Skeleton System

Components

a. **Bones:** 206 in number in an adult, bone is made up of hard, dense tissue which is softer before mineralization. The skeleton is not a dead tissue but living which grows, changes and adapts, depending on the demands put on it. Each bone is a living organ with rich supply of blood.
b. **Cartilage:** is a resilient and smooth elastic tissue, a rubber-like padding that covers and protects the ends of long bones at the joints and nerves, and is a structural component of the rib cage, the ear, the nose, the bronchial tubes and the intervertebral discs. It is not as hard as the bone but stiffer than muscle.
c. **Ligaments:** A ligament is a structure which serves to bind together two bones at the joints.
d. **Tendons:** Towards the point of attachment, a skeletal muscle usually narrows down to a strong, tough cord of connective tissue known a tendon. Tendons are fibrous structures which connect a muscle to bone. An example of a particularly snout tendon is Achilles tendon on the ankle.
e. **Joints:** The point of contact between two bones is a joint.

The Skeleton is divided into two parts

a. **Axial Skeleton:** The axial skeleton is parallel to the centre of gravity and consists of skull, vertebral column and rib cage. (The trunk)

   The Skull is set on top of the first vertebra consists of 23 irregularly shaped flat bones which make up the cranium and the bones of face. It protects the delicate brain, inner ear and eyes and few glands.

   The spine or the vertebral column, is the central support of the skeleton system and is made up of articulated blocks called

vertebrae, which are set upon the other to form a column, the spine supports the trunk and protects the spinal cord.

The 12 pair of ribs originate from spine and join the sternum (breast bone) in front to form a rib cage which protects vital organs like lungs and heart.

b. **Appendicular Skeleton**: It consists of shoulder and pelvic girdle and the bones of Upper and Lower limbs. (The branches)

The two shoulder blades along with collar bones form the shoulder girdle. The arm and hand consists of upper arm(humerus), forearm(radius and ulna), bones of wrists(carpals) and bones of palms(metacarpals and phalanges)

There are two large flat bones from the sacrum on each side form the pelvis. The pelvis provides the base for attachment of the legs. The legs consists of upper leg (femur), knee cap(patella), the lower leg(tibia and fibula), ankle(tarsals) and bones of the foot(metatarsals and phalanges.

Functions of skeleton system

1. Structural Framework
2. Support and protection
3. Blood formation
4. Storehouse of minerals

Vertebral column

The spine or the backbone is the strong column of bone from head to the bottom of the back. The spine is composed of 33 vertebrae, which are joint together by cartilage and spinal ligaments. Each vertebra, except coccyx, has a central hole through which the spinal cord runs. The 33 vertebrae are divided into 5 groups

1. Cervical Vertebrae(7)
2. Thoracic Vertebrae(12)
3. Lumbar Vertebrae(5)
4. Sacral Vertebrae (5 fused into 1 to form sacrum)
5. Coccygeal Vertebrae (4 fused into 1 to form coccyx or tail bone)

In a normal adult standing erect, spinal column is slightly curved in 4 parts. Beginning at the head to shoulder, spine curves slightly forward (as **cervical curvature**), then sweeps backward under shoulders (as **thoracic curvature**), the slightly forward is the middle back region (as **lumbar curvature**) and backward at the end of spine (as **pelvic curvature**).

Improper posture may exaggerate the curves of the vertebral column. An increase in the thoracic curve is called **kyphosis** (rounded shoulders and upper back). An exaggerated lumbar curve is called **lordosis**, also referred to as swayback. A lateral curvature (side twist) of spine is called **scoliosis**. The regular practice of asanas may help correct posture to correct posture by balancing and strengthening muscles of abdomen and back.

Types of spinal movements

1. **Flexion:** Forward bending of the spine. It is maximal in the cervical region, though also occurring to a considerable extent in lumbar spine. For eg. Paschimotanasana, Padahastasana
2. **Extension:** Back bending of the spine. For eg. Bhujangasana, Dhanurasana.
3. **Rotation:** Longitudinal twisting of spine. The greatest rotation is possible rotation is possible between the atlas and axis (1^{st} and 2^{nd} vertebrae) with possible rotation of 45^{o}. The joints between the remaining cervical vertebrae make another 45^{o} possible for total of 90^{o} rotation of the head relative to the shoulders. Further rotation of the thoracic vertebrae and very little in the lumbar section of the spine. For eg. ArdhaMatsyandrasana.

4. **Sideways bending:** Maximal in cervical and lumbar regions. For eg. Trikonasana.
5. **Circumduction:** Swaying movement combining all the above. For eg. Chakki chalavan.
6. **Elongation:** Stretching of the spine upwards in direction away from the away from base of spine. For eg. Tadasana, Urdhvahasta dandasana.

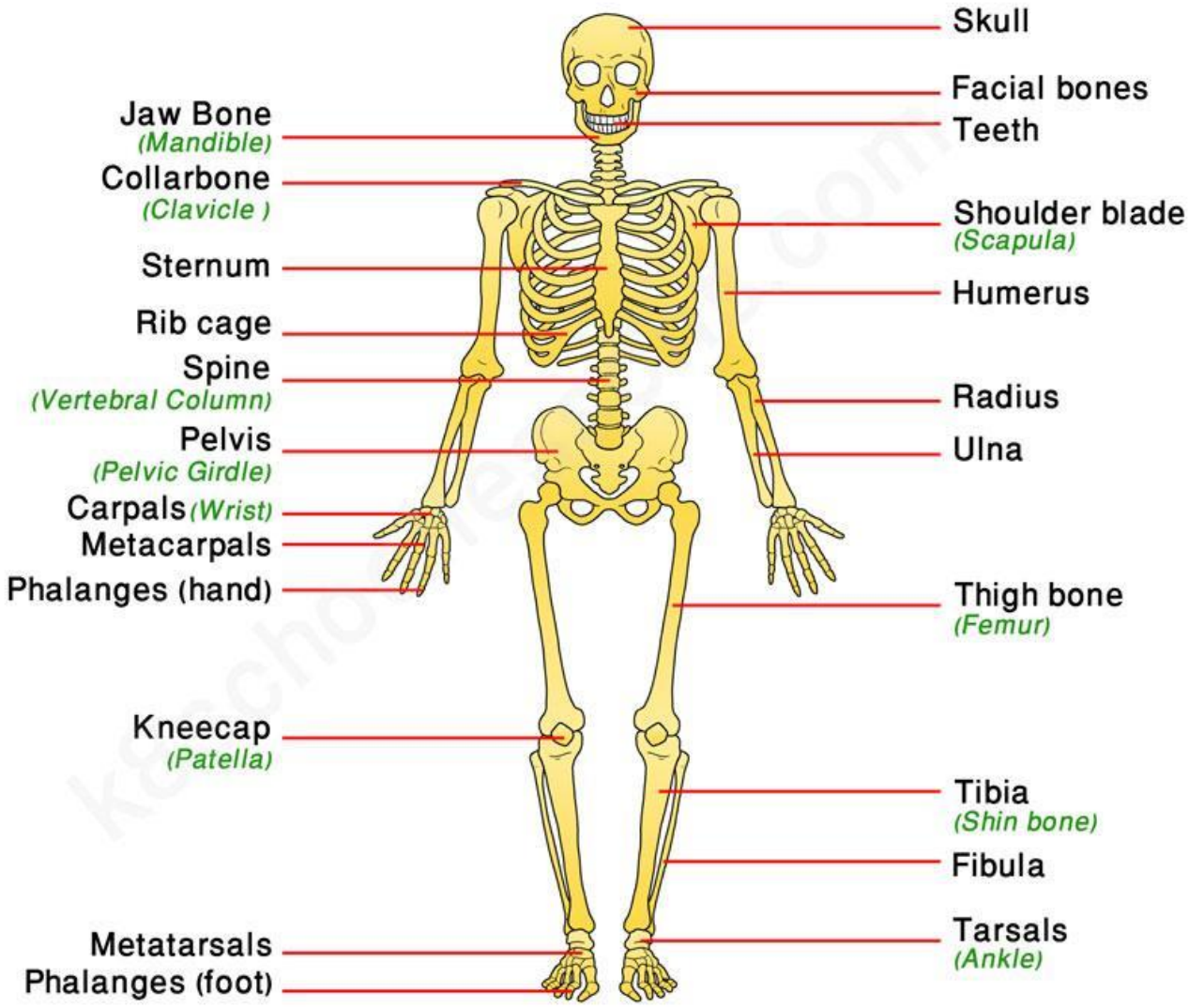
Joints

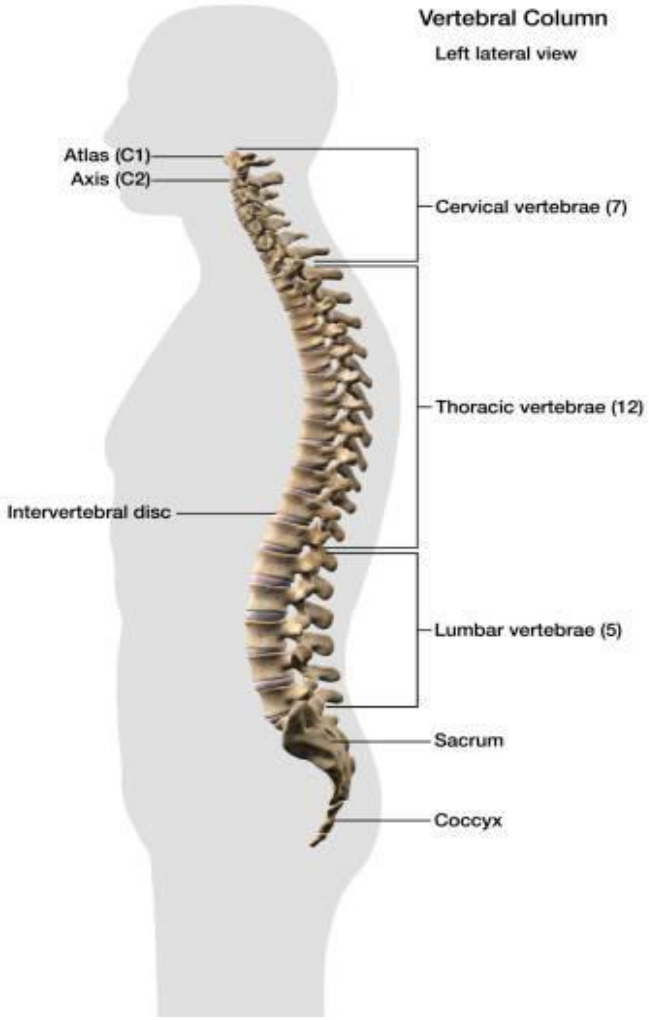
The point of contact between two bones is a joint. There are 3 types of joints.

