General Knowledge Today

General Science-4: Human Body Systems

Target 2016: Integrated IAS General Studies

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Model Questions

Prelims MCQ Topics

Basic idea about Animal Tissues; Tendons and Ligaments; Types of Teeth; Dental Formula in Children and Adults; Teeth Tissues (pulp, dentin, enamel, and cementum); Steps in Digestion; Digestive Enzymes; Gut flora; Digestion of cellulose in Ruminants; Open and Closed Circulatory Systems, Pulmonary and Systematic Circulation; Systole and Diastole; comparison of Arteries and Veins; Blood composition and Features; RBCs and WBCs, Blood Clotting, Blood Related Diseases, Types of Anemia, Functions of Bones; Parts of Brain; Various Endocrine Glands and Hormones

Animal Tissues

In all the animals, tissues develop from the embryonic germ layers during the blastula (early stage of embryonic development) phase. On the basis of germ layers, all animals except Porifera and Protozoa; there are either two or three germ layers.

- The animals which develop from two germ layers (ectoderm and endoderm) are called Only Ctenophores (comb jellies) and Cnidarians (*Hydra, Corals, Sea Anemones, Jelly Fishes, Sea Pens)* have this feature.
- The animals which develop from three germ layers viz. ectoderm, mesoderm and endoderm are called *triploblastic*. All animals from Platyhelminthes to Humans are triploblastic.

Types of Animal Tissues

There are 4 categories of animal tissues viz. Epithelial Tissue, Connective Tissue, Muscular Tissue and Nervous Tissue.

Epithelial Tissue

Epithelial tissue makes the covering of the internal organs as well as our body. This is the simplest and non specialized tissue. Epithelial tissue originates from all the three embryonic layers viz. Ectoderm, Mesoderm and Ectoderm.

Connective Tissue

The tissues that bind several tissues in the body are called connective tissues. They do the function of supporting the organs and packaging of the organs. Please note that except muscles all the connective tissue is derived from the mesoderm of the embryonic blastula. 30% of the body by mass is composed of connective tissue. This tissue includes connective tissue proper, skeletal issue and fluid tissue.

- **Collective tissue** proper includes the below two types:
  - *Collagen fibres* which make *tendons that connect muscles to bones*. We note here that *Vitamin C helps in synthesis of Collagen* and lack of vitamin C causes a deficiency of connective tissue called "Scurvy".
  - Yellow elastic fibres which make *ligaments that connect bones to bones*. Yellow elastic fibres are also present in arteries to provide elasticity to them. We note here that Yellow Elastic Fibre is resistant to chemical change, though it loses elasticity with aging. Resistance to chemical change is also evident from the fact that when mummies are dissected, arteries are among the internal organs that might be found in most intact condition!
- **Skeletal Tissue** is *derived from the mesoderm of embryonic blastula* {this question is frequently asked in UPSC and state exams}. There are two types of skeletal tissues viz. cartilage and bone.

  - Cartilage is softer, elastic tissue that makes joints between bones, rib cage, ear, nose, bronchial tubes, intervertebral discs etc.
  - Bone is a highly mineralized tissue in which connective tissue part is 1/3rd while mineral part is 2/3rd portion.
- **Fluid Connective Tissue includes** Blood, Lymph and Cerebrospinal fluid(CSF). Blood and Lymph circulate in the body and help in transportation of the metabolites. They have a common matrix called plasma. They have various kinds of cells which are called "corpuscles. There are no fibers or matrix in fluid connective tissue.

Nervous Tissue

Nervous Tissue is the main component of brain; spinal cord and peripheral nerves. It helps in the regulation and control of body functions and activities and allows us to see and perceive the world. It is made of neurons {nerve cells}, and Neuroglia, which helps in propagation of the nerve.

Muscular Tissue

These tissues are made of muscle fibres whose contractions and relaxations provoke the movement and locomotional activities.

Digestive System

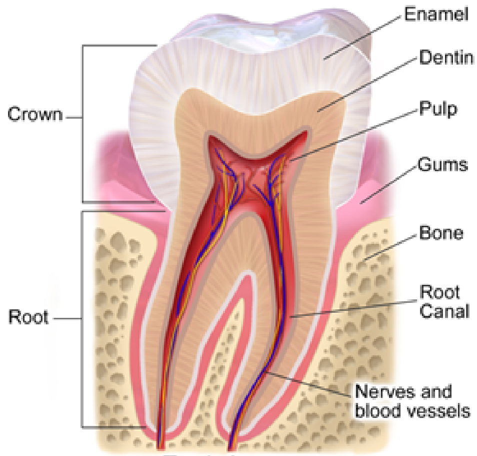
The digestive system is made up of the digestive tract and other organs that help the body break down and absorb food. Organs that make up the digestive tract include mouth, oesophagus, stomach, small intestine, large intestine (also known as colon rectum) and anus. Inside these hollow organs is a lining called the mucosa.

Mouth / Oral Cavity

The oral cavity has a number of teeth and a muscular tongue.

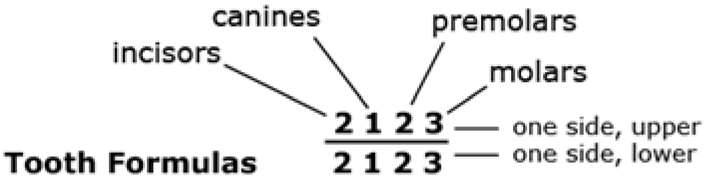
Teeth

Each tooth is embedded in a socket of jaw bone. Most of the animals including humans have two sets of teeth during their life. First set is of temporary milk or deciduous teeth, which is replaced by a set of permanent or adult teeth. Adult human has 32 permanent teeth which are of four different types viz. Incisors, Canines, Premolar and Molars.



Tooth Anatomy

Incisors are the eight front teeth (4 up, 4 down). Canines are another four teeth on either side of incisors in both sides (2 up, 2 down). Beyond canines are eight premolars (4 up, 4 down). These teeth have two pointed cusps on their biting surface and are sometimes referred to as *bicuspids*. Beyond Premolars are 12 molars (6 up and 6 down) thus making a set of 32 teeth in humans. The three pairs of molars in upper or lower jaw are denoted as first, second and third molars. Third molar is also known as wisdom teeth that come up in 30s. The above system is arranged in the form of a dental formula, which is 2123/2123 in humans.

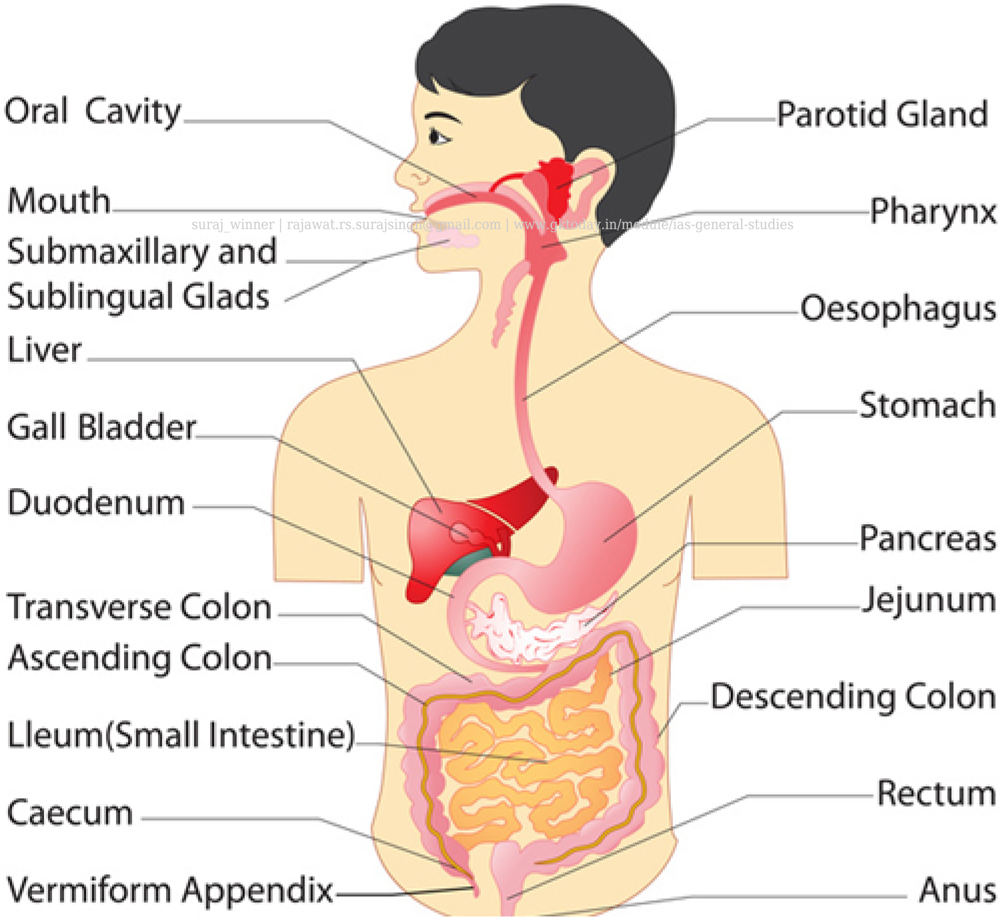


In children, there are only 20 deciduous teeth or ***milk teeth***. They begin to develop before birth and begin to fall out when a child is around 6 years old. The dental formula for milk teeth is 2102. *We note here that Children don't have premolars.* Their premolar is called by dentists as first molars rather. These baby molars are replaced by adult premolars.

