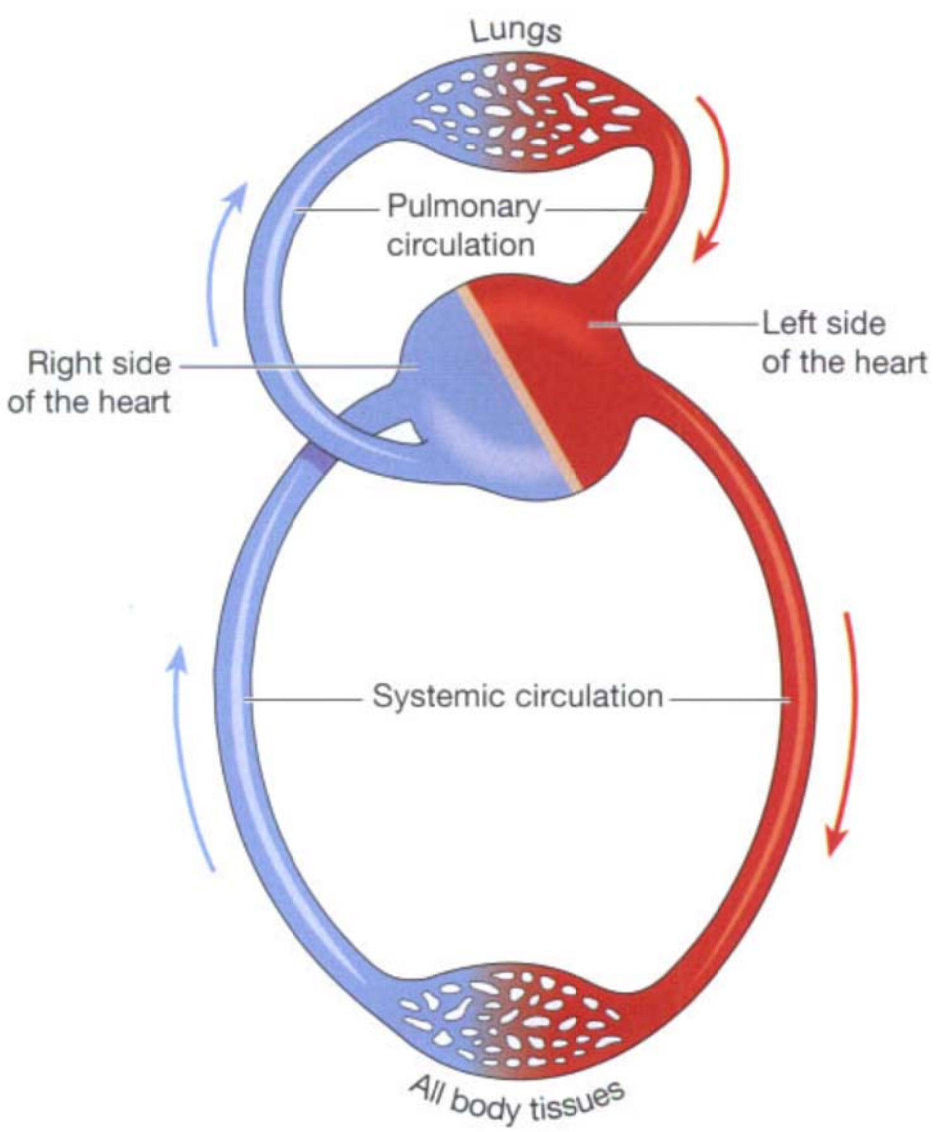
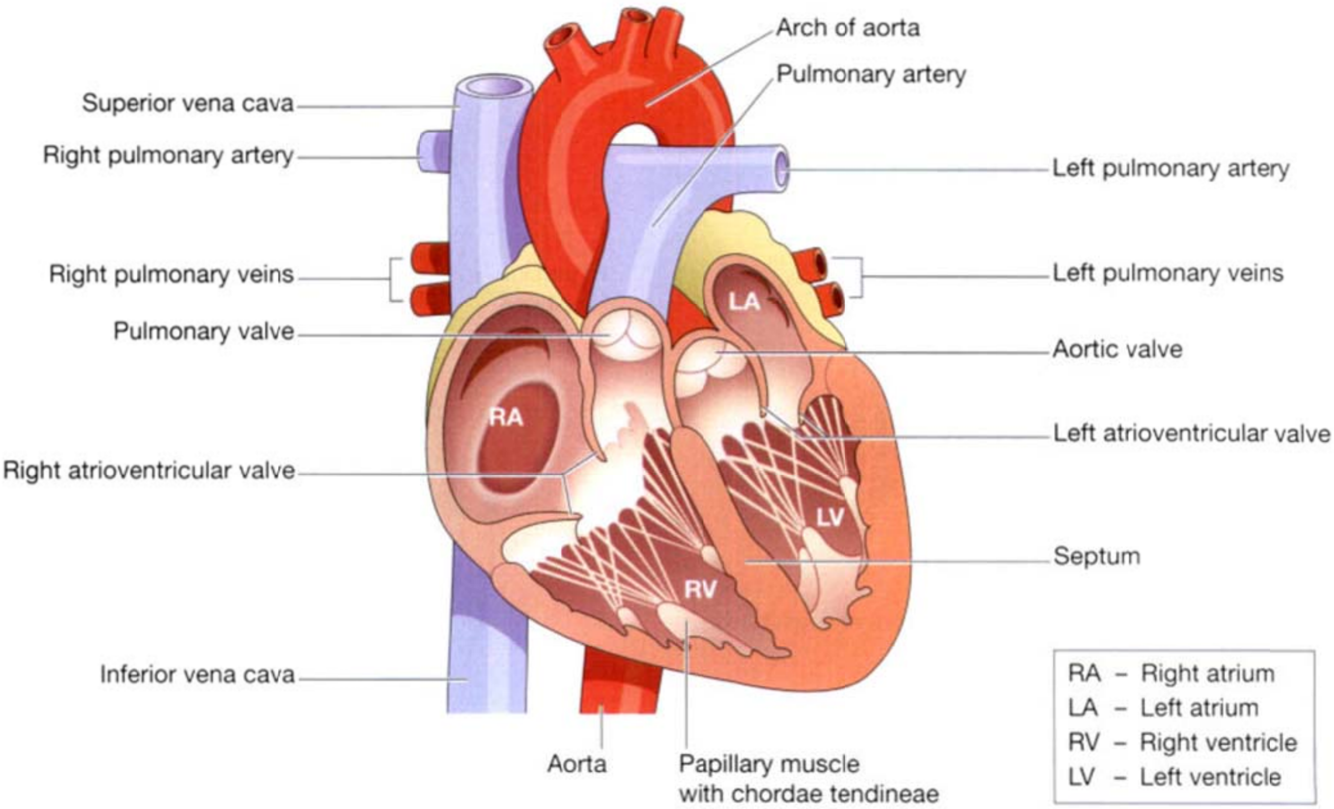
Cardiovascular system

The circulatory system of the blood is seen as having two components.

