Program	:	B. Pharmacy
Semester	:	1st
Subject /Course	:	Remedial Biology
Subject/Course ID	:	BP106RBT
Module No.	:	03
Module Title	:	Human body systems Part-2
Maximum Hours to Complete	:	07
Course coordinator	:	Dr. Richa Gupta
Mobile No.	:	9041393001
Email id	:	rgcognosy@gmail.com

Learning Outcome of Module

LO	Particular
1.	Students will learn about Human excretory system parts and functioning.
2.	Students will learn about Human Nervous system parts and functioning.
3.	Students will learn about structure of human brain and spinal cord.
4.	Students will learn about Human endocrine system and different hormones functioning.
5.	Students will learn about Human reproductive system both male and female and functioning

Module Content Table

No.	Topic
1.	Human excretory system
2.	Renin angiotensin system
3.	Human Nervous System
4.	Human brain and spinal cord
5.	Human Endocrine System
6.	Human Reproductive System
7.	Menstrual cycle

Contents

Human Excretory System

- Elimination of metabolic waste products from the animal body to regulate the composition of body fluids and tissues is called excretion. These waste products include ammonia, uric acid, urea, carbon dioxide and ions like Na^+, K^+, Cl^- and phosphates and sulphate.
- Ammonia is the most toxic and uric acid is the least toxic. The process of removing ammonia is called **ammonotelism** and organisms that excrete ammonia are called **ammonotelic** (bony fishes, aquatic amphibians and insects).
- The organism that release urea as nitrogenous wastes are called **ureotelic** (mammals, terrestrial amphibians). The organism that excretes uric acids is called **uricotelic** (reptiles, birds and land snails).

Animals	Excretory organs
Flat worms, some annelids and cephalochordates.	Protonephridia or flame cells.
Earthworms and annelids	Nephridia
Insects including cockroaches	Malpighian tubules
Mammals	Kidney

Modes of Excretion

Based on the excretory product, five modes of excretion are known in animals. They are:

- Ammonotelism (Type of excretion- ammonia)
- Ureotelism (Type of excretion – urea)
- Uricotelism (Type of excretion – uric acid)
- Aminotelism (Type of excretion – amino acids)
- Guanotelism (Type of excretion – guanine)

Ammonotelism

The process of eliminating ammonia from the body is known as ammonotelism, and the organisms which exhibit this nature are called ammonotelic. Most fish, protozoans, echinoderms, poriferans and crustaceans fall into this category. Aquatic animals excrete ammonia directly into the environment; where the compound is quickly diluted. It is also very toxic to tissues.

Ureotelism

In some mammals and amphibians, urea is excreted as a metabolic waste product. Such organisms are called ureotelic. In these organisms, ammonia that is produced is converted to urea in the liver of animals and is released back into the blood. The kidneys filter the urea and expel the urea outside the body. Some of the urea is retained in the matrix of the kidney to maintain a desired osmolarity in the organisms. Humans are ureotelic as we expel the urea through urine. Moreover, urea is comparatively less toxic than ammonia.

Uricotelism

Uricotelic animals remove nitrogenous wastes as uric acid in the form of pellets or paste. Metabolically, this process is quite costly; however, the water loss is minimal, and it is the least toxic. Moreover, since uric acid is not readily soluble in water, the excrements form pasty white suspensions. Most reptiles, birds, and insects are classified as uricotelics.

Aminotelism

Certain molluscs and echinoderms excrete excess amino acids. This feature is called aminotelism.

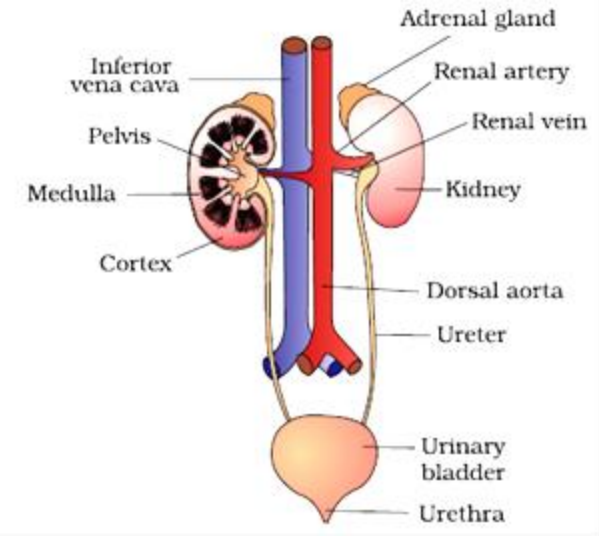
Guanotelism

Spiders convert the ammonia into guanine before excretion. This characteristic is also found in some reptiles, birds and earthworms. It is also insoluble in water; hence no water is required for its excretion.

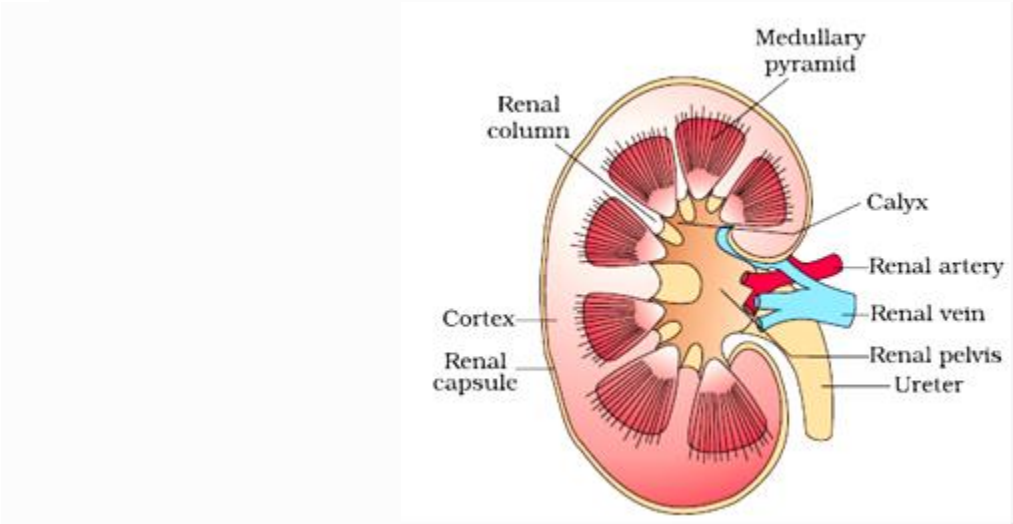
Human Excretory System

Human excretory system consists of:

1. A pair of kidneys
2. A pair of ureters
3. A urinary bladder
4. A urethra

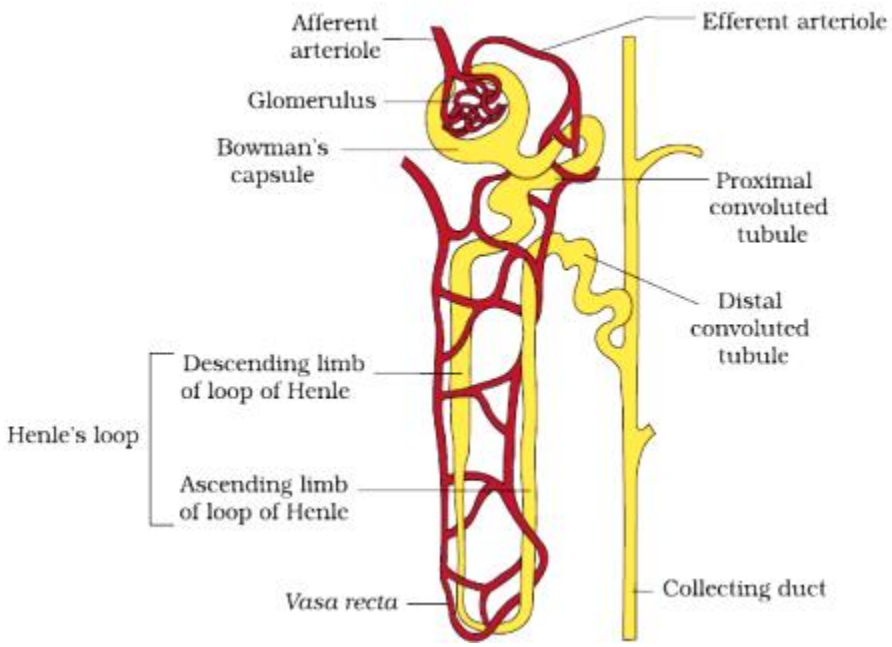


- **Kidneys** are reddish brown bean shaped structure situated between last thoracic and lumber vertebra. Each kidney has a notch on its inner side called **hilum** through which ureter, blood vessels and nerves enter.



