18BEBME306 ANATOMY AND HUMAN PHYSIOLOGY 3 0 0 3 100

OBJECTIVE:

- To provide the students a basic understanding of the structure and function of the human body.

INTENDED OUTCOMES:

- Relate basic human body functions and life processes.
- Name the major human body systems and relate their functions.
- Name the major components of each system and describe briefly their anatomical locations, structures and their physiological functions.

UNIT I CELL
(9)

Structure of Cell – Organelles and description – Function of each component of the cell – Membrane potential – Action Potential – Generation and Conduction – Electrical Stimulation. Blood Cell – Composition – Origin of RBC – Blood Groups – Estimation of RBC, WBC and Platelet.

UNIT II CARDIAC AND NERVOUS SYSTEM
(9)

Heart, Major blood vessels – Cardiac Cycle – ECG – Blood Pressure – Feedback Control for Blood Pressure – Nervous Control of Heart - Cardiac output – Coronary and Peripheral Circulation – Structure and function of Nervous tissue – Neuron - Synapse - Reflexes - Receptors -Brain -Brainstem -Spinal cord – Reflex action – Velocity of Conduction of Nerve Impulses - Electro Encephalograph – Autonomic Nervous System.

UNIT III RESPIRATORY SYSTEM AND MUSCULO SKELETAL SYSTEM
(9)

Physiological aspects of respiration – Trachea and lungs - Exchange of gases – Regulation of Respiration - Disturbance of respiration function - Pulmonary function test - Muscles - tissue - types - structure of skeletal muscle - types of muscle and joints.

UNIT IV DIGESTIVE AND EXCRETORY SYSTEM

(9)

Organisation of GI System, Digestion and absorption – Movements of GI tract – Intestine - Liver - Pancreas - Structure of Nephron – Mechanism of Urine formation – Urine Reflex – Skin and Sweat Gland – Temperature regulation.

UNIT V EYE, EAR, ENDOCRINE GLANDS

(9)

Optics of Eye – Retina – Photochemistry of Vision – Accommodation - Neurophysiology of vision – EOG. Physiology of internal ear – Mechanism of Hearing – Auditory Pathway, Hearing Tests - Endocrine glands.

Total : 45

TEXT BOOKS:

S.NO.	Author(s) Name	Title of the book	Publisher	Year of publication
1	Sarada Subramanyam, K.Madhavan Kutty and H.D.Singh	Text Book of 'Human Physiology	S.Chand & Company	1996
2	Ranganathan, T.S	Text Book of Human Anatomy	S.Chand &Co. Ltd., Delhi	1996

REFERENCES:

S.NO.	Author(s) Name	Title of the book	Publisher	Year of publication
1	Tobin, C.E.,	Basic Human Anatomy	McGraw-Hill Publishing Co. Ltd.	1997
2	J.Gibson	Modern Physiology and Anatomy for Nurses	Blackwell SC Publishing	1981
3	Arthur.C.Guyton	John E Hall – ,Textbook of Medical Physiology	W.B. Saunders Company	2000

KARPAGAM ACADEMY OF HIGHER EDUCATION
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LECTURE PLAN

Name of the staff : M.Bhuvaneswari
Designation : Assistant Professor.
Class : II-B.E BME
Subject : Anatomy And Human Physiology
Subject code : 18BEBME306