- The pulmonary circulation
- The systemic circulation.



The right side of the heart pumps blood to the lungs (the pulmonary circulation) where gas exchange occurs; i.e. CO2 leaves the blood and enters the lungs, and O2 leaves the lungs and enters the blood. The left side of the heart pumps blood into the systemic circulation, which supplies the rest of the body. Here, tissue wastes are passed into the blood for excretion, and body cells extract nutrients and O2.



There are four chambers in heart:

- left atrium and left ventricle
- right atrium and right ventricle.

The valves of the heart

The valves of the human heart can be grouped in two sets:[6]

1- Two Atrioventricular (AV) valves to prevent backflow of blood from the ventricles into the atria

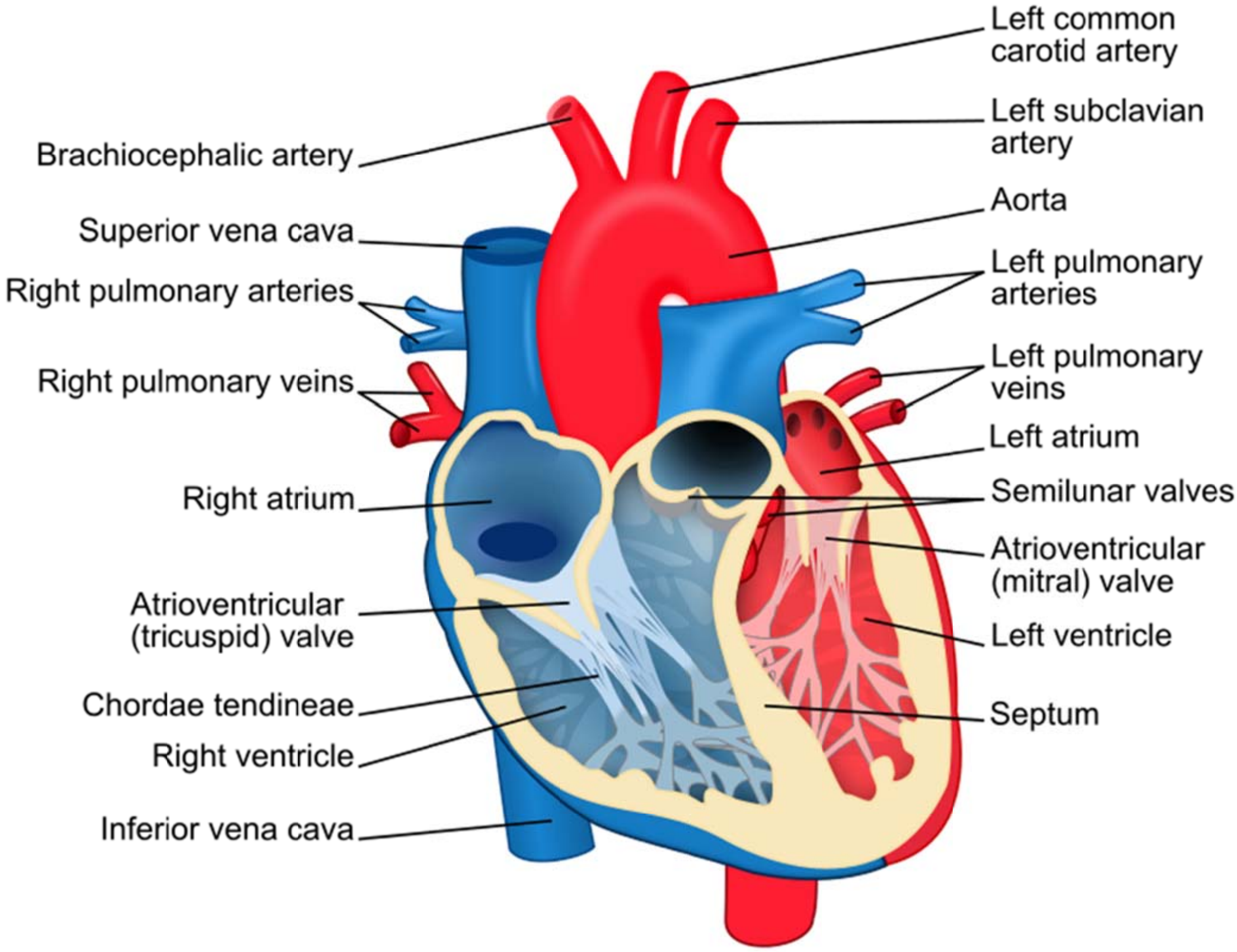
a) Tricuspid valve, located between the right atrium and right ventricle.

b) Bicuspid or mitral valve, located between the left atrium and left ventricle.

2- Two Semilunar valves to prevent the backflow of blood into the ventricle

a) Pulmonary semilunar valve, located at the opening between the right ventricle and the pulmonary trunk.

b) Aortic semilunar valve, located at the opening between the left ventricle and the aorta.



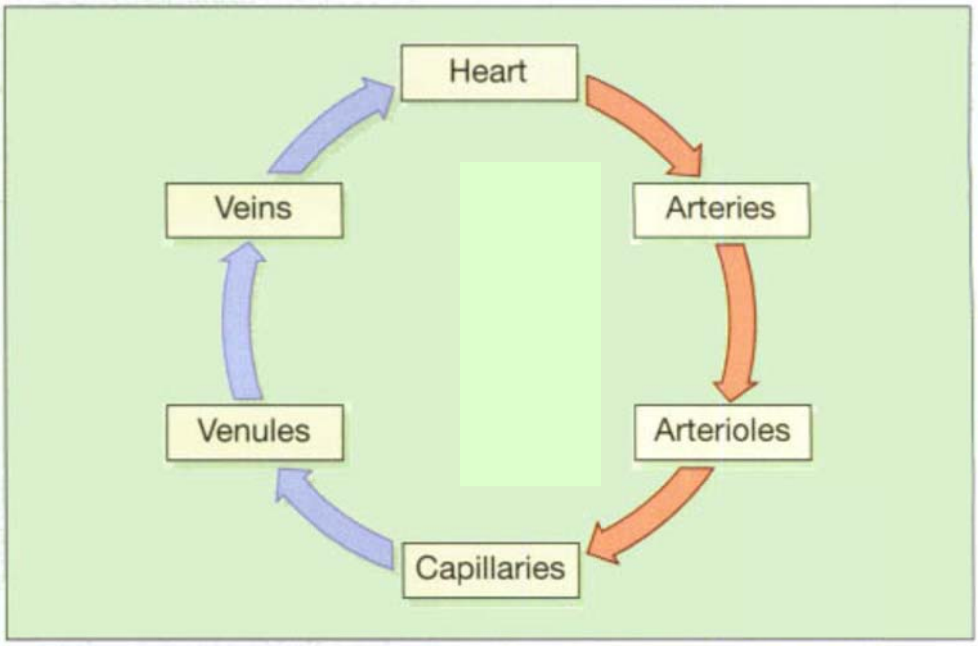
Pulmonary circulation

This consists of the circulation of blood from the right ventricle of the heart to the lungs and back to the left atrium. In the lungs, carbon dioxide is excreted and oxygen is absorbed.