- Inside the hilum has broad funnel shaped space called renal pelvis with projection called calyces.
- Inside the kidney are two zone- outer cortex and inner medulla. Medulla is divided into medullary pyramids projecting into calyx.
- Cortex extends between medullary pyramids as renal column called **Columns of Bertini**.
- The functional unit of kidney is nephron. Each kidney contains about one million nephrons.
- Each nephron has two parts- **the glomerulus and renal tubules**. Glomerulus is the tuft of capillaries formed by **afferent arteriole**. Blood from glomerulus is carried away by **efferent arteriole**.

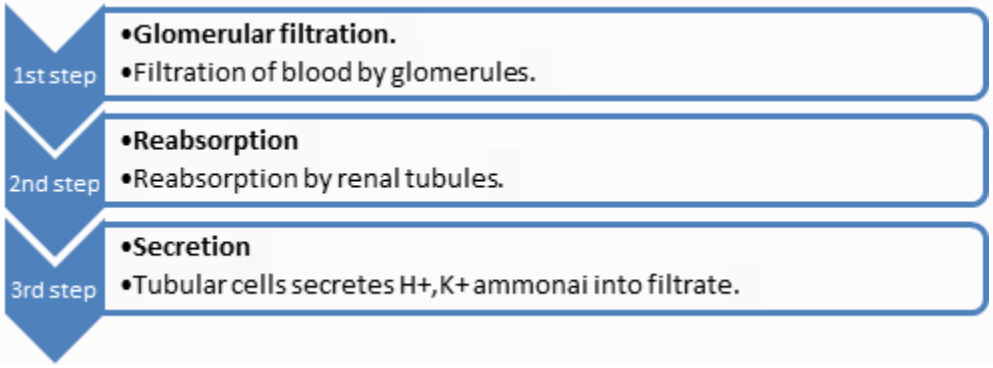
- Renal tubules starts with **Bowman's capsule** continue with tubular parts divided into **Proximal Convoluted tubules**, **Henle's loop** and **Distal Convoluted tubule**.



- The malpighian tubules, PCT and DCT of nephron are situated in cortical region where as loops of Henle's into medulla.

Juxta medullary Nephrons	Cortical Nephrons
a. Loop of Henle's is short and extend only a little into medulla.	a. Loop of Henle's are very long and extend deep into medulla.
b. The glomeruli lie close to the inner margin of the cortex.	b. The glomeruli lie in the outer cortex.

Urine formation

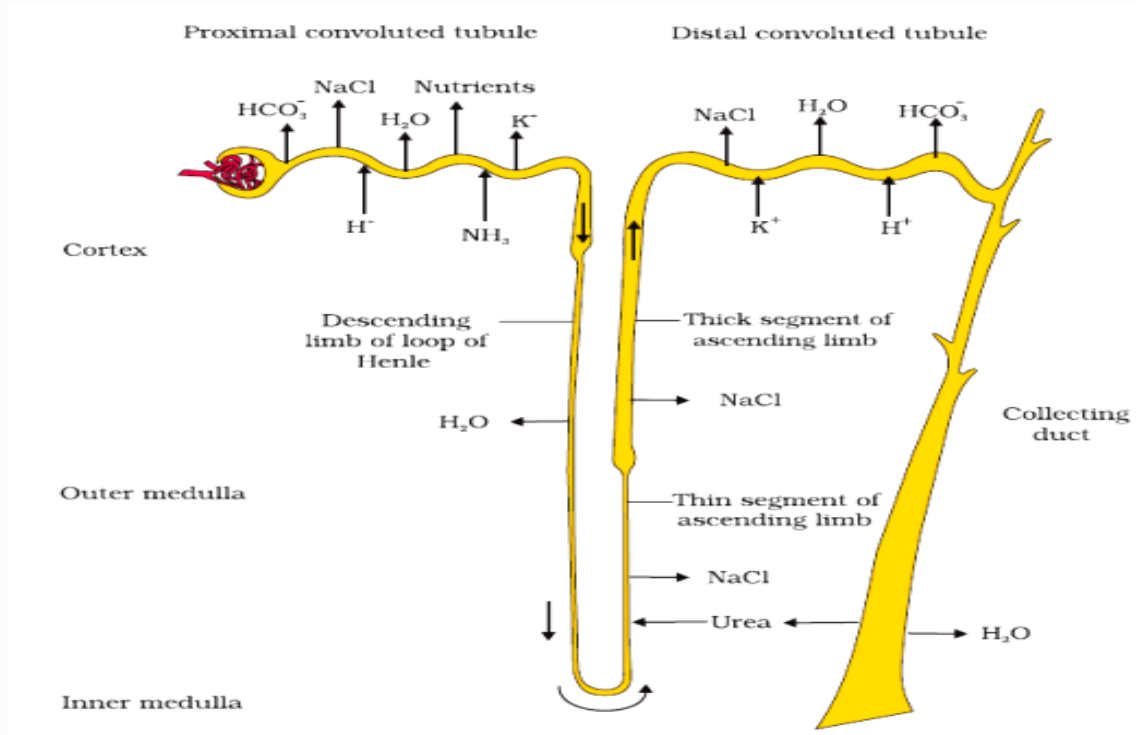


- **Glomerular capillaries** blood pressure cause filtration of blood through 3 layers (endothelium of glomerular blood vessels, epithelium of Bowman's capsule and basement layer between two membranes as ultra-filtration.
- The amount of filtrate formed by kidneys per minute is called **glomerular filtration rate (GFR)** which is 125 ml/minute.
- **Glomerular Filtration rate** is controlled by Juxta glomerular apparatus (JGA).
- 99% of filtrate has to be reabsorbed by renal tubules called **reabsorption.**

Function of Tubules

1. **Proximal Convoluted Tubules (PCT)** – all the important nutrients, 70-80% electrolytes and water are reabsorbed.
2. **Henle's Loop**– maintains high osmolarity of medullary interstitial fluid.
3. **Distal Convoluted Tubules (DCT)** – conditional reabsorption of Na+ and water. Maintains pH and sodium- potassium balance.
4. **Collecting Duct**– large amount of water is reabsorbed to produce concentrated urine.

Mechanism of concentration of urine– The flow of filtrate in two limbs of Henle's loop is in opposite direction to form counter current. The flow of blood in two limbs of vasa recta increase the osmolarity towards the inner medullary interstitium in the inner medulla.