Human teeth are made up of four different types of tissues viz. pulp, dentin, enamel, and cementum. Pulp is the innermost portion of the tooth and consists of connective tissue, nerves, and blood vessels, which nourish the tooth. Pulp is surrounded by Dentin, a hard yellow substance that makes up most of the tooth and is as hard as bone. Enamel which covers the dentin is *hardest tissue in the body* and forms the outermost layer of the crown. A bony layer of cementum covers the outside of the root, under the gum line, and holds the tooth in place within the jawbone. Cementum is also as hard as bone.

Steps in Digestion

The digestive system performs four functions viz. ingestion, digestion, absorption and elimination. Ingestion is intake of food. Digestion is of two types viz. mechanical (food is broken down into smaller pieces, this begins as soon as we put food in our mouth) and chemical (use of enzymes and acids to break down consumed food). Absorption is the assimilation of digested food in cells while elimination is passing out of what we cannot digest. The entire digestive system is made of alimentary canal and accessory digestive organs. Alimentary canal is made of salivary glands, Pharynx, Oesophagus, stomach, small intestine and large intestine. Accessory digestive organs are liver, gallbladder and pancreas.



Digestion in Mouth Cavity

Salivary glands release saliva in mouth cavity which contains *Salivary Amylaze* enzyme that digests starch into sugars. Further, another enzyme called lingual lipase also begins digestion of the lipids / fats in mouth cavity only. *Thus, while digestion of carbohydrates and lipids begins in mouth cavity, digestion of proteins begins only in stomach in highly acidic environment.* Mouth cavity leads to pharynx that is common passage for food and air. When we swallow the food, the windpipe is closed by a flap of cartilage behind the root of the tongue. This flap is called epiglottis. Beyond epiglottis is Oesophagus, a food pipe which ends in stomach. At the junction of the oesophagus and stomach, there is a ring like muscle, called the ***oesophageal sphincter*** that relaxes and allows the food to pass through to the stomach. No digestion takes place in oesophagus.

Digestion in stomach

The ***Stomach*** has three mechanical tasks. To store the swallowed food, to mix up the food, liquid, and digestive juice produced by the stomach and to empty its contents slowly into the small intestine. Digestion of carbohydrates, proteins as well as fats takes place in stomach. We note here that least time is needed to digest carbohydrates, more for protein and maximum for fats.

Key Enzymes in Stomach

The main gastric enzyme is *Pepsin* which is secreted in inactive form called Pepsinogen. It is activated by stomach acid (HCl). It breaks protein into peptide fragments and amino acids. Here, Hydrochloric acid plays role to denture the proteins and kill any bacteria or viruses in the food. Another stomach enzyme is *Gastric lipase.* It works in acidic environment {other lipases such as pancreatic lipase work in alkaline environment} digests fats and lipids.

How stomach saves itself from acids secreted?

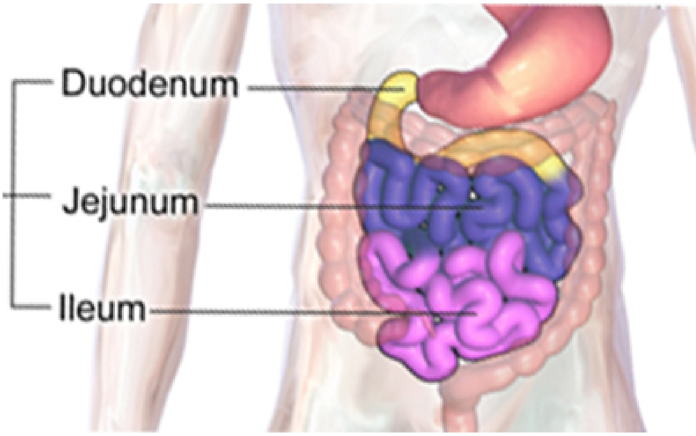
Stomach has highly acidic environment. To protect its own lining from digestion by digestive juices, it secrets Mucin and carbonate from its mucous cells. This is one way to save its own cells. Another way is a high turnover of stomach cells.

Function of Gastrin Hormone

Gastrin is an important hormone of G-cells of stomach. It stimulates stomach cells to produce hydrochloric acid (HCl) and another chemical called Intrinsic factor (IF).

Digestion in Small Intestine

Small intestine is largest part of digestive system (around 6 meters) and divided into three parts viz. the duodenum, jejunum and ileum.



By the time food is ready to leave the stomach, it has been processed into a thick liquid called ***chyme***. A walnut-sized muscular valve at the outlet of the stomach called the ***pylorus*** keeps chyme in the stomach until it reaches the right consistency to pass into the small intestine. Once entered into duodenum, the chyme comes into contact with pancreatic juice with a pH of approximately 8.5. Thus, the hitherto acidic environment of stomach (pH near 2) is turned into alkaline environment.

Here we note that the neutralization of the acidity of the chyme is *necessary* for the functioning of the digestive enzymes that act in the duodenum. Further, without neutralization of the acidity of the chyme, mucous membrane of the intestine would be damaged.

What happens here is that the acidity of chyme stimulates production of a hormone called *secretin in the duodenum*. Secretin stimulates the pancreas to release pancreatic juice and also signals the gallbladder to expel bile in the duodenum. The pancreatic secretion, rich in bicarbonate ions, is released in the duodenum and neutralizes the chyme acidity; this acidity is also neutralized by the secretion of bile in the duodenal lumen.

Further, most of the chemical digestion of fats begins only in duodenum via so called *emulsification* process.

Role of Liver: Bile Juice and Emulsification

Bile, an emulsifier liquid, is made by the liver and later stored in the gallbladder and released in the duodenum. Bile is composed of bile salts, cholesterol and bile pigments. Bile salts are detergents, amphiphilic molecules, or rather, molecules with a polar water-soluble portion and a non-polar fat-soluble portion. This feature allows bile salts to enclose fats inside water-soluble micelles in a process called emulsification. Through this process, fats come into contact with intestinal lipases, enzymes that break them down into simpler fatty acids and glycerol.

Why patients with gall stones are not allowed to take fatty foods?

Bile is concentrated and stored in the gallbladder. When foods high in fat are ingested, the gallbladder contracts to release bile into the duodenum. This is the reason why patients with gallstones are advised to not to eat fatty foods, because the reactive contraction of the gallbladder may move some of the stones to the point of blocking the duct that drains bile into the duodenum, causing pain and other complications.

Other functions of Liver

Apart from making bile for releasing in small intestine, Liver is also a site for storing, processing and inactivating poisons in food. This work is done by a network of veins in the liver called mesenteric circulation. Liver also polymerizes glucose and stores it as Glycogen. It stores many vitamins and the iron absorbed in the intestine. It detoxifies poisonous substances such as alcohol, nicotine, drugs etc.

Role of Pancreas

The ***pancreas*** produces enzymes that help digest proteins, fats, and carbohydrates. It also makes a substance that neutralizes stomach acid. The pancreatic juice is released into the mixture that contains the following enzymes to help chemically digest fats and carbohydrates:

- *Pancreatic Lipase* breaks apart fat molecules into fatty acids and glycerol.
- *Pancreatic amylase* breaks long carbohydrates into disaccharides, which are short chains of two sugars. The disaccharidases then break apart into monosaccharides that can be absorbed by the cells lining the small intestine.
- *Trypsin and chymotrypsin* are enzymes that break apart peptide fragments. After they break the peptides down into small chains, amino peptidases finish them off by breaking apart the peptides into individual, absorbable amino acids.

Intestinal Villi and Microvilli

After digestion, the next step is absorption by cells of the mucous membrane of the intestine. For this to happen, a large absorption surface is needed. This is done by two ways. *Firstly,* intestine itself is long and tubular and closely folded and numerous loop. *Secondly,* a more efficient process is done by intestinal Villi and the microvilli of the mucosal membrane cells. These are like gloved fingers which scale up the process of absorption by increasing absorption area manifold.

The majority of water, vitamins and mineral ions are absorbed by the small intestine.

