CIRCULATORY SYSTEM

1. INTRODUCTION

Our body is made of cells. Cells need nutrients and oxygen to survive, and wastes need to be removed from them. Hormones are also needed to be transported from the endocrine glands which secrete them to their respective target cells. This work of transportation of nutrients, gases, wastes and other substances from one part of our body to the other part, is carried out by blood, and termed circulation.

1.1 Functions of circulatory system

(i) Transport of nutrients to the tissues for their utilization

(ii) Transport of respiratory gases (O2 and CO2) to and from the cells.

(iii) Collection of metabolic wastes from different tissues and transporting them to excretory organs for their removal.

(iv) Transport of hormones from endocrine glands to target organs.

(v) Protection of body by destroying pathogens.

(vi) Uniform distribution of heat in the body.

2. HUMAN CIRCULATORY SYSTEM

The circulatory system consists of the following parts:

1. Heart – the central pumping organ.

2. Blood vessels – the connecting tubes – arteries, veins and capillaries

3. Blood – is the circulating fluid, a connective tissue made of a fluid matrix and Plants and animals cells.

4. Lymphatic system comprises of lymph nodes and lymph vessels.

2.1 The human heart

It is a muscular organ made of cardiac muscle fibres. It is able to perform its function by coordinating contraction and, relaxation and opening and closing of a number of valves present inside the heart. This fist sized organ consists of 4 chambers, the two upper chambers – the atria and two lower chambers – the ventricles. Ventricles have thick muscular walls for pumping blood to longer distances. Heart is covered by a membrane – the pericardium.

(i) Valves inside the heart Locate the following valves

The atrio-ventricular valves are between Atria and Ventricles.

(a) Right atrio-ventricular valve or tricuspid valve

(b) Left atrio-ventricular valve or bicuspid valve Semilunar valves at the origin of aorta and pulmonary artery. Valves open only on one side like a door. They regulate the flow of blood by opening on one side to let blood flow out in one direction only and prevent the back flow of blood.

(ii) Heart beat and cardiac cycle The beating of heart goes on by itself as long as one is alive. Each heartbeat consists of the steps mentioned below and makes two sounds – Lub and Dub during each beat.

(a) The heart beat starts with contraction or systole of atria, followed by relaxation or diastole. The lub sound or 1st heart sound occurs due to closure of atrioventricular valves, the atrial systole.

(b) Contraction of ventricles followed by relaxation accompanied by the dub sound or the 2nd heart sound occurs due to closure of semi lunar valves. At the beginning of every heart beat the four chambers of the heart are in the relaxed state (Joint diastole). At this stage the vena cava pour deoxygenated blood into right atrium and the pulmonary vein pours oxygenated blood into left atrium.

Heart beat originates at the Sinu-Atrial Node or S.A Node which is a modified part of the muscular wall in the upper corner of the right atrium

Atrio-Ventricular Node (A.V. Node), modified muscle is located in the interatrial septum. When impulse comes from SA node to AV node, the contracted atria begin to relax and impulse passes to Bundle of HIS lying in the interventricular septum and then passes to Purkinje Fibers lying in the walls of ventricles. As a result ventricles contract (Ventricular systole)

2.3 Blood vessels

The tubes transporting blood are called Blood Vessels. The wall of a blood vessel has three layers, tunica externa, tunica media and tunica interna.

There are 3 kinds of blood vessels: (i) Artery (ii) Capillary and, (iii) Vein. These three vessels differ in structure and speed of blood flow.

2.3.1 Major Arteries and Veins

Blood that has been circulated through the body has lost much of the O2, it carried. This de-oxygenated blood returns to the heart by two major veins.

1. Superior vena cava-brings deoxygenaled blood from head and shoulder region.

2. Inferior vena cava-brings deoxygenated blood from lower parts of the body.

2.4 Double circulation

Since blood passes twice through the heart, it is termed Double circulation

(i) First Deoxygenated blood passes from the body to heart and oxygenated blood from heart to the body.

(ii) Then Deoxygenated blood flows from heart to lungs and oxygenated blood Plants and animals from lungs again to heart, from lungs. In one circulation, the blood passes through the heart twice. Once from body to heart to lungs and second time from lungs to heart to body. Path of circulation

- *First from body to heart (Venae cavae carry blood from tissues with very little oxygen and lot of CO2 to Right atrium)*
- *Tricuspid valve opens*
- *Right ventricle*
- *Pulmonary arteries*
- *(Pulmonary arteries carry blood to lungs to give up CO2 and to collect O2 from lungs) Pulmonary veins*
- *(Pulmanary veins carry oxygenated blood back to left atrium of heart)*
- *Left atrium*
- *Bicuspid valve*
- *Left ventricle*
- *Aorta (carries blood with a lot of oxygen and distributes this oxygenated blood to different parts of the body)*

3. COMPONENTS AND FUNCTIONS OF BLOOD

Blood is a red coloured, thick and slightly alkaline, fluid which keeps circulating in our body through the blood vessels. Why is blood so important? It is important because 1. it transports substances in the body such as Oxygen, nutrients, and hormones. It also carries waste to the kidney. 2. it protects body against disease. 3. it maintains normal body temperature.

3.1 The components of blood

3.1.1 Plasma

It is a pale yellow liquid consisting of blood proteins like albumin, globulin and fibrinogen.

Functions:

Plasma has the following functions: - Plants and animals

1. Transport of products of digestion from small intestine to various tissues.

2. Transport of waste products from tissues to excretory organs.

3. Transport of hormones from endocrine glands to target organs.

4. Maintenance of temperature by distribution of heat all over the body.

5. Provides factors for clotting of blood (Fibrinogen).

6. Retention of fluids in blood (through plasma proteins).

7. Maintenance of acid-base equilibrium in the blood.

8. Provides body immunity through antibodies (Immunoglobulin) which are made by one kind of WBC and then released into the plasma.

3.1.2 Blood Cells

The cells of blood are Red Blood Corpuscles (RBC) and White Blood Corpuscles (WBC) and cell fragments, the Platelets. Blood cells are formed in the bone marrow. Their formation is termed haemopoiesis

3.1.3. Coagulation of Blood (Blood Clotting)

Sometime or the other, got a cut on your finger and seen blood flowing out of it . You would have noticed that after a few minutes, the blood flow stops, as the blood thickens and forms a lump. This lump is called clot. The process of thickening of blood is called coagulation or clotting of blood.