- The transport of substance facilitated by special arrangement of Henle's loop and vasa recta is called **counter current mechanism.**

Regulation of kidney function–

- Functioning of kidney is monitored by hormonal feedback mechanism of hypothalamus and JGA. Change in blood volume, body fluid and ion concentration activates the

osmoreceptors in the body that stimulate the hypothalamus to release ADH or vasopressin hormones. The ADH facilitates water absorption in tubules.

- Decrease in glomerular blood pressure activate JG cells to release renin which converts angiotensinogen to angiotensin I and II that increase the glomerular blood pressure and release of aldosterone that increase absorption of Na+ ions and water.

Micturition – The process of expulsion of urine from the urinary bladder is called micturition. The neural mechanism that causes it is called micturition reflex. Urine formed in nephron is stored in urinary bladder till a voluntary signal is given by CNS. This initiates the contraction of smooth muscles of the bladder and simultaneous relaxation of the urethral sphincter causing the release of urine.

- Lungs, liver and skin also play important role in process of excretion. Lungs remove CO_2 and water, liver eliminates bile containing substances like bilirubin, biliverdin. Sweat glands remove NaCl, small amount of urea and lactic acid. Sebaceous glands excrete sterol, hydrocarbons and waxes.

Disorders of Excretory System

- **Uremia**– there is high concentration of non-protein nitrogen (urea, uric acid, creatinine). Urea can be removed by hemodialysis.
- **Renal failure**– also known as kidney failure where glomerular filtration is ceased and both kidney stops working. Kidney transplant is the ultimate method in correction of acute kidney failure.
- **Renal Calculi**– formation of stone or insoluble mass of crystallized salts formed within the kidney.
- **Glomerulonephritis (Bright's Disease)**-inflammation of glomeruli of kidney due to entry of protein or red blood corpuscles in to filtrate due to injury.

Renin-Angiotensin System

Renin-angiotensin system is a physiological hormone system involved in the regulation of arterial blood pressure and plasma sodium concentration.

When renin is liberated in the blood, it acts on angiotensinogen (a circulating layer) which goes through proteolytic cleavage to make decapeptide angiotensin I. Vascular endothelium has an enzyme called angiotensin transforming enzyme that separates two amino acids and form angiotensin II (AII) and other tissues in the body, including brain and heart also form angiotensin II (AII).

The members of the renin-angiotensin system are:

- Renin
- Angiotensin I
- Angiotensin II
- Angiotensin-Converting Enzyme (ACE)

Functions of the Renin-Angiotensin System

Listed below are the important functions of Renin-angiotensin system.

- Build resistance vessels, hence increasing arterial pressure and systemic vascular resistance.
- Stimulates delivery of sodium at different renal tubular sites and increasing the body's water retention.
- Stimulates the liberation of vasopressin from the posterior pituitary and increases liquid retention by the kidneys.
- Provides release of norepinephrine from sympathetic nerves and prevents norepinephrine uptake thereby optimizing sympathetic adrenergic function.
- Stimulates vascular hypertrophy and cardiac hypertrophy.
- The renin-angiotensin route is not regulated only by the mechanisms which encourage the release of renin, but also regulated by natriuretic peptides that are released by the human heart and these peptides serve as a critical counter regulating system.

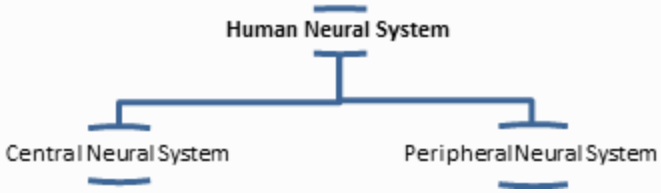
Importance of the Renin-Angiotensin System

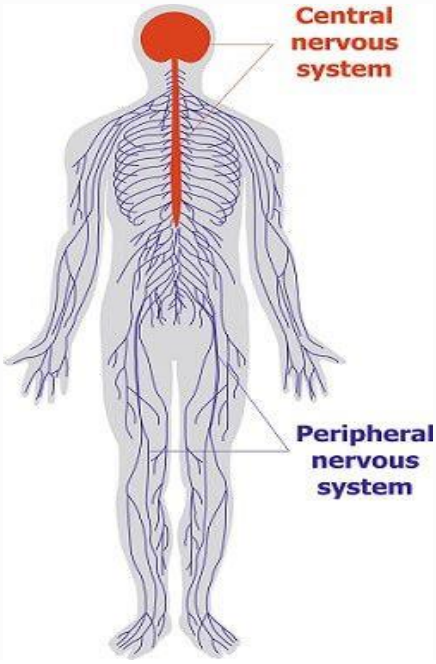
Renin-angiotensin system controls and maintains the blood pressure level in the blood cells. When there is a drop or rise in the blood pressure level of a person, this system functions immediately by releasing renin into the bloodstream.

Manipulative therapies play a major role in treating heart failure and hypertension. Every receptor blockers and ACE inhibitors are utilized in decreasing arterial blood pressure, blood volume, ventricular afterload, and ventricular preload along with vascular hypertrophy and reverse cardiac.

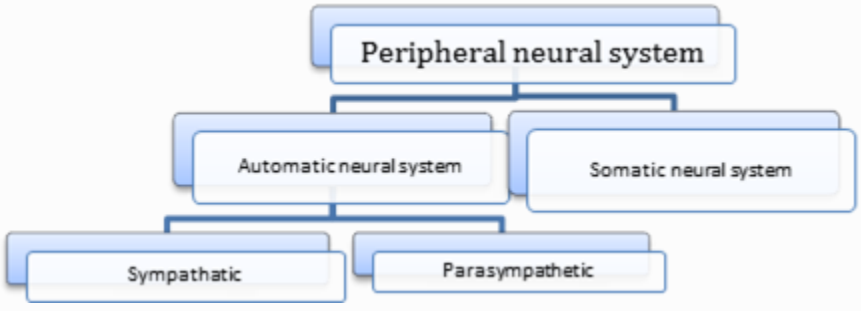
Neural Control and Coordination

- **Coordination** is the process through which two or more organs interact and complement the function of each other.
- **Neural system** provides an organized network of point to point connection for quick coordination. **The endocrine** system provides chemical integration through hormones.
- **Neural system** of animals is composed of specialized cells called neuron, which can detect, receive and transmit different kinds of stimuli. In hydra neural system is composed of network of neuron. In insects it consists of brain and a number of ganglia. Vertebrates have highly developed neural system.
- **Central nervous system (CNS)** includes brain and spinal cord. It is the site for information processing and control.





- **Peripheral nervous system** includes all nerves associated with CNS. There are two types of nerve fibres-
- Afferent fibres- transmit impulses from tissue/organ to CNS.
- Efferent fibres- transmit regulatory impulses from CNS to concerned peripheral organs. **Somatic neural systems** relay impulses from CNS to skeletal muscles. **Autonomic neural system** transmits impulses from CNS to involuntary system and smooth muscles.