Digestion in Large Intestine

The large intestine is not responsible for digestion but only for reabsorption of nearly 10% of ingested water, a significant amount that gives consistency to feces. If there is some disease in colon, water will not be absorbed and person will suffer from diarrhoea.

How food is assimilated?

The sugars, amino acids, mineral salts and water are taken from the capillary vessels of small intestine to mesenteric circulation. The blood from the mesenteric circulation distributes nutrients to tissues in body.

Role of vegetable fibres

Plant fibers are not absorbed by the intestine but play an important role in its functioning. They retain water inside the bowels and therefore contribute to the softening of the feces. Softer feces are easier to eliminate during defecation. People who eat less dietary fiber may suffer from hard stool and constipation.

Intestinal Microflora

Bacteria that live inside intestine play an important role in digestion. Some polysaccharides such as cellulose, hemicelluloses and pectin are not digested by digestive enzymes secreted by the body; instead, they are broken down by enzymes released by bacteria in the gastrointestinal tract. Intestinal bacteria also produce substances vital to the functioning of the bowels, facilitating or blocking the absorption of nutrients and stimulating or reducing peristalsis. Further, *gut bacteria are the main source of vitamin K for the body* and, as a result, they are essential for the blood clotting process.

Special features of Birds digestive system

The digestive system of birds contains special structures called crop, the proventriculus and the gizzard. Crop works as temporary storage of ingested food. Proventriculus is the chemical stomach of birds, in which food is mixed with digestive enzymes. Gizzard is a muscular pouch that serves as a mechanical stomach, in which food is ground up to increase the exposure area of the food particles to digestive enzymes.

Mutualistic Digestion of cellulose in Ruminants

Herbivorous animals eat large amounts of cellulose, which is not digested by their digestive enzymes. In such animals, one region of the digestive tract is colonized by microbes that digest cellulose. This type of digestion is found in horses, cows, and rabbits and also in some insects, such as termites.

Further, food ingested by cows and other ruminant animals first passes through two compartments of the digestive tract called the rumen and the reticulum. Within them, the food is subject to the action of digestive enzymes released by microorganisms that live there in a mutualistic digestion. In the reticulum, the food is broken down. After passing through reticulum, the food (cud) is regurgitated to the mouth to be chewed and swallowed once again in a process called rumination.

Disorders of Digestive System

- ***Appendicitis***, an inflammation of the appendix, most often affects kids and teens between 11 and 20 years old, and requires surgery to correct. The classic symptoms of appendicitis are abdominal pain, fever, loss of appetite, and vomiting.
- ***Gastrointestinal infections*** can be caused by viruses, by bacteria (such as Salmonella, Shigella, Campylobacter, or E. coli), or by intestinal parasites (such as amebiasis and giardiasis). Abdominal pain or cramps, diarrheal, and sometimes vomiting are the common symptoms of gastrointestinal infections.

- ***Inflammatory bowel disease (IBD)*** is chronic inflammation of the intestines that affects older kids, teens, and adults.
- ***Hepatitis***, a condition with many different causes, is when the liver becomes inflamed and may lose its ability to function.

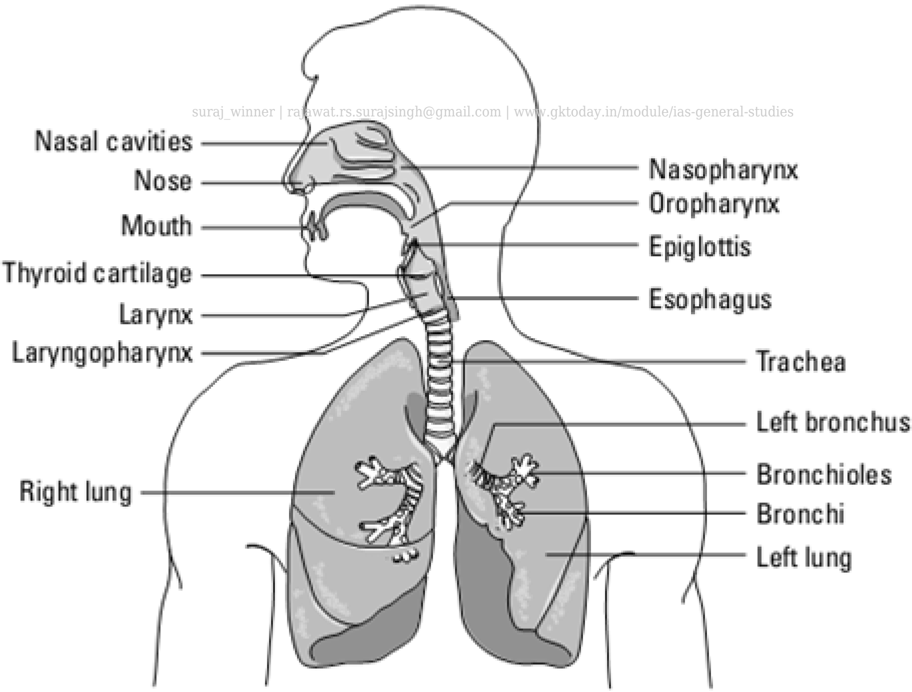
Respiratory System

Respiration is the entire process of taking air in, exchanging needed gases for unnecessary gases, using the needed gases, and releasing the waste form of gases. The Human respiratory system consists of the following parts, divided into the upper and lower respiratory tracts.

Upper Respiratory Tract

Mouth, nose & nasal cavity

The nostrils act as the air intake, bringing air into the nose, where it's warmed and humidified. Tiny hairs called cilia protect the nasal passageways and other parts of the respiratory tract, filtering out dust and other particles.



Pharynx

Pharynx is part of the digestive system as well as the respiratory system because it carries both food and air.

Larynx

This is also known as the voice box as it is where sound is generated. It also helps protect the trachea by producing a strong cough reflex if any solid objects pass the epiglottis.

Lower Respiratory Tract

Trachea (Wind Pipe)

It carries air from the throat into the lungs. The inner membrane of the trachea is covered with cilia. The trachea is surrounded by 15-20 C-shaped rings of cartilage at the front and side which help protect the trachea and keep it open.

Bronchi

The trachea divides into two tubes called bronchi, one entering the left and one entering the right lung.

Bronchioles

Tertiary bronchi continue to divide and become bronchioles, very narrow tubes, less than 1 millimetre in diameter. There is no cartilage within the bronchioles and they lead to alveolar sacs.

Alveoli

Individual hollow cavities contained within alveolar sacs. Alveoli have very thin walls which permit the exchange of gases Oxygen and Carbon Dioxide. They are surrounded by a network of capillaries, into which the inspired gases pass.

Thorax or the chest cavity

It is the airtight box that houses the bronchial tree, lungs, heart, and other structures. The top and sides of the thorax are formed by the ribs and attached muscles, and the bottom is formed by a large muscle called the diaphragm.

Diaphragm

It is located below the lungs. It is a large, dome-shaped muscle that contracts rhythmically and continually, and most of the time, involuntarily. Upon inhalation, the diaphragm contracts and flattens and the chest cavity enlarges which pulls air into the lungs. Upon exhalation, the diaphragm relaxes and returns to its domelike shape, and air is forced out of the lungs.

Steps in Respiration

Respiration involves the following steps:

1. Breathing or pulmonary ventilation by which atmospheric air is drawn in and CO2 rich alveolar air is released out.
2. Diffusion of gases (O2 and CO2) across alveolar membrane.
3. Transport of gases by the blood.
4. Diffusion of O2 and CO2 between blood and tissues.
5. Utilisation of O2 by the cells for catabolic reactions and resultant release of CO2.

The process of Respiration

In a process called diffusion, oxygen moves from the alveoli to the blood through the capillaries (tiny blood vessels) lining the alveolar walls. Blood has a massive capacity to dissolve oxygen – much more oxygen can dissolve in blood than could dissolve in the same amount of water. This is because blood contains Haemoglobin – a specialized protein that binds to oxygen in the lungs so that the oxygen can be transported to the rest of the body. This oxygen-rich blood then flows back to the heart, which pumps it through the arteries to oxygen-hungry tissues throughout the body.

In the tiny capillaries of the body tissues, oxygen is freed from the hemoglobin in the blood and moves into the cells. Carbon dioxide, which is produced during the process of diffusion, moves out of these cells into the capillaries, where most of it is dissolved in the plasma of the blood.

Blood rich in carbon dioxide then returns to the heart via the veins. From the heart, this blood is pumped to the lungs, where carbon dioxide passes into the alveoli to be exhaled.

Circulatory System

Circulatory system is responsible for movement of nutrients, gases and wastes within blood vessels.