3.1.4 Blood group

The blood of an individual may belong to any one of the four blood groups, A, B, AB, and O. Blood group remains constant throughout lifetime as it is genetically controlled and is inherited from parents. These blood groups are due to the presence of special proteins present on the membrane of RBCs termed as antigens. Antigens present could be A, B both A and B or no Antigen may be present in the cell membranes of RBC of a particular blood group. Blood plasma, on the other hand, contains antibodies a, b, or both a and b, or neither of the two. Antigen A reacts with antibody b and antigen B with antibody a causing clumping of blood.

4. BLOOD PRESSURE

We already learnt that during systole, the ventricles contract and force the blood into the arteries, which carry it to all parts of the body. The flow of the blood in the arteries exerts a pressure on their elastic walls. This pressure is called blood pressure. The pressure of blood at the time of ventricular contraction is higher and is called systolic pressure. When ventricles are relaxed and are being filled by blood, there is a drop in pressure. This lower pressure is called diastolic pressure. These two pressures can be measured in the arteries of the arms. The device used for measuring blood pressure is called Sphygmomanometer. A reading of 120/75 means that the person's systolic pressure is 120 mm of mercury and diastolic pressure is 75 mm of mercury. A typical reading for a healthy adult is 120 ± 570 ± 5 mm of mercury. The difference between diastolic and systolic pressure can be felt as a throb in the arteries

of the wrist. This throb at the wrist is called Pulse. The number of throbs felt at a particular point on the wrist (due to systole) per minute is called Pulse Rate. It is equal to the number of heart beats i.e. around 70 beats per minute for a normal adult.

5. LYMPHATIC SYSTEM

This system consists of a series of branching vessels and a collection of lymphatic organs. Let us understand. A continuous exchange of materials between the blood capillary and the intercellular fluid (fluid present between cells of tissues) goes on. Some important components like proteins that could not be sent back to blood capillaries from intercellular fluid, are taken up by the lymph capillaries as lymph and drained into veins in the lower neck portion of the body (subclavian vein). Lymph should be regarded as modified tissue fluid. The clear, colourless liquid moving out of the capillary wall is called Lymph. Lymph comes into direct contact with body cells.

5.1 Functions of lymph

(i) Supplies nutrition and oxygen to those parts of body where blood cannot reach

(ii) Drains away, excess tissue fluid from extra-cellular spaces and pours back into the blood.
(iii) Absorbs and transports fats absorbed from small intestine (lacteals)

(iv)Collect nitrogenous waste

(v) Lymphocytes and antibodies present in lymph help in removing bacteria

5.2 Lymph nodes

Each node is a clump of tissue housing a number of lymphocytes. These nodes act as filters for bacteria, viral particles and cancerous cells. These resident lymphocytes then immediately attack the disease causing germs or pathogens.

5.3 Spleen

It is the largest lymphoid organ and has the following functions

- *(i) Haemopoiesis – Formation of Blood cells in the foetus*
- *(ii) Destruction of old and worn out blood cells and hence termed as 'grave yard' of RBC.*
- *(iii) Blood reservoir*
- *(iv) Defensive action by engulfing bacteria*

6. DISORDERS RELATED TO BLOOD AND HEART

The state of having high blood pressure is called hypertension. Hypertension is usually related to stress, overweight, age or faulty diet. Other heart related disorders are atherosclerosis and arteriosclerosis. Sometimes, especially if too much of fatty food is taken over a long period, there is a tendency for fat to deposit on the inner wall of the arteries. Such a deposit is called atheroma and the disorder atherosclerosis

7. ECG

Electrocardiograph is a machine which can record the heartbeat like a graph which is called electrocardiogram (ECG). From the ECG, the doctor can make out which chamber of the heart is not contracting or relaxing properly and suggests treatment accordingly.

HUMAN ENDOCRINE SYSTEM

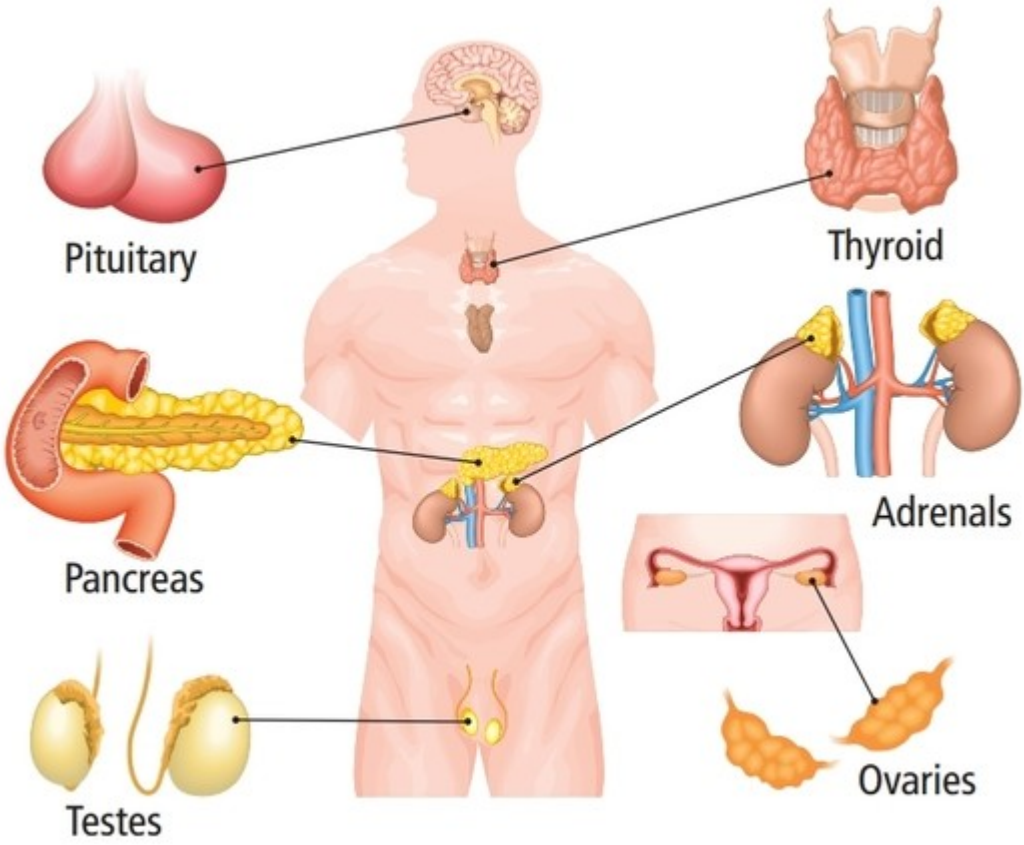
Learning objectives:

- *Introduction*
- *Endocrine glands*
- *questions*

1. INTRODUCTION

The human endocrine system is composed of endocrine glands.