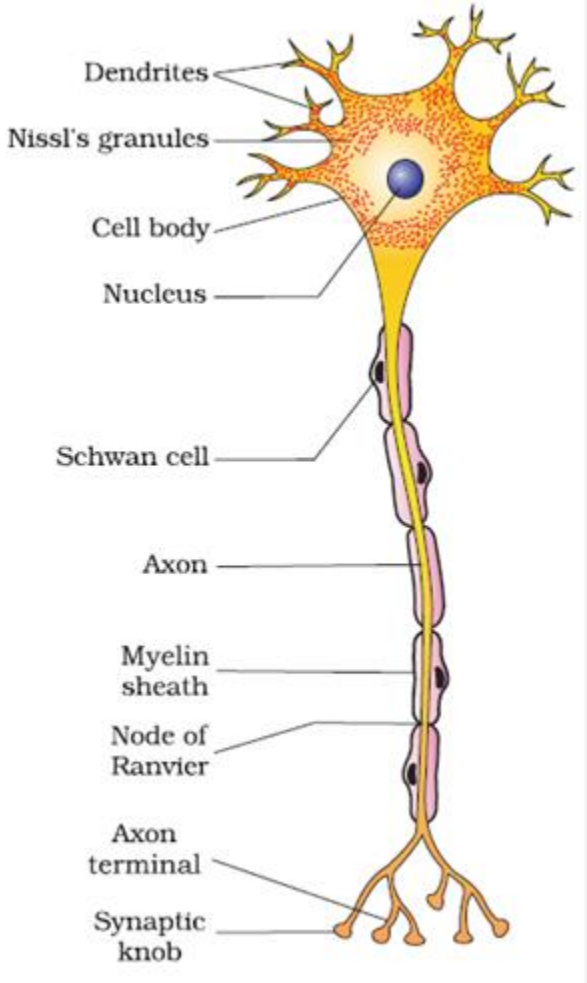
Neuron as Structural and Functional Unit of Neural System

Neuron is made up of three major parts- **cell body**, **dendrite** and **axon**.

- Cell body contains cytoplasm, cell organelles and Nissl's granules. Short fibres projecting out from cell body is called dendrites. The axon is long fibre having branched structure at the end that terminates into knob like structure called **synaptic knob**.

- Based on number of axon and dendrites neuron are of three types-

1. **Multipolar**– one axon and two or more dendrite found in cerebral cortex.
2. **Bipolar**– one axon and one dendrite found in retina of eyes.
3. **Unipolar**– cell body with only one axon found in embryonic stage.



- There are two types of axon-
  - **Myelinated**– fibres are enveloped with **Schwann cells** to form myelin sheath around the axon. The gap between two myelin sheaths is called **nodes of Ranvier.** Found in spinal and cranial nerves.
  - **Unmyelinated-** fibre is enclosed by Schwann cells that do not form myelin sheath around the axon. Found in autonomous and somatic neural system.

Generation and Conduction of Nerve Impulse

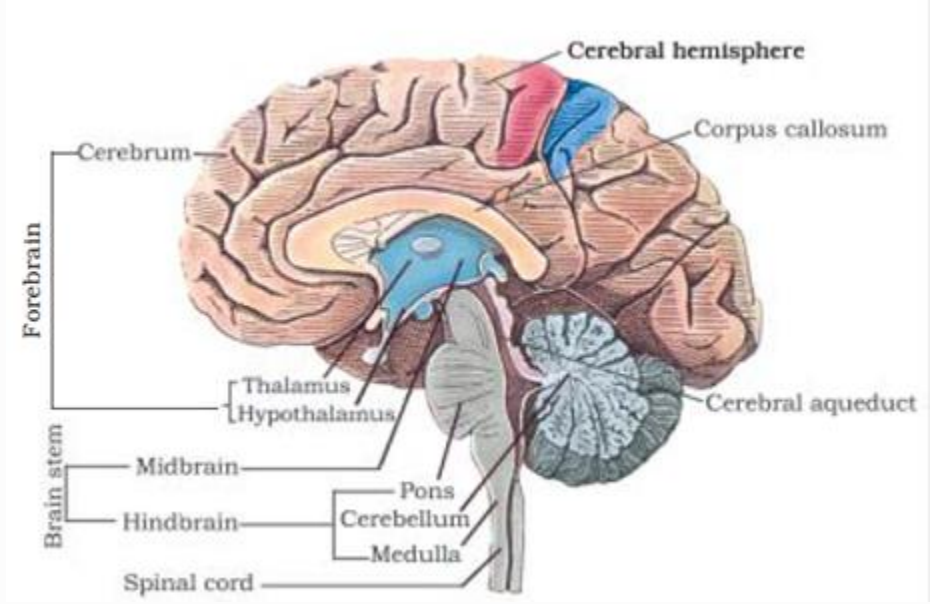
- Ion channels are present in neural membrane which is selectively permeable to different ions. When neuron is not conducting impulse (resting), axonal membrane is more permeable to K+ ions and impermeable to Na+ ions.
- Ionic gradient across the resting membrane is maintained by active transport of ions by sodium-potassium pump. This will develop positive charge outside the axonal membrane and negative charge on inner side.

- The electrical potential difference across the resting membrane is called **resting potential**.

- When stimulus is applied at site A, the membrane becomes permeable to Na+ ions to make rapid influx of Na+ ions to create outer surface negatively charged and inner membrane positively charged that create **Action Potential** or nerve impulse.
- The nerve impulse from A moves to B in inner surface and B to A on outer surface. This process is repeated several times to transmit the impulse.
- Nerve impulse is transmitted from one neuron to another neuron through synapse.
- There are two types of synapse-

1. **Electrical synapse-** the membrane of pre and post synaptic neuron is very close to each other and current flow directly from one neuron to another.
2. **Chemical synapse-** pre and post synaptic neuron is separated by fluid filled space called **synaptic cleft**. Neurotransmitters are involved in transmission of impulses.

Central Neural System –Brain is the central information processing organ of our body and act as command and control centre. Human brain is protected by skull (cranium) and three layers of cranial meninges- outer **dura mater**, middle **arachnoid** and inner **pia mater**.



Brain can be divided 3 parts- **forebrain, midbrain and hindbrain**.

Forebrain– consists of **cerebrum, thalamus and hypothalamus**. Cerebrum is divided into left and right cerebral hemispheres which are covered by cerebral cortex (grey matter). Cerebral cortex contains sensory neuron, motor neuron and association area. Association area controls complex functions like intersensory associations, memory and communication.

Thalamus– cerebrum wraps around a structure called thalamus. It is a major coordinating centre for sensory and motor signaling.

Hypothalamus controls the urge for eating, drinking and body temperature. They also release hypothalamic hormones. Limbic system is involved in controlling sexual behavior and expression of emotional reactions.
Midbrain is located between hypothalamus and pons of hindbrain. Dorsal portion consists of four round lobes called **corpora quadrigemina**. They are involved in relay of impulses back and forth between cerebrum, cerebellum, pons and medulla.
Hind brain consists of **pons, medulla oblongata** and **cerebellum**.
Pons consists of fibre tracts that interconnect different regions of the brain.

The **medulla** contains centres which control respiration, cardiovascular reflexes and gastric secretions.

Cerebellum controls balance and posture.

Spinal Cord

The spinal cord is a part of the central nervous system. It is a long pipe-like structure arising from the medulla oblongata, part of the brain consisting of a collection of nerve fibres, running through the vertebral column of the backbone. It is segmented with a pair of roots (dorsal and ventral roots) consisting of nerve fibres joining to form the spinal nerves.