Systemic or general circulation

The blood pumped out from the left ventricle is carried by the *branches of the aorta* around the body and is returned to the right atrium of the heart by the *superior* and *inferior venae cavae.*

Thus, the heart pumps blood into vessels that vary in structure, size and function, and there are several types: arteries, arterioles, capillaries, venules and veins.



<u>Conducting system of the heart/</u> The heart has an intrinsic system whereby the cardiac muscle is automatically stimulated to contract without the need for a nerve supply from the brain .

However, the intrinsic system can be stimulated or depressed by nerve impulses initiated in the brain and by circulating chemicals including hormones.

There are small groups of specialized neuromuscular cells in the myocardium which initiate and conduct impulses causing coordinated and synchronized contraction of the heart muscle.

Sinoatrial node (SA node)/ This small mass of specialised cells is in the wall of the right atrium near the opening of the superior vena cava.
The SA node is the *'pace-maker'* of the heart because it normally initiates impulses more rapidly than other groups of neuromuscular cells.

Atrioventricular node (AV node)/ This small mass of neuromuscular tissue is situated in the wall of the atrial septum near the atrioventricular valves. Normally the AV node is stimulated by impulses that sweep over the atrial myocardium. However, it too is capable of initiating impulses that cause contraction but at a slower rate than the SA node.

Atrioventricular bundle (AV bundle or bundle of His)/ This is a mass of specialised fibres that originate from the AV node. The AV bundle crosses the fibrous ring that separates atria and ventricles then, at the upper end of the ventricular septum, it divides into *right and left bundle branches.* Within the ventricular myocardium the
branches break up into fine fibres, called the *Purkinje fibres.* The AV bundle, bundle branches and Purkinje.
fibres convey electrical impulses from the AV node to the apex of the myocardium where the wave of ventricular contraction begins, then sweeps upwards and outwards, pumping blood into the pulmonary artery and the aorta.

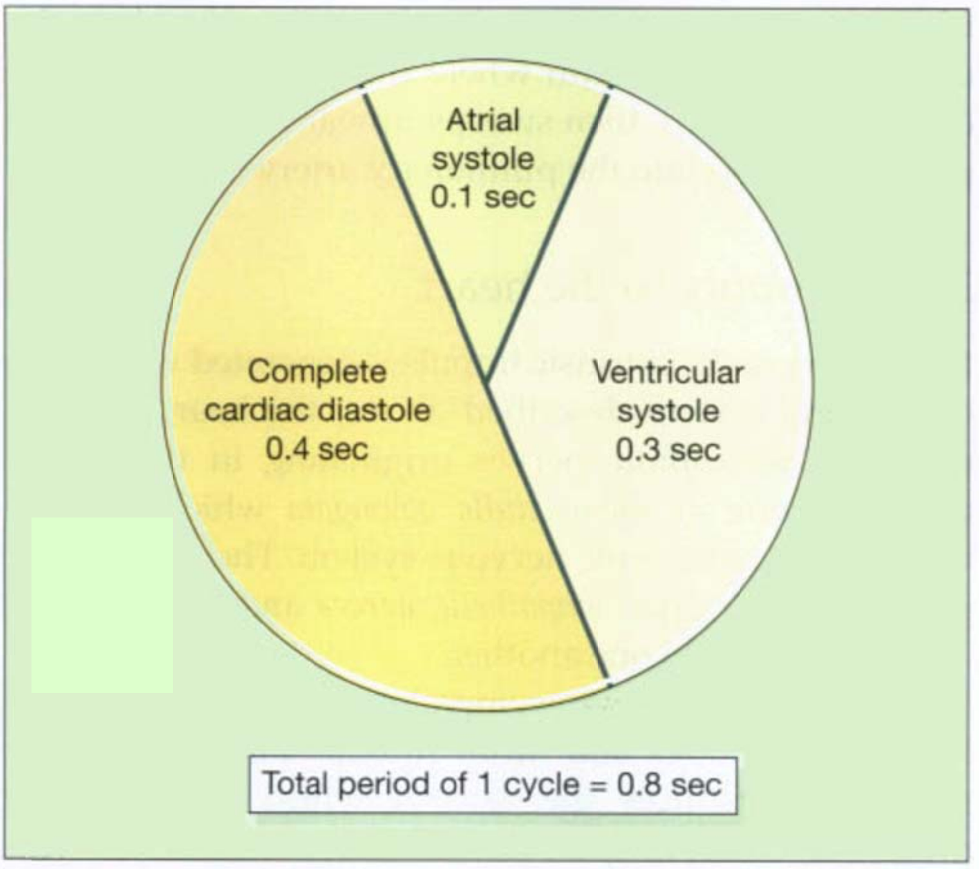
The cardiac cycle/ The function of the heart is to maintain a constant circulation of blood throughout the body. The heart acts as a pump and its action consists of a series of events known as the *cardiac cycle.*
During each heartbeat, or cardiac cycle, the heart contracts and then relaxes. The period of contraction is called *systole* and that of relaxation, *diastole.*

Stages of the cardiac cycle. The normal number of cardiac cycles per minute ranges from 60 to 80. Taking 74 as an example each cycle lasts about *0.8 of a second* and consists of:

• *atrial systole* — contraction of the atria

• *ventricular systole* — contraction of the ventricles

• *complete cardiac diastole* — relaxation of the atria and ventricles.



Factors affecting heart rate

1. **Autonomic nervous system.** As described above, the rate at which the heart beats is a balance of sympathetic and parasympathetic activity and this is the most important factor in determining heart rate.

2. **Circulating chemicals.** The hormones adrenaline and noradrenaline, secreted by the adrenal medulla, have the same effect as sympathetic stimulation, i.e. they increase the heart rate. Other hormones including thyroxine increase heart rate by their metabolic effect.
3. **Position.** When the person is upright, the heart rate is usually faster than when lying down.
4. **Exercise.** Active muscles need more blood than resting muscles and this is achieved by an increased heart rate and selective vasodilatation.
5. **Emotional states.** During excitement, fear or anxiety the heart rate is increased. Other effects mediated by the sympathetic nervous system may be present
6. **Gender.** The heart rate is faster in women than men.
7. **Age.** In babies and small children the heart rate is more rapid than in older children and adults
8. **Temperature.** The heart rate rises and falls with body temperature.
9. **Baroreceptor reflex.**

Functions of the cardiovascular system

Blood circulates through a network of vessels throughout the body to provide individual cells with oxygen and nutrients and helps dispose of metabolic wastes and carbon dioxide. The heart pumps the blood around the blood vessels.

