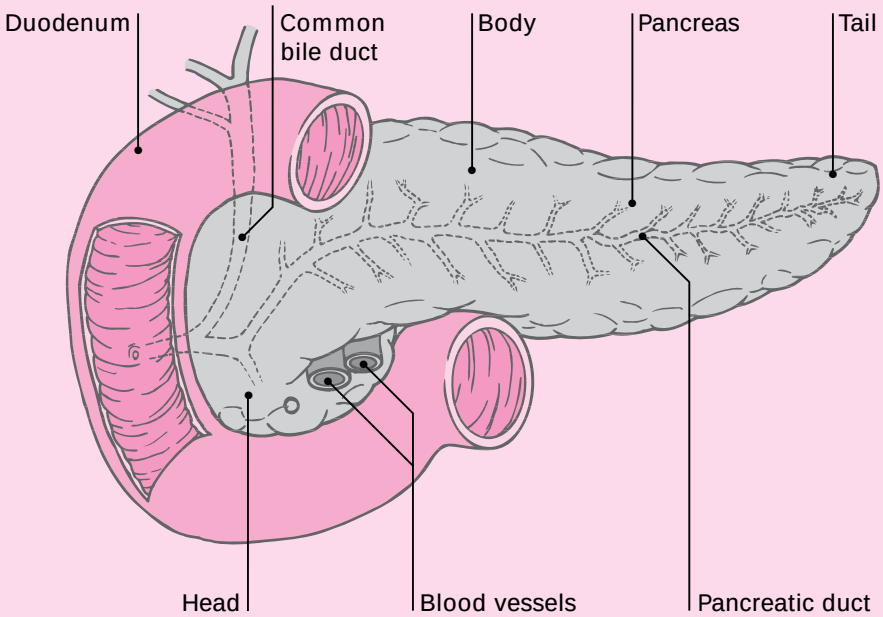


Pancreas

Functions

The pancreas is both an exocrine (ducted) gland that secretes digestive enzymes (pancreatic juice) into the pancreatic duct, and an endocrine (ductless) gland that secretes hormones. The hormones insulin and glycogen regulate the body's blood sugar level.

Anatomy of the pancreas



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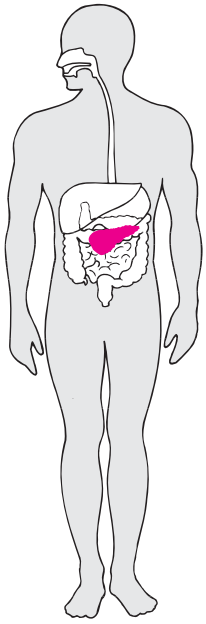
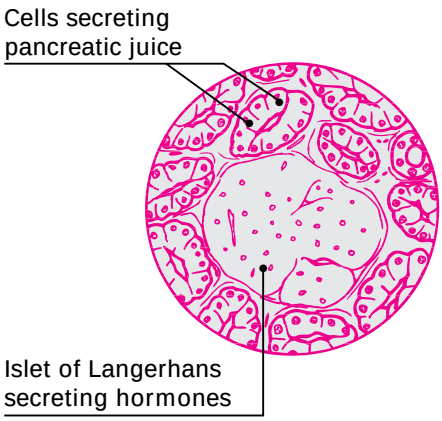


Islets of Langerhans

The hormones of the pancreas are secreted by clusters of cells, called islets (of Langerhans). These islets have no contact with any ducts, and their hormones pass straight into the blood flowing through the pancreas.

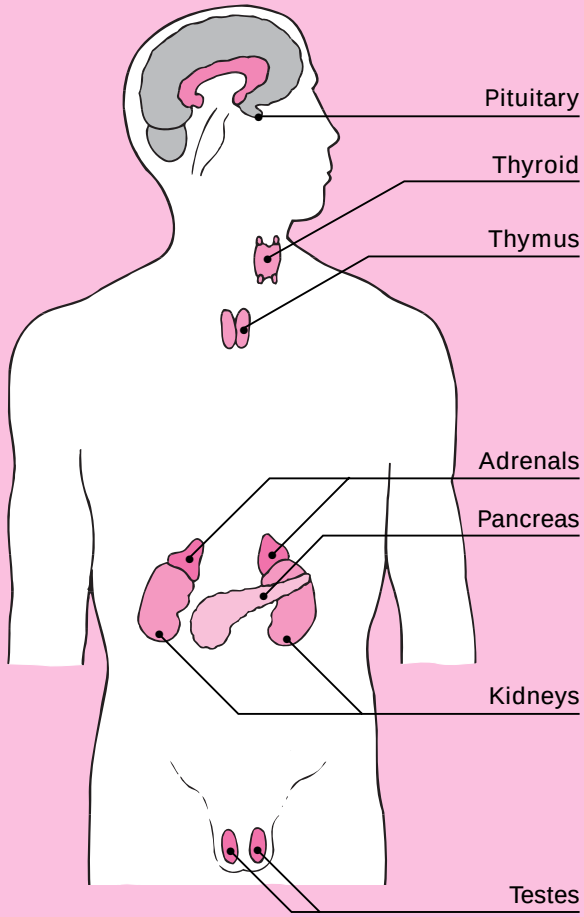
Section of the pancreas

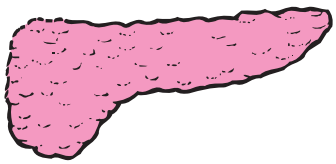


Hormones of the pancreas

The islets of Langerhans consist of more than a million clusters of cells, but make up less than one hundredth of the pancreas by weight. They secrete two hormones, which are chemical messengers that travel in the blood. There are two types of cells in the islets: alpha cells, which secrete glucagon, and beta cells, which secrete insulin. Glucagon results in an increased blood glucose level. This is achieved by moving glucose and fatty acids from where they are stored in the body. Glucagon also stimulates the liver to release glucose and to manufacture glucose from proteins and fats.
Insulin is secreted when there is a high level of glucose in the blood. It works in the opposite way to glucagon, and has the overall effect of decreasing blood sugar levels. Insulin stimulates the liver and muscles to remove glucose from the blood. When the liver has stored as much glucose as it can, excess glucose is converted into fat. Insulin also inhibits the manufacture of glucose from proteins and fats.

Glands that secrete hormones



Hormones	Target tissues	Effects
Glucagon	Liver	• increases the level of glucose in the blood
Insulin 	Liver, skeletal muscles, adipose (fat tissue)	• decreases the level of glucose in the blood • promotes the storage of glucose • decreases the level of potassium in the blood

Pancreatic juices

Pancreatic secretion

The secretion of pancreatic juice by the pancreas is stimulated by hormones from the small intestine.

1 Chyme (semifluid mixture of food and digestive juices) enters the small intestine.

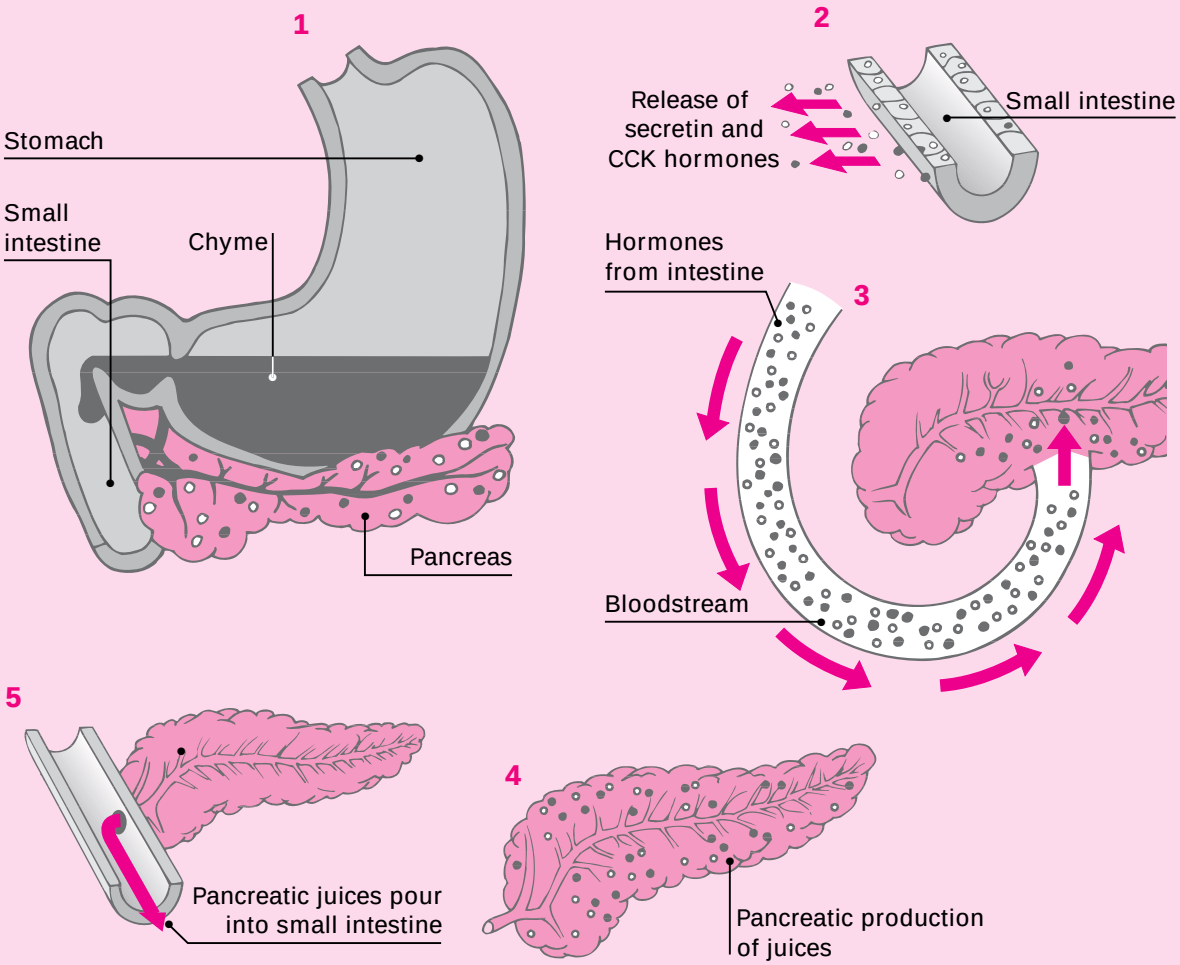
2 Release of the hormones secretin and cholecystokinin (CCK) is triggered.