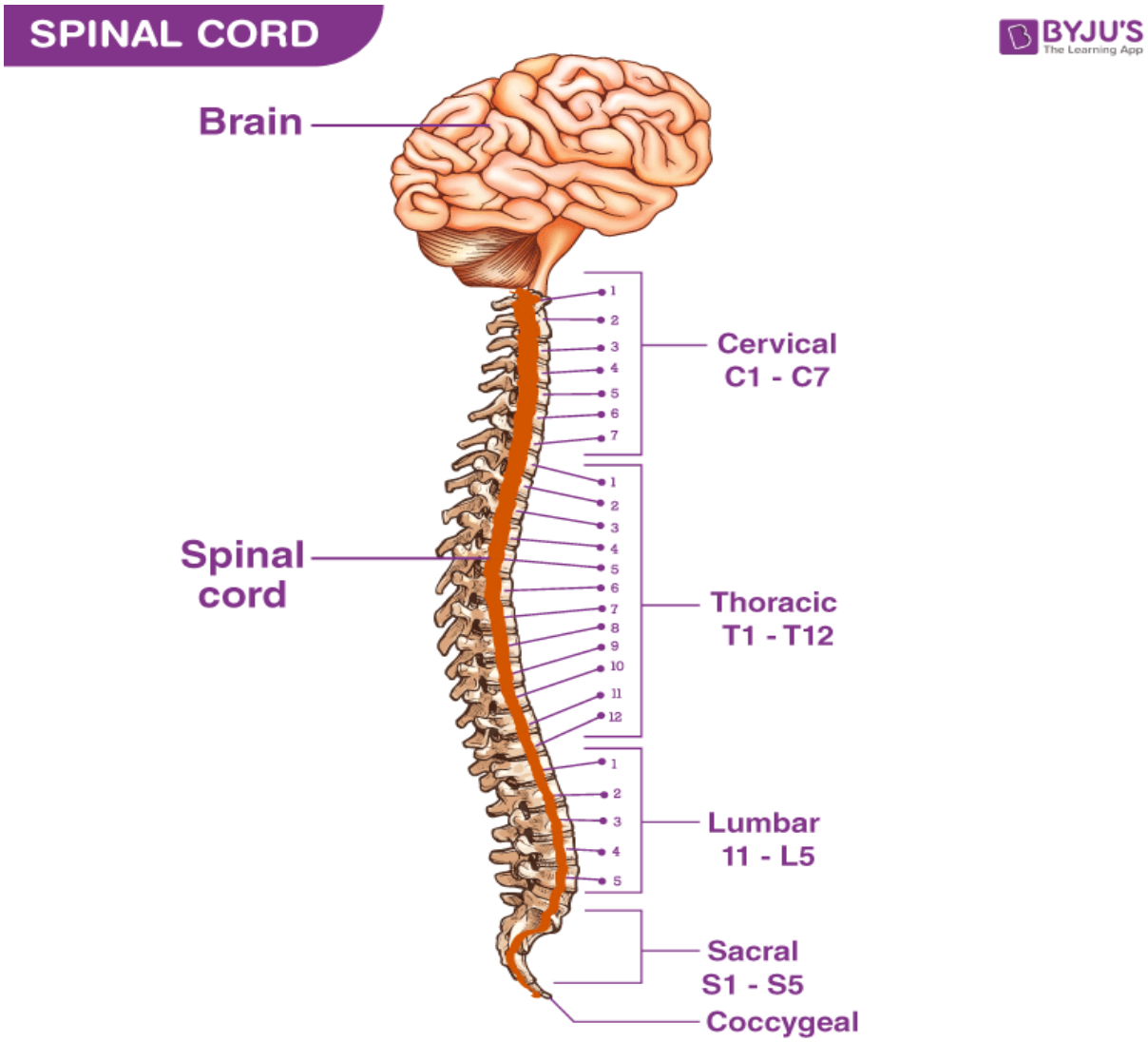
Spinal Cord Anatomy

In adults, the spinal cord is usually 40cm long and 2cm wide. It forms a vital link between the brain and the body.
The spinal cord is divided into five different parts.

- Sacral cord
- Lumbar cord
- Thoracic cord
- Cervical cord
- Coccygeal

Several spinal nerves emerge out of each segment of the spinal cord. There are 8 pairs of cervical, 5 lumbar, 12 thoracics, 5 sacral and 1 coccygeal pair of spinal nerves
It performs the primary processing of information as it carries sensory signals from all parts of the body to the Central Nervous System through afferent fibres.
Nerve tissue consists of the grey and white matter spread across uniformly.

Spinal Cord Diagram



Structure of Spinal Cord

The Spinal cord runs through a hollow case from the skull enclosed within the vertebral column. Spinal nerves arise from different regions of the vertebral column and are named accordingly, the regions are – Neck, chest, pelvic and abdominal.

Cross-section of spinal cord displays grey matter shaped like a butterfly surrounded by a white matter.

Grey matter consists of the central canal at the centre and is filled with a fluid called CSF (Cerebrospinal fluid). It consists of horns (four projections) and forms the core mainly containing neurons and cells of the CNS. There are two dorsal and two ventral horns.

The white matter consists of a collection of axons permitting communication between different layers of CNS. A tract is a collection of axons and carries specialized information. Ascending tracts and descending tracts send and transmit signals from the brain respectively to various nerve cells across the body.

Spinal nerves act as mediators, communicating information to and from the rest of the body and the spinal cord. We have 31 pairs of spinal nerves.

Three layers of meninges surround the spinal cord and spinal nerve roots.

- Dura mater
- Arachnoid mater
- Pia mater

Dura mater consists of two layers- periosteal and meningeal. Epidural space is present between the two layers.

Subarachnoid space lies between the arachnoid mater and pia mater. It is filled with cerebrospinal fluid.

Spinal Cord Nerves

The spinal nerves consist of a group of 31 nerves. These nerves are attached to the spinal cord by two roots- dorsal sensory root and ventral motor root.

The sensory root fibres carry sensory impulses to the spinal cord. The motor roots, on the contrary, carry impulses from the spinal cord.

The spinal nerves carry messages to and from the skin of specific regions of the body called dermatomes.

The spinal cord nerves can be grouped as:

- Cervical
- Thoracic
- Sacral
- Lumbar
- Coccygeal

Cervical Nerves

Cervical means of the neck. There are 8 cervical nerves that emerge from the cervical spine (C1-C8).

Thoracic Nerves

Thoracic means of the chest. There are 12 thoracic nerves that emerge from the thoracic spine (T1-T12).

Lumbar Nerves

Lumbar means from the lower back region. There are 5 lumbar nerves that emerge from the lumbar spine (L1-L5).

Sacral Nerves

Sacral means of the sacrum. The sacrum is a bony plate at the base of the vertebral column.

There are 5 sacral nerves that emerge from the sacral bone (S1-S5).

Coccygeal Nerves

Coccygeal means of the tailbone. There is 1 nerve that emerges from the coccygeal bone.

Function of Spinal Cord

Important functions of Spinal Cord are mentioned below:

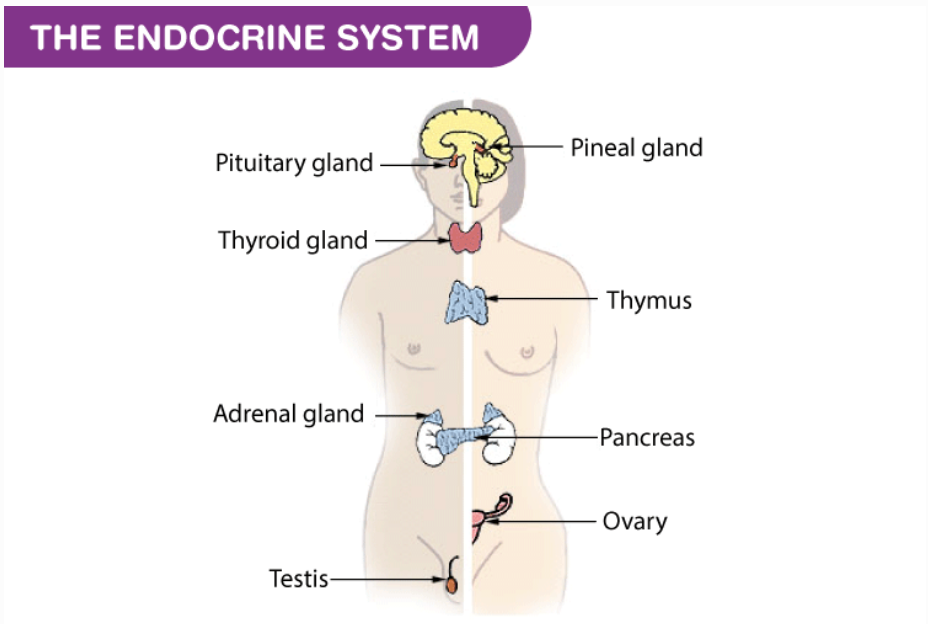
- Forms a connecting link between the brain and the PNS
- Provides structural support and builds a body posture
- Facilitates flexible movements
- Myelin present in the white matter acts as an electrical insulation
- Communicates messages from the brain to different parts of the body
- Coordinates reflexes
- Receives sensory information from receptors and approaches towards the brain for processing.