Functions of blood and circulation:

1) Circulates OXYGEN and removes Carbon Dioxide.
2) Provides cells with NUTRIENTS.

3) Removes the waste products of metabolism to the excretory organs for disposal.
4) Protects the body against disease and infection.
5) Clotting stops bleeding after injury.
6) Transports HORMONES to target cells and organs.
7) Helps regulate body temperature.

Blood pressure

Blood pressure is the force or pressure which the blood exerts on the walls of the blood vessels. The systemic arterial blood pressure, usually called simply arterial blood pressure, is the result of the discharge of blood from the left ventricle into the already
full aorta.
When the left ventricle contracts and pushes blood into the aorta the pressure produced within the arterial system is called the *systolic blood pressure.* In adults it is about 120 mmHg (millimeters of mercury).
Diastole occurs when the heart is resting following the influx of blood, the pressure
within the arteries is called *diastolic blood pressure.*
In an adult this is about 80 mmHg . The difference between systolic and diastolic blood pressures is the *pulse pressure.*

Endocrine system:

the group of glands of an organism that secrete hormones (chemical messenger) directly into the circulatory system to regulate the function of distant target organs, and the feedback loops which modulate hormone release so that homeostasis is maintained.

Special features of endocrine glands are, in general, their ductless nature, their vascularity, and commonly the presence of intracellular vacuoles or granules that store their hormones. In contrast, exocrine glands, such as salivary glands, sweat glands, and glands within the gastrointestinal tract, tend to be much less vascular and have ducts or a hollow lumen.

The endocrine system is in contrast to the exocrine system, which secretes its hormones to the outside of the body using ducts.

Glands

The major glands of the endocrine system include:

hypothalamus ,

pituitary gland, The hypothalamus and pituitary gland are neuroendocrine organs.

pineal gland pancreas,

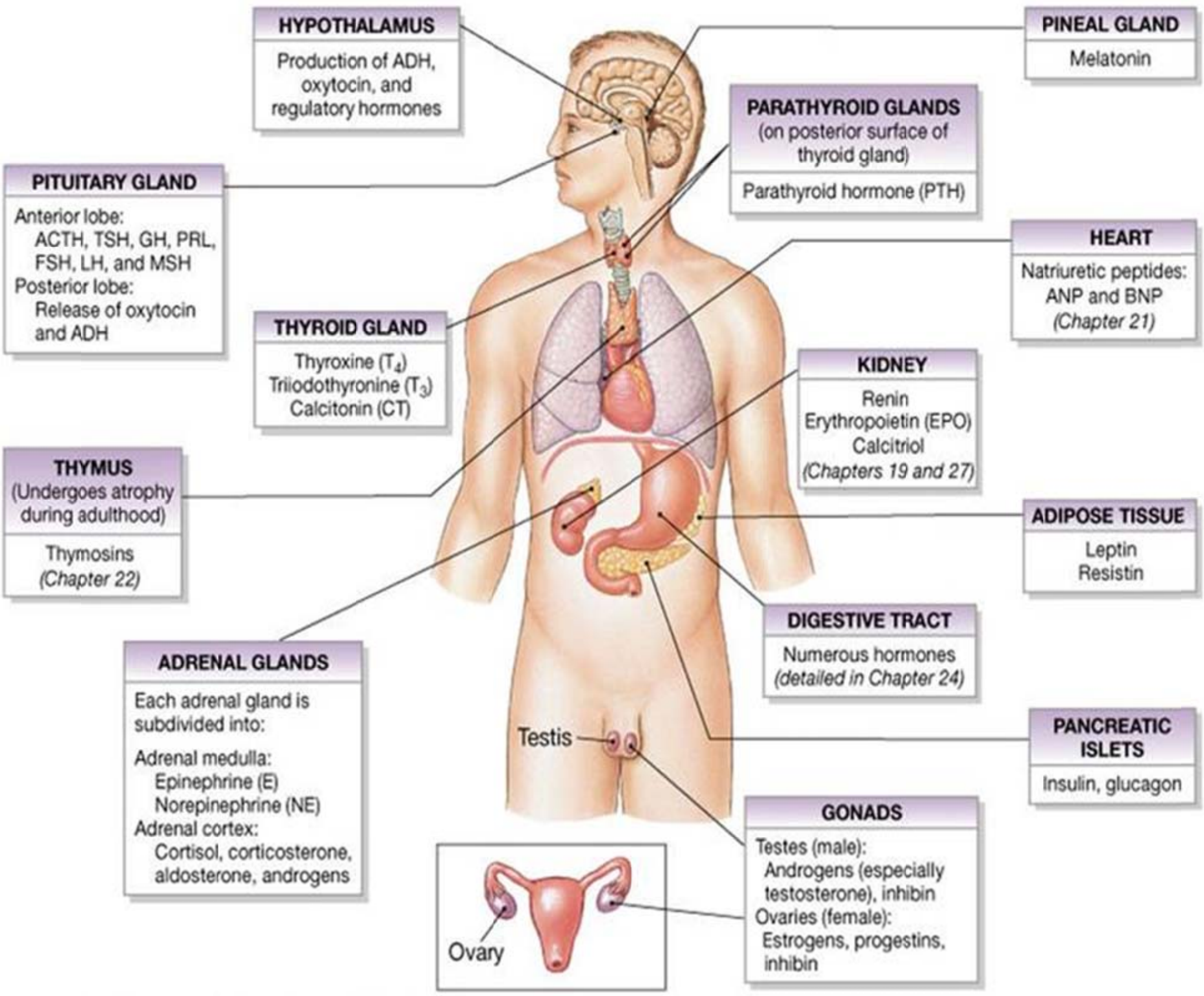
ovaries, testes, thyroid gland, parathyroid gland,

and adrenal glands

Glands discharge hormones directly into the bloodstream. They have built in feedback mechanisms that maintain a proper balance of hormones, and prevent excess hormone secretion. Low concentrations of a hormone will often trigger the gland to secrete. Once the concentrations of the hormone in the blood rise this may cause the gland to stop secreting, until once again hormone concentrations fall. This feedback mechanism (which is characteristic of most glands) causes a cycle of hormone secretions.

Disposal of waste.

Once hormones have served their function on their target organs/tissues they are destroyed. They are either destroyed by the liver or the actual tissues of the target organs. They are then removed by the kidneys



The Pituitary Gland

This is known as the **"master gland"** because it exerts control over all of the other glands of the endocrine system. Despite its importance the pituitary gland is no larger than a small pea. The Pituitary gland is made up of two separate glands: the **Anterior lobe** which is an outgrowth of the pharynx, and the **Posterior lobe** which is an outgrowth of the brain composed of neural (nerve) tissue.