3 These enter the bloodstream and travel to the pancreas.

4 Secretin stimulates the production of juice with a high bicarbonate content.

5 Cholecystokinin stimulates the production of juice with a rich enzyme content.

The secretion of pancreatic juices



Pancreatic juice

The main ingredient of pancreatic juice is water. It also contains digestive enzymes (proteins that act as biological catalysts) and bicarbonate (a salt). Pancreatic juice is the main agent of chemical digestion. This occurs, however, in the small intestine. In order to protect the pancreas, most of the enzymes are secreted in an inactive form and then activated by other enzymes, or the presence of bile, when they reach the small intestine. The chart below shows the functions of each of the agents in pancreatic juice.

Agent	Function
Trypsinogen (inactive enzyme)	• inactive form of trypsin activated by the intestinal enzyme enterokinase
Chymotrypsinogen (inactive enzyme)	• inactive form of chymotrypsin activated by trypsin
Peptidases (inactive enzymes)	• inactive enzymes activated by trypsin
Trypsin (active enzyme)	• reduces proteins into shorter chains of amino acids called peptides • activates chymotrypsinogens and peptidases
Chymotrypsin (active enzyme)	• reduces proteins into peptides
Peptidases (active enzymes)	• reduce segments of proteins called peptides into their building blocks: amino acids*
Lipase (active enzyme)	• breaks down fats into their components: monoglycerides* and fatty acids*
Pancreatic amylase (active enzyme)	• reduces complex carbohydrates (for example, starch) into disaccharides (double sugars)
Bicarbonate (salt)	• neutralizes acidic chyme • provides correct environment for chemical digestion

* substances ready for absorption

Liver disorders

Causes of liver disorders, such as hepatitis, include drinking too much alcohol, viral infections of the liver, and drug abuse. Long-term damage from any of these causes can lead to cirrhosis (scarring) of the liver. Hepatitis causes the liver to swell up and stop working well. It is often caused by a viral infection, particularly with hepatitis A, B, or C viruses. There are vaccines for hepatitis A and B, but not for C. Viral hepatitis is usually an acute, short-lived illness. Most people get over the acute inflammation in a few days or weeks. Sometimes the inflammation does not go away, and develops into chronic hepatitis, which can cause liver failure and death.

Viral hepatitis

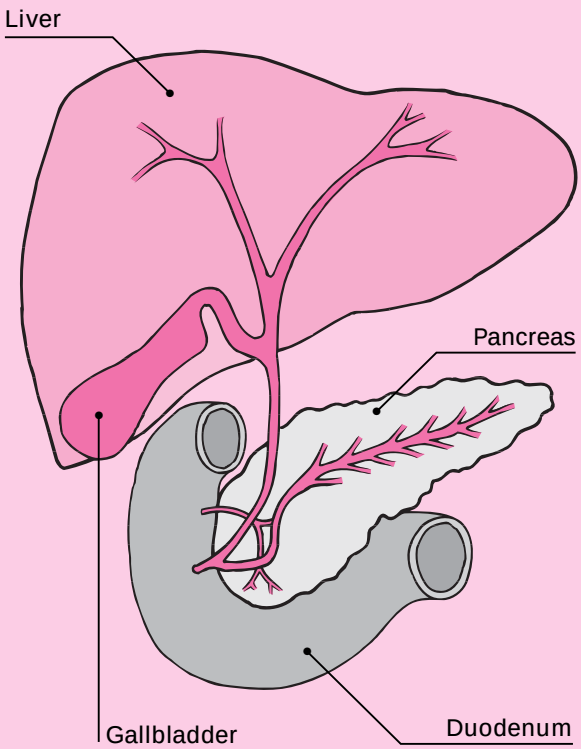
Several viruses can infect the liver. Each one is named with a letter of the alphabet. People usually get hepatitis A or E by drinking water infected with the virus. Hepatitis B is spread through infected blood or syringes, while hepatitis C is usually spread through contact with infected blood, e.g. by sharing syringes. Hepatitis D is a defective virus that needs hepatitis B to exist. People can only get hepatitis D if they already have hepatitis B.

Sites of liver problems

In alcoholic hepatitis, the liver becomes inflamed, and damage allows yellow bile pigment to enter the bloodstream, causing jaundice. The spleen is enlarged, fluid collects in the abdominal cavity, and there is usually fever.

Hepatitis A, B, C, D, and E also feature an inflamed liver but are due to viral infection. Abdominal discomfort and fever occur, and jaundice develops. In rare cases the liver is destroyed and the patient dies.

Cirrhosis is a chronic liver disease that destroys liver cells, replacing them with fibrous material; the liver may enlarge and harden. As it stops working properly, there may be internal bleeding, or blocked blood flow. Accumulating fluid may stretch the abdomen, and jaundice and kidney failure are likely.



Signs and symptoms

This illustration locates the sites of some of the signs and symptoms that are produced by certain ailments affecting the liver. Some of these conditions plainly show disease that needs urgent medical aid, whereas others hint at trouble less dramatically. Many of the symptoms are common to various ailments, some slight and some serious, and a doctor's diagnosis of liver disease will often depend on the presence of several or many of these signs and symptoms. See a doctor immediately if you experience any of these severe symptoms, or if you exhibit several of the slighter ones at the same time.

1 Fever occurs in hepatitis.

2 Yellowing of the whites of the eyes and the skin indicates jaundice, which is a common symptom of hepatitis. This is caused by a waste product, bilirubin, which builds up in the blood and tissues when the liver is not working properly. Bilirubin and other waste products may also cause itching, nausea, fever, and body aches.

3 Nausea and loss of appetite, perhaps with vomiting, also occur in hepatitis and cirrhosis.

4 Thin, spider-shaped blood vessels suddenly showing up on the face, upper trunk and arms are often caused by cirrhosis of the liver.

5 A swollen and tender liver often indicates early cirrhosis; the liver may become shrunken as the condition progresses.

6 White nails are a common sign of cirrhosis, and the ends of the fingers may become clubbed in shape.

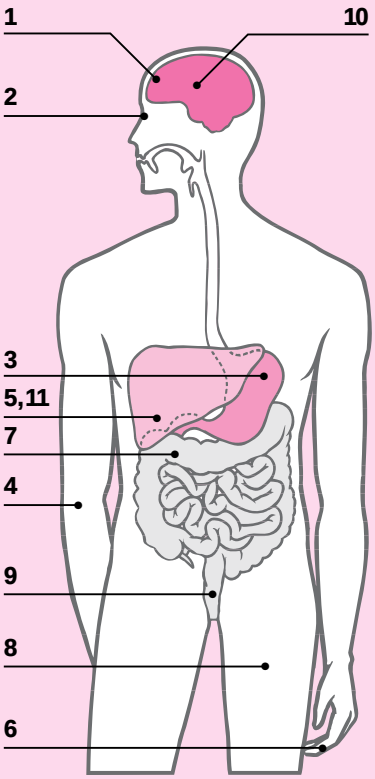
7 Severe pain in the upper right part of the abdomen may be caused by hepatitis.

8 Weight loss is often associated with cirrhosis and hepatitis.

9 Dark-colored urine and pale stools can be a sign of advanced hepatitis.

10 Muscle aches, headaches, and tiredness can be common early signs of hepatitis.

11 Liver abscesses can cause fever, nausea, weight loss, liver enlargement, and chest pain. They can be caused by infection with bacteria or amoebas. Bacteria may spread from another part of the body, such as the appendix. Diarrhea may precede amoebic liver abscesses, which are common in the tropics.



Pancreas and gallbladder disorders

Inflammation of the pancreas may be due to viral infections, gallstones, or alcohol abuse. If the pancreas does not produce enough insulin, the amount of glucose builds up in the blood and diabetes will develop. Insulin-dependent diabetes, also called juvenile onset diabetes, usually affects people under 40 years of age. Non-insulin dependent diabetes, or late onset diabetes, usually affects older people. Most disorders of the gallbladder are due to the presence of gallstones.

People at risk

Pancreatitis often occurs in alcoholics, and individuals with bile tract disease. Overweight white women aged over 40 seem most liable to gallstones, although the reasons for gallstone formation are still unclear. Diabetes among adults may be linked with excessive carbohydrate intake.

Pancreas and gallbladder problems

Pancreatitis is inflammation of the pancreas, when pancreatic enzymes build up inside it, for instance if a gallstone blocks its outlet. It may occur in association with disease of the gallbladder. Steady, severe upper abdominal pain and vomiting after excessive alcohol intake may signal an acute attack. In chronic pancreatitis, people suffer recurrent but milder attacks. Swift medical aid is essential; treatment includes bed rest, and at first only intravenous nourishment.

Diabetes occurs when the pancreas fails to make any or enough of the hormone insulin which the body needs for using sugar and starches. Juvenile onset diabetes usually involves the complete failure of the parts of the pancreas that make insulin (the islets of Langerhans); in these cases insulin injections are needed at regular intervals. In late onset diabetes, the islet failure is often only partial, and if this is the case, the patient can be treated with diet regulation and tablets. Regular meals help to keep the sugar and insulin in balance—too much or too little sugar can cause coma. Complications of diabetes may include arterial degeneration, heart disease, kidney disease, gangrene of the feet, and retinopathy (retinal (hemorrhages). Untreated severe diabetes can produce coma and death.

Gallstones are small lumps, usually of cholesterol, forming in people who tend to overconcentrate cholesterol in the bile. They may occur in the gallbladder without causing discomfort, but can also lodge in the bile duct, causing pain and jaundice.

Cholecystitis is inflammation of the gallbladder. An acute form may be due to bacterial infection of the gallbladder. Chronic cholecystitis is usually due to gallstones. If they block the bile duct, there may be liver damage.

Signs and symptoms

This illustration locates the sites of some of the signs and symptoms produced by certain ailments affecting the pancreas and gallbladder.

1 Excessive fatigue and lethargy are common signs of juvenile onset diabetes. Coma may result if the condition is left untreated.