Chemical coordination and regulation- Endocrine System

Endocrine Gland-

Animals including humans have a complex system of living. In the case of animals, they have the nervous system and endocrine system for control and coordination. The Endocrine System is responsible for the chemical coordination. Numerous involuntary physiological activities are under the control of the endocrine system. It consists of glands which release hormones. Endocrine glands are also called ductless glands. Hormones play a vital role in various activities in the body including growth and development. They also support the nervous system.

Endocrine glands in animals are the hypothalamus, the pituitary gland, the pineal gland, the thyroid, the parathyroid, the thymus, the pancreas, the adrenal gland and the gonads.



Different endocrine glands along with the hormone they release are given below:

Hypothalamus

This gland is a part of the brain that consists of neuro secretory cells. They connect both nervous and endocrine systems. The hypothalamus secretes various releasing hormones like gonadotropin-releasing hormones, **growth hormone**-releasing hormones. These hormones act on pituitary glands to stimulate other glands.

Pituitary Gland

The pituitary gland is the master gland. This is pea-sized and is located at the bottom of the brain. They control and regulate other glands in the body. Hormones released by this gland are growth hormone, thyroid-stimulating hormone, LH, FSH etc.

Pineal Gland

This is also a gland located in the brain. It releases the hormone called melatonin which regulates the wake-up and sleep clock and helps in **immunity** etc.

Thyroid Gland

This is present in front of the neck. It releases the hormones triiodothyronine (T3) and thyroxine (T4). They regulate body metabolism. Iodine is vital for thyroxine synthesis. Its deficiency leads to a disease called goitre.

Parathyroid Gland

This is a butterfly-shaped paired gland. The hormone released by this gland is called parathormone which regulates calcium and phosphorus level in bones.

Pancreas

The pancreas is endocrine as well as an exocrine gland. The pancreas secretes hormones like glucagon, insulin; these two balance the blood sugar level in the body. Other hormones secreted are somatostatin and pancreatic polypeptide.

Adrenal glands

Adrenal glands have two regions known as the adrenal cortex and adrenal medulla. Cortex region secretes the hormones cortisol, aldosterone, and androgens while the medulla region secretes the hormones adrenaline and noradrenaline. Adrenaline is the “hormone of fight or flight”.

Gonads

Gonads are reproductive glands present in male and female. Male gonad is the pair of testes which secretes the hormone testosterone. This is responsible for the secondary sexual characteristics in males. Female gonad consists of a pair of ovaries. They secrete two hormones estrogen and progesterone. Both of these regulate the secondary sexual characteristics in females.

Hormones and their functions-

Hormones are the chemicals the endocrine system uses to send messages to organs and tissue throughout the body. Once released into the bloodstream, hormones travel to their target organ or tissue, which has receptors that recognize and react to the hormone. Below are some examples of hormones that are produced by the endocrine system.

Hormone	Secreting gland(s)	Function
Adrenaline	adrenal	increases blood pressure, heart rate, and metabolism in reaction to stress
Aldosterone	adrenal	controls the body's salt and water balance
Cortisol	adrenal	plays a role in stress response
Dehydroepiandrosterone sulfate (DHEA-S)	adrenal	aids in production of body odor and growth of body hair during puberty
Estrogen	ovary	works to regulate the menstrual cycle, maintain pregnancy, and develop female sex characteristics; aids in sperm production
Follicle-stimulating hormone (FSH)	pituitary	controls the production of eggs and sperm
Glucagon	pancreas	helps increase levels of blood glucose (blood sugar)
Insulin	pancreas	helps reduce your blood glucose levels
Luteinizing hormone (LH)	pituitary	controls estrogen and testosterone production as well as ovulation
Melatonin	pineal	controls sleep-wake cycles
Oxytocin	pituitary	helps with lactation, childbirth, and mother-child bonding
Parathyroid hormone	parathyroid	controls calcium levels in bones and blood
Progesterone	ovary	helps prepare the body for pregnancy when an egg is fertilized
Prolactin	pituitary	promotes breast-milk production

Testosterone	ovary, teste, adrenal	contributes to sex drive and body density in males and females as well as development of male sex characteristics
Thyroid hormone	thyroid	helps control several body functions, including the rate of metabolism and energy levels

Human Reproductive System

Reproduction can be defined as the biological process of producing a new individual or an offspring identical to the parents. This process ensures the increase in the number of individuals of a species when conditions are favourable. It is one of the fundamental characteristics of living things and an essential life process.

There are two types of reproduction – asexual and sexual.

Sexual Reproduction –This process of reproduction is very complex that involves the formation and transfer of gametes, followed by fertilization, the formation of the zygote, and embryogenesis.

Asexual Reproduction — This process of reproduction involves only one parent and the new offspring produced is genetically similar to the parent.

Reproduction in Human Beings

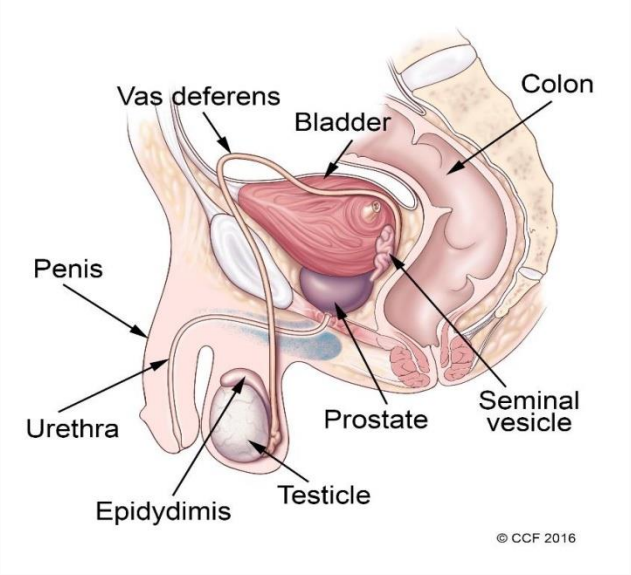
All human beings undergo a sexual mode of reproduction. In this process, two parents are involved in producing a new individual. Offspring are produced by the fusion of gametes (sex cells) from each parent. Hence, the newly formed individual will be different from parents, both genetically and physically. Human reproduction is an example of sexual reproduction.

In human beings, both males and females have different reproductive systems; hence, they are known to exhibit sexual dimorphism. Males have testes- also called testicles, while the females have a pair of ovaries.

Human Reproductive System

The reproduction in human beings involves the fusion of male and female gametes produced in their reproductive system. The male reproductive system is different from the female reproductive system, both in structure and in function.