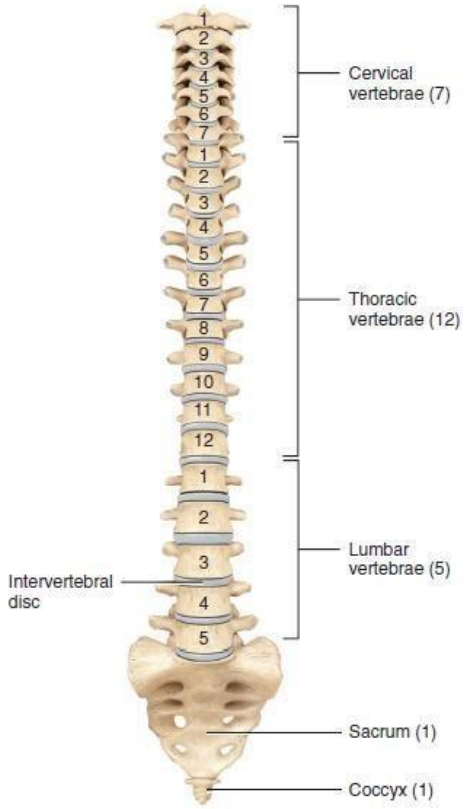
a. **Fibrous Joints:** Fixed fibrous joints allow the least amount of movement and are found in immovable parts of the skeletal system. For eg. Sutures in skull
b. **Cartilaginous Joints:** This joint is formed when two bones are connected by a cartilage. For eg. Ribs attached to the sternum bone which is a relatively fixed joint for strong structure but provides movement when necessary like breathing.
c. **Synovial Joints:** These are the joints which are designed for highest mobility. The joint features a coating of cartilage on each bone and a synovial membrane which produces synovial fluid which reduces friction between the two bones. The joint is sealed in a fluid filled joint capsule. There are 6 kinds of synovial joints

Type of joint	Hinge Joint	Pivot Joint	Ball and socket Joint
Structure	Spool shaped process fits into concave socket	Circular process fits around peglike process	Ball shaped process fits into a concave socket
Movement	Flexion, extension	Rotation	Widest range of movements- flexion, extension, abduction, adduction, rotation circumduction.
Examples	Elbow joint, knee joint, finger joints.	Joint between 1st and 2nd vertebrae	Shoulder joint, hip joint.

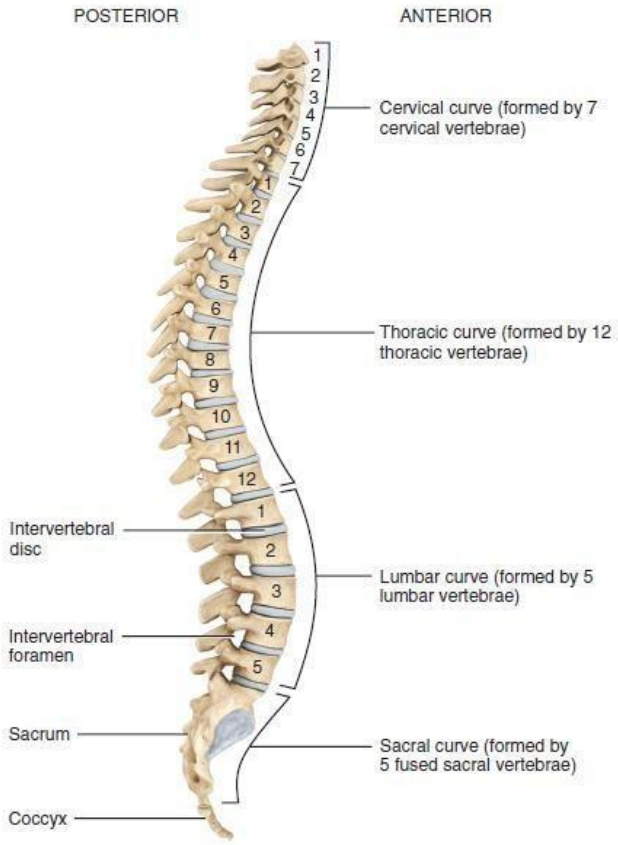
Type of Joint	Condyloid joint or ellipsoid joint	Gliding Joint	Saddle Joint
Structure	The ball shaped modified into oval ellipsoid, concave socket is oval	Relatively flat articulating surfaces which glide over each other	The opposing surfaces are reciprocally convex and concave
Movement	Flexion, extension, abduction adduction, circumduction	Gliding movement without any angular or circular movement	Flexion, extension, abduction, adduction, circumduction
Examples	Carpals and radius joint	Wrist and ankle joints	Thumb joint


Skull
Facial bones
Teeth
Jaw Bone
(Mandible)
Collarbone
(Clavicle)
Shoulder blade
(Scapula)
Sternum
Humerus
Rib cage
Spine
(Vertebral Column)
Radius
Pelvis
(Pelvic Girdle)
Ulna
Carpals (Wrist)
Metacarpals
Phalanges (hand)
Thigh bone
(Femur)
Kneecap
(Patella)
Tibia
(Shin bone)
Fibula
Tarsals
(Ankle)
Metatarsals
Phalanges (foot)

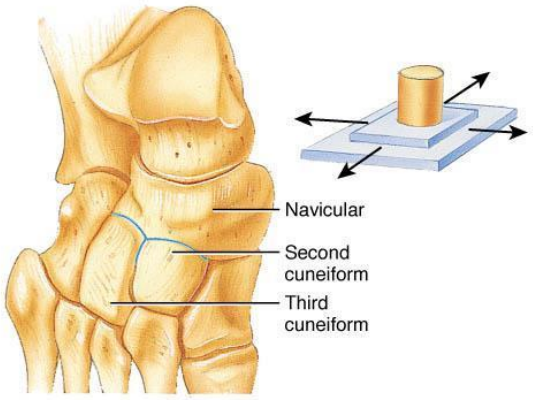

Vertebral Column
Left lateral view
Atlas (C1)
Axis (C2)
Cervical vertebrae (7)
Thoracic vertebrae (12)
Intervertebral disc
Lumbar vertebrae (5)
Sacrum
Coccyx



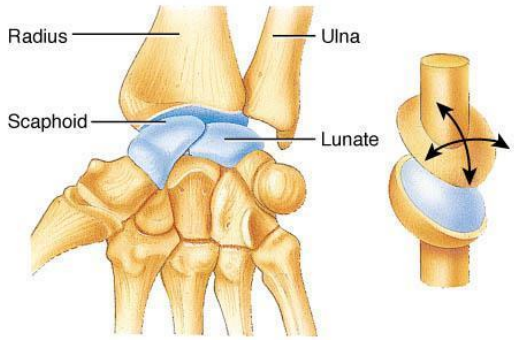
(a) Anterior view showing regions of the vertebral column



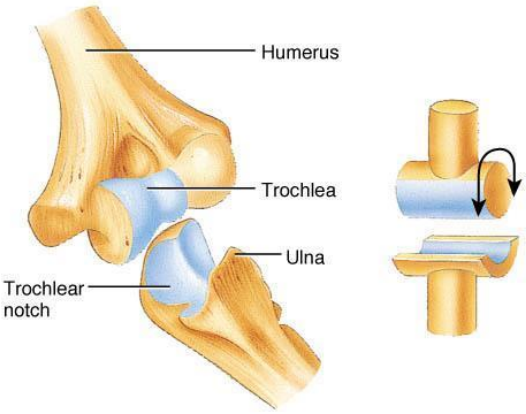
(b) Right lateral view showing four normal curves



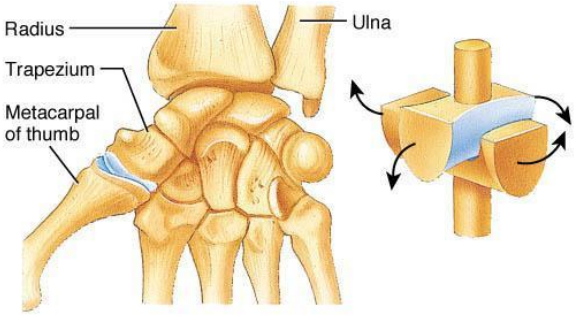
(a) Planar joint between the navicular and second and third cuneiforms of the tarsus in the foot



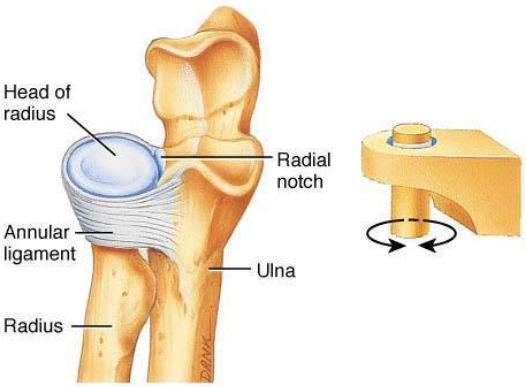
(d) Condyloid joint between radius and scaphoid and lunate bones of the carpus (wrist)



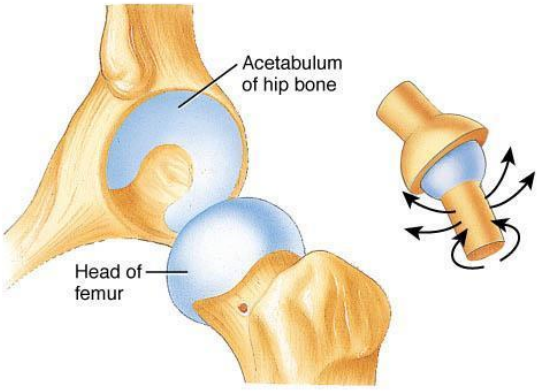
(b) Hinge joint between trochlea of humerus and trochlear notch of ulna at the elbow



(e) Saddle joint between trapezium of carpus (wrist) and metacarpal of thumb



(c) Pivot joint between head of radius and radial notch of ulna



(f) Ball-and-socket joint between head of the femur and acetabulum of the hip bone

Muscular System

Movements of all creatures are due to muscular contractions. Muscles are contractile tissues capable of creating tension and when stimulated. They are specialized tissues which convert chemical energy into mechanical energy. In the body there are three types of muscles:

1. **Voluntary muscles:** also known as skeletal or striated form the greatest part of muscular tissue, are consciously controlled by the individual. They help in walking, balancing, holding, writing etc.
2. **Involuntary muscle:** are those which are not under the direct conscious control of the individual but autonomic nervous system or some hormones. For eg. Wave like contraction in the food pipe or blood vessels or intestines or bladder.
3. **Cardiac muscle:** is a specialized muscle for the coordinated contraction of the whole heart. It is auto rhythmic, meaning it can contract without stimulation.

Functions of Muscular System

1. Production of movement. Maintaining posture against gravity.
2. Protection of internal organs
3. Heat production
4. Store for energy (protein and carbohydrates)

5. Functioning of internal organs because of involuntary muscles.

Muscle Contraction

Each muscle is composed of a bundle of fibres (cells) wrapped in a sheath. The muscle fibres contain bundles of microscopic protein filaments. Thin filaments (actin) and thick filaments(myosin) overlap each other lying parallel. The movement of these filaments relative to each other shorten the muscle fibres and create tension. When relaxed these filaments have a minimal overlap. When stimulated, these filaments slide across each other in opposite directions, increasing the overlap and causing the muscle to contract. At maximal contraction the thick and thin filaments will overlap each other completely.