2 Insatiable thirst strongly suggests diabetes.

3 Breath that smells fruity and sweet is another common sign of diabetes.

4 Diabetes may affect the eyesight because blood vessels in the retina can be damaged.

5 Fever occurs in pancreatitis.

6 Sweating and shock may be caused by pancreatitis.

7 Belching associated with severe right-sided upper abdominal pain may occur in gallstone troubles. The pain may spread to the right shoulder blade. This usually happens within an hour of eating, and lasts several hours. Where symptoms occur only after eating fats, a low-fat weight-reducing regime, supplemented with vitamins, may suffice. Doctors sometimes remove the gallbladder to avoid possible fatal bile blockage.

8 Nausea and loss of appetite, perhaps with vomiting, occur in pancreatitis.

9 A painful sensation of fullness in the stomach is another sign of pancreatitis.

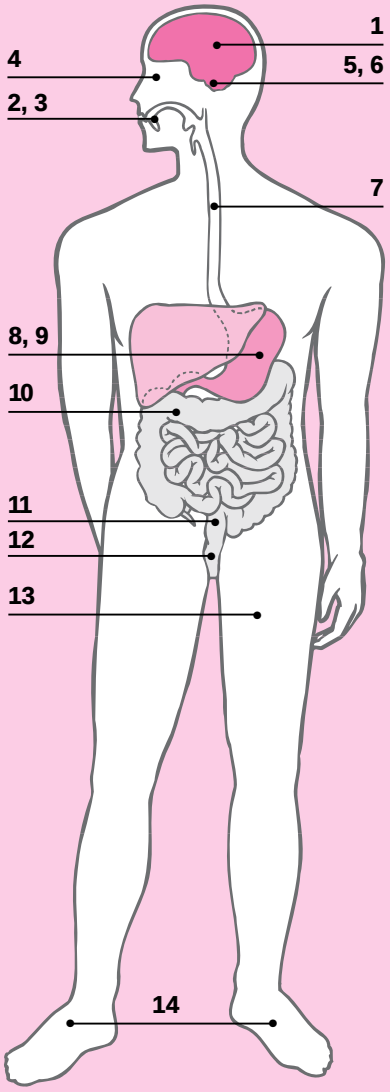
10 Severe pain in the upper right part of the abdomen may be caused by gallbladder inflammation.

11 Clay-colored stools are one symptom of gallbladder inflammation and indicate that the bile duct has been blocked; an emergency operation is necessary.

12 Heavy urine output may well indicate diabetes; in women, intense itching of the vulva may also occur. Dark brown or yellow urine may be indicative of gallbladder disease.

13 Weight loss is often associated with diabetes.

14 Long-term diabetes may damage the nerves and cause numbness in the feet. If this happens, a diabetic person may injure or burn their feet. Keeping the feet clean and dry and wearing shoes that fit well is very important for diabetics.



Introduction

The urinary system is one of the methods by which the body eliminates toxins and wastes produced during chemical reactions inside body cells. It produces a fluid waste called urine. The system consists of two bean-shaped kidneys, a muscular bladder, two tubes called ureters linking the kidneys to the bladder, and one tube called a urethra, through which the urine from the bladder leaves the body.

Urinary system facts

- The right kidney is usually 0.4–0.8 inches (1–2 cm) lower than the left one.
- Each ureter is about 12 inches (30 cm) long.
- The bladder holds about two pints (1 l) of urine.

Functions

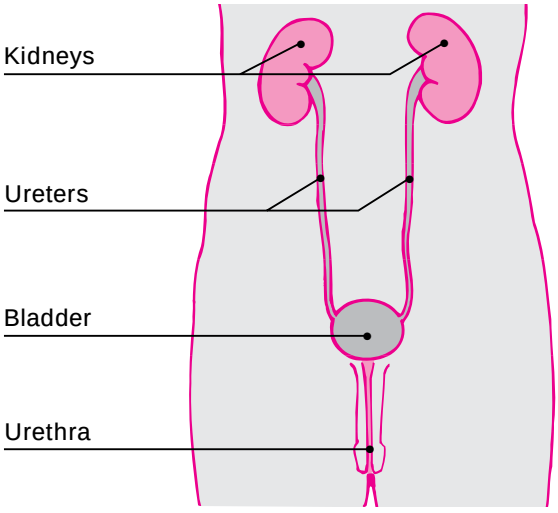
The urinary system filters the blood, removes wastes, and flushes wastes out through the urine. Other functions of the system include maintaining the balance of water and salts in the body, and regulating the acid-base balance of the blood.

The kidneys remove wastes, excess water, and salts from the blood, and form urine, which is a pale yellow, slightly acid fluid. They also secrete the hormones renin and erythropoietin, and activate vitamin D. The ureters take urine from the kidneys to the bladder.

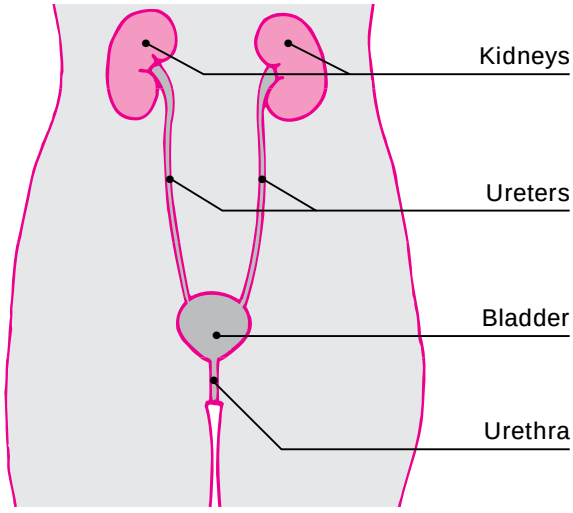
The bladder is a stretchable bag near the base of the abdomen, which collects and stores urine.

The urethra is the duct through which urine from the bladder flows to the outside of the body during urination. In men, it also carries sperm during ejaculation.

Male



Female



Urinary system: key words

Adrenal glands (*or* Suprarenal glands) Two endocrine glands, situated one above each kidney. The adrenal glands secrete adrenaline and noradrenaline, as well as various hormones.

Bladder A sac, especially the muscular bag inside the pelvis where urine collects before being expelled from the body.

Bowman's capsule (*or* Glomerular capsule) The dilated end of a kidney tubule: a little cup surrounding a glomerulus.

Calyx A cup-shaped part. *See also* **Renal calyx**.

Capsule *See* **Renal capsule**.

Cortex *See* **Renal cortex**.

Epithelium The cell layer covering the outer surface of the body and lining the urinary, gastrointestinal and respiratory tracts.

Glomerular capsule *See* **Bowman's capsule**.

Glomerulus A convoluted mass of blood-filtering capillaries in a nephron.

Kidney A bean-shaped organ that filters wastes from blood to form urine. The two kidneys lie in the upper rear of the abdomen, one on each side of the vertebral column.

Loop of Henle The U-shaped turn in the medullary portion of a renal tubule.

Medulla The inner part of any organ that is distinguishable from the outer part or cortex. *See also* **Renal medulla**.

Mucous membranes The mucus-secreting linings of the urinary, digestive, respiratory, and reproductive tracts.

Nephron The basic filtration unit in a kidney. *See also* **Glomerulus**; **Renal tubule**.

Pelvis *See* **Renal pelvis**.

Renal Relating to the kidney.

Renal artery The large artery supplying a kidney. It arises from the abdominal aorta and divides into an anterior and a posterior branch.

Renal calyx A recess enclosing a pyramid within the renal pelvis.

Renal capsule The tough, fibrous sheath in which a kidney is enclosed.

Renal cortex The outer layer of a kidney, situated immediately beneath its fibrous capsule, and containing the nephrons.

Renal medulla The inner part of a kidney, composed mostly of collecting elements and loops of Henle organized into pyramids.

Renal pelvis The core of a kidney, containing the broad upper end of a ureter.

Renal pyramid One of the conical masses that constitute the renal medulla.

Renal tubule (*or* Uriniferous tubule) A tiny, convoluted tube within a kidney, forming part of a nephron.

Renal vein The large vein taking blood from the kidney, usually to the inferior vena cava.

Sphincter A ring of muscle around an opening. *See also* **Urinary sphincter**.

Suprarenal glands *See* **Adrenal glands**.

Tubule A tiny tube. *See also* **Renal tubule**.

Ureter The tube conveying urine from a kidney to the bladder.

Urethra The passage taking urine from the bladder to the body's exterior. The male urethra stretches along the penis to its tip.

Urinary sphincter The ring of muscle between the bladder and the urethra.

Urinary system The kidneys, ureters, bladder, and urethra.

Urine Liquid waste excreted by the kidneys.

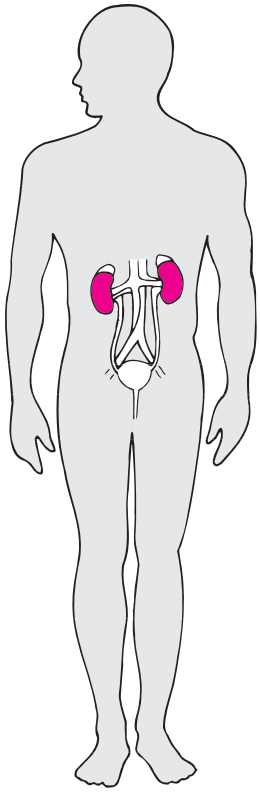
Uriniferous tubule *See* **Renal tubule**.