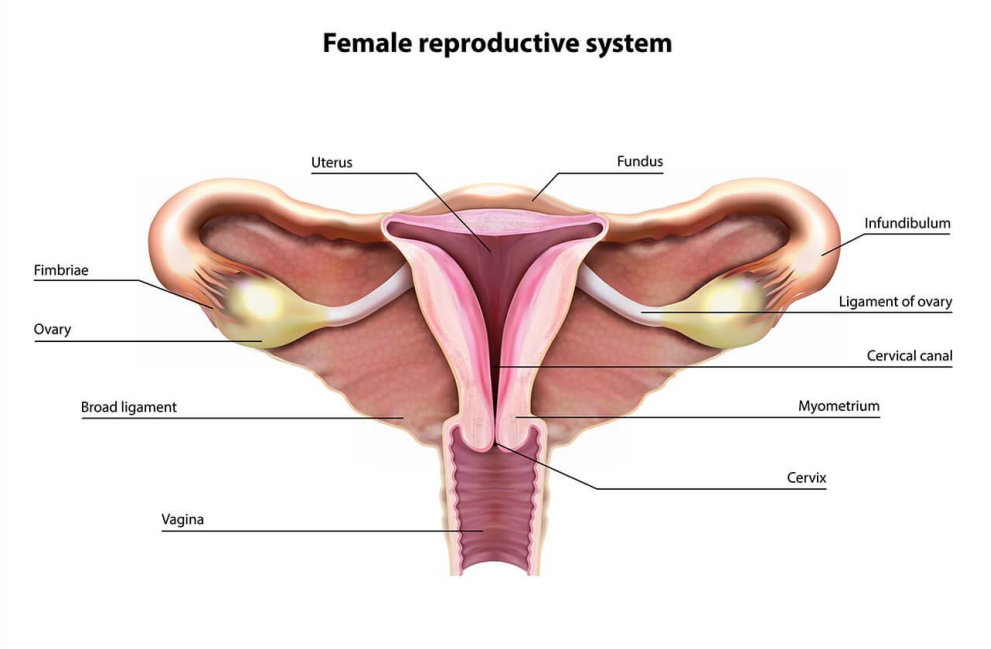
Male Reproductive System- The male gametes, i.e., sperms are produced within the male reproductive system. Sperms are small unicellular structures with a head, middle piece, and a tail.



The male reproductive system consists of:

- **Testicles (testes):** A pair of oval-shaped organs masked in a pouch called the scrotum. They are responsible for the production of sperms and the male hormone testosterone.
- **Scrotum:** It is a sac-like organ that hangs below the penis and behind it. It is the houses of the testicles, or testes, and maintains a temperature that is required for the production of sperm by it.
- **Vas deferens:** The sperms produced in testes are stored in a tube called the epididymis. Here the sperms get matured and pass to urethra through the muscular tube called vas deferens.
- **Accessory glands:** This includes three glands, namely seminal vesicles, prostate gland, and Cowper's gland. The secretions from the three glands mix to form a fluid called semen. Semen nourishes the sperm, increases the volume and helps in lubrication.
- **Penis:** Penis is a cylindrical tube which serves as both reproductive organ and an excretory organ. It delivers sperms into the vagina during sexual intercourse.

Female Reproductive System



The female reproductive system is active before, during and after fertilization as well. It consists of the following parts:

- **A pair of ovaries**: Ovaries produce and store ovum in them. They also produce a female hormone called estrogen.
- **Fallopian tubes (Oviducts)**: They are the site of fertilization. They connect ovaries with the uterus.
- **Uterus**: Uterus is the site of development for the embryo.
- **Vagina:** It is the part which connects the cervix to the external female body parts. It is the route for the penis during coitus as well as a fetus during delivery.

Female reproductive system has two functions –

1. Production of female gamete called ovum/egg.
2. Providing nutrition and protecting the developing embryo.

During puberty, eggs in the ovaries start to mature. One of the ovaries releases the matured ovum in every 28 to 30 days and is called ovulation.

Reproduction Process in Human Beings

The process of fusion of sperm with egg (ovum) to produce zygote is called fertilization. Fertilization is a crucial stage of reproduction in human beings. The fertilized egg is called the zygote. Zygote starts to divide into many cells and develops into an embryo.

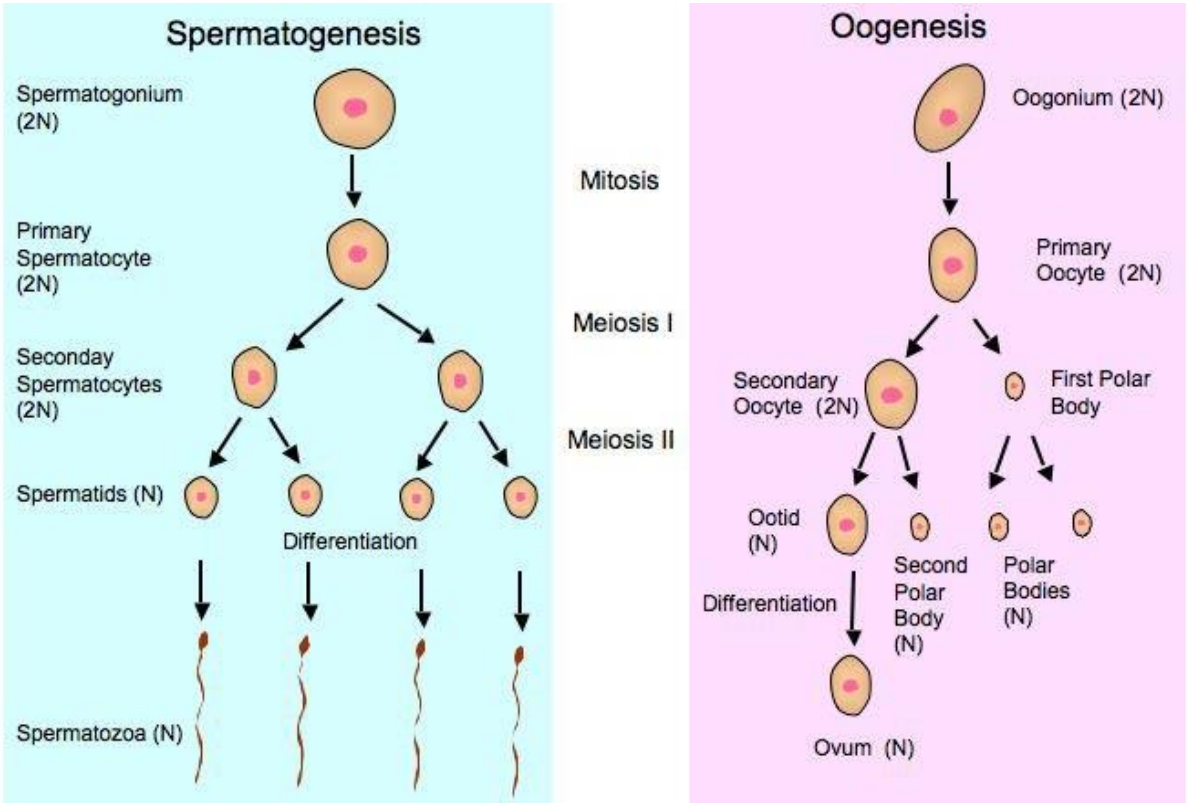
Embryo moves into the uterus and gets attached to its walls. This process is referred to as implantation, and the implanted embryo eventually develops into a fetus.

Gametogenesis - Spermatogenesis and Oogenesis

An organism undergoes a series of changes throughout its life cycle. Gametogenesis (spermatogenesis and oogenesis), plays a crucial role in humans to support the continuance of generations.