Muscle strength refers to:

- Either increasing the number of muscle fibres sliding across (modern gym exercise with weight training)
- Or increasing the efficiency of the existing fibre by making sure they slide and overlap completely. (yoga asanas)

There are two types of muscle contractions:

1. Isotonic Contraction: where the load remains constant but the movement is such that the muscle contracts and change in shape. For eg. Lifting dumbbells.

2. Isometric Contraction: where the size and shape of the muscle remain same yet the load increases gradually. For eg. Holding an asana for longer duration.

Reflex action & reciprocal inhibition

Number of nerves innervate a group of muscle fibres called motor unit. Motor unit represents the smallest number of nerve fibres within a muscle capable of being stimulated by a single nerve impulse. Nerves also carry sensory information from the muscles to the brain with respect to the relative position of body parts because of receptors called proprioceptors. The proprioception helps in maintaining steady postures and make coordinated movements.

Proprioceptors also initiate spinal reflexes such as **stretch reflex.** This happens when the muscle is lengthened suddenly which will initiate a proportionally strong contraction of same fibres. Therefore if we bounce and jerk forward in forward bend then an immediate signal will be sent to contract the muscles of back. Slow movements helps with deep breathing.

Another type of reflex promotes relaxation of a muscle group when the opposing muscle group is contracting. Eg. When biceps contract, triceps relaxes. This is known as **reciprocal inhibition.**

Types of Muscle Movements

1. **Flexion:** Movement that decreases the angle of joint, bringing two bones closer to each other. For eg. Bending of elbow.
2. **Extension:** Movement that increases the angle of a joint, moving the two bones apart. For eg. Straightening the elbow
3. **Abduction:** is moving the bone away from the midline of the body. For eg. Lifting the arms to the side
4. **Adduction:** is moving the bone towards the midline of the body. For eg. Bringing the legs together.
5. **Elevation:** movement in superior direction. Eg. Shrugging the shoulders.
6. **Depression:** movement in inferior direction. For eg. Shoulders away from the ears.
7. **Pronation:** movement where palms are facing down.
8. **Supination:** movement where palms are facing the sky.
9. **Rotation:** movement around the longitudinal axis. It could be internal or medial (towards the midline of the body) or external or lateral (away from the midline of the body).
10. **Sphincter opening:** reduces or increases the size of opening. Most commonly found in involuntary muscles.

Muscle breathing

All cells of muscles require energy to generate the contraction. Just like all other cells of the body the cell of the muscles get their energy from the metabolism of simple sugars like glucose using oxygen to produce energy and water and carbon di oxide as by products.

glucose + oxygen → carbon dioxide + water + energy

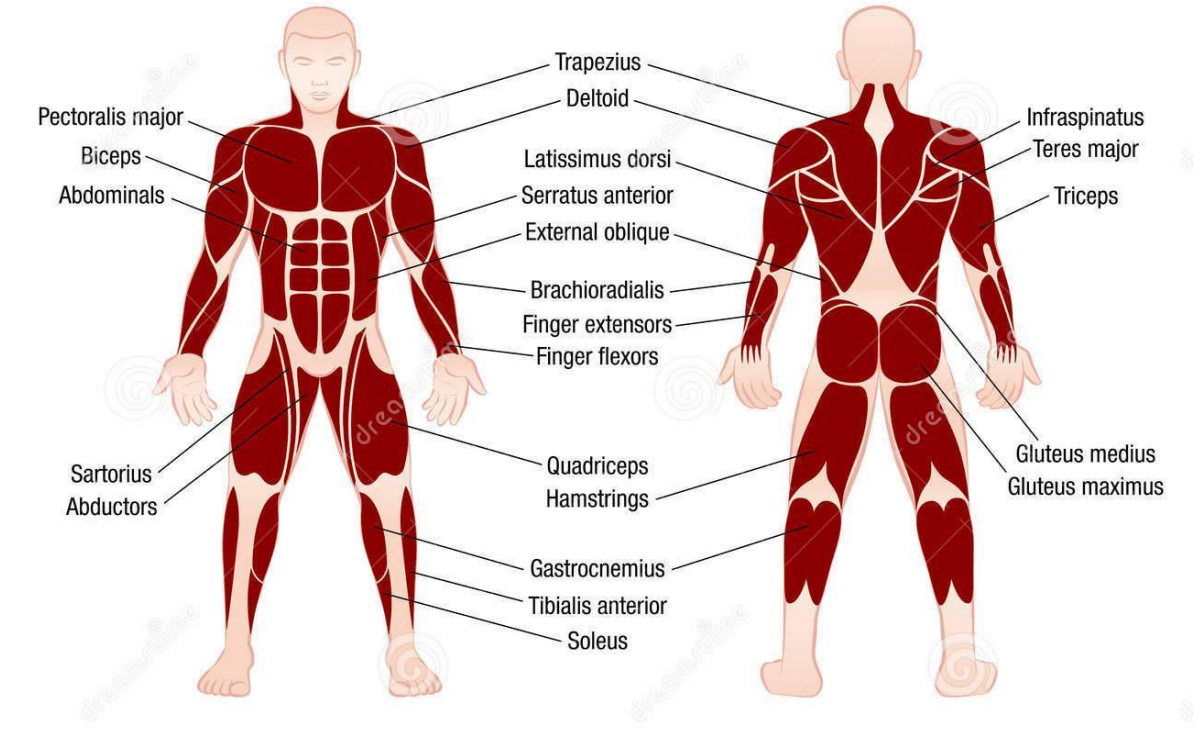
This is known as **aerobic respiration ('with oxygen').** This type of respiration is used in activities that not high in intensity but high in volume. For eg: running a marathon, recreational sports, dance etc.

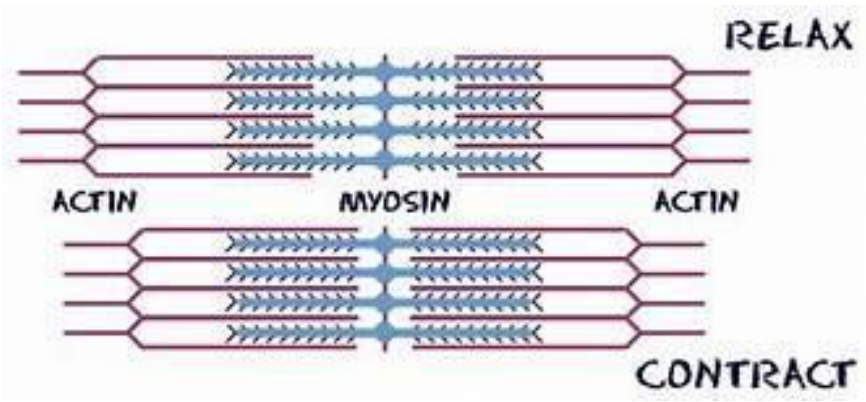
During strenuous exercise or exertion, the body may not be able to provide adequate oxygen to meet the demands of the cell or it may so happen that the action performed is so fast that oxygen did not have any time to reach the cell, for this some muscle fibres are adapted to perform **anaerobic respiration ('without oxygen').** Glucose is metabolised in absence of oxygen to form energy and lactic acid as by product. Such type of respiration happens for high intensity activities. For eg. Weight training, golf swing, sprint runs.

glucose ⟶ lactic acid + energy

Once the exertion is over, the muscle will recover as oxygen is used to breakdown lactic acid into water and carbon di oxide. The amount of oxygen needed to break down the accumulated lactic acid is known as the **oxygen debt.**

By focussing on proper breathing during the practice of yoga asanas, fatigue is reduced as increased oxygen is provided to the muscles. Short periods of relaxation during yoga practice allows muscles to eliminate lactic acid accumulated in during the exercise.





Cardiovascular System

In order for us to survive, there has to be a transport system which carries nutrients, gases, waste products, hormones from all the cells. We have the cardio vascular system for that. It consists of the follows:

1. **Blood**: blood is a fluid connective tissue consisting of the liquid plasma about 54% of the total blood mass, red blood cells 45% and 1% white blood cells and the platelets.
    a. **Red blood cells:** are round sac shaped cells which have a red pigment on its membrane which is able to bind to oxygen and carbon di oxide and regulate the exchange of gasses. RBCs are produced in the bone marrow and circulate throughout the body till being broken down and eliminated by the spleen after 120 days. If RBCs count fall below 30% of blood mass, it a condition known as anaemia.
    b. **White blood cell:** are formed in bone marrow, lymph nodes and spleen and are of 5 types of shapes and structure and perform particular roles in providing immunity to the body. Their lifespan is 30 hours to 25 days.
    c. **Platelets:** are formed in bone marrow. They stick to the damaged blood vessel surface to prevent further bleeding. Their average life span is 4 days.

Blood Cell	Scientific name	Size	Function	Normal range per unit blood	Abnormal increase	Abnormal decrease
Red Blood Cells (RBCs)	Erythrocytes	6.2–8.2 µm	Contains Haemoglobin that transports oxygen and carbon di oxide	Women 4-5 million per mm^3, Men 5-6 million per mm^3	Polycythemia	Erythropenia
White Blood cells (WBCs)	Leucocytes		Associated with immunity, there are 5 kinds of WBCs	4000-10000 per mm^3	Leukemia	Leucopenia
	Neutrophils	12-15 µm	Primary defence against Bacterial infection	40-80% of WBCs		
	Eosinophils	12-15 µm	Cells that kill parasites and inflammatory reaction in allergies	2-3% of WBCs		
	Basophils	12-15 µm	Produce a chemical called histamine which dilates the blood vessels for other leucocytes to reach the infected site	0.5-1% of WBCs		
	Lymphocytes	7-10 µm	Determine Specificity of immune response (produce antibodies) to infectious microorganisms and other foreign substances	20-40% of WBCs		

	Monocytes	15-25 µm	Cells that consume dead or damaged cells. They are the 'clean up' crew.	1-10% of WBCs		
Platelets	Thrombocytes	2-3 µm	Helps clotting of blood in order to stop bleeding from injury	150000-450000 per mm^3	Thrombocytosis	Thrombocytopenia

2. **Blood vessels:** transport the blood all over the body. **Arteries** carry blood away from the heart which divide into arterioles and then further divide into thin walled capillaries which are very close to the cells through which exchange of substances take place. Capillaries later converge in venules which converge into **veins** and veins carry blood towards the heart. **Systemic circulation** is the circulation of blood to and from the heart to the whole body. Whereas **pulmonary circulation** is the circulation of the blood to and from the heart to the lungs.

3. **Heart:** is a hollow, muscular organ situated near the middle of the chest and acts as a pump to push the blood through blood vessels. It is triangular in shape, approximately the size of a closed fist, with the apex at the bottom slightly to the left just above the diagram. The walls of the heart are made up of cardiac muscle tissues and unlike skeletal muscles, this is specialized muscle is

designed to continuously contract and relax without fatigue throughout the life.

The heart is made up of 4 chambers – the upper **atria** or auricles and the lower **ventricles**. The right atrium and left ventricle enable systemic circulation. The left atrium and right ventricle enable pulmonary circulation. The atria receive the blood and pump it further into their lower ventricles, ventricles pump the blood out of heart. There are valves between the auricles and ventricles (atrioventricular valves) as well as the arteries emerging from ventricles (semilunar valves) to prevent back flow of blood. The valve between right atrium and ventricle has three flaps know as tricuspid valve. And the valve between left atrium and left ventricle has two flaps known as bicuspid or mitral valve.