Kidney structure

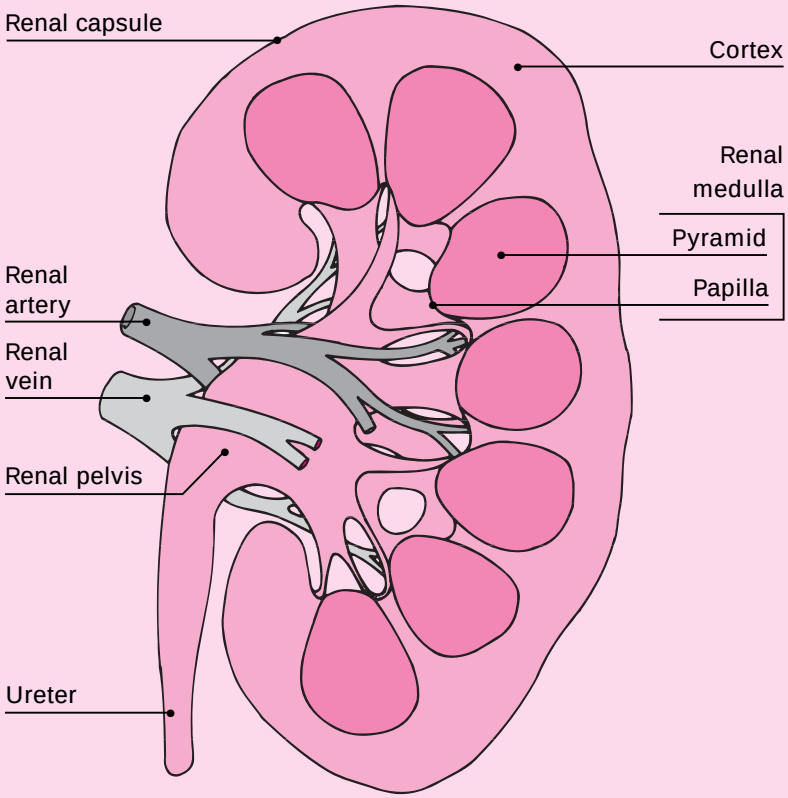
Macro structure

Each kidney is covered by a layer of connective tissue called a renal capsule. It has three distinct regions—the renal cortex on the outside, the renal medulla in the middle, and the renal pelvis on the inside. The renal pelvis is an expansion of the upper end of a ureter.

Locator



Section through a kidney



Renal medulla

The middle of the kidney, the renal medulla, is divided into triangular sections called renal pyramids. The narrow, innermost end of a pyramid is called a papilla. Renal pyramids consist of tubules and collecting ducts of the nephrons that form urine.

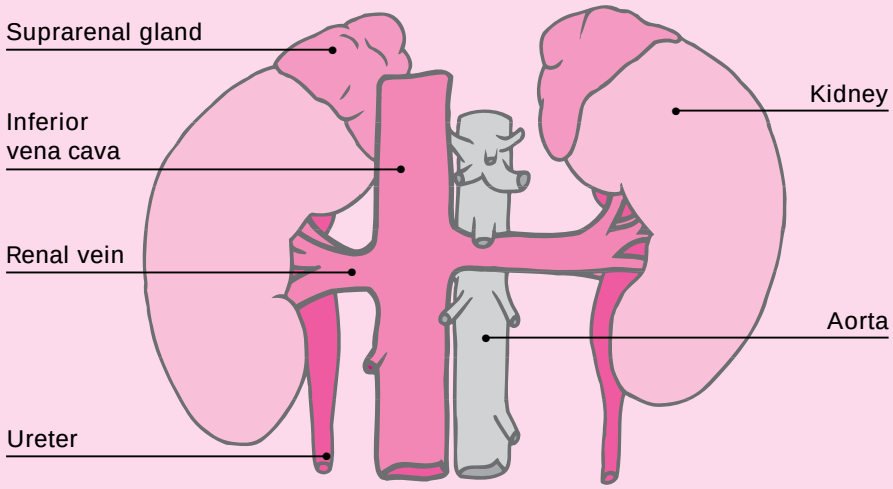
Kidney facts

- Each kidney is about 4.7 inches (12 cm) long, and 2.7 inches (7 cm) wide. It weighs about 4.8 ounces (135 g).
- About a third of a gallon (1.2 l) of blood passes through the kidneys every minute.

Blood supply

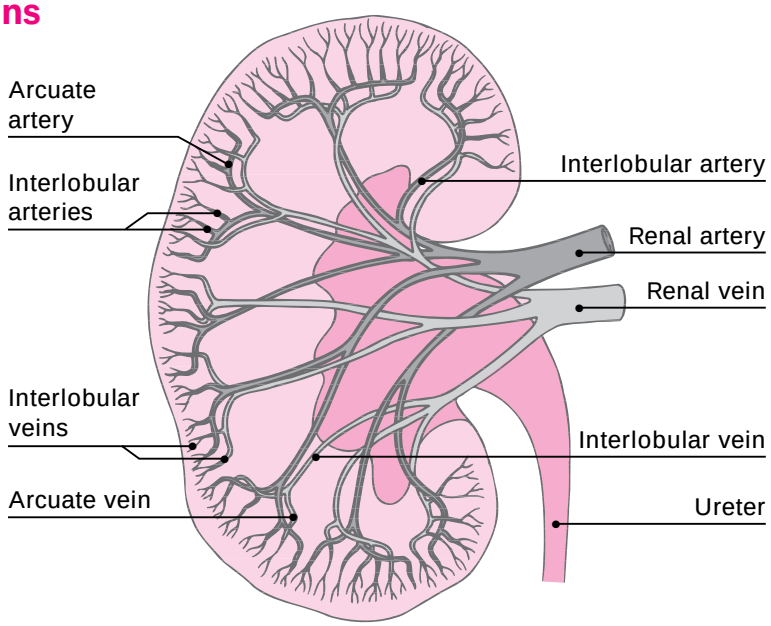
Oxygenated blood comes to each kidney from the abdominal aorta through the renal artery, which delivers 20 percent of the blood pumped by the heart each minute. Deoxygenated blood leaves the kidneys through the renal vein, which carries blood to the inferior vena cava.

Front view of kidneys and blood vessels



Renal arteries and veins

Inside the kidney, the renal artery branches into the interlobular arteries, which pass through the renal columns (cortical tissue between the renal pyramids). When the arteries reach the cortex, they form arcuate arteries, which run parallel to the bases of the renal pyramids. The arcuate arteries branch into interlobular arteries, which stretch up into the cortex.



Nephrons

Cleaning the blood

Nephrons are the microscopic filtration units within a kidney. More than a million nephrons make up the medulla and cortex of each kidney. Different parts of the nephron are responsible for different functions. These include filtration (the process by which substances are filtered out of blood), reabsorption (the process by which substances are taken out of urine and put back into blood), and secretion (the process by which substances are taken out of blood and put into urine).

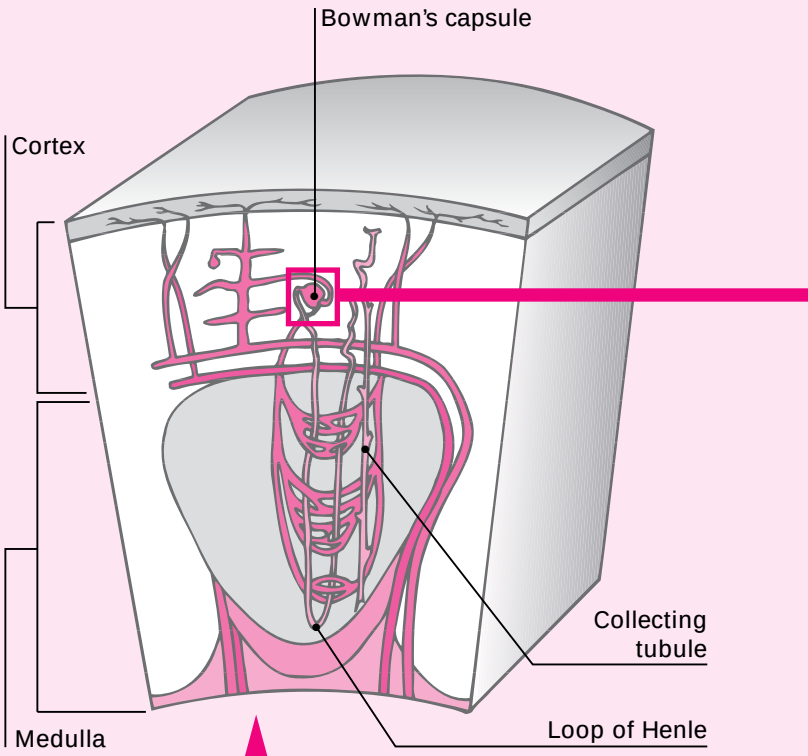
Nephron structure

Nephrons look like tiny funnels with very long, and convoluted, stems. Each nephron consists of several parts. Blood is filtered through a tiny knot of blood capillaries called a glomerulus housed within a structure called the Bowman's capsule.

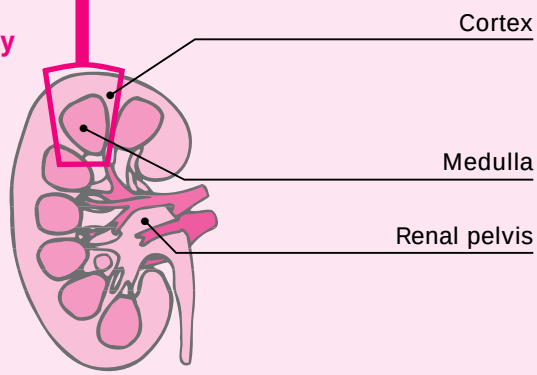
Each Bowman's capsule is the expanded beginning of a long, thin renal tubule (small tube) with many bends, which winds away from the glomerulus and capsule, and joins with other tubules to form a larger collecting tubule. The kidney medulla contains the looped ends of the renal tubules, while the kidney cortex contains many thousands of glomeruli. The length of the kidney tubules are entwined with blood capillaries, facilitating filtration, reabsorption, and secretion.