Open and Closed Circulatory Systems

Circulatory system is not found in Porifera, Cnidaria, Platyhelminthes, Nematodes and Echinoderms. An open circulatory system is found in arthropods, gastropods, bivalves and protochordates. In open circulatory system blood (called hemolymph) flows *in vessels as well as open in body cavities*. Such circulatory system has low blood pressure.

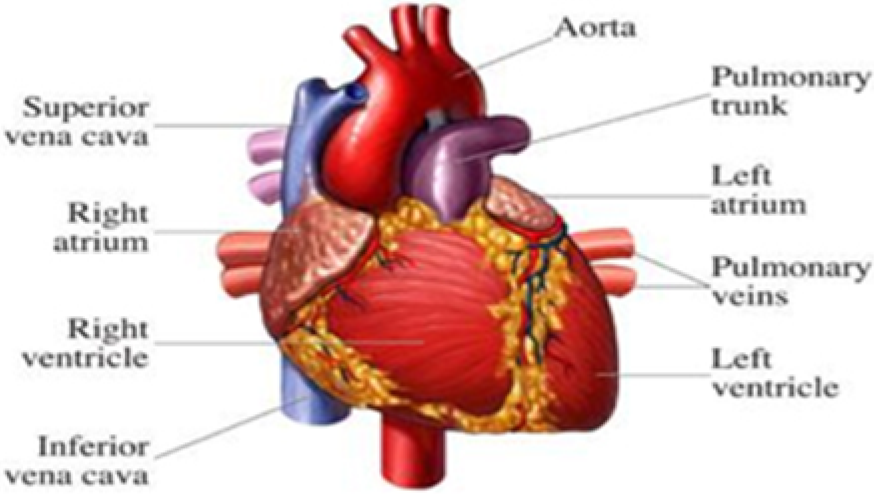
In annelids, Cephalopods and Vertebrates, closed circulatory system in found in which blood circulates only inside blood vessels. Due to this, the blood pressure is high in these organisms and thus blood can travel greater distances to the organs and tissues. Further, higher circulatory speed also increases the capacity to distribute large supplies of oxygen.

Human Heart and Circulatory system

The main components of human circulatory system include blood vessels (arteries, veins and capillaries), heart, blood, lymph and lymphatic system.

Human Heart

Human heart has four chambers viz. right atrium & right ventricle and left atrium & left ventricle through which blood passes.



We note that two sides of our heart are anatomically and functionally separate pumping units. The cardiovascular system is composed of these two circulatory paths.

Pulmonary Circulation

Pulmonary circulation or circuit refers to the movement of deoxygenated blood from heart to lungs, getting oxygenated in lungs and then coming back to heart.

Systematic Circulation

Systemic circulation or circuit is the movement of blood from the heart through the body to provide oxygen and nutrients, and bringing deoxygenated blood back to the heart.

Notable points about the above two circulations are as follows:

- The *right side of heart pumps blood through the* ***pulmonary circulation***, while the *left side of the heart pumps blood through the* ***systemic circulation***.
- Usually, arteries carry oxygen rich blood. But the pulmonary artery (which takes blood from heart to lungs) carries deoxygenated blood. Similarly, usually veins carry deoxygenated blood, but pulmonary veins carry oxygenated blood.

Systole and Diastole

Systole and diastole are the two stages into which the cardiac cycle is divided. Systole is the stage when the contraction of ventricular muscle fibers occurs and the ventricles are emptied. Diastole is the stage of the cardiac cycle when the ventricular muscle fibers expand and the ventricles are filled with blood. When ventricles contract (systole), the blood is sent to pulmonary and systemic circulation. To prevent the flow of blood backwards into the atria during systole, the atrio-ventricular valves close, creating the sound (lubb). When the ventricles finish contracting, the aortic and pulmonary valves close to prevent blood from flowing back into the ventricles. This is what creates the second sound (dubb). Then, the ventricles relax (called diastole) and fill with blood from the atria, which makes up the second phase of the cardiac cycle. This is how sounds of our heart are represented as lubb-dubb-pause-lubb-dubb-pause.

Heart Beat Rate

The normal heart beat is 70-72 per minute in males and 78-82 per minute in females. The heartbeat of a child is more than that of an adult at around 140/min.

Coronary Circulation

The coronary arteries supply blood to the heart muscle. These vessels originate from the aorta immediately after the aortic valve and branch out through the heart muscle. The coronary veins transport the deoxygenated blood from the heart muscle to the right atrium.

Arteries, Veins and Capillaries

Arteries carry blood from the heart to various body parts. All arteries carry oxygenated blood from the heart *except pulmonary artery*. Arteries have thick elastic muscular walls; they don't have valves and blood in them flows under high pressure. *Arteries are pulsating blood vessels*. The arterial pulse can be felt during a medical examination, for instance through the palpation of the radial artery in the internal-lateral face of the wrist near the base of the thumb.

Veins carry blood from the various body parts to the heart. All veins carry deoxygenated blood from the various body parts *except pulmonary vein*. They have thin non elastic walls and they consist of valves to prevent back the backward flow of blood. Blood flows under low pressure in veins.

Capillaries

Capillaries are fine branching blood vessels that form a network between the arteries and veins. They help to enable the exchange of water, oxygen, carbon dioxide, and many other nutrients and waste substances between the blood and the tissue.

Blood

Blood comprises of around 9% of body mass in adult human. In an average man, blood is 90 milliliter per kg of body weight and in an average woman blood is 65 milliliter per kg of body weight. Its specific gravity {specific gravity means Relative density) is 1.060 {this means slightly more than water} and average pH is 7.4 {means blood is little alkaline). Its osmotic pressure at room temperature is 7.6 atmospheres. Hemoglobin in normal healthy adult is 14-16 gm per 100 milliliter.

Blood is a connective tissue and means of substance transportation in body. It distributes nutrients, oxygen, hormones, antibodies and cells specialized in defense to tissues and collects waste such as nitrogenous wastes and carbon dioxide from them. It is made of two portions viz. fluid part (plasma) and cellular part (blood cells or corpuscles).

Plasma

Plasma is 55% of the blood by volume and constitutes 5% of the body weight. Plasma is a pale yellow transparent clear fluid which consists of 90-92% water and 8-10% organic and inorganic substances. Organic substances are mainly plasma proteins viz. albumin, globulin, prothrombin and fibrinogen. Albumins are responsible for maintenance of osmotic pressure of Blood. Globulins are chief sites for formation of antibodies; while prothrombin and fibrinogen are essential for clotting of blood. Inorganic substances in plasma include Glucose, Fructose, cholesterol, nucleosides, Vitamins, hormones, uric acid etc. and gases such as oxygen and carbon dioxide in dissolved phase.

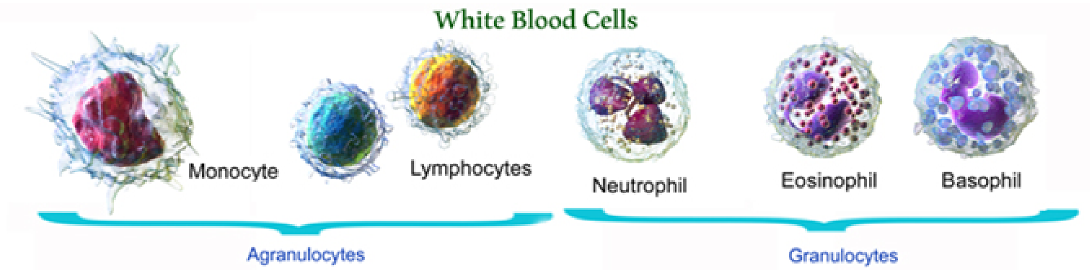
Red Blood Corpuscles

RBCs or Erythrocytes *are biconcave cells which don't have a nucleus*. They are responsible for transporting oxygen from the lungs to tissues with the help of respiratory pigment hemoglobin, which is main constituent of RBCs.

In the embryonic stage RBC are produced in Liver, spleen and Lymph nodes (all the three). Up to 20 years of age, they are produced in bone marrow of long bones such as femur. After 20 years they are produced in the bone marrows of membranous bones. RBCs complete a circulation in the body in 20 seconds. Their life span is 100-120 days. Their main constituent Hemoglobin is made of *four polypeptide chains and four heme (iron) groups*. The *spleen is the main organ where old red blood cells are destroyed*. During the destruction of red blood cells, the heme groups turns into bilirubin and this substance is then captured by the liver and later excreted to the bowels as a part of bile.

White Blood Corpuscles

White Blood Cells leukocytes are specialized in the defense of the body against foreign agents and are part of our immune system. There are several types of WBCs such as lymphocytes, monocytes, neutrophils, eosinophils and basophils. Out of them, the neutrophils, eosinophils and basophils are called granulocytes because their cytoplasm looks containing granules when viewed under microscope. Lymphocytes and monocytes are called agranulocytes.