The Anterior Lobe of the pituitary plays the 'master' role secreting six major hormones that affect most of the body, including the other Endocrine glands:

- **ACTH** (Adrenocorticotrophic hormone) stimulates the adrenal glands to secrete its hormones.
- **HGH** (Human growth hormone) also known as somatotrophic hormone is responsible for the growth of long bones, muscles and viscera.
- **TSH** (Thyroid stimulating hormone) influences the structure of the thyroid and causes it to secrete thyroid hormone.
- **FSH** (Follicle stimulating hormone) stimulates female egg production or male sperm production.
- **PRL** (Prolactin) in females causes the corpus luteum the area around the mature follicle to produce two important hormones: Oestrogen and Progesterone. During pregnancy PRL is also responsible for the development of the glandular tissues of the breast which produce milk.
- **LH** (Luteinzing hormone) works in conjunction with FSH in females to cause ovulation and prepares the uterus for pregnancy, in males the testes to secrete testosterone.

The Posterior Lobe of the Pituitary Gland (or neurophpophysis) stores and releases hormones secreted by the hypothalamus section of the brain including:

- **ADH** (Antidiuretic hormone) stimulates the smooth muscles, blood vessels and the intestine. ADH increases the kidney's permeability to water allowing the body to re-absorb water that would otherwise escape in urine.

- **OT** (Oxytocin) stimulates the smooth muscles of the uterus during pregnancy, causing it to contract during labour. It also stimulates the lacteals (milk ducts) in the breast.

The Thyroid gland: is a butterfly shaped gland which is located at the base of the throat. It has two lobes separated in the middle by a strip of tissue (the isthmus). The Thyroid itself secretes three main hormones:

- **Thyroxin** contains iodine which is essential for the body's normal growth, and metabolism. Thyroxin helps control body size, regulating not only the growth of tissues but also the differentiation or specialisation of tissues.
- **Triiodothyronine** has similar functions to thyroxin.
- **Calcitonin** causes a in the blood. Calcitonin works with secretions from the parathyroid glands to maintain the balance of calcium necessary for the body to function.

People who have surgery to remove the thyroid gland (thyroidectomy) for cancer or other thyroid problems usually need to take thyroxin supplements in order to maintain normal weigh and body functions.

Parathyroid gland: There are four Parathyroid glands which are small and rounded, arranged in two pairs usually located above and below the thyroid. Each Parathyroid is small, yellow and smooth; sometimes they imbed themselves in the thyroid itself.

Parathyroid hormone increases the blood concentrations of calcium and phosphorous, working to balance the **Calcitonin** which is secreted by the thyroid to maintain the body's balance of calcium.

Pancreas: is a long, narrow, lobed gland located behind the stomach. The Pancreas has two types of cells: exocrine and endocrine cells. The exocrine cells secrete Pancreatic juices which are used in the duodenum as an important part in the digestive system. The endocrine cells are arranged in clusters throughout the Pancreas, these known as **Islets of Langerhans.** There are three types of endocrine cells; alpha cells which secrete glucagon, beta cells which secrete insulin, and delta cells which inhibit the secretion on glucagon and insulin:

- **Glucagon** increases the blood glucose level by stimulating the liver causing convert Glycogen into Glucose (sugar).
- **Insulin** increases the cells permeability to glucose, which the cells use for energy. By promoting the utilisation of glucose by the tissue cells, insulin causes a decrease in the concentration of glucose in the blood. Insulin also promotes the storage of glycogen in the liver.

Adrenal Glands: The adrenal glands resemble small caps perched on top of each kidney. The Adrenal is actually a combination of two glands the adrenal cortex and the adrenal medulla.

The adrenal cortex is essential for life, as opposed to the adrenal medulla which is important but not indispensable. The anterior pituitary controls the adrenal cortex by secreting the hormone ACTH. All of the secretions of the adrenal cortex are known as steroids, many of which can now be manufactured synthetically. The adrenal cortex is made up of three layers associated with three classes of hormones:

- **Mineralocorticoids** are produced by the outer layer of the adrenal cortex, the most important of which is aldosterone. Aldosterone promotes the retention of sodium (Na+) and the excretion of potassium (K+). This helps to maintain both the electrolyte and water content of the body.
- **Glucocorticoids** are produced by the middle cortex. These affect almost every cell in the body regulating the metabolism of fats, proteins, and carbohydrates. Cortisone is one such glucocorticoid.
- **Gonadal hormones** are produced by the inner cortex, there are roughly even amounts of two types of hormones secreted: Androgen (male) and Estrogen (female). The adrenal gland is not the only gland to secrete sex hormones.

The Adrenal Medulla is the inner part of the adrenal gland. The hormones secreted effect the structures in the body that are under the control of the sympathetic nervous system, aiding the body to deal with stressful situations such as fright, attack or pursuit. They are both associated with an increased heart beat, higher blood pressure, and higher blood glucose levels, thus preparing the body for quick action.

- **Adrenalin** (or epinephrine) affects both alpha and beta receptors in the nervous system.
- **Noradrenalin** (Nor-epinephrine) affects only the alpha receptors of the nervous system.

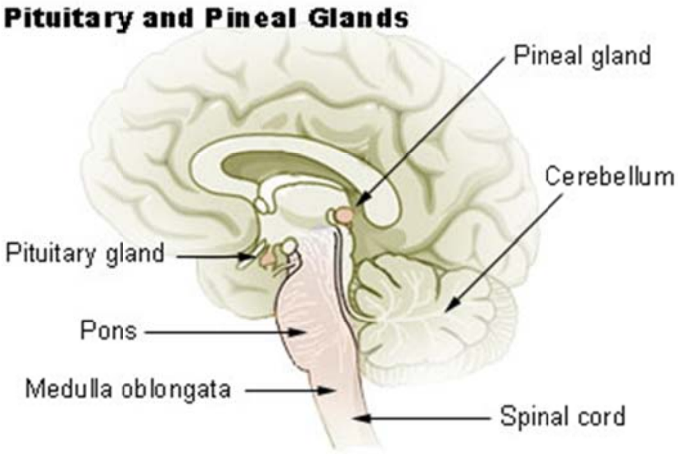
The Gonads

The gonads consist of ovaries in the female and testes in the male. These glands produce hormones important in the development and functioning of the reproductive organs. They are under the control of the pituitary gland, and produce the secondary sexual traits.

Male testes are egg shaped glands located in the sac like scrotum, and serve two main functions: (i) The production of sperm cells, and (ii) The secretion of testosterone. Testosterone is the masculizing hormone inducing male secondary sexual characteristics after puberty.

Female ovaries are two almond shaped glands on each side of the uterus. They have three main functions; (i) Containing immature ova (eggs), (ii) The secretion of oestrogen, and (ii) the secretion of progesterone. **Estrogen** is secreted by the adrenal cortex as well as the ovaries, and is present in the blood of all females from puberty through to the menopause. Estrogen acts on the structure of the reproductive organs, especially during the menstrual cycle. This induces and maintains female secondary sexual characteristics. Progesterone works on the uterus to prepare it for the implantation of a fertilised ovum (egg). It causes the development of the breasts, and is essential for the complete development of the maternal proportion of the placenta.