Functions of cardiovascular system

1. Transport, blood circulation.
2. Protection, immunity.
3. Homeostasis.

Conduction System of Heart

The state of contraction of a chamber of the heart is known as systole and the state of relaxation is known as diastole. The heart works in a systematic way know as cardiac cycle having three phases:

a. **Relaxation:** All four chambers of the heart in diastole. The atria fills passively.
b. **Ventricular filling:** feature atrial systole and ventricular diastole. The AV valves are open and ventricles are filled by atria forcefully.
c. **Ejection:** features ventricular systole and ventricles pumps the blood away from the heart. AV valves close and Semilunar valves are open. Atria are in diastole.
   At the end of ejection semilunar valves close and new cardiac cycle begin.
   During each cardiac cycle the cardiac sounds of 'lub-dub' are heard. The first sound 'lub' is heard when the AV valves close followed by 'dub' when semilunar valves close.

The heart has the ability to contract even in absence of external stimulation. The cardiac cycle is stimulated first by the sinoatrial node(contractile tissue) or pacemaker located in the upper wall of right atrium. Ventricular filling starts. After which the AV node located between the chamber walls of the two ventricle will fire and stimulate ejection. The stimulus is conducted through the ventricle wall by conducting fibres.

Venous return of the blood and respiratory pump: heart essentially pumps the blood into the arteries but there is no such pump which brings the blood back towards the heart. This is done by the contraction of the wall of veins with the help of skeletal muscles around them as well as respiration.

When we inhale it creates a negative pressure which draws blood back to heart.

Cardiac output is the volume of blood pumped per minute. It is equal to the stroke volume (volume of blood ejected per heartbeat) times heart rate.

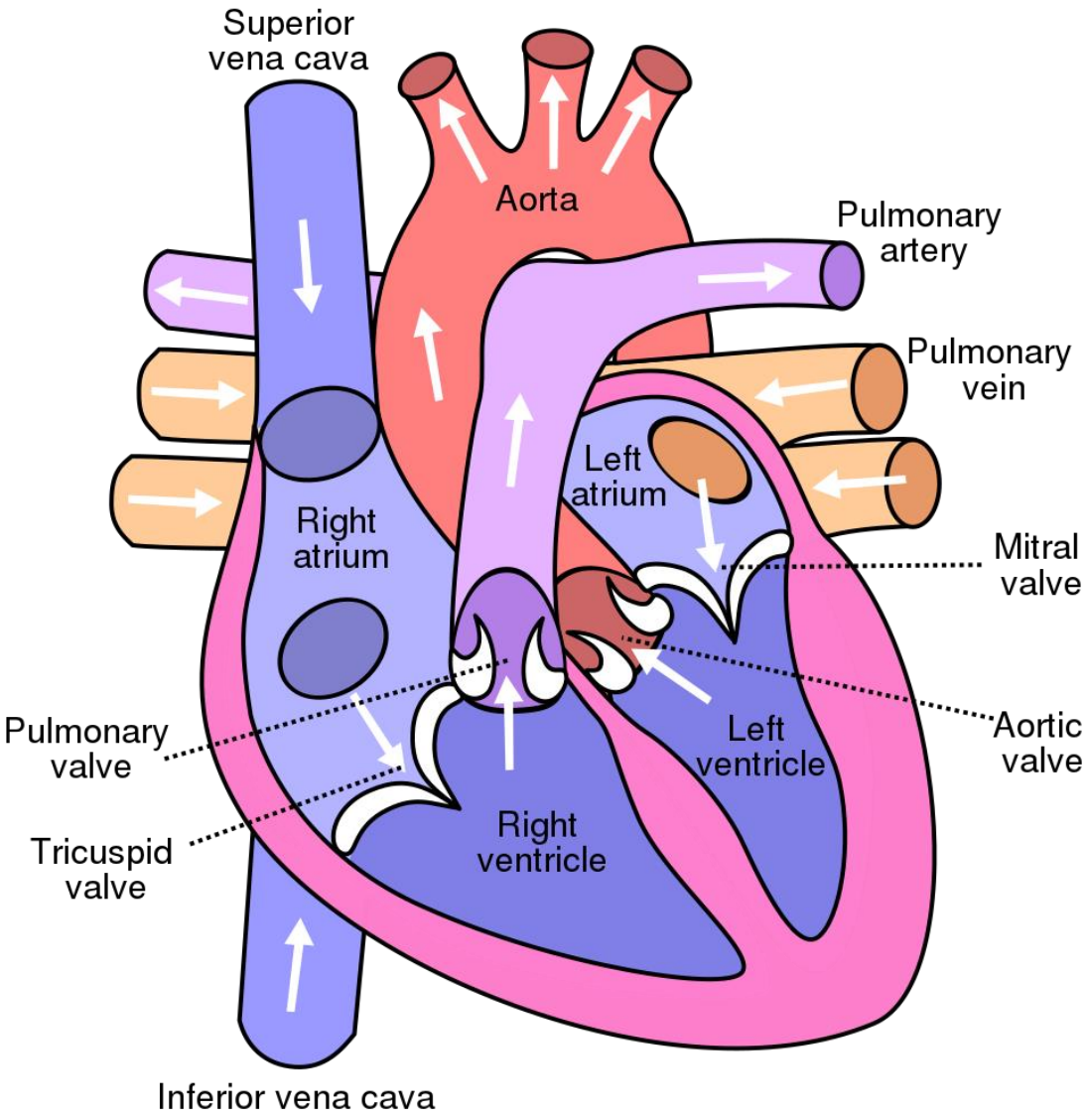
CO = stroke volume × heart rate

For avg person CO approx. 5ltrs = 70ml × 75

Blood pressure is the push or force of blood in the blood vessels. It is the highest in the arteries and lowest in the veins.

BP = CO × peripheral resistance × viscosity (mmHg)

The standard BP measurement is taken on the left arm at the level of heart recorded as arterial pressure at ventricular systole and ventricular diastole. For average adult it is 120/80 mmHg.


Superior vena cava
Aorta
Pulmonary artery
Pulmonary vein
Left atrium
Right atrium
Mitral valve
Pulmonary valve
Aortic valve
Left ventricle
Right ventricle
Tricuspid valve
Inferior vena cava

Respiratory System

Respiration is exchange of oxygen and carbon di oxide. It occurs at the pulmonary level where the capillaries near the alveoli carry deoxygenated blood, oxygen diffuses into the capillaries and carbon di oxide into the alveoli because of the gaseous gradient. The same thing happens in systemic circulation where the capillaries are near the cells.

Respiratory track is the path the air travels to and from the lungs. It has the following parts.

1. **Nose:** it filters, warms and moistens the inhaled air. It is the sense organ for smell.
2. **Pharynx:** is the area behind the mouth and is a common passageway from mouth as well as nose. It is connected to larynx and epiglottis is a flap that covers the opening of larynx when solid food is swallowed to prevent the food from entering the wind pipe.
3. **Larynx:** is the voice box in the throat, serving as voice production organ.
4. **Trachea:** is the wind pipe from larynx to the lungs, is held open by the rings of cartilage.
5. **Bronchi, bronchioles, alveoli:** the trachea branches into the two lung on the right and the left side of the chest as bronchi. Each bronchus further divides into finer branches bronchioles. These bronchioles culminate in microscopic air sac alveoli which have a network of

capillaries around them where the exchange of gases takes place.

6. **Lungs:** are the triangular shaped air sacs in the chest cavity, two in number, one on left with two lobes to make space for heart and other on the right with three lobes. This is where the exchange of gases take place.

   Respiratory mucosa is a special membrane which lines the respiratory track. It consists of mucus secreting cells as well as ciliated cells. It produces 125ml of mucus everyday which forms a sticky blanket and serves as a air purifier by trapping inhales irritants such a pollens or dust. Bronchial cilia moves the mucus upwards to pharynx for removal.

   Sinuses are a group of four paired air-filled spaces that surround the nasal cavity. The paranasal sinuses are joined to the nasal cavity via small orifices called ostia. These become blocked easily by allergic inflammation, or by swelling in the nasal lining that occurs with a cold. If this happens, normal drainage of mucus within the sinuses is disrupted, and sinusitis may occur.

Functions of respiratory system

1. Exchange of gases
2. Maintaining pH balance
3. Speech production.

Muscles of respiration

There are four types of muscles used in breathing

a. **Diaphragm:** is a dome shaped sheet of muscle that is below the lungs and separates chest cavity from abdominal cavity.
b. **Intercostal muscles:** are attached to the ribs on the sides of the chest, contraction brings the ribs together and lifts the rib cage up for inhalation and vice versa.
c. **Accessory muscles:** refer to the muscles in the neck attached to the collarbone enabling clavicular breathing especially inhalation
d. **Muscles of expiration:** refer to the abdominal muscles which are especially used for forceful exhalation.

Volumes of air exchange

Tidal Volume: The tidal volume is the total amount of air inhaled or exhaled during regular respiration or relaxed breathing. Approximately 500 ml of air is utilized during normal respiration in a healthy man.

Inspiratory Reserve Volume: approximately ranging between 2500 to 3100 ml of air which could be effectively inhaled after the normal inhalation (standard tidal volume).

Expiratory Reserve Volume: the additional capacity of air which is about 1200 ml are that could be forcibly exhaled out after normal exhalation (standard tidal volume).

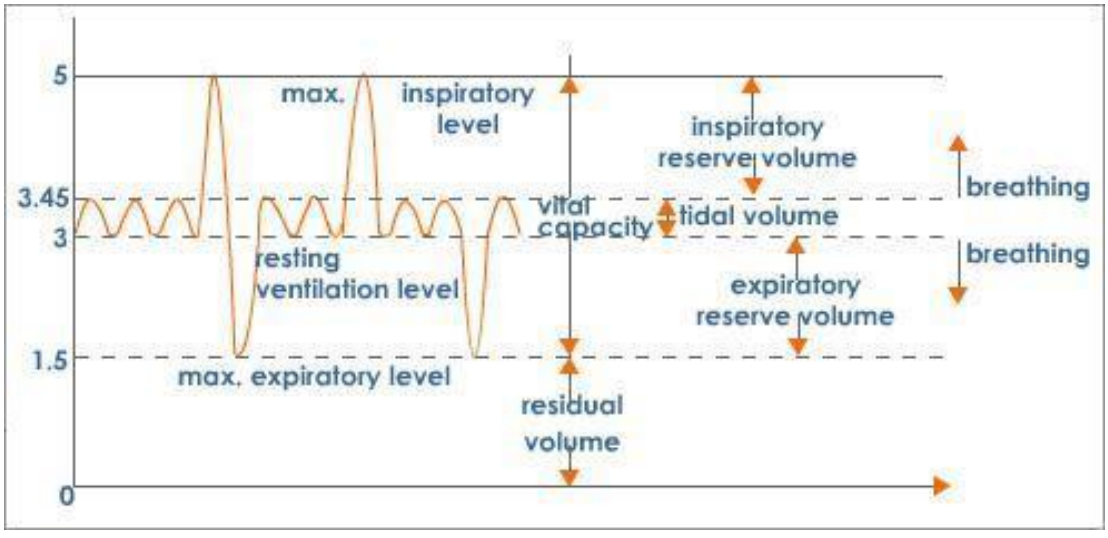
Residual Volume/Reserve Volume: the amount of air that remains in the lungs after the most forceful exhalation. Lungs are never fully empty. It is about 1100ml to 1200ml.