Sl.No.	Topics to be covered	Time Duration	Teaching aids
	INTRODUCTION		
1	Introduction to Anatomy & Human Physiology	01	
	UNIT-I CELL		
2	Introduction and outline of Organ Systems	01	R4 9-18
3	Structure of Cell	01	T2 1-3
4	Organelles and description	01	R4 32-33
5	Function of each component of the cell	01	.T2 1-3
6	Membrane potential & Action Potential	01	R4 36, W1
7	Generation and Conduction of Electrical Stimulation	01	W5
8	Blood Cell & its Composition	01	R4 63
9	Origin of RBC	01	R4 63-67
10	Blood Groups	01	R4 68,W1
11	Estimation of RBC, WBC and Platelet.	01	
	UNIT-II CARDIAC AND NERVOUS SYSTEM		
12	Heart, Major blood vessels	01	T2 420,R1 74
13	Cardiac Cycle & ECG	01	T1 124-138
14	Blood Pressure, Feedback Control for Blood Pressure	01	T1 154,R4 88-96
15	Cardiac output ,Coronary and Peripheral Circulation	01	R4 89-97
16	Structure and function of Nervous tissue, Neuron Synapse , Reflexes	01	R4 144,W1
17	Brain, Brainstem & Reflex action	01	R4 154 159
18	Spinal cord, Velocity of Conduction of Nerve Impulses		T2 625,R4 160-168
19	Electro Encephalograph	01	T1 776,W2
20	Autonomic Nervous System	01	T2 703
	UNIT-III RESPIRATORY SYSTEM AND MUSCULO SKELETAL SYSTEM		
21	Physiological aspects of respiration	01	T1 213,
22	Trachea And Lungs	01	R4 250-254
23	Exchange Of Gases , Regulation Of Respiration	01	R4 255-260
24	Disturbance Of Respiration Function		T1 279 R4262
25	Pulmonary Function Test	01	T1 258,R4 400
26	Muscles, Types Of Tissue	01	R4 38-44
27	Structure Of Skeletal Muscle	01	W2
28	Types Of Muscle	01	T1 621 R4 410-411
29	Types Of Joints	01	T2 42,140

UNIT-IV DIGESTIVE AND EXCRETORY SYSTEM			
30	Organisation of GI System	01	T1 299,R4 287
31	Digestion Process & Movements of GI tract	01	T1 352,R4 313
32	Absorption in GI tract	01	T1 363
33	Intestine	01	W1
34	Liver & Pancreas		T2 297,305,R4 308
35	Kidney,Structure of Nephron	01	T1 341,R4 338-341
36	Mechanism of Urine formation – Urine Reflex	01	R4 341-344
37	Skin and Sweat Gland	01	R4 362
38	Temperature regulation	01	R4 366-367
UNIT-V EYE, EAR, ENDOCRINE GLANDS			
39	Optics of Eye	01	T2 604,R4 196
40	Photochemistry of Vision	01	T2 609
41	Vision Accommodation &Neurophysiology of vision	01	R4 200,202
42	EOG	01	T1 887,W4
43	Physiology of internal ear	01	T1 536, W3
44	Mechanism of Hearing, Auditory Pathway	01	W3
45	Hearing Tests	01	T1 914,W3
46	Endocrine glands.	01	W2

Website:

W1- https://www.news-medical.net/health
W2- https://www.healthline.com/health
W3- https://www.earq.com/hearing-loss/ear-anatomy
W4- https://www.webmd.com/eye-health
W5- https://www.ncbi.nlm.nih.gov/books/NBK21668

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3	Arthur.C.Guyton	John E Hall – ,Textbook of Medical Physiology	W.B. Saunders Company	2000
4	Ross & Wilson	Anatomy & Physiology In Health & Illness	Oxford	2014

Staff In-Charge **HOD/ECE**

18BEBME306 ANATOMY AND HUMAN PHYSIOLOGY
UNIT I
CELL

Structure and organelles:

- The cell is the basic unit of structure and function in living things. Cells vary in their shape size, and arrangements but all cells have similar components, each with a particular function.
- Some of the 100 trillion of cells make up human body.
- All human cell are microscopic in size, shape and function.
- The diameter range from 7.5 micrometer (RBC) to 150 mm (ovum).
- Cell is defined as the fundamental living unit of any organism.
- Cell is important to produce energy for metabolism (all chemical reactions within a cell).
- Cell can mutate (change genetically) as a result of accidental changes in its genetic material (DNA).
- Cytology: the study of the structure and functions of cells.