- *An endocrine gland is an organ that secretes a hormone directly into the bloodstream.*
- *A hormone is a chemical messenger secreted by an endocrine gland directly into the bloodstream where it travels to a target organ/tissue where it exerts a specific effect.*



Exocrine versus endocrine glands:

- *Exocrine gland is an organ that secretes its product into a duct.*
- *Endocrine gland secretes its product directly into the bloodstream.*

Endocrine action versus nerve action:

- *Endocrine action is slow, prolonged, and chemical in nature.*
- *Nerve action is fast, short-lived, and electrical in nature.*

2. ENDOCRINE GLANDS

2.1 Hypothalamus:

Hypothalamus: secretes hormones that control the secretions of the pituitary, e.g. growth hormone releasing hormone

2.2 Pineal gland:

Pineal: secretes melatonin – regulates biorhythms such as sleep and menstrual cycle

2.3 Pituitary gland:

Pituitary (master gland) – controls all other glands: secretes many hormones – one example is growth hormone (GH) stimulates protein synthesis and bone elongation (growth)

2.4 Thymus gland:

Thymus: secretes thymosin which helps white blood cells (that are made in the bone marrow) to mature into active immune cells

2.5 Pancreas endocrine gland:

Pancreas: the islets of Langerhans in the pancreas secrete insulin which stimulates all cells to absorb glucose

- *Diabetes results if there is no insulin or lack of insulin in the body*
- *Insulin is used as a hormone supplement to treat type I diabetes*

2.5 Adrenal glands:

Adrenals: secrete adrenaline ('fight or flight' hormone) which is secreted in times of stress or danger

Adrenaline:

- Increases blood flow to the brain and muscles
- Decreases blood flow to the skin and internal organs such as the intestines and kidneys
- Dilates the bronchioles allowing more air in

- Increases blood glucose levels
- Increases heart rate

2.6 Ovaries and testes:

Ovaries: secrete oestrogen (stimulates changes that occur at puberty in females) and progesterone which are both involved in the menstrual cycle and in preparing the female body for a possible conception

Testes: secrete testosterone which stimulates the changes that occur in the male at puberty and also help to maintain these changes (called secondary sexual characteristics)

- Anabolic steroids act in the same way in which testosterone acts – builds up muscle - therefore, anabolic steroids are used by body-builders and they have also been used (illegally) by athletes to boost athletic performance

2.7 Thyroid and parathyroid glands

Thyroid: secretes thyroxine which increases metabolism

Parathyroid: secretes parathormone which stimulates release of calcium from bone

***Thyroxine deficiency leads to myxoedema**:*

Goitre (swelling of the thyroid gland)

- *Low metabolic rate and mental retardation (cretinism in children)*
- *Tiredness, fatigue*
- *Weight gain (fluid build up – oedema)*
- *Treatment:*
- *Thyroxine is administered (tablets)*
- *Iodine is administered (tablets)*
- *Excess of thyroxine leads to:*
- *Bulging eyeballs*
- *Goitre*
- *Increased appetite*

- *Irritability*
- *Heat intolerance*

Treatment:

- *Surgical removal of part of the thyroid*
- *Anti-thyroid drugs*
- *Administration of radioactive iodine*

Negative Feedback Mechanism of Thyroxine

- *When thyroxine levels rise above normal:*
- *Pituitary stops secreting thyroid-stimulating hormone (TSH) thereby causing the thyroid to reduce secretion of thyroxine*
- *When thyroxine levels fall below normal:*
- *Pituitary starts secreting TSH causing the thyroid gland to secrete more thyroxine*
- *When iodine is completely absent from diet thyroxine cannot be made – therefore, pituitary keeps secreting TSH which builds up to extreme levels in the thyroid causing goitre*

Q1. Define the following:

(a) Exocrine gland,

(b) Endocrine gland,

(c) Hormone.

Q2. Diagrammatically indicate the location of the various endocrine glands in our body.
Q3. List the hormones secreted by the following:

(a) Hypothalamus

(b) Pituitary

(c) Thyroid

(d) Parathyroid

(e) Adrenal

(f) Pancreas

(g) Testis

(h) Ovary

(i) Thymus

(j) Atrium

(k) Kidney

(l) G-l Tract.

Q5. Write short notes on the functions of the following hormones:

(a) Parathyroid hormones (PTH)

(b) Thyroid hormones

(c) Thymosin

(d) Androgens

(e) Estrogens

(f) Insulin and Glucagon.

HUMAN REPRODUCTIVE SYSTEM

Learning objectives:

- *Sexual reproduction*
- *Male reproductive system*
- *Female reproductive system*
- *Fertilization*
- *Questions*

1. SEXUAL REPRODUCTION

In sexual reproduction, genes from two individuals are combined in random and novel ways. This generates diversity within the species.

- *Normally each cell in the adult has 23 pairs of chromosomes or 46 total chromosomes.*
- *22 pairs are called autosomal chromosomes*
- *1 pair is called the sex chromosomes*
  - *XX sex chromosome is female*
  - *XY sex chromosome is male.*

1.1 Formation of the zygote

At puberty cells in the gonads (testis or ovaries) undergo meiosis. 23 pairs of homologous chromosomes become 23 chromosomes. The germ cell from the male (sperm) will then fuse with the germ cell of the female (ovum) during reproduction to reform a cell with 23 pairs of homologous chromosomes. The sex of the zygote is determined by the sex chromosome of the fertilizing sperm.

1.2 Development of the Reproductive System

Formation of Testis and Ovaries

After conception the embryonic gonads of males and females are similar (for about the first 40 days). Therefore the embryo can form either testes or ovaries. The presence or absence of the Y chromosome determines what happens. SRY (sex determining region of the Y chromosome) on the Y chromosome ® male. SRY gene encodes the testi-determining factor.