Monocytes

Monocytes are largest WBCs and have a horse shoe shape. They are most powerful phagocytes {cells which eat other cells} which work as scavengers. Monocytes make around 5% of the total WBC count.

Lymphocytes

Lymphocytes make around 25% of the WBC count and they are made in lymph nodes and lymphatic tissues in spleen, liver etc. They are able to show some amoeboid movement. Their function is to make antibodies.

Neutrophils

Neutrophils are WBCs with multi-lobbed nucleus. They ingest and destroy the bacteria or other foreign bodies. Wherever there is some infection, neutrophils pass out from the blood streams and accumulate creating puss by eating debris and bacteria.

Eosinophils

The main function of histamine rich eosinophils is to combat the multicellular parasites and certain infections. Along with the mast cells, they also control mechanisms associated with allergy and asthma. Thus, their number increases during chronic bronchitis, asthma or allergic conditions.

Basophils

Basophils appear during inflammatory reactions which cause allergy. They contain anticoagulant heparin, which prevents blood from clotting too quickly.

White blood cells perform several functions in the body as:

Leucocytosis

Leucocytosis and leukopenia are clinical conditions in which a blood sample contains an abnormal count of leukocytes. When the leukocyte count in a blood sample is *above the normal* level for the individual, it is called leukocytosis. When the leukocyte count is lower than the expected normal level, it is called leukopenia. Leukocytosis generally happens when body is suffering from infections or in cancer of these cells. Leukopenia, occurs when some diseases, such as AIDS, attack the cells or when immunosuppressive drugs are used.

Platelets and Hemostasis

Platelets or thrombocytes are fragments of large bone marrow cells called megakaryocytes. Through their properties of aggregation and adhesiveness, they are directly involved in blood clotting as well as release substances that activate other hemostatic processes. When tissue wound contains injury to a blood vessel, the platelets and endothelial cells of the wall of the damaged vessel release substances (platelet factors and tissue factors, respectively) that trigger the clotting process.

Blood Clotting

Blood clotting is basically a sequence of chemical reactions whose products are enzymes that catalyze the subsequent reactions. This is the reason that clotting reactions are called cascade reactions. In plasma, thromboplastinogen transforms into thromboplastin, a reaction triggered by tissue and platelet factors released after injury to a blood vessel. Along with calcium ions, thromboplastin then catalyzes the transformation of prothrombin into thrombin. Thrombin then catalyzes a reaction that produces fibrin from fibrinogen. Fibrin, as an insoluble substance, forms a network that traps red blood cells and platelets, thus forming the blood clot and containing the hemorrhage.

Clotting factors

Clotting factors are substances (enzymes, coenzymes, reagents) necessary for the clotting process to happen. In addition to the triggering factors and reagents already described (tissue and platelet factors, thromplastinogen, prothrombin, fibrinogen, calcium ions), other substances participate in the blood clotting process as clotting factors. One of these is factor VIII, the deficiency of which causes hemophilia A, and another is factor IX, the deficiency of which causes hemophilia B. Most clotting factors are produced in the liver. Vitamin K participates in the activation of several clotting factors and is essential for the proper functioning of blood coagulation.

Lymphatic System

The lymphatic system is a network of specialized vessels with valves, which drains interstitial fluid called lymph. The lymphatic system is also responsible for the transport of chylomicrons (vesicles that contain lipids) produced after the absorption of fats by the intestinal epithelium.

Along lymphatic vessels are ganglial-like structures called lymph nodes, which contain many immune system cells. These cells filter impurities and destroy microorganisms and cellular waste. The lymphatic vessels drain to two major lymphatic vessels, the thoracic duct and the right lymphatic duct, which in turn drain into tributary veins of the superior vena cava.

The lymph nodes, or lymph glands, have lymphoid tissue that produces lymphocytes (a type of leukocyte). In inflammatory and infectious conditions, it is common to see the enlargement of lymph nodes in the lymphatic circuits that drain the affected region due to the reactive proliferation of leukocytes.

Blood Related Diseases

Sickle-cell disease

Sickle-cell disease (SCD) is an autosomal recessive genetic blood disorder with overdominance, characterized by red blood cells that assume an abnormal, rigid, sickle shape. Sickling decreases the cells' flexibility and results in a risk of various complications. The sickling occurs because of a mutation in the haemoglobin gene. Red Blood Cells alter shape and threaten to damage internal organs.

Anemia

Anemia refers to low RBC count or low hemoglobin or abnormality of the RBCs. It is characterized by low oxygen transport capacity of the blood.

Pernicious anemia is an autoimmune disease in which body lacks intrinsic factor required to absorb vitamin B12 from food. Vitamin B12 is needed for the production of hemoglobin.

Aplastic anemia is caused by the inability of the bone marrow to produce blood cells. Pure red cell aplasia is caused by the inability of the bone marrow to produce only red blood cells.

Thalassemia

Thalassemia results in the production of an abnormal ratio of hemoglobin subunits. It's a genetic disease.

Malaria link of Sickle-cell disease and Thalassemia

Malaria parasite spends big part of its life-cycle in Red Blood Cells. During this period it feeds on the hosts hemoglobin and then breaks them apart. This causes fever at several intervals. Both sickle-cell disease and Thalassemia are more common in malaria prone areas, because these mutations convey some protection against the parasite.

Leukemia

A great increase in abnormal leukocytes may occur for unknown reasons, resulting in the diseases known as the leukemias. These range in severity from the chronic lymphocytic leukemia, in which a person may live for many years, to devastating acute leukemia, often causing death within months.

Thromboembolic Disease

This disease results in abnormal clotting in the blood vessels. It is caused by a relatively inactive lifestyle, or by a person's confinement to bed, is one of the most common causes of death in middle-aged and elderly persons.

Arteriosclerosis

The single major cause of artery disease is the thickening and hardening of arterial walls by deposits of fatty materials, known as *arteriosclerosis*. In major vessels such as the aorta, this process is called *arthrosclerosis.* These are common cause of coronary heart disease, including heart attacks. *Bypass surgery*, the surgical replacement of the narrowed segment of artery with a vein taken from elsewhere in the body, is a common medical treatment for arterial narrowing in coronary arteries. Another medical therapy, *angioplasty*, is the dilation of the narrowed segment with a tiny balloon delivered by catheter.

Aneurysms

Other major diseases of the aorta include true aneurysms and so-called dissecting aneurysms. The former are balloon-like swellings that result from weakening of the aorta wall, most commonly because of atherosclerosis.

Vein Diseases

The most common peripheral vascular disease of the veins is ***thrombophlebitis or phlebitis***. This disorder involves the formation of a blood clot (or clots) in large veins, usually in the leg or pelvis. A distressing but usually minor disorder of the veins, known as ***varicose veins***, results from a failure of valves in the veins to keep blood flowing back toward the heart.

Hypertension

High blood pressure is a common disorder among the adult population. By far the most common type is essential hypertension, the causes of which are medically unknown. The remaining cases of high blood pressure are secondary to at least 30 different conditions.

Stroke

Stroke, also known as Cerebro-Vascular Accident (CVA), involves damage to the brain because of impaired blood supply and causes a sudden malfunction of the brain. Some stroke risk factors include increasing age, gender (more men have strokes), diabetes mellitus, prior stroke, and family history of stroke, hypertension, heart disease, cigarette smoking, and transient ischemic attacks (TIAs), or little strokes. Strokes are of three kinds viz. Ischemia, Haemorrhage and Heart Failure. Ischemia is the narrowing or blockage of an artery by means of atherosclerosis or by an embolus.

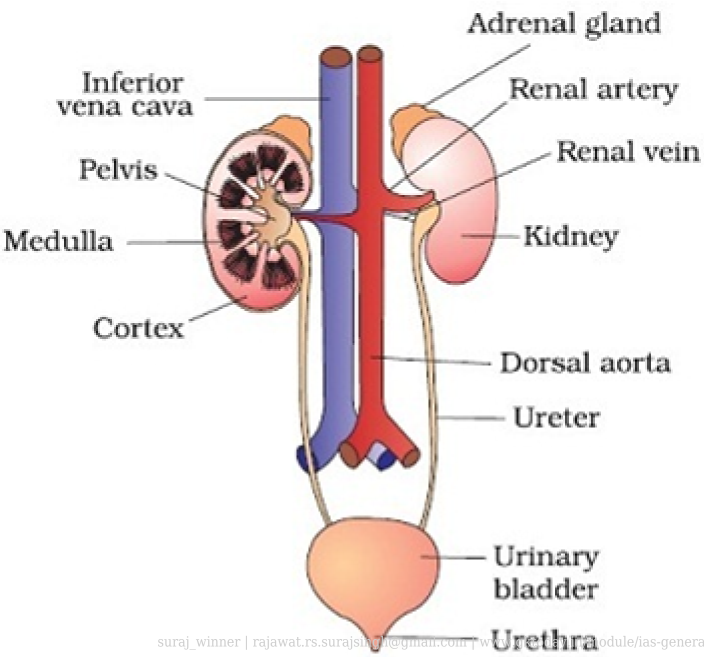
- About 63% of strokes are ischemic. Atherosclerosis, or progressive hardening of the arteries, produces ischemia by obstruction of vessels with fatty deposits. Another form of ischemia is thrombosis, or blockage resulting from an embolus.
- About 22% of all strokes are caused by cerebral hemorrhage or bleeding in the brain. The most common causes of spontaneous intracranial hemorrhage, commonly called *apoplexy*, are hypertension and aneurysm.
- Heart Failure is a condition in which the heart fails to maintain an adequate output, resulting in diminished blood flow and congestion in the circulation in the lungs and/or the body. The causes of heart failure are high blood pressure and heart disease. To properly manage heart failure the underlying heart disease must be treated.