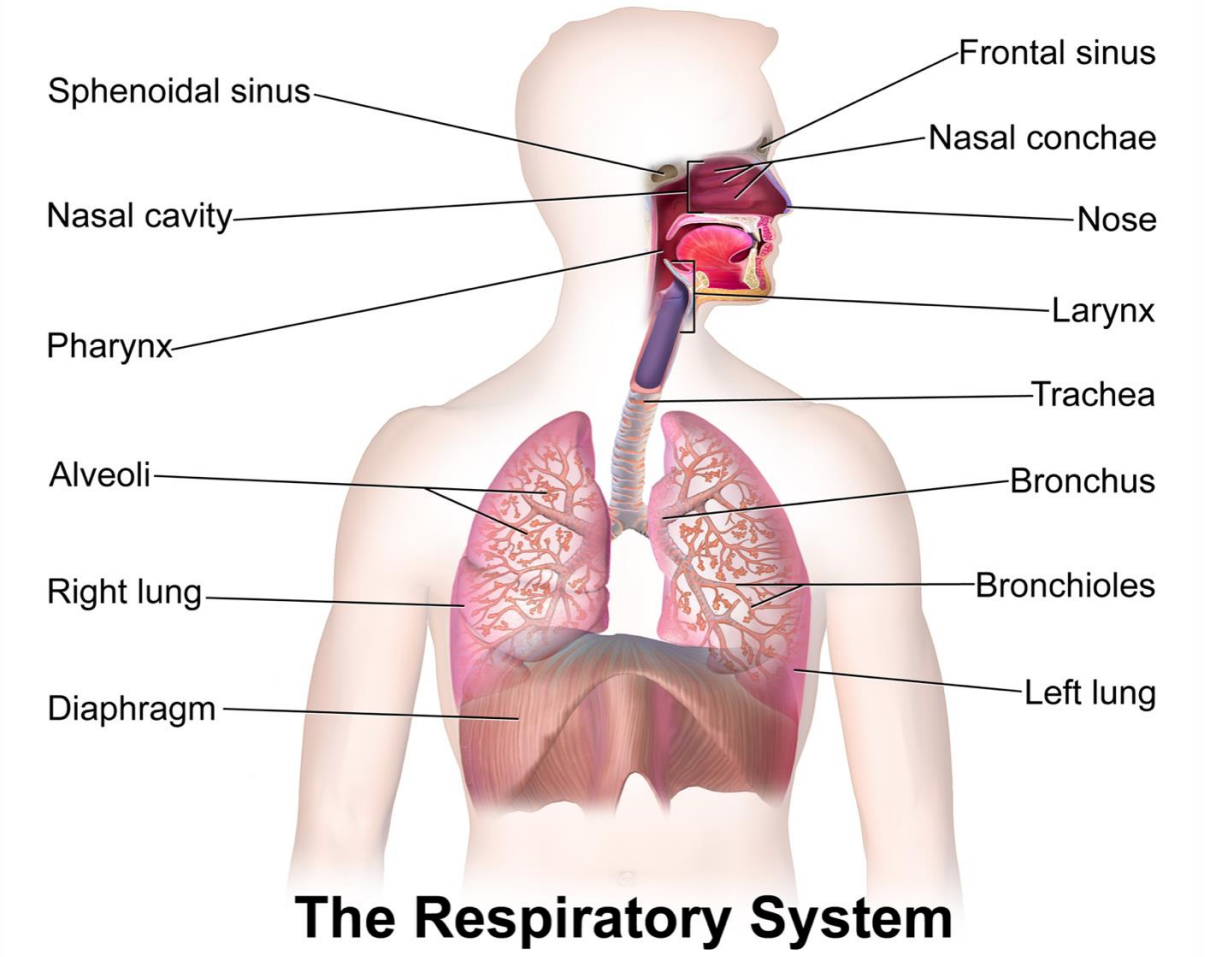
Vital Capacity: The vital capacity is the total volume of air that can be expired after a maximum inhalation or maximum air that a person can breathe in after forced expiration. It is an important measure of a person's respiratory health. A decreased vital capacity is an indication of restrictive lung disease where the lungs cannot expand completely. In the case of normal vital capacity, the improper functioning of lungs indicates obstructive lung disease where the lungs are blocked in the airways.

VC = TV + ERV + IRV

Total Lung Capacity: The total lung capacity applies to the total volume of air-filled in the lungs after a forced inspiration. The lung capacity of a healthy man is estimated to be 6000 ml.

TLC = TV + ERV + IRV + RV





The Respiratory System

Digestive System

Digestion in simplest terms is breaking down of complex macro molecules in to simple micro molecules. This essentially happens for carbohydrates, fats and proteins which are converted into simple glucose, fatty acids and amino acids respectively. All the essential nutrients are absorbed and that which is not needed by the body is eliminated.

The Alimentary Canal & Process of Digestion

The alimentary canal is a muscular tube, approximately 12 meters in length, with mucosal lining, keeping the surface smooth and slippery. Each section of this tube is specialized for a particular function in the digestive process. Food moves through the canal by peristalsis, wave like contractions of the involuntary muscles. It consists of the following sections:

1. **Mouth:** This is where the mechanical breakdown of the food happens when we chew the food we eat. Chewing prepares the food to be swallowed and increases the surface area in contact with the juices. The saliva secreted by the salivary glands breakdown large carbohydrate molecules to smaller sugar molecules.
2. **Oesophagus:** or the food pipe, unlike trachea is flat when empty, connects the mouth to stomach. Neither digestion nor absorption takes place here.
3. **Stomach:** is a muscular bag, situated against the front wall of the abdomen just beneath the diaphragm. When a person is standing up, stomach represents the letter ‘J’.

The main function of the stomach is mechanical breakdown of the food because of the smooth wall of the stomach which is capable of churning action and initial chemical digestion of the protein with help of enzyme **pepsin**, some fats with help of enzyme **lypase** and milk with the help of enzyme **renin**. There is no absorption in the stomach. The hydrochloric acid released in the stomach helps kill any harmful bacteria in the food. The **cardiac sphincter** at the top of stomach remains firmly shut to prevent the food from returning into oesophagus. The **pyloric sphincter** at the opening of small intestine remains shut as well only relaxing at intervals to let some of the partly digested food to pass through.

4. **Small Intestine:** is a narrow tube which is 6m long, divided into 3 sections- **duodenum, jejunum, ileum** is highly coiled and twisted to fit into the abdominal cavity. Bile is secreted from the liver into duodenum which breaks down lipids and contains emulsifiers which make fat water soluble. Pancreatic juices are also released into the duodenum which continue the digestion of fats, proteins, carbs, as well as neutralize the acidity coming from the stomach. Most absorption takes place in jejunum and ileum to complete digestion, they also release the enzymes of their own.

   The small intestine is lined with 4-5 million hair like projections known as villi to increase the surface area for better absorption of stomach. The amino acids and sugars are directly absorbed into the blood stream. The blood supply from the intestines directly goes to liver via

hepatic portal vein, delivering the amino acids and sugars for processing before entering systemic circulation. Fatty acids through the villi enter the lymphatic vessels which empty into the big vein below the clavicle.

5. **Large Intestine:** passes up the right side of the abdomen as ascending colon, then across the abdomen as transverse colon and then down the left side as descending colon into a final section known as **rectum** and an opening as **anus** where the unwanted stools are eliminated. The lining of the large intestine secrets mucous but no digestive enzymes. The function of it is feces formation and reabsorption of water. Around 8-9 litres of water is reabsorbed, two third coming from digestive juices. Defecation happens when rectum fills up.

Digestive secretions

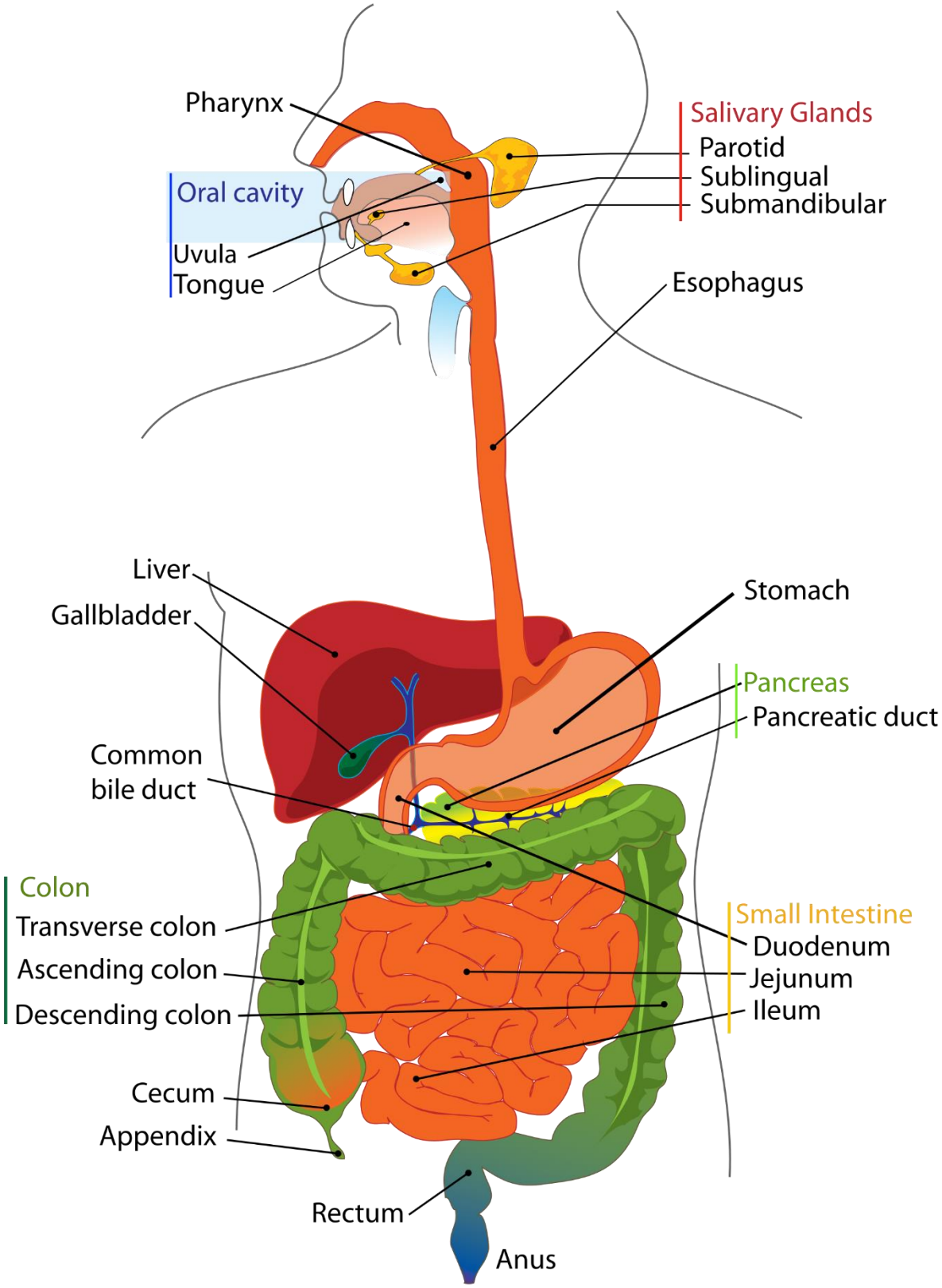
Chemical name	Released by	Released where	Action
Salivary amylase	Salivary glands	Mouth	Carbohydrate digestion
Pepsin	Stomach	Stomach	Protein digestion
Hydrochloric acid	Stomach	Stomach	Kill bacteria and pepsin activation
Renin	Stomach	Stomach	Milk digestion
Pancreatic amylase	Pancreas	Duodenum	Carbohydrate digestion
Pancreatic protease	Pancreas	Duodenum	Protein digestion
Pancreatic lipase	Pancreas	Duodenum	Fat digestion
Bile	Liver	Duodenum	Emulsification of fat.