1.3 Accessory Sex organs:

For the first 40 days the reproductive system of the embryo is undifferentiated and has accessory organs characteristic of either sex.

***Male**: Wolffian ducts ,epididymis, ductus (vas deferens), seminal vesicles, ejaculatory duct.*

- *Sertoli cells: Mullerian inhibitory factor (MIF): regression of the Mullerian ducts*
- *Leydig cells: Testosterone: epididymis, ductus (vas) deferens, seminal vesicles, ejaculatory duct.*

***Female**: Mullerian ducts ,uterus, fallopian tubes*

External Genitalia

External genitalia of males and females are identical for the first 60 days.

- *Male: penis, urethra, prostate, and scrotum*
- *Female: clitoris, labia majora*

2. MALE REPRODUCTIVE SYSTEM

2.1 Testis:

The testis contains two compartments:

- *Seminiferous tubules (90% of weight): Sertoli cells, spermatogenesis, stimulated by FSH*
- *Interstitial compartment: Leydig cells, stimulated by LH*

2.1.1 <u>Spermatogenesis</u>

From spermatogonia (original stem cell in gonad) to spermatozoa. Cells migrate from the embryonic yolk sac to the testes. In the seminiferous tubules they become spermatogonia and then through a process called spermatogenesis the spermatogonia become spermatids and then mature spermatozoa. The process from spermatids to spermatozoa is called spermatogenesis.

- *Testosterone required for spermatogenesis in adult.*
- *Later stages of spermatogenesis require FSH. Testosterone and FSH act on Sertoli cells which probably release paracrine substances that stimulate spermatogenesis*
- *spermatozoa are non-motile in testes. They become motile and undergo other changes outside of the testes.*

Spermatozoa have 3 parts:

a. *oval-shaped head: contains the DNA*
b. *midpiece or body: contains mitochondria for energy*
c. *tail: for swimming*

2.2 Male Reproductive Tract

- Testes: formation of sperm
- Epididymis: sperm maturation and sperm storage
- Vas deferens: duct to transport spermatozoa towards the seminal vesicles
- Seminal vesicles: add secretions to form semen
- Prostate gland: add secretions to semen

Semen

1. *seminal vesicles: 60% of semen volume comes from seminal vesicles — contains fructose*

2. *prostate gland: citric acid, calcium, coagulation proteins*

3. FEMALE REPRODUCTIVE SYSTEM

- *Ovaries: contain follicles which contain ova.*
- *Accessory Sex Organs*
- *Uterine or Fallopian tubes: ducts directly connected to uterus*
- *Uterus: 3 layers perimetrium (connective tissue), myometrium (smooth muscle), endometrium (epithelium)*

3.1 Oocyte and Follicle Development

At 5 months of gestation there is a peak of about 6-7 million oogonia. After 5-6 months production of oogonia stops and never resumes. These oogonia become primary oocytes by the end of gestation. At puberty there are only about 400,000 primary oocytes. Only about 400 of these oocytes will actually ovulate during a woman's lifetime.

- *Oocyte Development: oogonia (46 chromosomes)-primary oocyte (46 chromosomes) - secondary oocyte (23 chromosomes) -zygote (if fertilized)*
- *Follicular Development: primary follicles - secondary follicles - graafian follicle - corpus luteum (after ovulation)*

Types of Follicles:

- *Primary follicle: immature: primary oocyte + a single layer of follicular cells mature: primary oocyte + a number of layers of follicular cells.*
- *Secondary follicle: primary oocyte or secondary oocyte plus numerous layers of granulosa cells and fluid filled vesicular cavities*
- *Graafian follicle: secondary oocyte, arrested before second meiotic division, plus layers of granulosa cells and a single large fluid filled cavity (antrum).*

3.2 Menstrual Cycle

Changes in Ovary

- *Menstruation (Day 1 to Day 4or 5): steroid hormones lowest, ovaries contain primary follicles*

- *Follicular Phase (Day 1 to Day 13, highly variable): FSH- growth of follicles, one becomes mature graafian follicle, granulosa cells secrete estradiol*

***Positive feedback loop:** (LH surge): estradiol- GnRH-LH secretion-estradiol by ovaries*

- *Ovulation: FSH, followed by LH surge causes rupture of graafian follicle, expulsion of secondary oocyte into uterine tubes. Occurs about 24 hours after beginning of LH surge*
- *Luteal Phase: empty follicle becomes corpus luteum, secretes estradiol and progesterone.*

***Negative feedback loop**: progesterone, estradiol -FSH, LH secretion-development of follicles.*

Changes in the endometrium

- *Proliferative Phase: proliferation of endometrium and increase in blood vessels (spiral arteries)*
- *Secretory Phase: development of endometrium — thick, vascular, spongy — in preparation for the embryo.*
- *Menstrual Phase: constriction of spiral arteries - cell death - sloughing of layer of endometrium. Bleeding phase.*

3.3 Contraceptive Methods

Conception is most likely to occur when intercourse takes place 1-2 days prior to ovulation.

- *Contraceptive pill: contains estrogen and progesterone, maintains negative feedback throughout cycle, so no LH surge and therefore no ovulation.*
- *Rhythm method: measure slight variations in temperature that normally occur just prior to ovulation. Often hard to detect temperature changes.*

4. FERTILIZATION

Fertilization occurs in the uterine tubes.

1. *Sperm capacitation, a series of changes which makes sperm fertile, occurs in the female tract. Sperm can last up to 3 days in female reproductive tract.*
2. *Sperm fuses with ovulated oocyte in the uterine tube*
3. *Fusion of one sperm prevents other sperm from fertilizing oocyte*
4. *Zygote (diploid, 46 chromosomes) forms 12 hours after fertilization*
5. *The zygote begins dividing (cleavage)*
6. *Unfertilized oocyte will degenerate 12-24 hours after ovulation.*

Fertilization cannot take place more than 1 day after ovulation. Since sperm live for 3 days in the female reproductive tract, fertilization can occur up to 3 days prior to ovulation.

4.1 Blastocyst Formation

- *3 days after ovulation the embryo (8 cells at this point) enters the uterus*
- *2 days later blastocyst forms*
- *7 days after fertilization embryo is implanted in the uterine wall (endometrium)*

4.2 Human chorionic gonadotropin

The embryo secretes chorionic gonadotropin (hCG). This maintains the corpus luteum and thus estradiol and progesterone secretion remain elevated. Since estradiol and progesterone levels remain elevated the endometrium is maintained, menstruation is prevented, and the embryo continues to grow.