Excretory System

Several kinds of wastes, including sweat, carbon dioxide gas, feces (stool), and urine are produced by our body. These wastes exit the body by

- Sweat is released through pores in the skin.
- Water vapor and carbon dioxide are exhaled from the lungs.
- Undigested food materials are formed into feces in the intestines and excreted from the body as solid waste in bowel movements.

In humans, the excretory system consists of a pair of kidneys, one pair of ureters, a urinary bladder and a urethra.



Kidneys

The kidneys are located just under the ribcage in the back, one on each side. The right kidney is located below the liver, so it's a little lower than the left one.

The functional unit of Kidney is a Nephron. Each Kidney has around 1 million Nephrons that work as tiny filtering units which remove the harmful substances from the blood. Each of the nephrons contains a filter called the **glomerulus,** which contains a network of tiny blood vessels known as **capillaries**. Blood travels to each kidney through the **renal artery. Once in Nephrons,** it is filtered by glomerulus then travels down a tiny tube-like structure called a **tubule,** which adjusts the level of salts, water, and wastes that are excreted in the urine. Filtered blood leaves the kidney through the renal vein and flows back to the heart. The continuous blood supply entering and leaving the kidneys gives the kidneys their dark red color.

Urine

Urine is a concentrated solution of waste material containing water, urea (a waste product that forms when proteins are broken down), salts, amino acids, by-products of bile from the liver, ammonia, and any substances that cannot be reabsorbed into the blood. Urine also contains **urochrome,** a pigmented blood product that gives urine its yellowish color.

Antidiuretic hormone

Antidiuretic hormone (ADH) from the pituitary promotes water retention by the kidneys, and its secretion is regulated by a negative feedback loop involving blood water and salt balances.

Other functions of Kidney

The kidneys also secrete the hormone erythropoietin, which stimulates and controls red blood cell production. In addition, the kidneys help regulate the acid-base balance (or the pH) of the blood and body fluids.

Skeletal and Muscular System

The main organs and tissues of the musculoskeletal system in humans are bones, cartilages and muscles. These systems provide support and protection to organs; maintain structure of the body; help in movement of organs and limbs; and store nutrients {muscles store glycogen; while bones store calcium and phosphorus}. Further bones also have function of Hematopoiesis {making of blood cells} in bone marrow (mainly within flat bones).

Bone

Bone is a highly mineralized tissue in which connective tissue part is 1/3rd while mineral part is 2/3rd portion. Apart from providing mechanical strength, the bones work as homeostatic reservoir for ions such as calcium, magnesium and phosphorous. Thus, bones have a very important function in acid base balance in the body. There are 270 bones in a new born baby and 206 in an adult human.

Bone as connective Tissue

Formation of bones is called Osteogenesis or Ossification. Bones are made of three types of specialized cells called *osteoblasts, osteocytes and osteoclasts*. Osteoblasts make the bone while Osteoclasts break / remodel the osteous tissue. They create canals in bones. Osteocytes provide support.

The intercellular part between Osteocytes is made of casein protein and inorganic phosphates. We note here that *bony tissue is highly vascular and has greater regenerative power than any other tissue of the body except Blood*. Bones have narrow tubes called *Haversian Canals* and *Volkmann's Canals* apart from the network of blood vessels.

Number of Bones

An adult human has 206 bones while a new born baby has 300 bones. 94 bones fuse as a baby grows. The total number of bones in human skull is 29. The face of a man is made up of 14 bones. Largest and longest bone is femur (thigh bone).The shortest bone in the human body is stapes or stirrup bone in the middle ear.

Cartilage

Cartilage is softer, elastic tissue that makes joints between bones, rib cage, ear, nose, bronchial tubes, intervertebral discs etc.

Muscles

The human body has more than 650 muscles, which make up half of a person's body weight. Humans have three different kinds of muscle: Skeletal, Involuntary and Cardiac muscles.

Skeletal muscle

These are voluntary muscles that hold the skeleton together, give the body shape, and help it with everyday movements. They are striated because they are made up of fibers that have *horizontal stripes* when viewed under a microscope. They can contract quickly and powerfully, but they tire easily and have to rest between workouts.

Involuntary or smooth muscle:

It is also made of fibers, but looks smooth, not striated and they're controlled by the nervous system automatically. Walls of the stomach and intestines, walls of blood vessels are the examples of involuntary muscles. Smooth muscles take longer to contract than skeletal muscles but they can stay contracted for a long time because they don't tire easily.

Cardiac muscle

It is an involuntary type of muscle found in the heart. Its rhythmic, powerful contractions force blood out of the heart as it beats. Cardiac muscle contraction is totally involuntary, meaning it occurs without nervous stimulation and doesn't require conscious control.

Sarcomeres

Sarcomeres are the functional units of muscle fibers. Within them, the blocks of actin and myosin molecules are placed in an organized manner. Sarcomeres are the contractile units of muscle tissue, formed of alternating actin blocks (thin filaments) and myosin blocks (thick filaments).

Myoglobin

Myoglobin is a pigment similar to hemoglobin which is present in muscle fibers. Myoglobin has a large affinity to oxygen. It keeps oxygen bound and releases the gas under strenuous muscle work. Therefore, myoglobin acts as an oxygen reserve for muscle cells. If oxygen from hemoglobin or myoglobin is not enough to supply energy to the muscle cells, the cell begins to use *lactic fermentation* in an attempt to compensate for that deficiency. Lactic fermentation releases lactic acid and this substance causes muscle fatigue and predisposes the muscles to cramps.

Joints

Joints are structures where two bones are attached so that bones can move relative to each other. Bones are held together at joints by ligaments, which are strong, fibrous, connective tissues. Joints are classified into three groups:

- Immovable (fibrous) joints, e.g. skull bones;
- Slightly movable (cartilagenous) joints, e.g. intervertebral discs;
- Freely movable (synovial) joints, e.g. limb joints.

Synovial joints permit the greatest degree of flexibility and have the ends of bones covered with a connective tissue (synovial membrane) filled with joint (synovial) fluid.

Vertebral Column

The spinal cord runs along the dorsal side of the body and links the brain to the rest of the body. Vertebrates have their spinal cords encased in a series of (usually) bony vertebrae that comprise the vertebral column. Our back is composed of 33 bones called vertebrae, 31 pairs of nerves, 40 muscles and numerous connecting tendons and ligaments running from the base of your skull to your tailbone. Between our vertebrae are fibrous, elastic cartilage called discs known as shock absorbers.

Nervous System

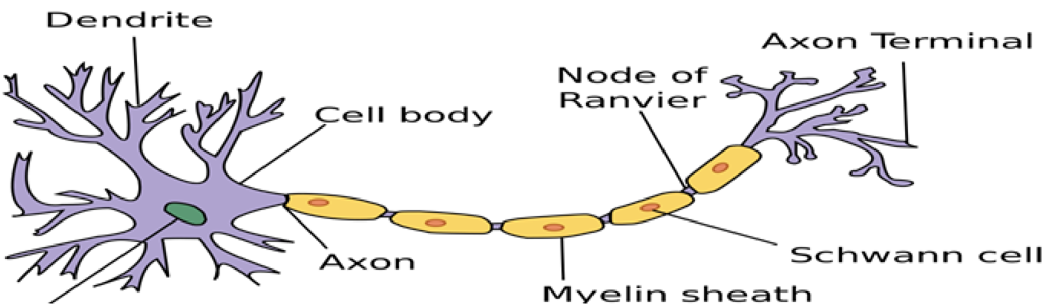
The nervous system is made of two parts viz. Central Nervous System (CNS) and the Peripheral Nervous System (PNS). CNS is made of Brain {cerebrum, brainstem and cerebellum} and spinal cord. The PNS is made of nerves and neural ganglia. Further, the meninges {three membranes that envelop the brain and spinal cord) are also a part of the nervous system.