Nutrient	Scientific name	Functions	Food sources	Deficiency diseases
Carbohydrates	saccharide	Instant energy, structural component of DNA, immunity, growth and development, defecation,	Simple sugars, fruits, daily, rice, wheat, pulses	Fatigue, loss of endurance, low blood sugar, fainting
Fats		Stored dense source of energy, acts as cushion to prevent injury, thermal insulation, nerve functions,	Cooking oils, ghee, milk and milk products, nuts	Loss of strength, sagging skin, lifelessness, nervous disorders, prone to injuries
Protein		Cell building, cell division, DNA component, hormones, enzymes, antibodies hair, skin, muscle integrity,	Milk, milk products, sprouts, pulses, grains, nuts	Kwashiorkor, Marasmus (There are other symptoms such as leg cramp, hair loss, loss of immunity, prolonged

		recovery from injury or surgery		fatigue, depression etc.)
Vitamin A	Retinol	Role in vision; transport of light impulse; bone formation	Carrots, Dairy products, sweet potato	Night blindness, remodelling of bones
Vitamin B1	Thiamine	Energy metabolism, supports normal appetite, nerve function, coenzyme	Yogurt, sunflower seeds, cereals, bread, rice, noodles	Beri beri, wet and dry beri beri
Vitamin B2	Riboflavin	Energy metabolism, support normal vision and skin health	Green leafy vegetables like spinach, broccoli, asparagus	Ariboflavinosis
Vitamin B3	Niacin	Energy metabolism, digestive and nervous system	Peanuts, avocados	Pellagra

Vitamin B6		Coenzyme, amino acid and glucose metabolism, Hb synthesis	Milk, bananas, potatoes	Microcytic anaemia
Vitamin B9	Folate/Folic acid	DNA synthesis, new cell formation	Spinach milk, fruits, peas, soya flour	Megaloblastic anaemia
Vitamin B12	Cobalamine	New cell synthesis, nerve function, coenzyme	Milk, eggs	Pernicious anaemia
Vitamin C	Ascorbic acid	Powerful anti-oxidant, immunity, collagen formation	Citrus fruits, berries, kiwis, guava	Scurvy
Vitamin D	Calciferol	Calcium, magnesium metabolism, bone growth, helps absorption in GI tract	Sunlight on skin, mushroom	Rickets, osteomalacia
Vitamin E	Tocopherol	Anti-oxidant, promotes fertility, skin health, stabilization	Vegetable oils, grains, vegetables	Cystic fibrosis,

		of cell membrane		
Vitamin K		Coagulation, bone density	Green leafy vegetables	Reduce blood clotting time, osteoporosis
Calcium		Structural component of bones and teeth, contraction of muscles, clotting of blood	Cauliflower, sprouts, dates, milk, tofu, almonds, sesame, spinach	Osteoporosis
Magnesium		Bone density, relaxation of muscles, active in many enzyme systems, anticoagulant	Nuts, grains, milk	Hypertension, muscle ache, osteoporosis
Iron		Structural component of haemoglobin	Green leafy vegetables, milk, fruits	Anaemia


Pharynx
Salivary Glands
Parotid
Sublingual
Submandibular
Oral cavity
Uvula
Tongue
Esophagus
Liver
Gallbladder
Stomach
Pancreas
Pancreatic duct
Common
bile duct
Colon
Transverse colon
Ascending colon
Descending colon
Small Intestine
Duodenum
Jejunum
Ileum
Cecum
Appendix
Rectum
Anus

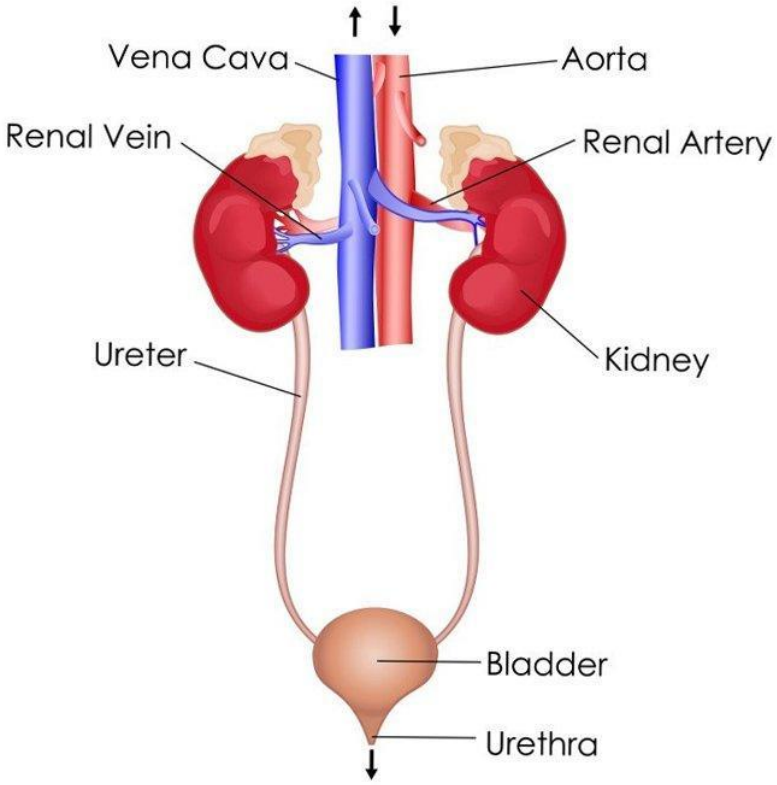
Excretory System

The excretory system also known as urinary system consists of the following organs:

1. **Kidneys:** The **kidneys** are two reddish-brown bean-shaped organs located on to a bit of lateral side of the body. They receive blood from the paired renal arteries; blood exits into the paired renal veins.
   The nephron is the structural and functional unit of the kidney which filters the blood entering the kidney. Each human adult kidney contains around 1 million nephrons.
2. **Ureters:** are tubes made of smooth muscle arising from each kidney that propel urine from the kidneys to the urinary bladder via peristalsis movement. In the human adult, the ureters are usually 20–30 cm long and around 3–4 mm in diameter.
3. **Urinary Bladder:** or simply **bladder**, is a hollow muscular organ that sits on the pelvis floor that stores urine from the kidneys before disposal by urination. It can hold up to 300-500ml of urine before there is urge to urinate but yet it can hold up to a considerable greater extent.
4. **Urethra:** is the tube connecting bladder to the external urethral orifice for expulsion of urine.

Functions of Excretory system

1. Eliminate waste from the body.
2. Regulate blood volume and blood pressure.
3. Control levels of electrolytes and metabolites
4. Regulate blood pH.



Endocrine System

The activities in our body are highly complex and they need to be so regulated that every activity takes place at a proper time and in correct sequence. This kind of regulation is also brought about by chemical regulators called hormones. **Hormones** are secretions from specific organs or glands in the body into the blood, carried by blood to the part where their effect is produced on that part specifically (target organ). Hormones are secreted by **endocrine glands.** Almost all the endocrine glands act in the coordinated manner, as system.

- Hormones are secreted directly into the blood
- Hormones are produce in very small quantities and are not stored in the body.
- Chemically some are water soluble proteins and amines and some are lipid soluble steroids.
- Their excess or deficiency both lead to serious consequences in the body.

Functions of endocrine system

1. Control
2. Communication
3. Coordination

Endocrine glands and the hormones secreted by them:

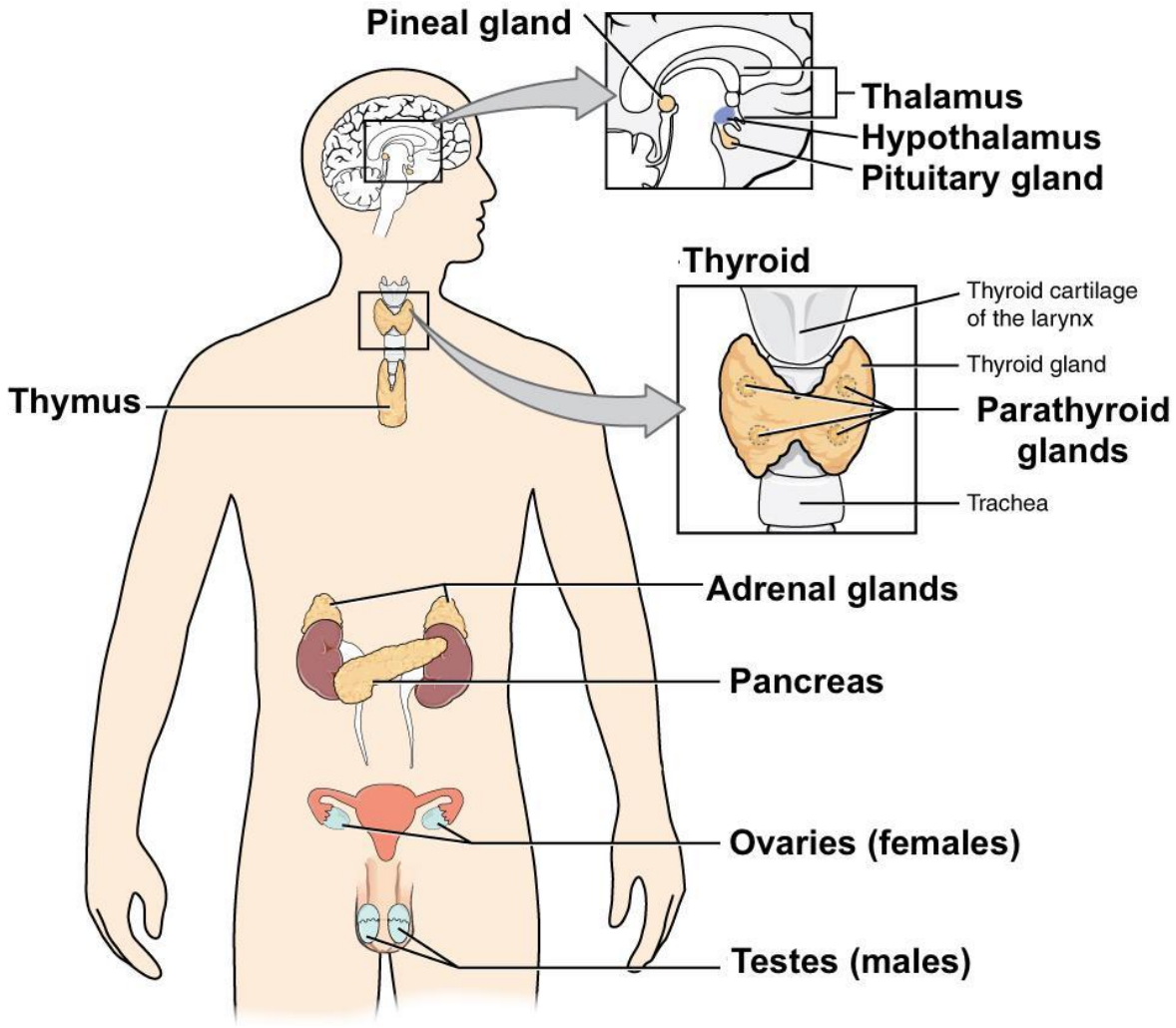
1. **Hypothalamus:** is a portion of the brain about size of almond that contains a number of small nuclei which secrets hormones which direct the pituitary gland
   a. **Releasing hormone (RH):** it asks pituitary to release any particular hormone in more quantity.
   b. **Inhibiting hormone (IH):** it asks pituitary to stop releasing any particular hormone.
2. **Pituitary gland:** it is a small projection about the size of pea which hangs from the base of midbrain popularly known as 'master gland'. It releases the following set of hormones which control other endocrine glands.
   a. **Growth hormone (GH):** for the growth from infancy to adulthood.
   b. **Follicle Stimulating Hormone (FSH):** stimulates egg formation in females and sperm formation in males.
   c. **Luteinizing Hormone (LH):** stimulates formation of corpus luteum to produce female hormone progesterone and relaxin.
   d. **Prolactin:** Milk secretion in new mothers.
   e. **Thyroid Stimulating Hormone (TSH):** stimulates thyroid to secret thyroxin.
   f. **Adrenocorticotropic Hormone (ACTH):** stimulates the adrenaline gland.
   g. **Antidiuretic Hormone (ADH):** increases reabsorption of water from kidney tubules.
   h. **Oxytocin:** Uterine contractions during child birth.
3. **Pineal Gland:** a small gland shape like a pine cone produces melatonin, a serotonin-