Gametogenesis is the process of division of diploid cells to produce new haploid cells. In humans, two different types of gametes are present. Male gametes are called sperm and female gametes are called the ovum.

- **Spermatogenesis**: Sperm formation
- **Oogenesis**: Ovum formation



Spermatogenesis

In the male, immature germ cells are produced in the testes. At puberty, in males, these immature germ cells or spermatogonia are converted into sperms by the process of spermatogenesis. Spermatogonia are diploid cells that undergo mitotic division and their number increases. Primary spermatocytes undergo meiosis and produce haploid cells- secondary spermatocytes. These secondary spermatocytes undergo the second meiotic division to produce immature sperms or spermatids. These spermatids undergo spermiogenesis to transform into sperms. Various hormones like GnRH, LH, FSH and androgens are involved in stimulating spermatogenesis.

Oogenesis

In females, the oogonia are converted to the mature ovum. This process is called oogenesis. In the female ovary, millions of oogonia or mother cells are formed during fetal development. These mother cells undergo the meiotic cell division, the meiotic division rests at the prophase-I and lead to the production of primary oocytes. Primary oocytes are embedded within the primary follicles on the outer layer. Primary follicles get surrounded by more granulosa cell layer and forms secondary follicles. Secondary follicles then turn into the tertiary follicle. At the stage of female puberty, the primary oocytes present in the tertiary follicles complete meiosis and form secondary oocytes (haploid) and the polar body by unequal division. The tertiary follicle undergoes some structural and functional changes and produces mature Graafian follicle. Secondary oocyte undergoes second meiotic division to form an ovum. Ovum is released from the Graafian follicle during the menstrual cycle. The release of an ovum from the Graafian follicle is called ovulation. Ovulation is controlled by the female reproductive hormone which is stimulated by the pituitary gland.

Menstrual Cycle-

Menstruation

In a life cycle, a woman's body is vulnerable to a variety of changes. The cycle of these changes occur in women every month, positively for pregnancy is called the menstrual cycle. When an ovum is unfertilized, the uterus lining sheds and leads to a haemorrhage, called menstruation.

In a girl, menstruation starts from the age of 10 to 15 when she attains puberty and this beginning is known as menarche. The ending of menstruation is known as menopause which takes place at the age range of 50.

The first day of bleeding is marked as the first day of a menstrual cycle and the period from one menstrual cycle to another can vary from 28 to 30 days.

Phases of the Menstrual Cycle

The menstrual cycle is divided into four phases, namely:

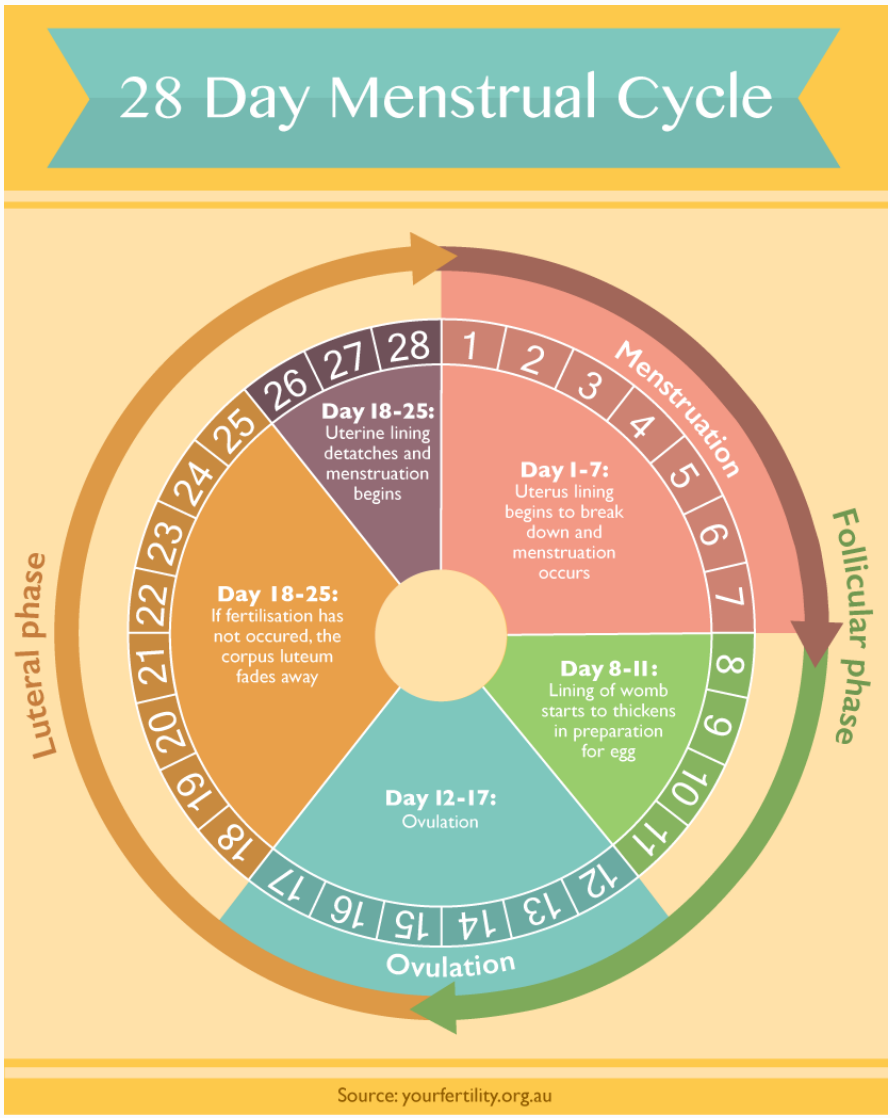
1. **Menstrual phase:** Day 1, uterus lining which is prepared for implantation starts to shed which lasts 3 to 5 days.

2. **Follicular phase:** In this phase, the primary follicle starts developing into a mature Graffian follicle. The endometrium also starts proliferating. The uterus starts preparation for another pregnancy.

3. **Ovulatory phase:** Mid-cycle phase, this is the phase in which ovulation takes place i.e., day 13-17. The end of the follicular phase along with the ovulation period defines the fertilisation period.

4. **Luteal phase:** It is the post-ovulation phase, where the fate of the corpus luteum is decided. If fertilisation occurs, pregnancy starts. If fertilisation doesn't occur, it marks the onset of another cycle.

Menstrual Cycle Diagram



Role of Hormones in Menstrual Cycle

The chemical messengers in our body called hormones, released by various endocrine glands are responsible for many changes in a human body. Menstruation is a slave to certain hormones. Every phase of the menstrual cycle is influenced by a female hormones namely estrogen, progesterone, FSH and LH. The variation in the level of each of these hormones decides the phase which a girl undergoes.

References for more learning

NCERT Biology books

Important question

2 marks

1. What do you mean by Excretion?
2. Define Menstrual cycle.
3. Define Oogenesis.
4. Enumerate various parts of human central nervous system.
5. What do you understand by endocrine glands?
6. Name the hormones secreted by Pancreas.
7. What is Renin-angiotensin system?

5 Marks

1. Explain role of Kidney in excretion.
2. Describe various phases of menstrual cycle.
3. Write a brief note on hormones that regulate sugar and growth in human body.
4. Draw a well labeled diagram of human brain.
5. What is Spinal cord? Enumerate various parts of spinal cord with diagram.
6. Discuss the process of urine formation.

10 marks

1. Write a detailed note on human excretory system.
2. Write a detailed note on human endocrine system.
3. Write a detailed note on human central nervous system.
4. Write a detailed note on formation of fertilization gametes in both male and female.