Q1. Draw a labelled diagram of male reproductive system.

Q2. Draw a labelled diagram of female reproductive system

Q3. Write two major functions each of testis and ovary.

Q4. What is spermatogenesis? Briefly describe the process of spermatogenesis.

Q5. Name the hormones involved in regulation of spermatogenesis.

Q6. Define spermiogenesis and spermiation.

Q7. What is oogenesis? Give a brief account of oogenesis.

Q8. What is menstrual cycle? Which hormones regulate menstrual cycle?

Q9. Fill in the blanks:
(a)Humans reproduce————— (asexually/sexually).
(b)Humans are————— (oviparous, viviparous,ovoviviparous).
(c)Fertilization is————— in humans (external/internal).
(d)Male and female gametes are————(diploid/haploid).
(e)Zygote is————— (diploid/haploid).
(f)The process of release of ovum from a mature follicle is called————— .
(g)Ovulation is induced by a hormone called————
(h)The fusion of male and female gametes is called————— .
(i)Fertilization takes place in————
(j)Zygote divides to form————— which is implanted in uterus.
(k)The structure which provides vascular connection between foetus and uterus is called ————— .

NERVOUS SYSTEM

Learning objectives:

- *Nervous system*
- *Central nervous system*
- *Peripheral nervous system*
- *Sensory organs*
- *Questions*

1. NERVOUS SYSTEM

Gathers information from both inside and outside the body –

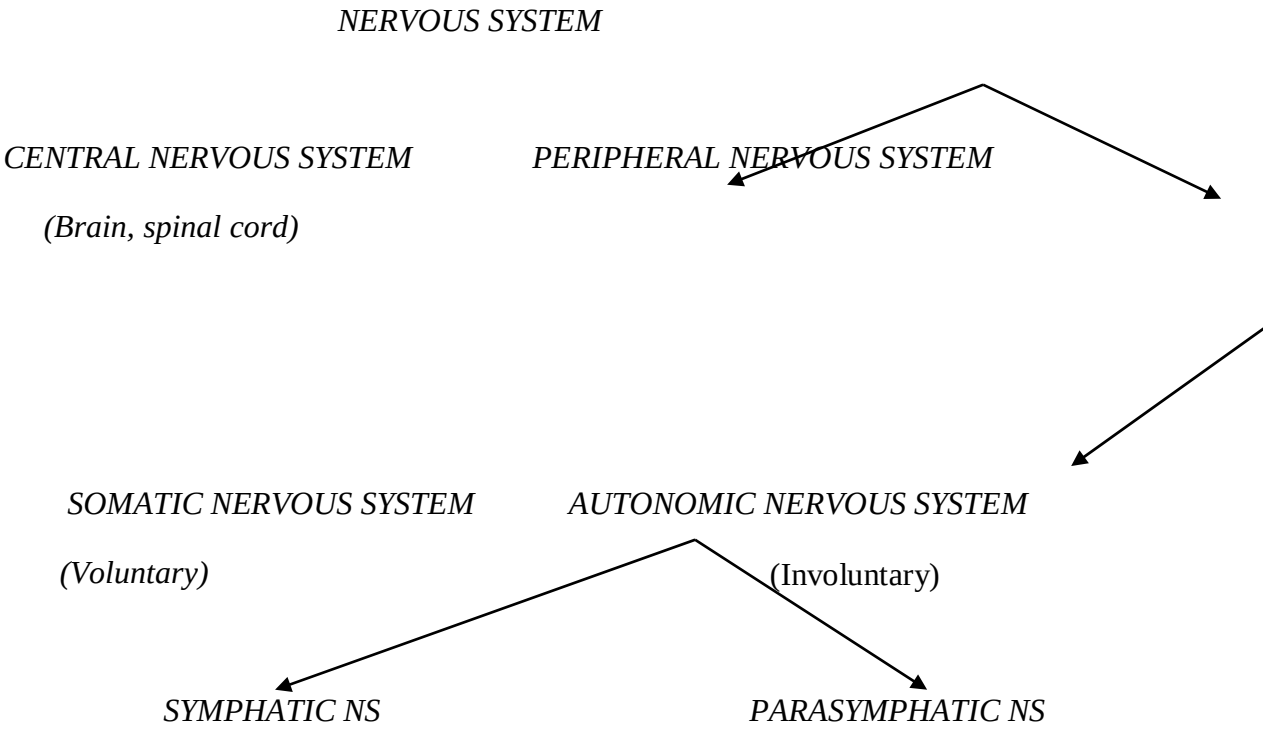
1. Sensory Function

2. Transmits information to the processing areas of the brain and spine

3. Processes the information in the brain and spine – Integration Function

4. Sends information to the muscles, glands, and organs so they can respond appropriately – Motor Function

The Nervous System is divided into Two Main Divisions: Central Nervous System (CNS) and the Peripheral Nervous System (PNS).



2. CENTRAL NERVOUS SYSTEM

2.1Basic Cells of the Nervous System Neuron

• Basic functional cell of nervous system

• Transmits impulses (up to 250 mph) Parts of a Neuron

• Dendrite – receive stimulus and carries it impulses toward the cell body

• Cell Body with nucleus – nucleus & most of cytoplasm

• Axon – fibre which carries impulses away from cell body

• Schwann Cells- cells which produce myelin or fat layer in the Peripheral Nervous System

• Myelin sheath – dense lipid layer which insulates the axon – makes the axon look gray

• Node of Ranvier – gaps or nodes in the myelin sheath

• Impulses travel from dendrite to cell body to axon Three types of Neurons o Sensory neurons – bring messages to CNS o Motor neurons - carry messages from CNS o Interneuron's – between sensory & motor neurons in the CNS.

2.2 Impulses

• A stimulus is a change in the environment with sufficient strength to initiate a response.

• Excitability is the ability of a neuron to respond to the stimulus and convert it into a nerve impulse

• All of Nothing Rule – The stimulus is either strong enough to start and impulse or nothing happens

• Impulses are always the same strength along a given neuron and they are self-propagation – once it starts it continues to the end of the neuron in only one direction- from dendrite to cell body to axon

• The nerve impulse causes a movement of ions across the cell membrane of the nerve cell.