Cells of the Nervous System

The main cells of the nervous system are neurons. In addition to neurons, the nervous system is also made up of glial cells. Neurons are cells that have the function of receiving and transmitting neural impulses. Glial cells support, feed and electrically insulate the neurons. One common example of Glial cells are the so called "Schwann cells" that produce the myelin sheath of the peripheral nervous system.

Neuron

The neuron is the functional unit of the nervous system with 3 parts viz. Dendrite, Cell Body and Axon. Dendrites receive information from another cell and transmit the message to the cell body. The cell body contains the nucleus, mitochondria and other organelles typical of eukaryotic cells. The axon conducts messages away from the cell body.



There are three types of the Neurons viz. Sensory, Motor and Inter. Sensory neurons carry messages from sensory receptors to the central nervous system. Motor neurons transmit messages from the central nervous system to the muscles. Inter neurons are found only in the central nervous system where they connect neuron to neuron.

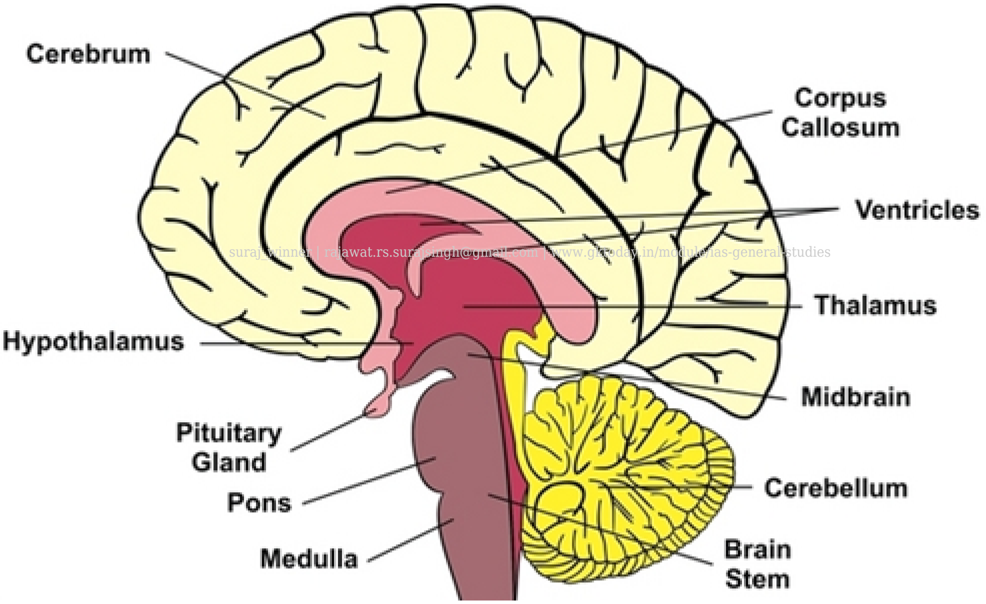
Some axons are wrapped in a myelin sheath by specialized glial cells known as ***Schwann cells.*** The gap between Schwann cells is known as the ***Node of Ranvier***, and serves as points along the neuron for generating a signal.

Synapses

Synapses are the structures that transmit a neural impulse between two neurons. When the electric impulse arrives, the presynaptic membrane of the axon releases neurotransmitters that bind to the postsynaptic receptors of the dendrites of the next cell. The activated state of these receptors alters the permeability of the dendritic membrane and the electric depolarization moves along the plasma membrane of the neuron to its axon.

Brain

The brain is made up of three main sections: the forebrain, the midbrain, and the hindbrain.



Forebrain

The forebrain is the largest and most complex part of the brain. It consists of the ***cerebrum*** and some other structures beneath it. The cerebrum contains the information that essentially makes us who we are: our intelligence, memory, speech, ability to feel etc. Specific areas of the cerebrum are in charge of processing these different types of information. These are called lobes, and there are four of them: the *frontal, parietal, temporal, and occipital lobes.*

The cerebrum has right and left halves, called hemispheres, which are connected in the middle by a band of nerve fibers (corpus collosum) that enables the two sides to communicate.

The left side is considered the logical, analytical, objective side. The right side is thought to be more intuitive, creative, and subjective.

The outer layer of the cerebrum is called the ***cortex*** (also known as "gray matter"). Information collected by the five senses comes into the brain from the spinal cord to the cortex. This information is then directed to other parts of the nervous system for further processing.

- In the inner part of the forebrain sits the thalamus, hypothalamus, and pituitary gland.
- The ***thalamus*** carries messages from the sensory organs like the eyes, ears, nose, and fingers to the cortex.
- The ***hypothalamus*** controls the pulse, thirst, appetite, sleep patterns, and other processes in our bodies that happen automatically.
- It also controls the ***pituitary gland***, which makes the hormones that control our growth, metabolism, digestion, sexual maturity, and response to stress.

The Midbrain

The midbrain, located underneath the middle of the forebrain, acts as a master coordinator for all the messages going in and out of the brain to the spinal cord.

The Hindbrain

The hindbrain sits underneath the back end of the cerebrum, and it consists of the cerebellum, pons, and medulla.

The cerebellum — also called the "little brain" because it looks like a small version of the cerebrum — is responsible for balance, movement, and coordination.

The pons and the medulla, along with the midbrain, are often called the brainstem. The brainstem takes in, sends out, and coordinates all of the brain's messages.

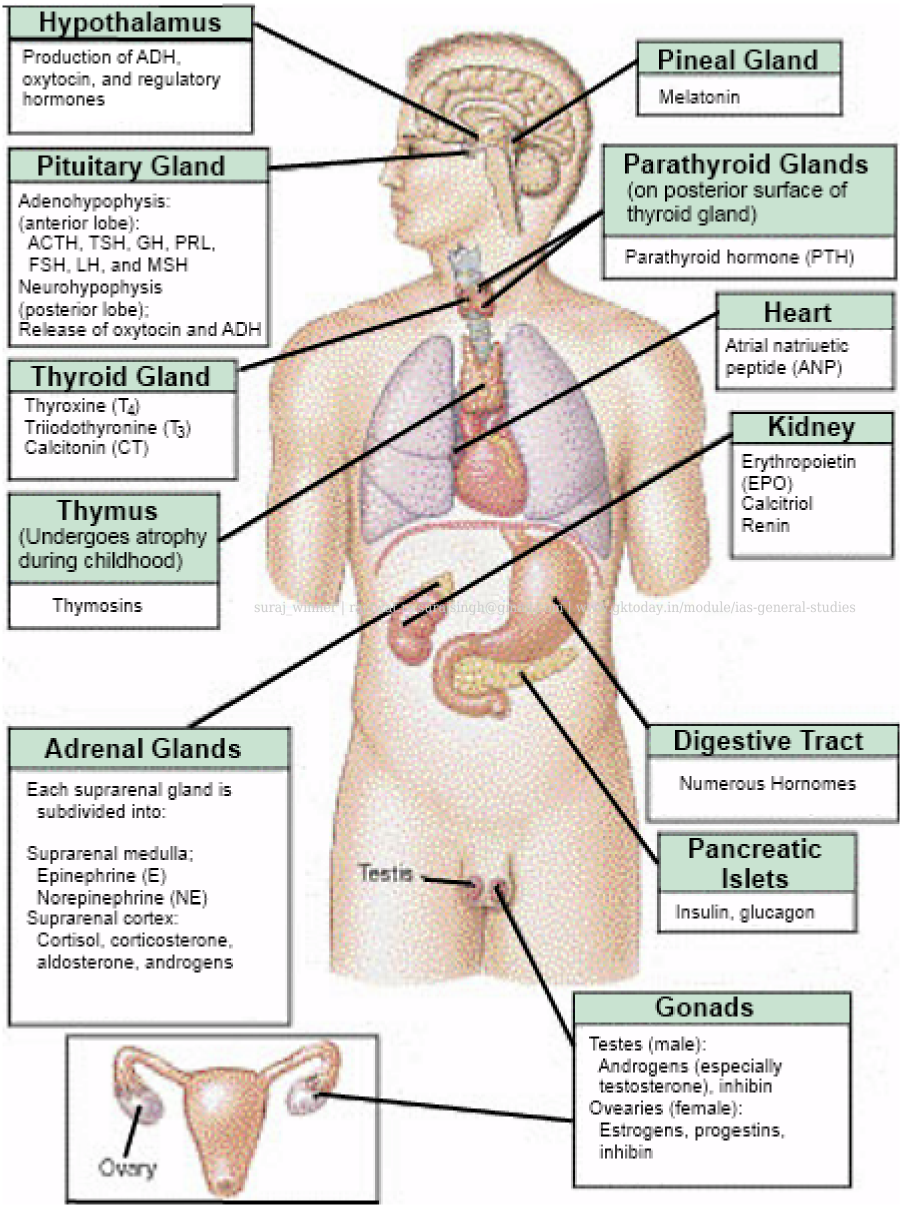
It also controls many of the body's automatic functions, like breathing, heart rate, blood pressure, swallowing, digestion, and blinking.