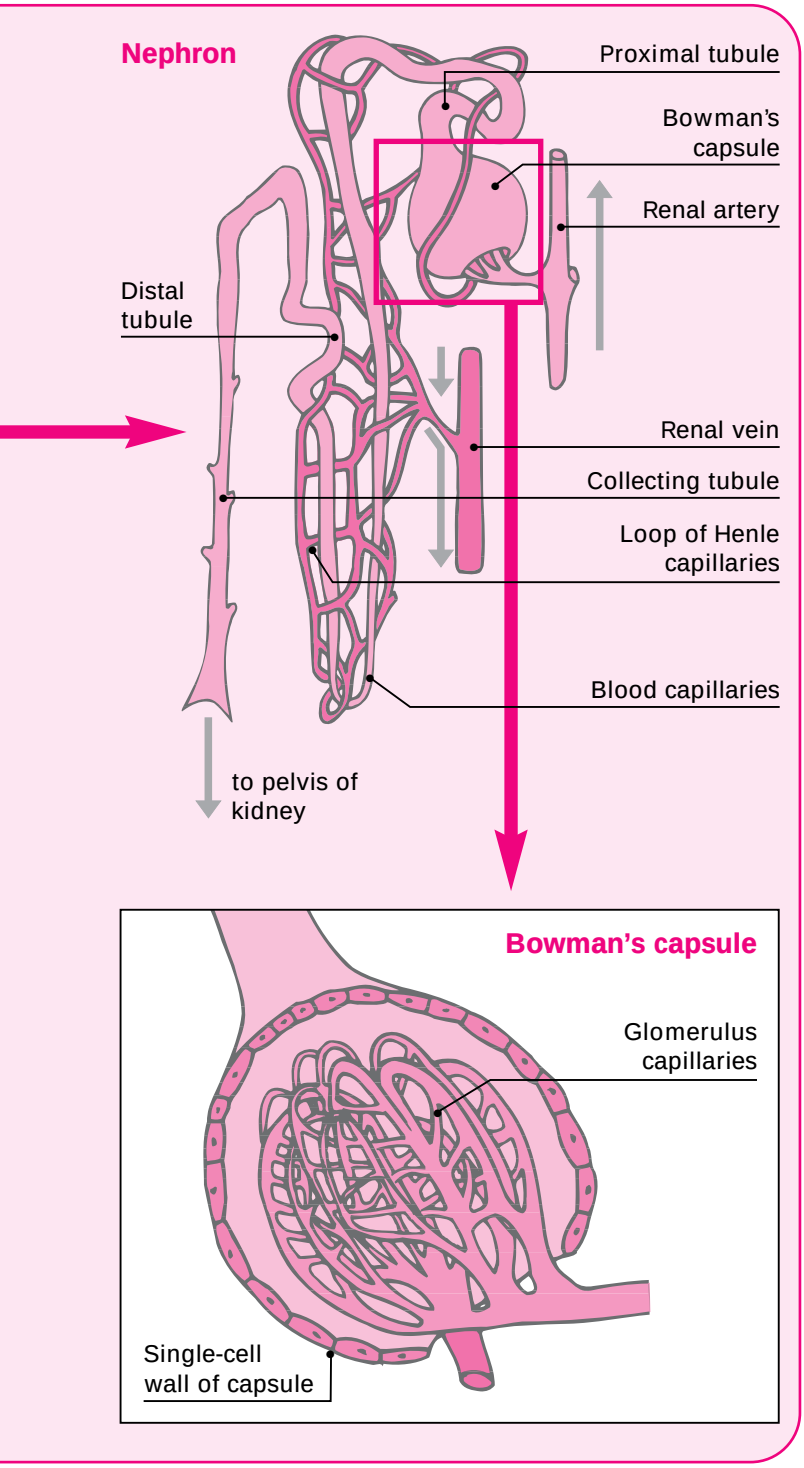
Structure and function

Inside a kidney



Whole kidney





Nephron function

Blood from the renal artery is forced into the glomerulus capillaries inside the Bowman's capsule. Large molecules and blood cells do not pass through the capillaries, but water and wastes filter through into the Bowman's capsule.

The fluid that has been filtered then passes along the coiled renal tubules, which run in great U-shaped loops through the medulla of the kidney. Each tubule consists of a proximal tubule, a loop of Henle, and a distal tubule. Water and solutes (dissolved substances) are reabsorbed back into the blood in the proximal tubule.

In the loop of Henle, sodium and chloride ions are reabsorbed from the filtered fluid back into the blood. This process continues in the distal tubule, where water is also reabsorbed. Here, certain substances (ammonia, potassium ions, hydrogen ions, and some drugs) are secreted from the blood into the urine solution.

Collecting urine

The distal tubules from different nephrons unite to form a collecting tubule which runs down toward the renal pelvis. This tube drains urine into the bladder. The kidneys can vary the amount of a substance that is reabsorbed or secreted, which changes the volume and composition of urine.

Urine and urine flow

Formation of urine

About 44 gallons (200 l) of filtered water and wastes are produced by the glomeruli each day. But most of the water, glucose, other nutrients, and sodium and other ions are reabsorbed into the blood as the filtrate trickles round the tubules of the nephrons. This brings the actual volume of urine produced down to one third of a gallon (1.2 l) a day.

Ureters

The passage of urine down the ureters occurs as they contract and relax their muscular walls (by peristalsis). Jets of urine are squirted from the ureters into the bladder at a rate of one to four times per minute.

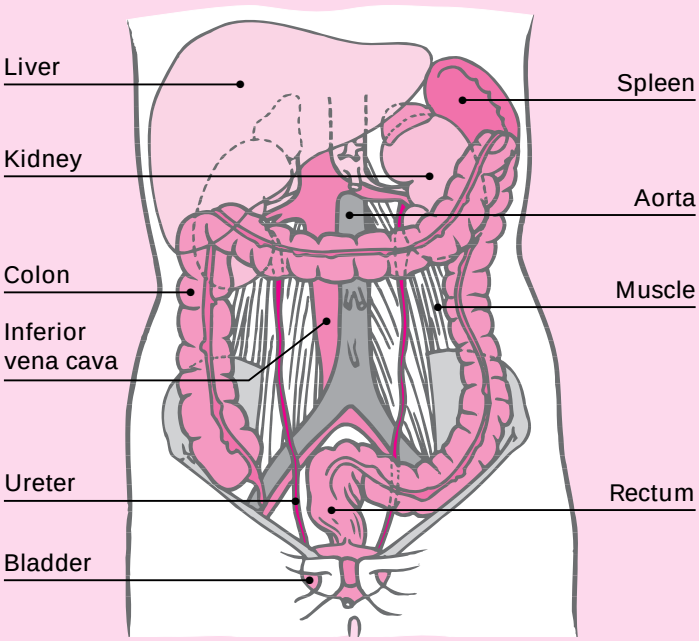
Bladder

The bladder is a temporary storage for urine. Generally the bladder is emptied when about 1 pint (500 ml) of urine is present. Pressure in the bladder begins to be felt once about half a pint (300 ml) has collected.

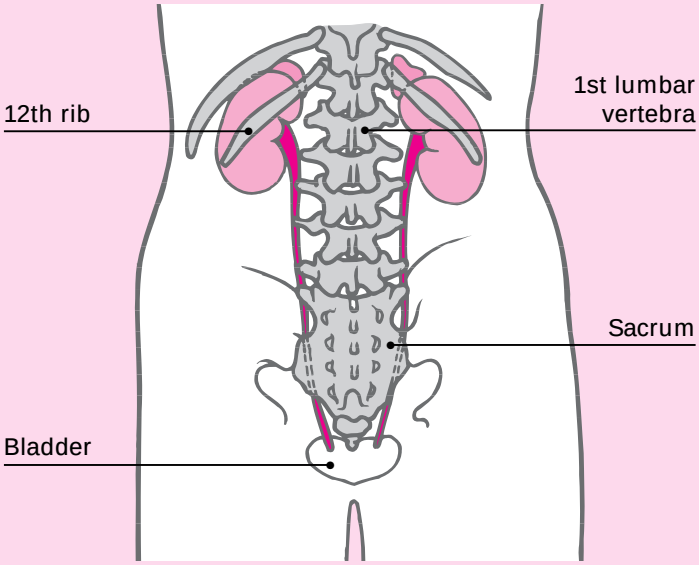
Urethra

The urethra has an internal sphincter, which keeps it closed when urine is not being passed, and an external sphincter. Both must relax for urination to take place; the internal sphincter is not under voluntary (conscious) control, but the external sphincter is.

Urinary tract and abdominal organs



Urinary tract and spine



Composition and properties

Urine is a slightly acidic, usually clear or yellowish fluid produced by the body as a means of expelling waste products. The volume of urine produced and its composition vary according to how much a person eats and drinks, physical activity, general state of health, temperature, and other factors. It is generally about 95 percent water and 5 percent metabolic waste products (although the proportion varies depending on the concentration of the urine). It may also contain drugs that have not been produced by the body but which need to be expelled.

Color

The yellow color of urine is due to a pigment called urobilinogen/urobilin, derived from the body's destruction of hemoglobin. Certain foods, drugs, and infections alter urine color and clearness; also, it is darker when concentrated.

Specific gravity

When comparing the weight of a substance with the weight of distilled water, the term specific gravity is used. The specific gravity of distilled water is 1.000. The specific gravity of urine ranges from 1.001 to 1.035, meaning that it is slightly heavier than water.

Constituents

Urine is made up of, in addition to water, urea (derived from the breakdown of protein), sodium, potassium, phosphates, sulfates, creatinine (derived from the breakdown of body tissues), and uric acid (a waste product of metabolism). Certain diseases alter this composition.

Acidity

The term pH is used to describe the acidity or alkalinity of substances. Urine has a pH range of 4.5 to 8.0, so it tends to be acidic. Diets high in protein make urine more acidic; vegetarian diets make it more alkaline.

Odor

Fresh urine has little smell, but if allowed to stand, it smells of ammonia. Certain vegetables, drugs, and diseases alter its usual odor.