Pineal Gland: gland secretes a single hormone—melatonin (not to be confused with the pigment *melanin*). This simple hormone is special because its secretion is dictated by light. Researchers have determined that melatonin has two primary functions in human **A/** to help control your circadian (or biological) rhythm and **B/** regulate certain reproductive hormones.



Other hormone-producing structures

Many body organs not normally considered endocrine organs contain isolated cell clusters that secrete hormones. Examples include the heart (atrial natriuretic peptide); gastrointestinal tract organs (gastrin, secretin, and others); the placenta (hormones of pregnancy estrogen, progesterone, and others); the kidneys (erythropoietin and renin); the skin (cholecalciferol); and adipose tissue (leptin and resistin).

Growth Hormone

The growth hormone is a pituitary hormone that controls the body's growth by stimulating cell division. It also increases the blood glucose level. If your body has too little growth hormone, the body fails to grow normally. Too much growth hormone can cause the body to grow more than usual

Digestive system

Basic structure of the alimentary canal

Adventitia (outer covering), Muscle layers, Sub-mucosa, Mucosa, Nerve supply and Blood supply

1-Mouth/ The mouth or oral cavity is bounded by muscles and bones:
Anteriorly —by the lips
Posteriorly —it is continuous with the oropharynx
Laterally —by the muscles of the cheeks
Superiorly —by the bony hard palate and muscular soft palate
Inferiorly —by the muscular tongue and the soft tissues of the floor of the mouth.

Tongue/ The tongue is a voluntary muscular structure which occupies the floor of the mouth.

Functions of the tongue

The tongue plays an important role in:

- mastication (chewing)
- deglutition (swallowing)
- speech
- taste

Teeth/ Functions of the teeth

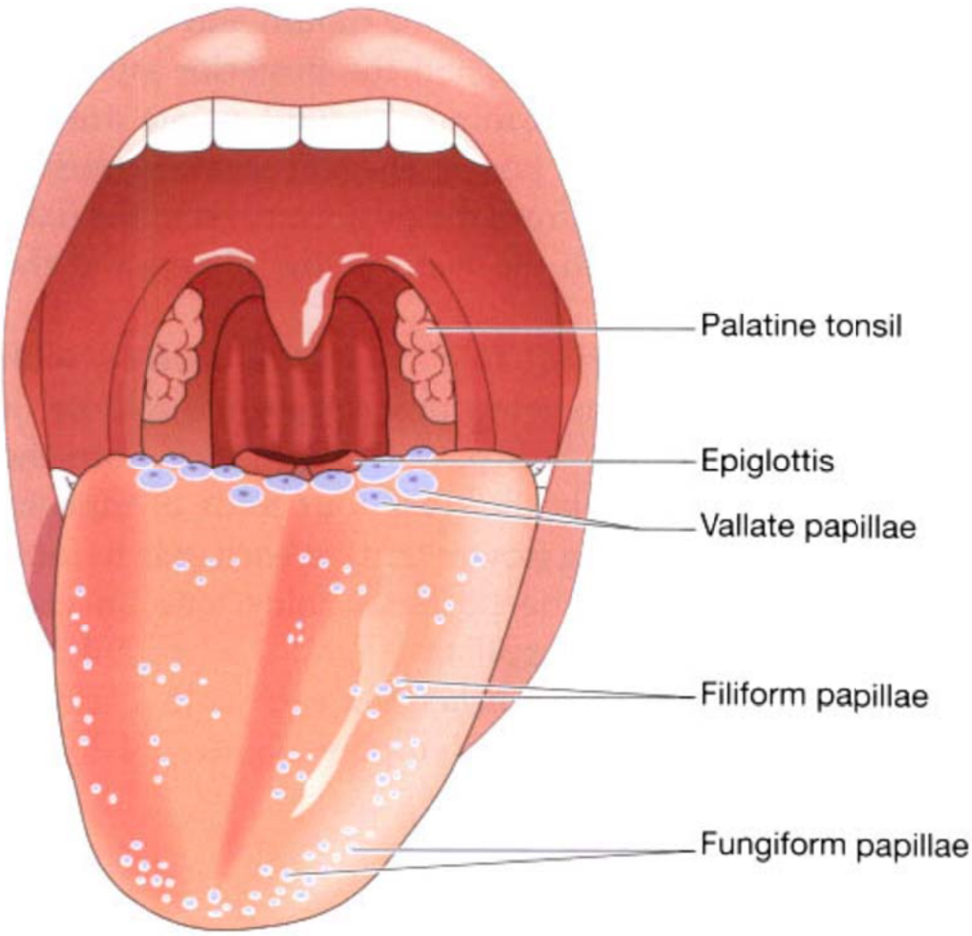
The **incisor and canine** teeth are the cutting teeth and are used for biting off pieces of food, whereas the **premolar and molar** teeth, with broad, flat surfaces, are used for grinding or chewing food

Salivary glands Salivary glands pour their secretions into the mouth. There are three pairs: **a)** the parotid glands, **b)** the submandibular glands and **c)** the sublingual glands.

Composition of saliva

Saliva is the combined secretions from the salivary glands and the small mucus-secreting glands of the lining of the oral cavity. About 1.5 litres of saliva is produced daily and it consists of:

- water
- mineral salts
- enzyme: salivary amylase
- mucus
- lysozyme
- immunoglobulins
- blood-clotting factors.