2.3 Synapse

Synapse is a small gap or space between the axon of one neuron. It is junction between neurons which uses neurotransmitters to start the impulse in the second neuron or an effectors (muscle or gland).The synapse insures one-way transmission of impulses.

2.4 Neurotransmitters

Neurotransmitters – Chemicals in the junction which allow impulses to be started in the second neuron

2.5 Reflex Arc

Components of a Reflex Arc

a) *Receptor - reacts to a stimulus*

b) *Afferent pathway (sensory neuron) - conducts impulses to the CNS*

c) *Interneuron - consists of one or more synapses in the CNS (most are in the spine)*

d) *Efferent pathway (motor neuron) conducts impulses from CNS to effector.*

e) *Effector - muscle fibers (as in the Hamstring muscle) or glands responds by contracting or secreting a product.*

Spinal reflexes *- initiated and completed at the spinal cord level. Occur without the involvement of higher brain centers.*

3. BRAIN

- *Brain stem – medulla, Pons,*
- *Midbrain Diencephalon –*

  thalamus hypothalamus

  Cerebellum
- *Cerebrum*

4. SPINE

- *Spinal Cord*

3.1Meninges

Meninges are the three coverings around the brain & spine and help cushion, protect, and nourish the brain and spinal cord.
Dura mater is the most outer layer, very tough

Arachnoids mater is the middle layer and adheres to the dura mater and has weblike attachments to the innermost layer, the pia mater

• Pia mater is very thin, transparent, but tough, and covers the entire brain, following it into all its crevices and spinal cord

• Cerebrospinal fluid, which buffers, nourishes, and detoxifies the brain and spinal cord, flows through the subarachnoid space, between the arachnoids mater and the pia mater.

3.2Cerebrum *– conscious activity including perception, emotion, thought, and planning*

3.2.1 Thalamus *– Brain's switchboard – filters and then relays information to various brain regions*

3.2.2 Medulla *– vital reflexes as heart beat and respiration Brainstem – medulla, Pons, and midbrain (involuntary responses) and relays information from spine to upper brain*

3.2.3 Hypothalamus*– involved in regulating activities internal organs, monitoring information from the autonomic nervous system, controlling the pituitary gland and its hormones, and regulating sleep and appetite.*

Cerebrum

- *Is the largest portion of the brain encompasses about two-thirds of the brain mass –*
- *It consists of two hemispheres divided by a fissure – corpus callosum*
- *It includes the cerebral cortex, the medullary body, and basal ganglia*
- *cerebral cortex is the layer of the brain often referred to as gray matter because it has cell bodies and synapses but no myelin*
- *The cortex (thin layer of tissue) is gray because nerves in this area lack the insulation or white fatty myelin sheath that makes most other parts of the brain appear to be white.*
- *The cortex covers the outer portion (1.5mm to 5mm) of the cerebrum and cerebellum*
- *The cortex consists of folded bulges called gyri that create deep furrows or fissures called sulci*
- *The folds in the brain add to its surface area which increases the amount of gray matter and the quantity of information that can be processed*

3.2.4 Medullary body *– is the white matter of the cerebrum and consists of myelinated axons*

- *Commissural fibers – conduct impulses between the hemispheres and form corpus callosum*
- *Projection fibers – conduct impulse in and out of the cerebral hemispheres o Association fibers – conduct impulses within the hemispheres • Basal ganglia – masses of gray matter in each hemisphere which are involved in the control of voluntary muscle movements.*

3.2.5 Lobes of the Cerebrum

- ***Frontal*** *– motor area involved in movement and in planning & coordinating behaviour*
- ***Parietal*** *– sensory processing, attention, and language*
- ***Tempora****l – auditory perception, speech, and complex visual perceptions*
- ***Occipital*** *– visual center – plays a role in processing visual information*

5. PERIPHERAL NERVOUS SYSTEM

5.1 Cranial nerves

• 12 pair

• Attached to under surface of brain

5.2 Spinal nerves

• 31 pair

• Attached to spinal cord Somatic Nervous System (voluntary)

• Relays information from skin, sense organs & skeletal muscles to CNS

•Brings responses back to skeletal muscles for voluntary responses Autonomic Nervous System (involuntary)

• Regulates bodies involuntary responses

• Relays information to internal organs

• Two divisions

Sympathetic nervous system *– in times of stress § Emergency response 'Fight or flight'*

Parasympathetic nervous system *– when body is at rest or with normal functions 'Normal everyday conditions'.*

6. MAJOR SENSE ORGANS

• *Vision – Eye*

• *Hearing – Ear*

• *Taste – Taste receptors (new)*

• *Smell – Olfactory system*

• *Skin – Hot, cold, pressure, pain*

6.1 EYE

The organ used to sense light

three layers –

1. Outer layer consists of sclera and cornea

2. Middle layer consists of choroid, ciliary body and iris

3. Inner layer consists of retina

- ***6.1.1 Functions of the major parts of the eye:***
- ***Sclera or Scleroid Layer*** *– (white of eye) a tough protective layer of connective tissue that helps maintain the shape of the eye and provides an attachment for the muscles that move the eye*
- ***Cornea*** *- the clear, dome-shaped part of the sclera covering the front of the eye through which light enters the eye*
- ***Anterior Chamber*** *– a small chamber between the cornea and the pupil*
- ***Aqueous Humor*** *- the clear fluid that fills that anterior chamber of the eye and helps to maintain the shape of the cornea providing most of the nutrients for the lens and the cornea and involved in waste management in the front of the eye*
- ***Choroid Layer*** *- middle layer of the eye containing may blood vessels*
- ***Ciliary Body*** *- the ciliary body is a circular band of muscle that is connected and sits immediately behind the iris- produces aqueous humor, changes shape of lens for focusing, and*
- ***Iris*** *- the pigmented front portion of the choroid layer and contains the blood vessels - it determines the eye color and it controls the amount of light that enters the eye by changing the size of the pupil (an albino only has the blood vessels – not pigment so it appears red or pink because of the blood vessels)*