There are two types of cells:

1. Prokaryotic- cells that DO NOT have a nucleus or other cell ORGANELLES
2. Eukaryotic- cells with a NUCLEUS & cell ORGANELLES
3. The parts of a cell that carry out a function are called cell ORGANELLES:
4. All cells have the following organelles:

Cell Membrane,Cytoplasm,Ribosomes,Cytoskeleton,Nucleus,Nucleolus, Mitochondria. Golgi Body Complex, Endoplasmic Reticulum,Vacuole,Lysosome

1.1 ORGANELLES:

- little “organs” of the cell
- Organelles are present in BOTH plants and animals
- Carry out cellular functions!
- Organelle= “little organ”

- Found only inside **eukaryotic cells**
- All the stuff in between the organelles is cytosol
- Everything in a cell except the nucleus is cytoplasm

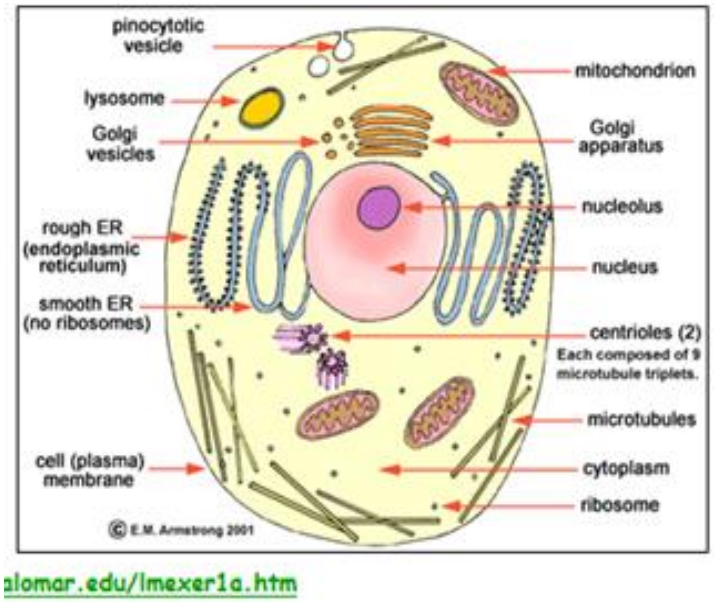


Fig 1.1 Cell

1.1.1 Cell membrane

- Function
  - separates cell from outside
  - controls what enters or leaves cell
    - O_2, CO_2, food, H_2O, nutrients, waste
  - recognizes signals from other cellsallows communication between cells
- Structure
  - double layer of fat
    - phospholipid bilayer
  - receptor molecules
    - proteins that receive signals
- The cell membrane is a thin, dynamic membrane that encloses the cell and controls what enters and leaves the cell.
- Serves as boundary of the cell.

- Serve as markers that identify the cells.
- Play significant role in transportation.
- Cell recognition proteins-allow cell to recognize other cells.

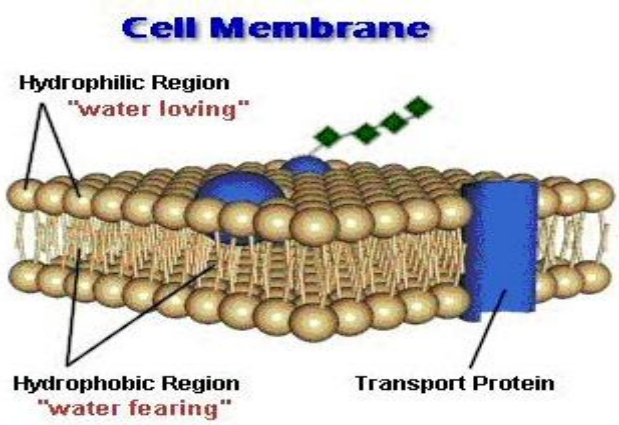


Fig 1.2 Cell Membrane

1.1.2 Lysosomes

- Function
  - digest food
    - used to make energy
  - clean up & recycle
    - digest broken organelles
- Structure
  - membrane sac of digestive enzymes
- spherical membranous sacs containing digestive enzymes;
- "suicide sacs" which destroy anything the cell no longer wants or needs.
- Autolysis is the process by which worn cell parts are digested by autophagy.
- Garbage disposal of the cell
- Contain digestive enzymes that break down wastes.