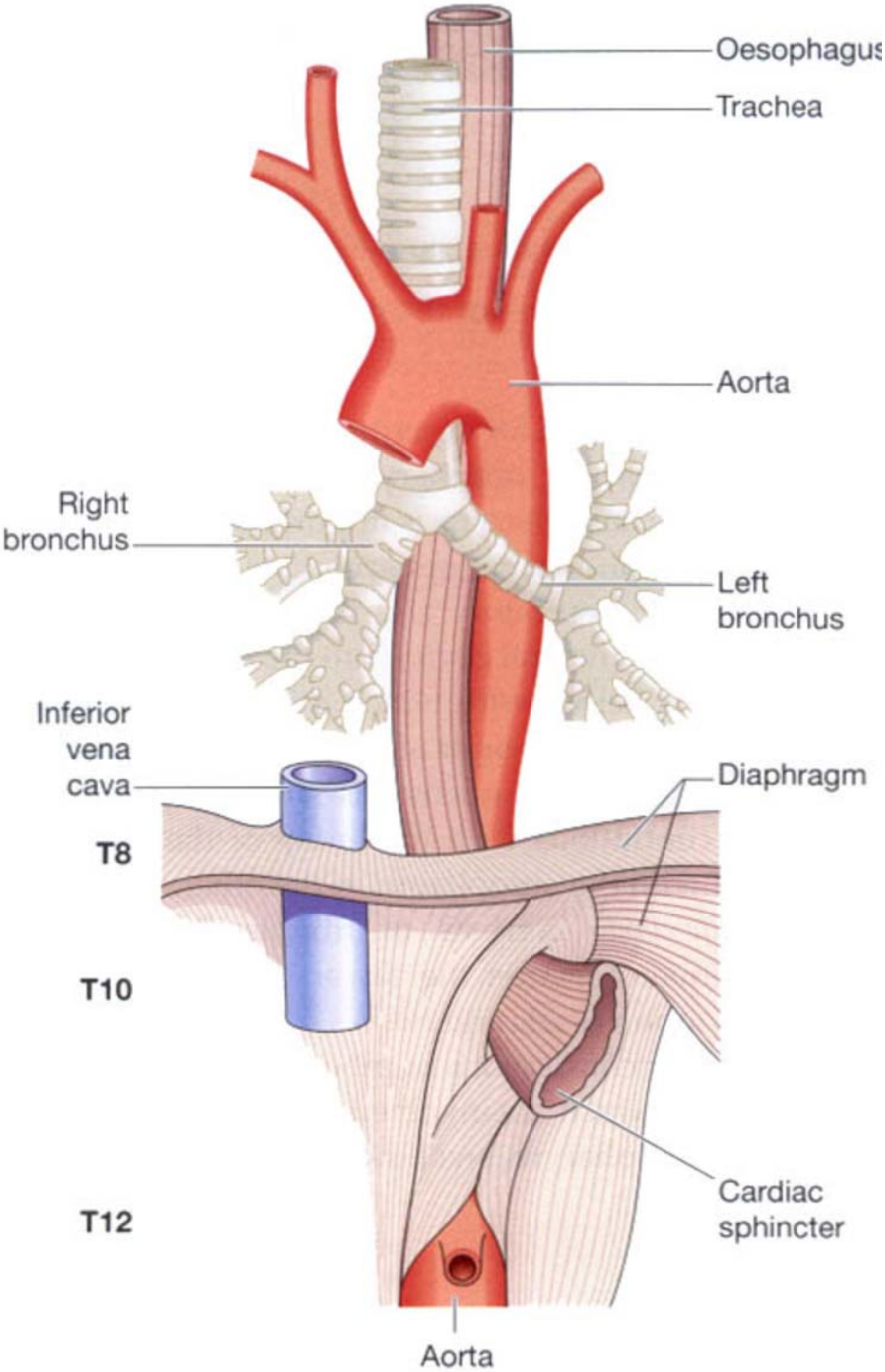
Functions of saliva

1. **Chemical digestion of polysaccharides** Saliva contains the enzyme amylase that begins the breakdown of complex sugars, reducing them to the disaccharide maltose.
2. **Lubrication of food.** Dry food entering the mouth is moistened and lubricated by saliva before it can be made into a bolus ready for swallowing.
3. **Cleansing and lubricating.** An adequate flow of saliva is necessary to cleanse the mouth and keep its tissues soft, moist and pliable.
4. **Non-specific defence.** Lysozyme, immunoglobulins and clotting factors combat invading microbes.
5. **Taste.**

2-Pharynx/is divided into three parts, the nasopharynx, oropharynx and laryngopharynx The nasopharynx is important in respiration. The oropharynx and laryngopharynx are passages common to both the respiratory and the digestive systems.

Food passes from the oral cavity into the pharynx then to the oesophagus**.**

Not /epiglottis preventing food entry into the airway.



<u>3-Esophagus/</u>presence of the bolus in the pharynx stimulates a wave of peristalsis which propels the bolus through the esophagus to the stomach.

Not/Peristalsis symmetrical construction and relaxation contracts in sequence of smooth muscle of gastrointestinal tract to produce a peristaltic wave,

4-Stomach/The stomach is continuous with the oesophagus at the *cardiac sphincter* and with the duodenum at the *pyloric sphincter*. Gastric muscle contraction consists of a churning
movement that breaks down the bolus and mixes it with gastric juice

Gastric juice/ About 2 litres of gastric juice are secreted daily by special secretory glands in the mucosa It consists of:

- Water
- mineral salts
- mucus secreted by goblet cells.

- hydrochloric acid secreted by *parietal*
  intrinsic factor
- inactive enzyme precursors: pepsinogens secreted by *chief cells* in the glands.

Functions of gastric juice

1. *Water* further liquefies the food swallowed.
2. *Hydrochloric acid:*
   - acidifies the food and stops the action of salivary amylase
   - kills ingested microbes
   - provides the acid environment needed for effective digestion by pepsins.

3-*Pepsinogens* are activated to *pepsins* by hydrochloric acid and by pepsins begin the digestion of proteins.

4- *Intrinsic factor* (a protein) is necessary for the absorption of vitamin B12 from the ileum.

5- *Mucus* prevents mechanical injury to the stomach wall by lubricating the contents.

Functions of the stomach:

1) temporary storage allowing time for the digestive enzymes, pepsins, to act
2) chemical digestion — pepsins convert proteins to polypeptides,
3) mechanical breakdown — the three smooth muscle layers enable the stomach to act as a churn, gastric juice is added and the contents are liquefied to *chyme*
4) limited absorption of water, alcohol and some lipidsoluble drugs
5) non-specific defence against microbes — provided by hydrochloric acid in gastric juice.
6) preparation of iron for absorption further along the tract — the acid environment of the stomach solubilises iron salts, which is required before iron can be absorbed
7) production of intrinsic factor needed for absorption of vitamin B12 in the terminal ileum
8) regulation of the passage of gastric contents into the duodenum. When the chyme is sufficiently acidified and liquefied.

5-Small intestine/ The small intestine is continuous with the stomach at the pyloric sphincter and leads into the large intestine at the *ileocaecal valve.* It is a little over 5 metres long and lies in the abdominal cavity surrounded by the large intestine. In the small intestine the chemical digestion of food is completed and most of the absorption of nutrients takes
place. The small intestine comprises three main sections continuous with each other.

a) The duodenum
b) The jejunum
c) The ileum

Intestinal juice/ About 1500 ml of intestinal juice are secreted daily by the glands of the small intestine. It consists of:

- water
- mucus
- mineral salts
- enzyme: enterokinase

Functions of the small intestine

- Onward movement of its contents which is produced by peristalsis
- Secretion of intestinal juice
- Completion of chemical digestion of carbohydrates, protein and fats
- protection against infection by microbes that have survived the antimicrobial action of the hydrochloric acid in the stomach, by the solitary lymph follicles and aggregated lymph follicles.
- secretion of the hormones cholecystokinin (CCK) and secretin
- absorption of nutrients.

Absorption of nutrients occurs by two possible processes:

- ***Diffusion***. Monosaccharides, amino acids, fatty acids and glycerol diffuse slowly down their concentration gradients into the enterocytes from the intestinal lumen.
- ***Active transport***. Monosaccharides, amino acids, fatty acids and glycerol may be actively transported into the villi.