- ***Lens*** *- a crystalline structure located just behind the iris - it focuses light onto the retina*
- ***Pupil*** *- the opening in the center of the iris- it changes size as the amount of light changes (the more light, the smaller the hole)*
- ***Vitreous*** *- a thick, transparent liquid that fills the center of the eye - it is mostly water and gives the eye its form and shape (also called the vitreous humor)*
- ***Retina*** *- sensory tissue that lines the back of the eye. It contains millions of photoreceptors (rods for black & white and cones for color) that convert light rays into electrical impulses that are relayed to the brain via the optic nerve*
- ***Optic nerve*** *- the nerve that transmits electrical impulses from the retina to the brain*
- ***6.1.2 Common eye defects include***
- ***Myopia*** *or* ***nearsightedness*** *where the eyeball is too long or the cornea is too steep;* ***hyperopia*** *or* ***far sightedness*** *where the eyeball is short or lens cannot become round enough: cataracts where the lens becomes fogged;*
- ***Presbyopia*** *where the muscles controlling the bulging of the lens become weak as we age;*
- ***nyctalopia*** *or night blindness where vision is impaired in dim light and in the dark due to pigment rhodospin in the rods not functioning properly.*

Images

• The cornea and the lens help to produce the image on the retina

• Images formed by the lens are upside down and backwards when they reach the retina

6.1.3 Two types of receptors on the retina

- *Rods – 125 million on a single retina – extremely sensitive to all wavelengths of visible light but do not distinguish different color – in dim light only rods are activated where one can see objects but not as sharp images and are not able to distinguish their color – most dense in peripheral view – night time vision Rods have a pigment called rhodospin*
- *As amount of light increases, the cones – 7 million on a single retina – mainly in central view are stimulated and the color becomes clear – daytime vision*
- *There are three types of cones which distinguish the three colors – blue, red, green*
- *Fovea – point of central focus – great density of cones - center of the eye's sharpest vision and the location of most color perception - the layers of the retina spread aside to let light fall directly on the cones.Light stimulates rods and cones and sends impulse via optic nerve to brain areas for vision*
- *The Optic Nerve exits the eye just off center near the Fovea - the Optic Nerve exits is referred to as the Blind Spot due to the lack of the receptors in this area • The two Optic Nerves come together at the Optic Chiasm located just under the hypothalamus - a crucial*

- *part of vision and perception must happen - cross-over of information from the right eye crosses over to the left side and visa versa happens here at the Optic Chiasm*
- *Information from each eye must be processed in both halves of the brain*
- *Information leaves the chiasm via the optic tract.*
- *Reorganized optic tract leaves the Optic Chiasm and passes onto the lateral geniculate nucleus*
- *At the lateral geniculate nuclei the information is separated, organized, and relayed to different areas of the visual cortex*
- *The different zones of the visual cortex process the different aspects of vision and information, taken from both visual fields, is processed and an image is perceived*

7. EAR

Outer Ear & ear canal – brings sound into eardrum

Eardrum – vibrates to amplify sound & separates inner and middle ear Middle ear has 3 small bones or Ossicles = anvil, stirrup, stapes – amplify sound (small bones) which vibrate sound Eustachian tube – connects middle ear to throat and equalizes pressure on eardrum Cochlea – in inner ear – has receptors for sound & sends signals to brain via Auditory

7.1 Nerve Process of hearing:

- *Sound waves enter your outer ear and travel through your ear canal to the middle ear.*
- *The ear canal channels the waves to your eardrum, a thin, sensitive membrane stretched tightly over the entrance to your middle ear.*
- *The waves cause your eardrum to vibrate.*
- *It passes these vibrations on to the hammer, one of three tiny bones in your ear. The hammer vibrating causes the anvil, the small bone touching the hammer, to vibrate. The anvil passes these vibrations to the stirrup, another small bone which touches the anvil. From the stirrup, the vibrations pass into the inner ear.*
- *The stirrup touches a liquid filled sack and the vibrations travel into the cochlea, which is shaped like a shell.*
- *Inside the cochlea, a vestibular system formed by three semicircular canals that are approximately at right angles to each other and which are responsible for the sense of balance and spatial orientation. It has chambers filled with a viscous fluid and small particles (otoliths) containing calcium carbonate. The movement of these particles over small hair cells in the inner ear sends signals to the brain that are interpreted as motion and acceleration. The brain processes the information from the ear and lets us distinguish between different types of sounds.*

8. TONGUE

- *The tongue is a muscular organ in the mouth. The tongue is covered with moist, pink tissue called mucosa.*
- *Tiny bumps called papillae give the tongue its rough texture.*
- *Thousands of taste buds cover the surfaces of the papillae. Taste buds are collections of nerve-like cells that connect to nerves running into the brain.*
- *The tongue is anchored to the mouth by webs of tough tissue and mucosa.*
- *The tether holding down the front of the tongue is called the fraenum.*
- *In the back of the mouth, the tongue is anchored into the hyoid bone.*
- *The tongue is vital for chewing and swallowing food, as well as for speech.*

***The four common tastes are** sweet, sour, bitter, and salty. A fifth taste, called umami, results from tasting glutamate (present in MSG). The tongue has many nerves that help detect and transmit taste signals to the brain. Because of this, all parts of the tongue can detect these four common tastes; the commonly described "taste map" of the tongue doesn't really exist.*

9. NOSE

The nose is the organ of smell located in the middle of the face. The internal part of the nose lies above the roof of the mouth. The nose consists of:

- ***External meatus.** Triangular-shaped projection in the center of the face.*
- ***External nostrils.** Two chambers divided by the septum.*
- ***Septum.** Made up primarily of cartilage and bone and covered by mucous membranes. The cartilage also gives shape and support to the outer part of the nose.*
- ***Nasal passages.** Passages that are lined with mucous membranes and tiny hairs (cilia) that helps to filter the air.*
- ***Sinuses.** Four pairs of air-filled cavities also lined with mucous membranes.*

9.1 Sinuses

The sinuses are cavities, or air-filled pockets, near the nasal passage. As in the nasal passage, the sinuses are lined with mucous membranes. There are 4 different types of sinuses:

- ***Ethmoid sinus.** This sinus is located inside the face, around the area of the bridge of the nose. It is present at birth, and continues to grow.*
- ***Maxillary sinus.** This sinus is located inside the face, around the area of the cheeks. It is also present at birth, and continues to grow.*
- ***Frontal sinus.** This sinus is located inside the face, in the area of the forehead. It does not develop until around 7 years of age.*

- ***Sphenoid sinus.*** *This sinus is located deep in the face, behind the nose. It does not typically develop until adolescence.*

9.2 Throats

The throat is a ring-like muscular tube that acts as the passageway for air, food, and liquid. The throat also helps in forming speech. The throat consists of:

- ***Larynx (also known as the voice box).*** *The larynx is a cylindrical grouping of cartilage, muscles, and soft tissue that contains the vocal cords. The vocal cords are the upper opening into the windpipe (trachea), the passageway to the lungs.*
- ***Epiglottis.*** *A flap of soft tissue located just above the vocal cords. The epiglottis folds down over the vocal cords to prevent food and irritants from entering the lungs.*
- ***Tonsils and adenoids.*** *They are made up of lymph tissue and are located at the back and the sides of the mouth. They protect against infection, but generally have little purpose beyond childhood.*

Very Short Answer Type Question

Q1. What is the basic unit of nervous system?