derived hormone which modulates sleep patterns in both circadian and seasonal cycles.

4. **Thyroid:** is a butterfly shaped gland in the throat area below larynx on the trachea produces thyroxin which is responsible for maintaining basal metabolic rate. It also secretes calcitonin which is responsible for lowering blood calcium levels.
5. **Parathyroid gland:** is regulates calcium metabolism in the body.
6. **Thymus:** is a two lobed gland located in the upper chest just behind the breast bone, is prominent in childhood but shrinks in adults. It creates the base line of immunity by initiating development of lymphocytes.
7. **Pancreas:** secretes insulin and glucagon to regulate sugar metabolism.
8. **Testes:** male gonads produce male hormone testosterone which plays a key role in the development of male reproductive tissues such as testes and prostate, as well as promoting secondary sexual characteristics such as increased muscle and bone mass, and the growth of body hair.
9. **Ovaries:** female gonads responsible for secretion of oestrogen, progesterone and relaxin. Oestrogen is responsible for the appearance of secondary sex characteristics for females at puberty and for the maturation and maintenance of the reproductive organs in their mature functional state. Progesterone prepares the uterus for pregnancy, and the mammary glands for lactation. Progesterone functions with oestrogen by

promoting menstrual cycle changes in the uterine wall. Relaxin helps in carrying out the uterine contractions for smooth child birth.

10. **Adrenal glands:** locate on top of the two kidneys, these are like triangular caps produce:
    a. **Adrenaline and noradrenaline** for 'fight or flight' response as well as 'rest and digest' response.
    b. **Glucocorticoids:** regulates carbohydrates, fat and protein metabolism
    c. **Mineralocorticoid:** regulates mineral metabolism.



Reproductive system

Every organism is designed to procreate for continuance of life on earth. Humans procreate in sexual way by production of union of **gametes** (sperm and egg) and genetic mixing. The gametes are microscopic sex cells containing half the number of chromosomes as opposed to other cells of the body, **sperms** produced in the males and **ovum** produced in females which unite on fertilization to form a **zygote** which through process of development finally becomes offspring.

Male reproductive system:

It consists of the following organs:

1. **Testes:** are oval shaped, two in number contained in a thin walled sac of skin called **scrotum**, are the primary sexual organs or gonads in males. Their main function is sperm production or spermatogenesis.
2. **Accessory glands:** seminal vesicles, prostrate and Cowper's gland are responsible for the production of semen.
3. **Penis:** lying in front of scrotum is a cylindrical tube shaped, serves for passing of both urine as well as semen.

Female reproductive system:

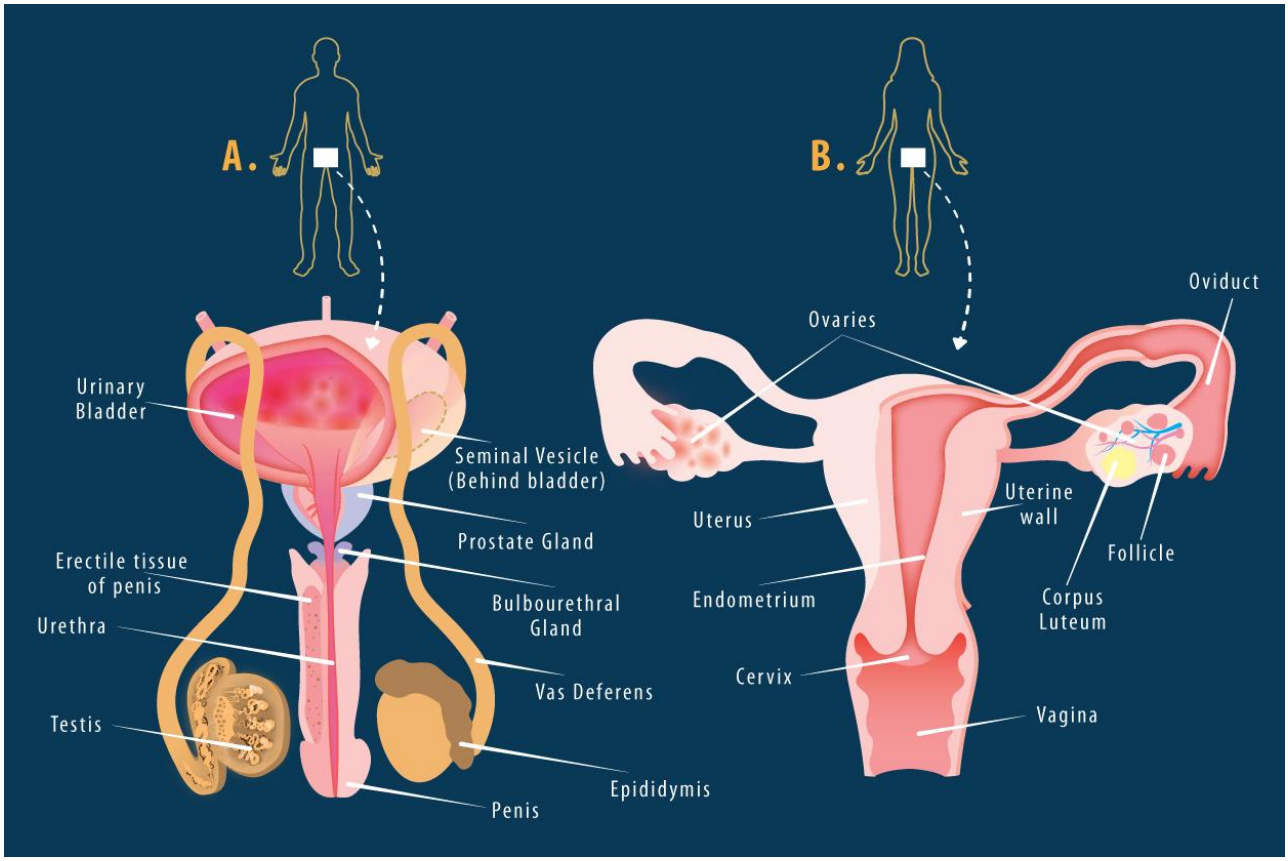
It consists of the following organs:

1. **Ovaries:** are small ovoid bodies on either side of the uterus are the primary female gonads, whose main function is the production (oogenesis) and maturation of

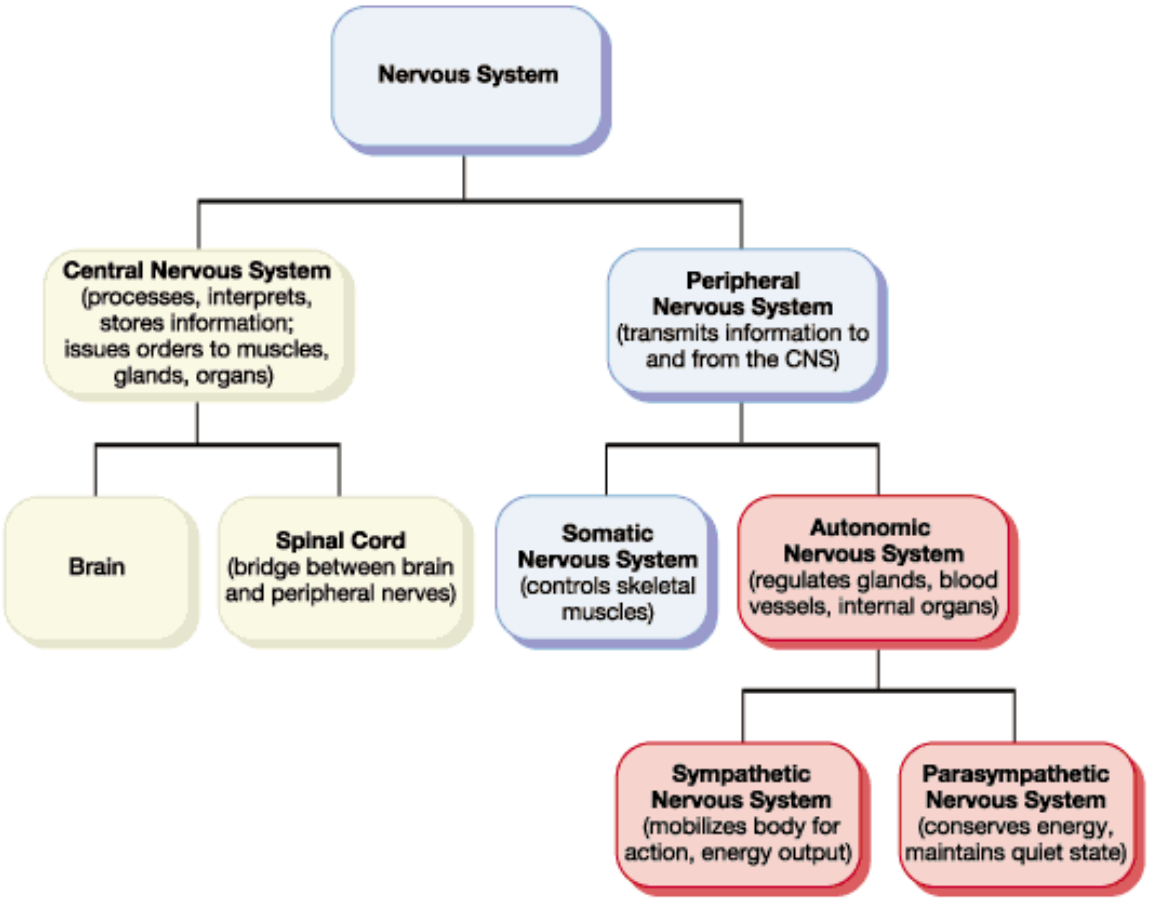
egg. Normally only one egg matures in every ovary every alternate month.