Properties of urine

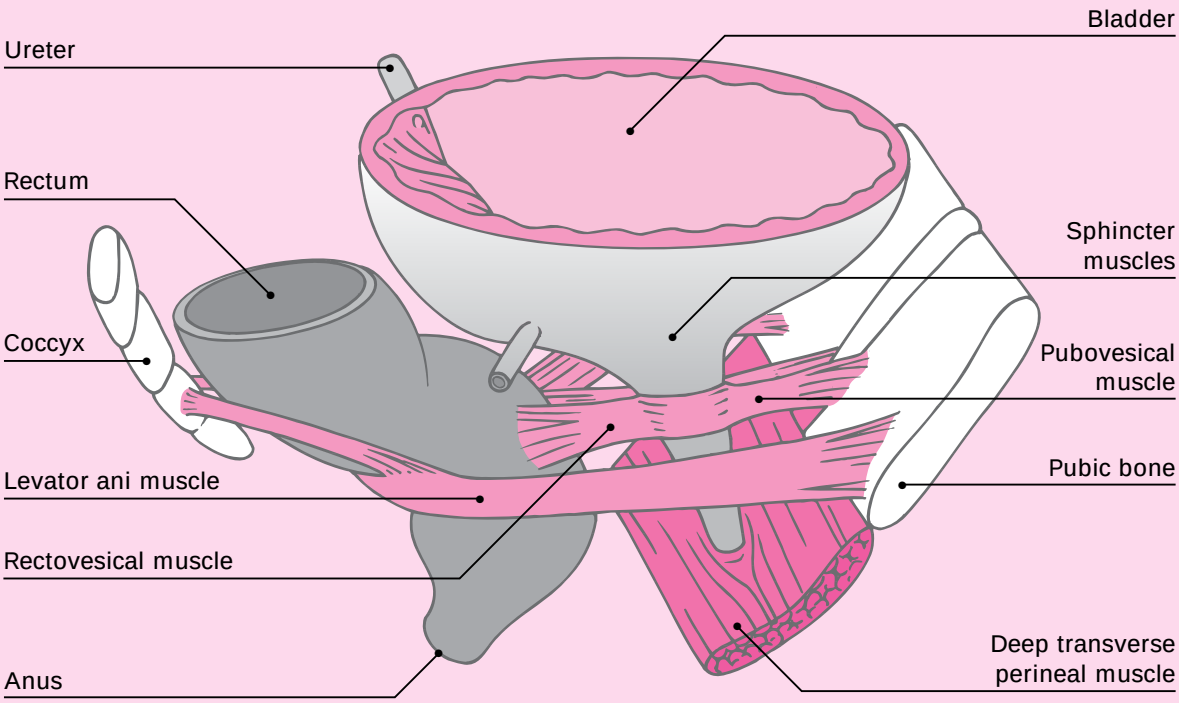
Volume	1–2 liters over 24 hours
Constituents	95 percent water, 5 percent solutes (but can vary)
Color	yellow (but can vary)
Odor	smells of ammonia if left to stand
Turbidity	transparent; becomes cloudy if left to stand
pH	between 4.5 and 8.0
Specific gravity	between 1.001 and 1.035

Bladder and urethra

Urinary bladder

The empty urinary bladder sits in the pelvis, but when full of urine, it projects upward into the lower part of the abdominal cavity. The bladder is a hollow, muscular organ that can distend considerably. This means that its size and shape vary. The wall of the bladder has three layers: a tough outer serosa, a thick middle layer of meshed muscle fibers, and an inner layer of mucosa, which prevents acidic urine from damaging the cells. The inner lining is loosely attached to the deeper muscle layer so it is very wrinkled and covered in folds called rugae when the bladder is empty. When the bladder is full, the inner surface is smooth. At the base of the bladder is the trigone, a triangular area extending between the openings of the two ureters above, and the urethra below. The trigone membrane is always smooth because the lining membrane at this point is tightly fixed to the deeper muscle coat. At the urethral opening is a muscle that forms the internal urethral sphincter. Another sphincter, the external urethral sphincter, is located just below, outside the bladder.

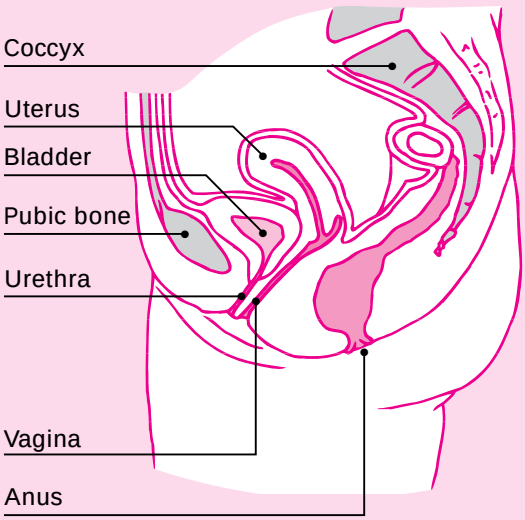
Bladder and pelvic floor muscles



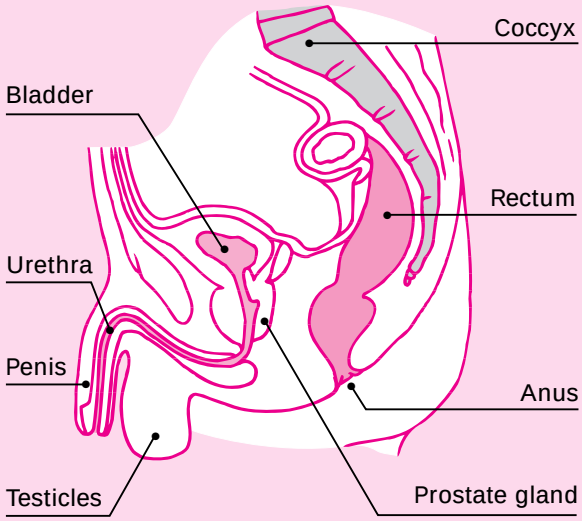
Urethra

The urethra is the narrow tube through which urine leaves the body, and so it is the lowest part of the urinary system. In women, the urethra is about 1.5 inches (4 cm) long. In men, the urethra is about 7–8 inches (18–20 cm) long, and stretches from the bladder, through the prostate gland, and along the penis. It serves as a passageway for both urine and semen. In women, the urethra is a part only of the urinary tract and is not part of the reproductive system. The shorter urethra in women makes them more prone to urinary infections.

Female



Male



Micturition

Micturition is another term for urination or voiding. It is partly under voluntary and partly under involuntary (unconscious) control.

When there is about 10 fluid ounces (300 ml) of urine in the bladder, stretch receptors in the bladder wall trigger the involuntary micturition reflex. The reflex transmits an impulse to the spinal cord, then to the bladder, and the urethra's internal sphincter. In adults, urination occurs when a voluntary impulse is sent to the urethra's external sphincter, relaxing it and allowing the urine to pass through and out of the body. For this reason, it is possible to control urination. Urination can occur without this conscious reflex, as is the case in infancy or with a condition called incontinence.

Urinary tract problems

1 In diabetes insipidus, a faulty hypothalamus stops the secretion of vasopressin (a hormone), so the kidneys reabsorb too little water. The result is high urine output and intense thirst. Treatment involves replacing vasopressin by injection or nasal spray.

2 An ectopic kidney is a kidney in an abnormal position (such as two kidneys on one side of the body). Ectopic kidneys are liable to kidney stones, infection, and blocked urine flow.

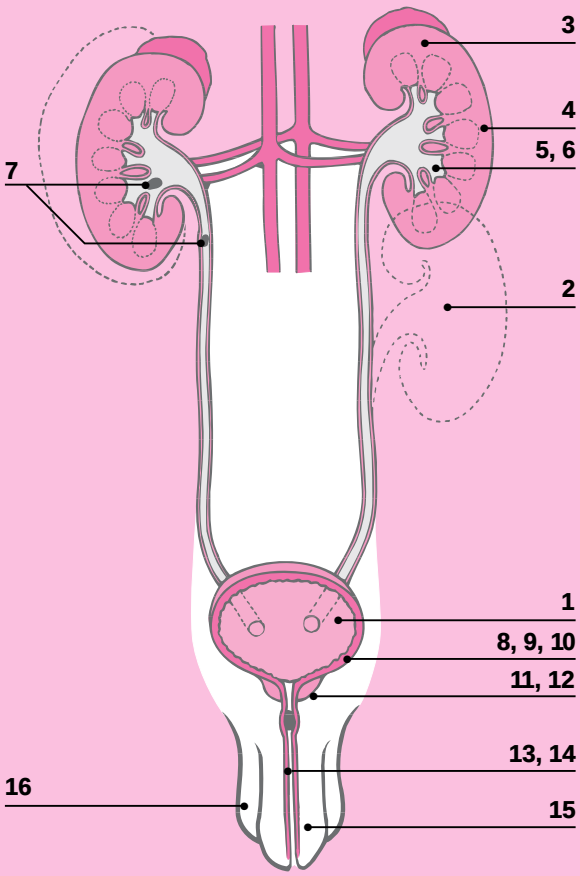
3 Some people are born with only one kidney, or have one removed, but one kidney can do the work of two.

4 Glomerulonephritis involves inflammation of the glomeruli, filtering capillaries within the kidney's nephrons. Water accumulates in body tissues and there may be kidney damage and heart failure.

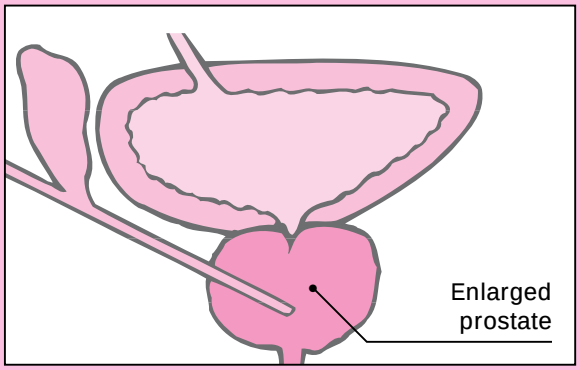
5 Pyelonephritis (kidney infection) may produce kidney damage and toxins in the blood.

6 Sudden kidney failure can be due to burns, injury, shock, heart attack, drugs, or certain other factors. Acute kidney failure can cause loss of kidney function, pulmonary edema (build-up of watery fluid in the lungs), hemorrhage, and uremia (poisoning by toxins accumulating in the body). Severely ill patients may need to use an artificial kidney machine until their own kidneys can restart.

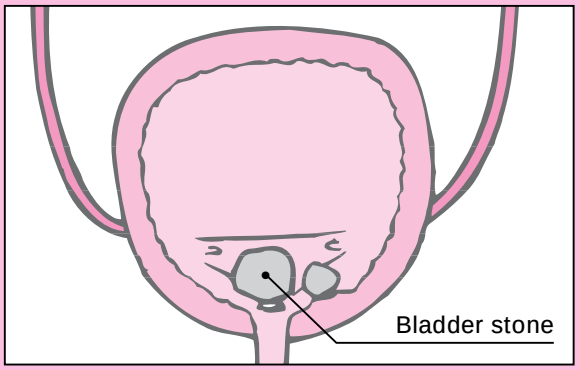
7 Stones may form in the kidneys from dissolved substances that have precipitated out from urine and grown around bacteria or other tiny nuclei. Small, smooth stones escape in the urine. Large stones stuck in the kidney or ureter can cause bleeding, extreme pain, and kidney damage. Such stones need to be removed by surgery or destroyed by ultrasound. If a stone blocks a ureter, urine accumulates above the stone, distending the ureter and enlarging the space inside the kidney. Kidney tissue grows thinner and may be destroyed.