Q2. The neuron is made up of which type of cell?

Q3. How neurons communicate with one another?

Q5. What is the function of rods?

Q6. Define neurotransmitters?

Q7 what is the common neurotransmitters?

Q8. Name the shortest bone of the body.

Q9. Which part of brain maintains equilibrium and posture of the body?

Q10. Define synapse?

Long answer type question

Q1. Draw the well labeled diagram of brain.

Q2. Explain the structure of brain

Q3. Explain the structure and function of eye

Q4.explain the structure and function of ear

Q5. Explain the structure of neurons and hoe neurons communicate

MUSCULAR SYSTEM

Learning objective:

- *Muscular system*
- *Functions*
- *Types of muscles*
- *Muscle contraction*
- *questions*

1. MUSCULAR SYSTEM

• *Consists only of skeletal muscles*

• *Muscle Organization and Function*

• *Muscle organization affects power, range, and speed of muscle movement*

2. MUSCLE FUNCTIONS

1. Produce movement

2. Maintain posture (i.e. standing, balance of head)

3. Stabilize joints (muscle tendons cross joints)

4. Generate heat

3. MUSCLE CELL CHARACTERISTICS

1. Excitability/irritability (respond to stimulus)

2. Contractility (they shorten their length)

3. Extensibility (may be stretched beyond their resting length)

4. Elasticity (resume resting length after stretching)

4. TYPES OF MUSCLES IN THE BODY

1. ***Smooth Muscle****. Not striated, uninucleate, involuntary, not individually named, exist in walls of tubes (e.g. blood vessels, ureters, gut, repro. tract)*

2. ***Cardiac Muscle****. Striated, branched, uninucleate, involuntary. Intercalated discs separate adjacent cells.*

3. ***Skeletal Muscle****. Multi-nucleate, striated, voluntary. (700 muscles, ~40% of body weight)*

4. ORGANIZATION OF MUSCLE

- *Organization of Connective Tissues*
- *Muscles have three layers of connective tissues*
  1. ***Epimysium*** *surrounds each individual muscle cell*
  2. ***Perimysium*** *surrounds each bundle of muscle cells called a Fascicle*
  3. ***Endomysium*** *surrounds each muscle*

5. CHARACTERISTICS OF SKELETAL MUSCLE FIBERS

- *The Sarcolemma and Transverse Tubules*
- *The sarcolemma*
- *The cell membrane of a muscle fiber (cell)*
- *Surrounds the sarcoplasm (cytoplasm of muscle fiber)*
- *A change in transmembrane potential begins contractions The Sarcolemma and Transverse Tubules*
- *Transverse tubules (T tubules) • Transmit action potential through cell*
- *Allow entire muscle fiber to contract simultaneously*
- *Have same properties as sarcolemma*

6. MYOFIBRILS

- *Lengthwise subdivisions within muscle fiber*
- *Made up of bundles of protein filaments (myofilaments)*
- *Myofilaments are responsible for muscle contraction*

6.1Types of myofilaments:

- *Thin filaments*
- *Made of the protein actin*
- *Thick filaments*
- *Made of the protein myosin*

7. THE SARCOPLASMIC RETICULUM (SR)

- A *membranous structure surrounding each myofibril*
- *Helps transmit action potential to myofibril*
- *Similar in structure to smooth endoplasmic reticulum*
- *Forms chambers (terminal cisternae) attached to T tubules*
- *The Sarcoplasmic Reticulum (SR)*
- *Triad*
- *Is formed by one T tubule and two terminal cisternae*
- *Cisternae*
- *Concentrate Ca2+ (via ion pumps)*
- *Release Ca2+ into sarcomeres to begin muscle contraction*

7.1Structural Components of a Sarcomere

• *Sarcomeres*

• *The contractile units of muscle*

• *Structural units of myofibrils*

• *Form visible patterns within myofibrils*

• *A striped or striated pattern within myofibrils*

• *Alternating dark, thick filaments (A bands) and light, thin filaments (I bands) Sarcomeres*
• *The A Band*
M line

• *The center of the A band*

• *At midline of sarcomere*

The H Band

• *The area around the M line*

• *Has thick filaments but no thin filaments*

• *Zone of overlap*

• *The densest, darkest area on a light micrograph*

• *Where thick and thin filaments overlap Sarcomeres*

• *The I Band*

Z lines

• *The centers of the I bands*
• *At two ends of Sarcomere*

• *Titin*

• *Are strands of protein*

• *Reach from tips of thick filaments to the Z line*

• *Stabilize the filaments*

8. **SKELETAL MUSCLE CONTRACTION**

• *The process of contraction*

• *Neural stimulation of sarcolemma*

• *Causes excitation–contraction coupling*

• *Muscle fiber contraction*

• *Interaction of thick and thin filaments*

• *Tension production*

8.1Skeletal Muscle Relaxation

• *Relaxation*

• *Contraction Duration*

• *Depends on:*

• *Duration of neural stimulus*

• *Number of free calcium ions in sarcoplasm*

• *Availability of ATP*

• *Ca2+ concentrations fall*

• *Ca2+ detaches from troponin*

• *Active sites are re-covered by tropomyosin*

Very short answer type question

Q1. What does muscle consist of?
Q2. What does muscle covered externally?
Q3. What is a muscle fiber?
Q4. During contraction, what does do Ca^{2+} ion binds to?
Q4. During contraction, what gets released during the creation of a cross-bridge?

Short and long answer type question

Q1. Draw the diagram of a Sarcomere of skeletal muscle showing different regions.
Q2. Define sliding filament theory of muscle contraction.
Q3. Describe the important steps in muscle contraction.
Q4. Write the difference between actin and myosin.
Q5. Explain the structural component of sacromere.