Pancreas /The function of the exocrine pancreas is to produce *pancreatic juice* containing enzymes that digest **A** carbohydrate by amylase enzyme, **B** proteins by Proteases (trypsin and chymotrypsin) and **C** fats by lipase enzyme. Other secretions are **D**water and mineral salts

Liver/

function:

1) **Carbohydrate metabolism.** *Conversion of glucose to glycogen* in the presence of insulin, and converting liver glycogen back to glucose in the presence of glucagon.
2) **Fat metabolism.** *Desaturation of fat*, i.e. converts stored fat to a form in which it can be used by the tissues to provide energy
3) **Protein metabolism.** *Deamination of amino acids*
4) **Breakdown of erythrocytes and defence against microbes.** This is carried out by phagocytic Kupffer cells (hepatic macrophages) in the sinusoids.
5) **Detoxification of drugs and noxious substances.** These include ethanol (alcohol) and toxins produced by microbes.
6) **Inactivation of hormones.** These include insulin, glucagon, cortisol, aldosterone, thyroid and sex hormones.
7) **Synthesis of vitamin A from carotene**.
8) **Production of heat.**
9) **Secretion of bile.**
10) **Storage.** The substances include:
    - fat-soluble vitamins: A, D, E, K,
    - iron, copper
    - Some water-soluble vitamins, g. riboflavine, niacin,pyridoxine, folic acid and vitamin B12.

Bile/ about 500 and 1000 ml are secreted daily. It consists of:
1. water
2. mineral salts
3. mucus
4. bile salts
5. bile pigments, mainly bilirubin
6. cholesterol.

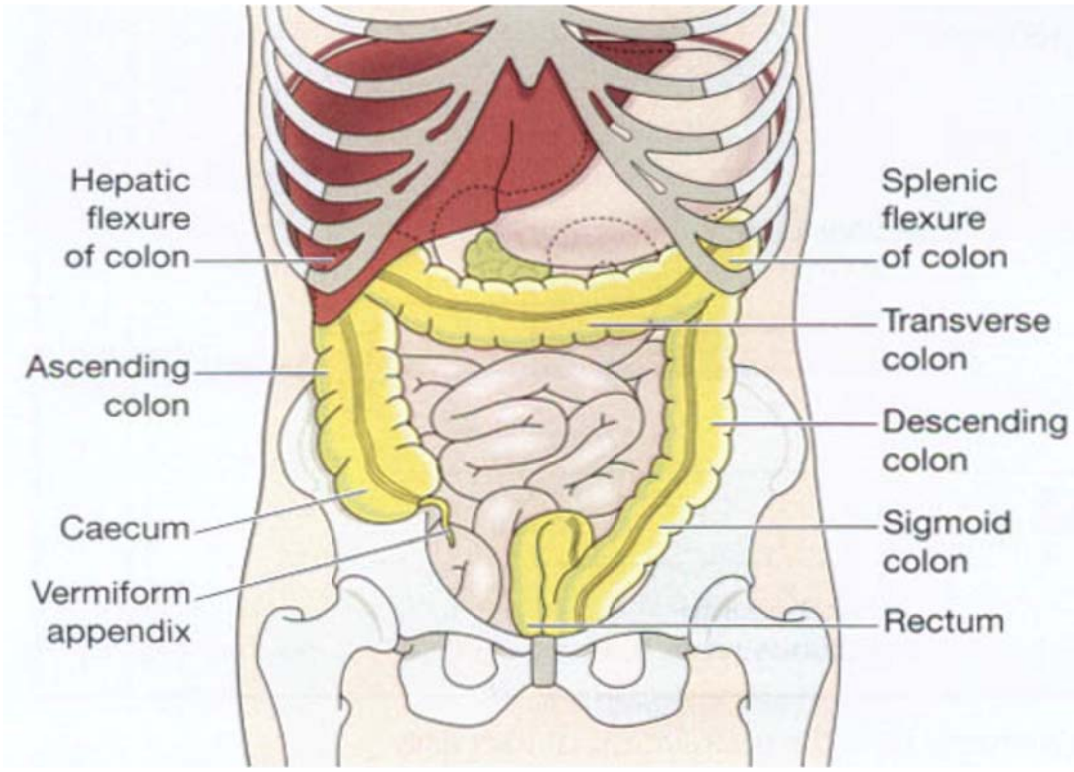
Function:

1-The bile salts, *sodium taurocholate* and *sodium glycocholate*, emulsify fats in the small intestine.

2- Fatty acids are insoluble in water, which makes them very difficult to absorb through the intestinal wall. Bile salts make fatty acids soluble, enabling fatty acid and fat-soluble vitamins (e.g. vitamin K) to be readily absorbed.

Note/ Stercobilin colours and deodorises the faeces.

6-Large intestine the colon is divided into the caecum, ascending colon, transverse colon, descending colon, sigmoid colon, rectum and anal canal.



Functions of the large intestine, rectum and anal canal

A) **Absorption**/The contents of the ileum which pass through the ileocaecal valve

In the large intestine absorption of water continues until the familiar semisolid consistency of faeces is achieved. Mineral salts, vitamins and some drugs are also absorbed into the blood capillaries from the large intestine.

B) Microbial activity/ The large intestine is heavily colonised by certain types of

bacteria, which synthesise vitamin K and folic acid. They include *Escherichia coli, Enterobacter aerogenes, Streptococcus faecalis* and *Clostridium perfringens (welchii).* These microbes are *commensals* in humans. They may become pathogenic if transferred to another part of the body

C) Movement **D) Defecation**

Constituents of faeces. The faeces consist of a semisolid brown mass. The brown colour is due to the presence of stercobilin.

Even though absorption of **water** takes place in the large intestine, water still makes up about 60 to 70% of the weight of the faeces. The remainder consists of: **fibers** (indigestible cellular plant and animal material) **dead and live microbes, epithelial cells** from the walls of the tract

fatty acids and **mucus** secreted by the epithelial lining of the large intestine.

Note/ Mucus helps to lubricate the faeces and an adequate amount of roughage in the diet ensures that the contents of the colon are sufficiently bulky to stimulate defaecation.

Metabolism constitutes all the chemical reactions that occur in the body, using absorbed nutrients to:

• provide energy by chemical oxidation of nutrients

• make new or replacement body substances.

Two types of processes are involved.

1- **Catabolism.** This process breaks down large molecules into smaller ones releasing *chemical energy* that is stored as adenosine triphosphate (ATP), and *heat.* Heat is used
to maintain core body temperature.

2- **Anabolism.** This is building up, or synthesis, of large molecules from smaller ones and requires a source ofenergy, usually ATP.

Note/Anabolism and catabolism usually involve a series of chemical reactions, known as *metabolic pathways.*