8 Cystitis is caused by inflammation of the bladder, often with urethritis, and is especially prevalent in women. Symptoms include a frequent urge to urinate (even though this causes burning pain), lower abdominal pain, and blood in the urine. The cause is often infection by bacteria from the bowel invading via the urethral opening, but sometimes via the kidneys.
9 Extroverted bladder is a congenitally incomplete bladder, causing urine leakage, and requiring surgery.
10 Some physical and psychological problems can cause lack of bladder control, giving rise to incontinence.
11 An enlarged prostate can lead to urine retention, which in turn can lead to infection. If an enlarged prostate gland blocks the bladder mouth, the bladder wall thickens. Accumulating urine dilates the ureters, and enlarges the space inside the kidneys. This causes the substance of the kidneys to grow thinner and may be destroyed.
12 Prostatitis is caused by inflammation of the prostate and requires antibiotic treatment. Symptoms include tenderness in the rectum, with fever, harsh pain, and difficulty passing water.
13 Urethritis is inflammation of the urethra. Symptoms may include watery or thick greenish-yellow discharge from the penis, pain or a burning sensation on passing water, and an urgent need to urinate often.
14 Urethral stricture can be caused by infection, especially gonorrhea, or injury.
15 Hypospadias and epispadias are conditions where the urethral opening in males is on the top or bottom of the penis shaft rather than in the correct place at the tip of the penis.
16 Diaper rash occurs on skin soaked with urine, especially in babies. Incontinent adults may also suffer skin problems.



Enlarged prostate
The prostate gland in men can become enlarged due to infection, multiplication of cells within the gland, or cancer.



Stones
Stones, or calculi, form from substances precipitated out of urine. They can form in the kidneys, ureters, or bladder.

Glossary of the human body

Adipose tissue Connective tissue containing numerous fat cells.
Adrenal glands (*or* Suprarenal glands) Endocrine glands located on each kidney. The cortex and medulla produce a range of hormones.
Afferent Directed toward a central organ or part of the body.
Alimentary canal (*or* Gastrointestinal tract *or* Gut) The digestive tract: a tube starting at the mouth and ending at the anus.
Anus The lower end of the rectum, forming the outlet of the alimentary canal.
Aorta The largest artery, arising from the left ventricle of the heart.
Appendix (*or* Vermiform appendix) A short, wormlike tube opening into the cecum but closed at the other end. It contains lymphoid tissue, which is involved in immunity.
Arteriole A small artery supplying blood from a main artery to a capillary.
Artery A blood vessel transporting blood from the heart to elsewhere in the body.
Atrioventricular valve (*or* AV valve) A valve between a ventricle and an atrium. The right atrioventricular valve (*or* tricuspid valve) has three cusps. The left atrioventricular valve (mitral valve or bicuspid valve) has two cusps.
Auditory Relating to hearing.
Axillary Relating to the armpit.
Backbone *See* **Vertebral column**.
Basal ganglia Paired structures deep in the forebrain: they help coordinate and control willed muscle movements.
Basophil A type of white blood cell that is readily stained by basic dyes.
Biceps A muscle with two heads: biceps brachii in the upper arm and biceps femoris in the thigh.
Bile ducts Tiny tubes that carry bile (a liver secretion) from the liver to the duodenum.
Bladder A sac, especially the muscular bag inside the pelvis where urine collects before being expelled from the body.
Blood A sticky red fluid consisting of colorless plasma, red blood cells (Erythrocytes), white blood cells (Leukocytes), and platelets (thrombocytes).
Blood pressure The pressure of blood against blood-vessel walls, especially artery walls.
Bone The hard, dense connective tissue that forms the skeleton's components.
Bone marrow Soft red and yellow substances that fill cavities in bone.
Bowel *See* **Large intestine**.
Brain The body's chief control center, consisting of billions of interconnected nerve cells.
Brainstem A stalklike part of the brain, between the cerebrum and spinal cord. It contains the midbrain, pons, and medulla oblongata.
Breast A female breast consists mainly of a mammary (milk-secreting) gland embedded in fatty tissue.
Breastbone *See* **Sternum**.
Bronchiole A small subdivision of a bronchus, ending in tiny air sacs called alveoli.
Bronchus The main tubes branching from the lower end of the trachea and forming the main airways to and from the lungs (plural: bronchi).
Capillary The tiniest type of blood vessel, connecting an arteriole and a venule.
Cardiac Relating to the heart.
Cardiovascular Relating to the heart and blood circulatory system.
Cartilage Gristle: dense, white connective tissue cushioning bones.
Cecum The first part of the large intestine, forming a blind pouch.
Cell The basic unit of the body, usually comprising an outer membrane, cytoplasm, a nucleus, and organelles.

Central nervous system (CNS) The brain and spinal cord.
Cerebellum The largest part of the hindbrain. It helps coordinate muscular movements.
Cerebral cortex The cerebrum's thin outer layer of gray matter.
Cerebral hemisphere Either of the two halves of the cerebrum.
Cerebrospinal fluid A clear fluid filling the brain's ventricles and surrounding the brain and spinal cord to protect them from injury.
Cerebrum The upper, major part of the brain, comprising cerebral hemispheres and diencephalon.
Cervix A neck, especially the neck of the uterus (womb) where it opens into the vagina.
Clavicle Either of the two collarbones.
Clitoris An erectile, pea-sized organ above the opening of the vagina; it is highly sensitive and is involved in female sexual response.
CNS *See* **Central nervous system**.
Coccyx Four fused vertebrae forming the "tail" of the backbone.
Collagen A fibrous protein that is a major constituent of connective tissue.
Colon The part of the large intestine between the cecum and rectum.
Connective tissue Tissue that supports, binds, or separates more specialized body tissues or acts as packing.
Corium *See* **Dermis**.
Cornea The transparent circular area at the front of the eye, which acts as a lens.
Coronary arteries Supply the heart muscle.
Corpuscles A term often used for red and white blood cells.
Cortex The outer layer of the brain.
Cranial nerves Twelve pairs of nerves linking the underside of the brain with parts of the head, neck, and thorax.
Cranium The part of the skull that contains the brain.
Cutaneous Relating to the skin.
Cuticle *See* **Epidermis**.
Deoxyribonucleic acid (DNA) A nucleic acid in the cell's chromosomes containing the cell's coded genetic instructions.
Dermis (*or* Corium) The layer of skin below the epidermis, containing nerves, blood vessels, glands, and hair follicles.
Diaphragm A muscular sheet used in breathing. It separates the thorax (chest) and abdomen (belly).
Digestion The chemical and mechanical breakdown of foods into substances that can be absorbed by the body.
DNA *See* **Deoxyribonucleic acid**.
Duodenum The upper part of the small intestine, where most chemical digestion takes place.
Ejaculation The discharging of semen from the penis.
Endocardium The membrane that lines the heart and the heart valves.
Endothelium The cell layer that lines the inside of the heart, blood vessels, and lymph vessels.
Enzymes Biological catalysts: proteins that speed up chemical reactions without undergoing change themselves.
Epidermis (*or* Cuticle) The skin's outer layer.
Epiglottis A cartilage flap behind the tongue that is closed during swallowing to stop food from entering the larynx.
Epiphysis *See* **Pineal gland**.
Epithelium The cell layer covering the body, and lining the alimentary canal and respiratory and urinary tracts.
Erythrocytes Red blood cells.
Esophagus (*or* Gullet) The muscular tube through which food travels between the pharynx and the stomach.

Fallopian tubes (*or* Uterine tubes *or* Oviducts) The tubes through which ova (eggs) travel from the ovaries to the uterus.
Femur The thigh bone: the long bone between the hip and the knee.
Follicle A small secreting cavity or sac. Ova (egg cells) develop in follicles in the female ovaries.
Forebrain The front part of the brain comprising diencephalon and telencephalon.
Gallbladder A pear-shaped bag where bile is stored, below the liver.
Gametes Sex cells: sperm in males; ova in females.
Gastric Of the stomach.
Gastrointestinal tract *See* **Alimentary canal**.
Genes Basic biological hereditary units, consisting of DNA, located on chromosomes.
Genitalia Sex organs.
Gland A structure that synthesizes and secretes a fluid.
Gonads Primary reproductive organs: the ovaries and testes.
Granulocytes White blood cells with cytoplasm that contains granules: basophils, eosinophils, and monocytes.
Gray matter The darker tissue of the brain and spinal cord mainly consisting of neurons' cell bodies and dendrites.
Gullet *See* **Esophagus**.
Gut *See* **Alimentary canal**.
Heart The hollow, muscular, fist-sized organ that pumps blood around the body.
Hemoglobin The iron-rich, oxygen-transporting pigment in red blood cells that gives them their color.
Hepatic Relating to the liver.
Hepatic portal vein *See* **Portal vein**.
Hindbrain Brain structures below the midbrain, comprising the pons, medulla oblongata, and cerebellum.
Hormones Chemical substances released into the blood by endocrine glands to influence organs or tissues in other parts of the body.
Hypophysis *See* **Pituitary gland**.
Hypothalamus A part of the brain with endocrine functions.
Ileum The last part of the small intestine.
Immune system The body's defense system against infective organisms or other foreign bodies. It includes the lymphatic system.
Involuntary muscle Muscle that is not under conscious control. *See also* **Smooth muscle**.
Jejunum The middle part of the small intestine.
Joint The junction between bones.
Karyotype The chromosome complement of a person or species: the genome.
Kidney A bean-shaped organ that filters wastes from blood to form urine.
Lactation Milk production by the mammary glands.
Large intestine (*or* Bowel) The lower part of the alimentary canal, comprising the cecum, colon, and rectum.
Larynx The cartilaginous voice box.
Leukocytes White blood cells. They attack invading microorganisms and help to combat injuries.
Ligament Fibrous tissue that connects bones.
Liver The largest organ in the body, it is involved in various metabolic processes.
Lungs The two organs of respiration, filling most of the chest cavity inside the rib cage and above the diaphragm.
Lymph A transparent fluid that leaks from blood vessels into tissue spaces.
Lymph gland *See* **Lymph node**.
Lymph node (*or* Lymph gland) One of the "knots" in the lymphatic system, which contain lymphocytes and macrophages that filter the lymph passing through the nodes.