1.1.3 Mitochondria

"Powerhouse" of the cell = site of cellular respiration where energy is released from glucose

- In electron micrographs of cells, mitochondria appears as – rods, spheres or filamentous bodies.
- Size: 0.5µm -1µm in diameter

up to 7µm in length.

- Mitochondria has got an inner membrane and an outer membrane. The space between these two is called intermembranous space.
- Inner membrane convolutes into cristae and this increases its surface area.
- Function
    - make ATP energy from cellular respiration
        - sugar + $O_2 \rightarrow$ ATP
        - fuels the work of life
- Structure
    - double membrane

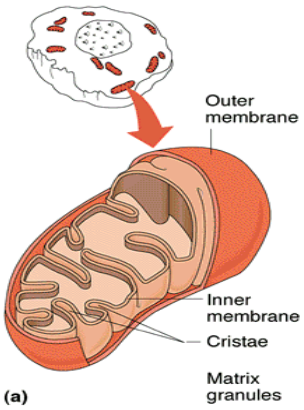


Fig 1.3 Mitochondria

1.1.4 Ribosome

- Function
    - protein factories
    - read instructions to build proteins from DNA
- Structure
    - some free in cytoplasm
    - some attached to ER

- Site of protein synthesis
- Found attached to rough ER or floating free in cytosol
- Produced in a part of the nucleus called the nucleolus
- Some ribosomes are found in the cytoplasm, but most are attached to the endoplasmic reticulum. While attached to the ER, ribosomes make proteins that the cell needs and also ones to be exported from the cell for work elsewhere in the body.
- Every cell contains thousand of ribosome's and many of them attached to the RER.
    - Each ribosome is nonmembranous structure, made of two pieces large unit and small unit and each subunit composed of rRNA.

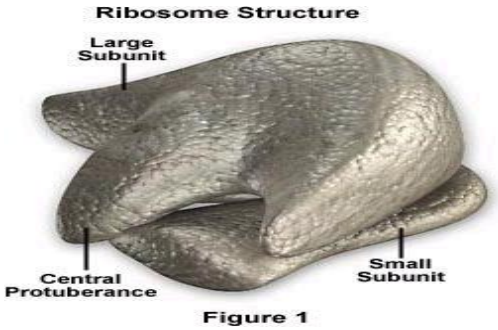


Fig 1.4 Ribosomes

- Protein released from the ER are not mature, need further processing in Golgi complex before they are able to perform their function within or outside the cell.

1.1.5 Nucleus

Function

- control center of cell
- protects DNA
- instructions for building proteins

Structure

- nuclear membrane
- nucleolus
    - ribosome factory

- chromosomes
  - DNA

the central core, control center or "brain" of the cell.

1. the largest organelle of the cell;
2. filled with nucleoplasm;

Nuclear Membrane (or nuclear envelope) is a double membrane that separates the contents of the nucleus from the cytoplasm

- self duplicating structure -divides when the cell divides
- Usually the easiest organelle to see under a microscope
- Usually one per cell

1.1.6 Cytoskeleton

- Acts as skeleton and muscle
- Provides shape and structure
- Helps move organelles around the cell
- Made of three types of filaments

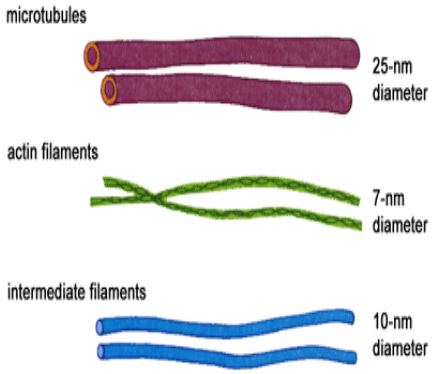


FIG 1.5 Cytoskeleton

- Is a network of fibers extending throughout the cytoplasm
  - Fibers appear to support the endoplasmic reticulum, mitochondria, and “free” ribosomes
  - Gives mechanical support to the cell