2. **Oviduct:** also known as fallopian tube two in number attached to the uterus has a funnel shaped opening called **oviduccal funnel** which pick up the matured ovum. It is also the place where fertilisation takes place.
3. **Uterus:** is a hollow pear shaped muscular organ situated in the pelvic cavity. It is the space for the complete development of the embryo. Its base is known as cervix.
4. **Vagina:** is the short muscular tube acting as the opening of the uterus. The vagina receives male penis during copulation. Vagina is well lubricated and its secretions kill germs.

Semen containing sperms are transferred into the vagina near cervix via sexual intercourse. The sperms, millions in number, swim up to the oviduct where the egg is present and only one sperm fertilize the egg to form **zygote**. This fertilized egg soon starts to divide into 2, 4, 8, 16 cells, and travels down to the uterine wall and gets implanted as **embryo** to cause state of pregnancy. There the embryo keeps developing to form **foetus**. The gestation period for humans is 280 days before delivery.


A.
B.
Urinary Bladder
Seminal Vesicle (Behind bladder)
Prostate Gland
Erectile tissue of penis
Bulbourethral Gland
Urethra
Vas Deferens
Testis
Epididymis
Penis
Ovaries
Oviduct
Uterus
Uterine wall
Follicle
Endometrium
Corpus Luteum
Cervix
Vagina

Nervous System



All actions in our body our body is properly timed and coordinated. Such coordination occurs because of nervous system. The smallest unit of a nervous system is neuron which is specialized cell for transmission of nerve signal. It has a cell body called Dendron and a long process from cell body called axon. Neurons are placed one after another and number of neurons together form nerves. There are two major divisions of nervous system. They are as follows:

Central Nervous System (CNS)

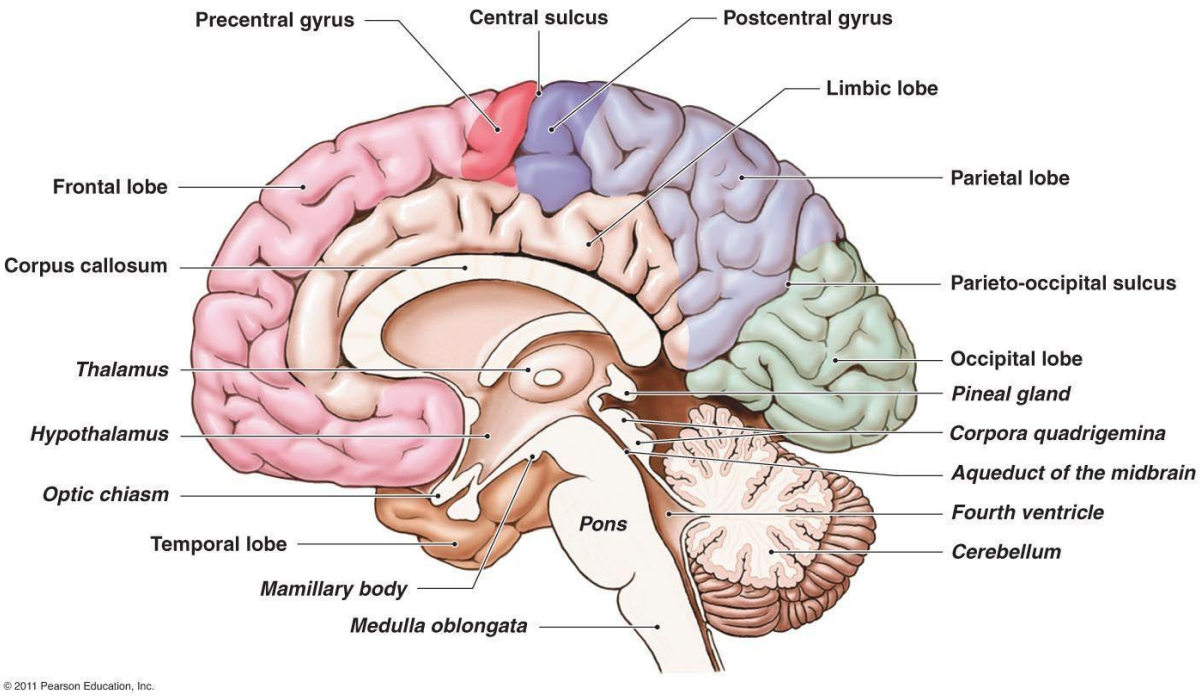
It consists of the brain and the spinal cord.

1. **Brain:** brain is delicate organ located in the skull, protected by cranium and protective membranes called **meninges**. There is a **cerebrospinal fluid** circulating between the layers which act as a cushion to protect the brain from shocks. The brain has three main parts:
   a. Cerebrum: largest portion of the brain is hemispherical in shape. Its surface is highly convoluted with ridges called **gyri** and grooves called **sulci**. The deepest sulci are called **fissures**. The longitudinal fissure divides the cerebrum into right and left hemispheres. These two are connected by **corpus callosum**. The central sulcus and lateral fissure divides cerebrum into four major lobes – **frontal, parietal, occipital and temporal lobe.** The cerebrum creates conscious thinking, memory, sensations, emotions, willed movements, as well as sense perception.
   b. **Cerebellum:** is a much smaller area of brain located at the base of cerebrum. It does not have convolutions but has numerous furrows. It is responsible for coordinated movements, maintenance of balance and equilibrium and sustaining normal postures.
   c. **Medulla oblongata:** is the lowest portion of the brain locates at the base of the skull, triangular in shape continues below as spinal cord. It controls cardiac, respiratory and vasomotor functions. The crossover

happens in the pons where the crossover happens for nerves due to which left brain controls the right side of the body and right brain control left side of the body.

d. **Diencephalon:** has hypothalamus which has major control over all internal organs and plays as a relay point between nervous system and endocrine system through pituitary. It also regulates sleep cycles and various emotions such as pleasure, pain, fear anger and sexual arousal. Thalamus in diencephalon relay impulses from sensory organs to the brain. It helps produce sensations and associate those sensations with emotions.

A midsagittal view showing the inner boundaries of the lobes of the cerebral cortex (Structures outside of the cerebrum are labeled in italics.)



2. **Spinal Cord:** extends from the medulla oblongata throughout the length of backbone and end in the 2nd lumbar vertebra. Its functions are reflex action and

conduction of sensory and motor impulses to and from the muscles. Externally the spinal cord is covered by the same meninges.

Peripheral Nervous System (PNS)

It includes nerves which carry impulses to and from the central nervous system. It is divided into the following:

1. **Somatic Nervous System (SNS):** sensory nerves brings the nervous impulses from the skeletal muscles and sensory organs (sensors) to the CNS and motor nerves carry impulses from the CNS to the effectors. There are 12 pairs of cranial nerves directly connected to the brain and 31 pairs of spinal nerves connected to spinal cord and emerging from it.

The Cranial Nerves

Nerve Number and Name		Composition	Some Functions
I	Olfactory	Sensory only	Olfaction (smell)
II	Optic	Sensory only	Vision
III	Oculomotor	Motor and sensory	Serves muscles of the eye
IV	Trochlear	Motor and sensory	Serves the superior oblique eye muscle
V	Trigeminal	Motor and sensory	Sensory from face and mouth; motor to muscles of mastication (chewing)
VI	Abducens	Motor and sensory	Serves the lateral rectus eye muscle
VII	Facial	Motor and sensory	Serves the muscles of facial expression, lacrimal glands, and salivary glands
VIII	Vestibulocochlear	Sensory only	Equilibrium and hearing
IX	Glossopharyngeal	Motor and sensory	Serves the pharynx (throat) for swallowing, posterior third of tongue, parotid salivary gland
X	Vagus	Motor and sensory	Sensations from visceral (internal) organs, and parasympathetic motor regulation of visceral organs
XI	Accessory	Motor and sensory	Serves muscles that move head, neck, and shoulders
XII	Hypoglossal	Motor and sensory	Serves muscles of the tongue

Actions of the spinal nerves

Level	Motor Function
C1–C6	Neck flexors
C1–T1	Neck extensors
C3, C4, C5	Supply diaphragm (mostly C4)
C5, C6	Move shoulder, raise arm (deltoid); flex elbow (biceps)
C6	externally rotate (supinate) the arm
C6, C7	Extend elbow and wrist (triceps and wrist extensors); pronate wrist
C7, C8	Flex wrist; supply small muscles of the hand
T1–T6	Intercostals and trunk above the waist
T7–L1	Abdominal muscles
L1–L4	Flex thigh
L2, L3, L4	Adduct thigh; Extend leg at the knee (quadriceps femoris)
L4, L5, S1	abduct thigh; Flex leg at the knee (hamstrings); Dorsiflex foot (tibialis anterior); Extend toes
L5, S1, S2	Extend leg at the hip (gluteus maximus); Plantar flex foot and flex toes

2. **Autonomic Nervous System (ANS):** consists of a pair of chains of ganglia on either side of the backbone. This system regulates involuntary actions of internal organs. There are two parts of ANS
    a. **Sympathetic Nervous System:** prepares the body for extreme action against abnormal conditions. This is known as the **'flight or fight' response**. It is emergency system when we need to cope up with any stress. It is stimulated by adrenaline or trigger of emotions and perceived threat. The response is wide ranged, involving many organs.
    b. Parasympathetic Nervous System: is to calm down the body after the end of the stress or threat. Also functioning of the body under normal conditions. It is known as the **'rest and digest' response.**

Sympathetic and Parasympathetic Effects		
Structure	**Sympathetic**	**Parasympathetic**
Eye (pupil)	Dilation	Constriction
Nasal Mucosa	Mucus reduction	Mucus increased
Salivary Gland	Saliva reduction	Saliva increased
Heart	Rate increased	Rate decreased
Arteries	Constriction	Dilation
Lung	Bronchial muscle relaxation	Bronchial muscle contraction
Gastrointestinal Tract	Decreased motility	Increased motility
Liver	Conversion of glycogen to glucose increased	Glycogen synthesis
Kidney	Decreased urine	Increased urine
Bladder	Contraction of sphincter	Relaxation of sphincter
Sweat Glands	↑Sweating	No change

Functions of Nervous System

1. Control
2. Communication
3. Coordination