Lymphatic system A network of lymph vessels and lymph nodes. Vessels collect lymph from body tissues and return it to the blood after harmful substances have been filtered out in the lymph nodes.
Mammary glands The milk-producing structures in the breast.
Medulla oblongata The lowest part of the brain stem, containing the vital centers that control heartbeat and respiration.
Meiosis A type of cell division that produces daughter cells (sperm and ova) each with half as many chromosomes as the parent cell.
Meninges Three protective membranes surrounding the brain and spinal cord.
Menopause When a woman ceases to have menstrual periods.
Menstruation Menstrual periods: the monthly flow of blood and uterine lining from the vagina of nonpregnant females of childbearing age.
Metabolism The array of continuous chemical changes that maintain life in the body.
Mitosis Ordinary cell division in which both daughter cells have as many chromosomes as the parent cell.
Mucous membranes The mucus-secreting linings of the digestive, respiratory, reproductive, and urinary tracts.
Nasal Relating to the nose.
Nasal cavity The space inside the nose between the base of the skull and the roof of the mouth.
Nerve A bundle of nerve fibers (axons) that transmit impulses to (in the case of sensory nerves) or from (in the case of motor nerves) the central nervous system.
Nervous system The coordinated networks of neurons that control the body. It is divided into the central nervous system (brain and spinal cord), and the peripheral nervous system (the somatic and autonomic nervous systems).
Neuron (*or* Neurone) A nerve cell: the basic unit of the nervous system.
Neurone *See* **Neuron**.
Neurotransmitter A chemical released at nerve endings to transmit nerve impulses across synapses.
Nucleic acids Molecules that store genetic information.
Nucleus The control center of a cell, which contains coded genetic instructions.
Olfactory Relating to smell.
Optic Relating to the eye.
Organ A body part with different types of tissue that performs a particular task.
Organelles Tiny structures (miniorgans) in a cell's cytoplasm with particular tasks.
Ovaries Female sex organs that produce ova (eggs) and sex hormones.
Oviducts *See* **Fallopian tubes**.
Ovulation The release of a ripe egg from a female's ovary.
Ovum An egg; a female sex cell (plural: ova).
Palate The roof of the mouth.
Pancreas An abdominal organ that produces pancreatic juice and the hormones glucagon and insulin.
Parasympathetic nervous system The part of the autonomic nervous system that predominates when the body is at rest.
Parathyroid glands Four pea-sized endocrine glands on the thyroid gland. They produce parathyroid hormone, which controls blood calcium level.
Pelvis A bony basin formed by the two hip bones, the sacrum, and the coccyx.
Pericardium The double-layered membrane that encloses the heart and attaches it to the diaphragm and sternum.
Peristalsis Waves of muscular contraction that propel substances through passageways, such as the alimentary canal.

Phagocytes Types of leukocytes that engulf and destroy microorganisms and foreign bodies.
Pharynx The throat.
Pineal gland (*or* Epiphysis) An endocrine gland in the brain that secretes melatonin.
Pituitary gland (*or* Hypophysis) A three-lobed, pea-sized gland below the hypothalamus. It produces growth hormone, hormones that act on other endocrine glands, oxytocin, and ADH. It is often called the body's "master gland."
Plasma The fluid part of blood.
Pleura The membrane that covers the lungs (visceral pleura) and lines the chest wall (parietal pleura).
Plexus A network of nerves (or blood or lymph vessels).
Portal vein (*or* Hepatic portal vein) Drains blood from digestive organs to the liver.
Prostate gland A gland situated below the bladder in males. It produces a sperm-activating fluid that forms nearly a third of the semen's volume.
Pudendum *See* **Vulva**.
Pulmonary Relating to the lungs.
Receptor A structure, such as a sensory nerve ending, specialized to detect environmental stimuli.
Rectum The last part of the colon, where feces collects before leaving the body.
Reflex action The body's automatic response to a stimulus, such as blinking.
Renal Relating to the kidney.
Respiration 1) Breathing; 2) Taking in oxygen and giving out carbon dioxide; 3) Deriving energy from food with or without using oxygen.
Respiratory system In humans, the mouth, nose, pharynx, larynx, trachea, bronchi, bronchioles, alveoli, and lungs.
Ribonucleic acid (RNA) A nucleic acid concerned with protein synthesis.
Ribs Twelve pairs of bones that protect the chest cavity and assist breathing by moving up and out during inspiration and down and in during expiration.
Salivary glands The lingual, parotid, sublingual, and submandibular glands that produce saliva.
Serum Blood plasma that does not contain clotting factors but does contain antibodies.
Sinus A cavity, such as the channels draining venous blood from the brain.
Skeleton The bony framework that protects and supports the body's soft tissues.
Skin The body's waterproof covering; its largest organ, comprising two main layers: the epidermis and dermis.
Small intestine The alimentary canal between the stomach and large intestine, comprising the duodenum, jejunum, and ileum. Most digestion occurs here.
Smooth muscle (*or* Unstriated muscle *or* Involuntary muscle) Muscle without striped fibers that automatically operates internal organs such as the stomach, bladder, and blood vessels.
Sphincter A ring-shaped muscle that contracts to close an orifice.
Spinal cord The cable of nerve tissue running down inside the vertebral column (spine) and linking the brain with nerves supplying most of the body.
Spine *See* **Vertebral column**.
Sternum The breastbone.
Subcutaneous tissue The sheet of connective tissue below the dermis.
Suprarenal glands *See* **Adrenal glands**.
Suture An immovable fibrous joint between the skull bones.
Taste buds Tiny sensory organs of the tongue and palate, distinguishing salty, sweet, sour, and bitter tastes.

Teeth Bonelike structures in the jaws. Different types (incisors, canines, premolars, molars) are specialized to tear, crush, and/or grind food.
Tendons Bands of fibrous connective tissue joining muscles to bones.
Testis (*or* Testicle) One of a pair of primary male sex organs that manufacture sperm (plural: testes).
Thalamus A brain structure above the hypothalamus. It sends sensory impulses to the cerebral cortex, links sensations with emotions, and affects consciousness.
Thymus An endocrine gland located behind the sternum. It produces thymosin.
Thyroid An endocrine gland at the front of the neck, producing thyroid hormone.
Tissue A collection of similar cells that perform a particular task.
Trachea (*or* Windpipe) The tube between the larynx and the bronchi.
Tubule A tiny tube.
Tunica A tissue layer forming a coating. Blood vessels have three such layers (intima, media, adventitia).
Unstriated muscle *See* **Smooth muscle**.
Ureter The tube conveying urine from a kidney to the bladder.
Urethra The passage taking urine from the bladder to the body's exterior.
Urinary system The kidneys, ureters, bladder, and urethra.
Urine Liquid waste excreted by the kidneys.
Uterine tubes *See* **Fallopian tubes**.
Uterus (*or* Womb) A hollow muscular organ located above the bladder. Inside it, a fertilized ovum develops into a fetus.
Uvula A conical tag hanging from the back of the palate. It helps to keep food out of the nasal cavities.
Vagina The muscular passage between the vulva and cervix (neck of the uterus).
Vascular Relating to or richly supplied with vessels, especially blood vessels.
Vein A blood vessel that transports blood from capillaries back to the heart. Veins contain valves to prevent the backflow of blood.
Venous Relating to veins.
Ventricle A cavity: one of the two lower chambers of the heart.
Venule A small vein.
Vermiform appendix *See* **Appendix**.
Vertebra A bone of the vertebral column (plural: vertebrae).
Vertebral column (*or* Backbone *or* Spine) The column of vertebrae between the skull and the hip bones, supporting the body and shielding the spinal cord. It has five sections: cervical, thoracic, lumbar, sacral, and coccygeal.
Vestibule A space before a passage begins, as in the inner ear beyond the oval window, between the semicircular ducts and cochlea.
Vocal cords Two belts of tissue stretched across the larynx which produce sounds when air rushes past them.
Vulva (*or* Pudendum) The external female genitals.
White matter The paler tissue of the brain and spinal cord comprised mainly of myelin-sheathed nerve fibers.
Windpipe *See* **Trachea**.
Womb *See* **Uterus**.

Web sites to visit

There is a lot of useful information on the internet. There are also many sites that are fun to use. Remember that you may be able to get information on a particular topic by using a search engine such as Google (**http://www.google.com**). Some of the sites that are found in this way may be very useful, others not. Below is a selection of Web sites related to the material covered by this book. Most are illustrated, and they are mainly of the type that provides useful facts.

Facts On File, Inc. *takes no responsibility for the information contained within these Web sites. All the sites were accessible in January 2005.*

Anatomy of the Human Body: Gray's Anatomy
Online version of the classic *Gray's Anatomy of the Human Body*, containing over 13,000 entries and over 1,200 images.
http://www.bartleby.com/107/

Biology Online
A source for biological information, suitable for homework, research projects, and general interest, with hundreds of biology Web site links.
http://www.biology-online.org

BIOME
A guide to selected, quality-checked internet resources in the health and life sciences.
http://biome.ac.uk

Health Sciences & Human Services Library
Provides links to selected Web sites that may be useful to both students and researchers.
http://www.hshsl.umaryland.edu/resources/lifesciences.html

Human Anatomy Online
Interactive resource, with visual keys to text on the human body
http://www.innerbody.com

North Harris College Biology Department
Tutorials and graphics on biology, human anatomy, human physiology, microbiology, and nutrition.
http://science.nhmccd.edu/biol/

Open Directory Project: Digestive Disorders
Comprehensive list of internet resources.
http://dmoz.org/Health/Conditions_and_Diseases/Digestive_Disorders/

Open Directory Project: Gastroenterology
Comprehensive list of internet resources.
http://dmoz.org/Health/Medicine/Medical_Specialties/Gastroenterology/

The Biology Project
Structured tutorials on life sciences. Particularly strong on cell biology, human biology, and molecular biology.
http://www.biology.arizona.edu

University of Texas: BioTech Life Sciences Resources and Reference Tools
Enriching knowledge of biology and chemistry, for everyone from high school students to professional researchers. The Dictionary and Science Resources are particularly useful.
http://biotech.icmb.utexas.edu