Spinal cord

The spinal cord is a long bundle of nerve tissue about 18 inches long and ¾ inch thick. It extends from the lower part of the brain down through spine. Along the way, various nerves branch out to the entire body. These are called the peripheral nervous system. Both the brain and the spinal cord are protected by bone: the brain by the bones of the skull, and the spinal cord by a set of ring-shaped bones called vertebrae. They're both cushioned by layers of membranes called meninges as well as a special fluid called cerebrospinal fluid.

Endocrine System

Endocrine system is a collection of glands that work interdependently and produce hormones that regulate the body's growth, metabolism, and sexual development and function. The Endocrine system influences almost every cell, organ, and function of our bodies. It is instrumental in regulating mood, growth and development, tissue function, metabolism, and sexual function and reproductive processes.



Hormones

Hormones, the chemical messengers are carried in the bloodstream to a target tissue elsewhere in the body, where they must be absorbed into the tissue before they can have an effect. There are two groups of Hormones viz. Peptide Hormones and Steroid Hormones. **Peptide hormones**, such as insulin, are short chains of amino acids. Peptide hormones are hydrophilic (water loving), so they don't pass easily through cell membranes. The receptors for peptide hormones are embedded in the plasma membranes of target cells. **Steroid hormones**, such as testosterone and estrogen, are lipids, so they're hydrophobic (water fearing) and can pass easily through the hydrophobic layer of the plasma membrane and enter cells. Thus, the receptors for steroid hormones are located inside the cell.

The Pineal Gland

The pineal gland or pineal body or **epiphysis** is located in the center of the head. It secretes the hormone *melatonin*, a hormone produced at night and related to the regulation of circadian rhythm (or the circadian cycle, the wakefulness-sleep cycle). Melatonin may also regulate many body functions related to the night-day cycle.

Pituitary Gland

The pituitary gland or hypophysis is located in one of the bones at the base of the skull. It has two portions viz. anterior hypophysis and posterior hypophysis. The anterior part produces two hormones that work directly viz. growth hormone (GH) and prolactin; and four tropic hormones {tropic hormones regulate the other endocrine glands} viz. adrenocorticotropic hormone (ACTH), thyroid-stimulating hormone (TSH), luteinizing hormone (LH) and follicle-stimulating hormone (FSH). The posterior part releases two hormones produced in the hypothalamus viz. oxytocin and antidiuretic hormone (ADH or vasopressin).

- Growth Hormone (GH) acts on bones, cartilage and muscles to promote the growth of these tissues. During childhood, GH secretion deficiencies may lead to dwarfism. Excessive production of GH in children may cause exaggerated bone growth and gigantism.
- Prolactin stimulates the production and secretion of milk by the mammary glands in women.
- ACTH stimulates the cortical portion of the adrenal gland to produce and secrete cortical hormones called glucocorticoids.
- TSH stimulates the activity of the thyroid gland, increasing the production and secretion of its hormones T3 and T4.
- FSH is a gonadotropic hormone {gonadotropic means it stimulates the gonads} and acts on the ovaries to induce the growth of follicles and, in men, it stimulates spermatogenesis.
- LH is also a gonadotropic hormone; it acts upon the ovaries of women to stimulate ovulation and the formation of the corpus luteum (which secretes estrogen); in men, it acts on the testicles to stimulate the production of testosterone.
- Oxytocin is secreted in women during delivery to increase the strength and frequency of uterine contractions and therefore to help the baby's birth. During the lactation period, the

infant's sucking action on the mother's nipples stimulates the production of oxytocin, which then increases the secretion of milk by the mammary glands.

- Vasopressin, or ADH, participates in the regulation of water in the body and therefore in the control of blood pressure, since it allows the reabsorption of free water through the renal tubules. As water goes back into circulation, the volume of blood increases.

Thyroid Gland

The thyroid is located in the anterior cervical region (frontal neck), in front of the trachea and just below the larynx. It is a bilobed mass below the Adam's apple. It secrets thyroxine (T4), triiodothyronine (T3) and calcitonin.

- T3 and T4 act to increase the cellular metabolic rate of the body (cellular respiration, metabolism of proteins and lipids, etc.) Goiter. the abnormal enlargement of the thyroid gland, can occur as a result of hypothyroidism or hyperthyroidism. Endemic goiter is caused by a deficiency in iodine consumption. Hypothyroidism caused by deficient iodine ingestion is more frequent in regions far from the coast because sea food is rich in iodine.
- Calcitonin inhibits the release of calcium cations by bones, thus controlling the level of calcium in the blood.

Parathyroids

The parathyroids are four small glands, two of which are embedded in each posterior face of one lobe of the thyroid. The parathyroids secrete parathormone, a hormone that, along with calcitonin and vitamin D, regulates calcium levels in the blood.

Pancreas

Pancreas is a mixed gland because it produces both endocrine and exocrine secretions. It releases pancreatic juice as exocrine gland while *insulin, glucagon and somatostatin hormones* as endocrine gland. These hormones are produced in so called *"islets of Langerhans"*.

Glucose Regulation

For normal body functions, the Blood glucose levels must be maintained. If blood glucose levels are abnormally low, it shall not be able to supply the energy metabolism of cells. If it is too high, it causes severe harm to peripheral nerves, the skin, the retina, the kidneys and other important organs, and may cause cardiovascular diseases.

- The pancreatic hormone Glucagon increases blood glucose while Insulin reduces it. Glucagon stimulates glycogenolysis, thus forming glucose from the breakdown of glycogen. Insulin is the hormone responsible for the entrance of glucose from blood into cells.
- When glucose is low (for example during fasts), glucagon is secreted and insulin is inhibited. When glucose is high (for example after meals) glucagon is inhibited and insulin secretion is increased.

While glucagon targets the liver, insulin works in all cells. Somatostatin inhibits both insulin and glucagon secretions.

Diabetes Mellitus

Diabetes mellitus is caused by deficient production or action of insulin and, as a result, characterized by a low glucose uptake by cells and a high blood glucose level. This diseases is identified by a so called *diabetic triad* called polyuria (excessive urine) , polydipsia (excessive thirst) and polyphagia (excessive hunger). Diabetic persons are advised to take less carbohydrates because these substances are broken down into glucose and this molecule is absorbed in the intestines.

Type-I and Type-II diabetes

Type I or juvenile diabetes or insulin-dependent diabetes is the impaired production of insulin by the pancreas and is caused by destruction of the cells of the islets of Langerhans by autoantibodies (autoimmunity). Type II diabetes occurs adults. In this, the pancreas secretes normal or low levels of insulin, but the main cause of the high glucose sugar is the peripheral resistance of the cells to the action of the hormone.

Type I diabetes is treated with the parenteral administration of insulin. Insulin must be administered intravenously or intramuscularly because, as a protein, it will be digested if ingested orally. In type II diabetes, treatment is done with oral drugs that regulate glucose metabolism or, in more severe cases, with parenteral insulin administration. The moderation of carbohydrate ingestion is an important aid in diabetes treatment.

Diabetes insipidus is the disease caused by deficient ADH secretion by the **pituitary gland.** In diabetes insipidus, blood lacks ADH and, as a result, the reabsorption of water by the tubules in the kidneys is reduced, and a large volume of urine is produced. The patient urinates in large volumes and many times a day.

Adrenal Glands

Each adrenal gland is located on the top of each kidney (forming a hat-like structure on the top of the kidneys). Each adrenal gland has two parts viz. outer cortical portion and inner adrenal cortex. Further, there is a central part called adrenal medulla.

- Adrenal medulla releases adrenaline (aka epinephrine) and noradrenaline (aka norepinephrine). These two hormones increase the breakdown of glycogen into glucose, thus increasing blood sugar and metabolic rate. They are released during situations of danger (fight or flight response) and they intensify the strength and rate of the heartbeat and selectively modulate blood irrigation in some tissues.
- The adrenal cortex releases cortical hormones viz. glucocorticoids, mineralocorticoids and cortical sex hormones. Glucocorticoids stimulate the formation of glucose and as immunosuppressive role, meaning that they reduce the action of the immune system and for

this reason are *used as medicine to treat inflammatory and autoimmune diseases* and the rejection of transplanted organs.

- Mineralocorticoids regulate the concentration of sodium and potassium in the blood and, as a result, control the water level in the extracellular space.
- Cortical sex hormones are Androgens. They promote secondary male and female features.