- Is involved in cell motility, which utilizes motor proteins
- Rodlike pieces that provide support and allow movement and mechanisms that can move the cell or its parts

1.1.7 Endoplasmic Reticulum

- cytoplasmic channels from the cell membrane to the nuclear membrane
- associated with the storage, synthesis, and transport of materials within the cell
- "HIGHWAY" for cell transport
- network of interconnected parallel membranes (maze), that is continuous with the nuclear membrane;

Two types:

Rough Endoplasmic Reticulum (RER)

- ER studded with ribosomes;
- Function = protein synthesis and intraceluar transportation of molecules ;

Smooth Endoplasmic Reticulum (SER)

- lacks ribosomes;
- Function = lipid & cholesterol synthesis and Stores calcium.

1.1.8 Golgi Apparatus

- Looks like a stack of plates
- Stores, modifies and packages proteins
- Molecules transported to and from the Golgi by means of vesicles
- Golgi complex is a network of flattened smooth membranous sacs-cisternae and vesicles.
- These are responsible for the secretion of proteins from the cells(hormones, plasma proteins, and digestive enzymes).
- It works in combination with ER.

- It is organelle in the cell that is responsible for sorting and correctly shipping the proteins produced in the ER.
- The Golgi apparatus are stacks of membrane-covered sacs.
- They also package proteins to be moved out of the cell.
- usually located near the nucleus
- synthesizes, packages, and secretes cellular products
- Packages waste & harmful materials

1.1.9 Nucleolus

- round organelle in the nucleus
- usually a pair
- involved with the synthesis of RNA in the ribosomes

1.1.10 Cytoplasm

- Is a gel-like matrix of water, enzymes, nutrients, wastes, and gases and contains cell structures (organelles).
- Fluid around the organelles called cytosol.
- Most of the cells metabolic reactions occur in the cytoplasm.
- fluid like material between the cell membrane and the nucleus
- over 80 % water
- "HOLDS" cell organelles in place
- site of most organelles and cellular chemical reactions

1.2CELL MEMBRANE

- All cells are covered with a thin covering of a double layer of Phospholipids and associated Proteins present here and there.

- Each phospholipid has a polar (hydrophilic) head and non-polar (hydrophobic) tails. In the double layer the tails face each other forming a hydrophobic barrier which keeps water dissolved contents inside.
- Proteins may be Intrinsic – embedded in the lipid double layer and Extrinsic associated outside the lipid double layer.
- Proteins are gate keepers of cell and make the cell membrane selectively permeable.

1.2.1 Cell Membrane and Transport

- In bacteria, plants, and fungi cell membrane is surrounded by a non-living cell wall. But cell membrane is the real boundary. Most cell walls are permeable others are impermeable.
- Semi-permeable: Cell membranes allow some materials to pass through them and prevent others from doing so. Regulators like hormones can change permeability of a cell membrane.
- Transport across membrane can be Passive or Active.

Passive Transport includes Diffusion, Osmosis and Facilitated Diffusion.

- **Diffusion**: All fluids (liquids + gases) move from area of higher concentration to area of lower concentration (concentration gradient). This movement of substances is called Diffusion. It can be through cell membranes. For example, spreading of fragrance, dissolving of ink drop in water, movement of O2 and CO2 between lungs and blood.
- **Osmosis** is always the net movement of water through cell membrane from its higher concentration (dilute solution) to its lower concentration

(concentrated solution) when the 2 solutions are separated by semi-permeable membrane. For example absorption of water by roots of plants.

- **Facilitated diffusion** is faster than normal diffusion but needs a carrier protein though no ATP needed. For example, absorption of glucose and amino acids in intestine.

Active Transport

- Only active transport can operate against concentration gradient.
- It is the fastest mode of transport.

- It always needs one or more transport proteins. For example absorption of minerals by plant roots, absorption of nutrients when their conc. is already higher inside the cells.

Vesicular Transport

- Large molecules like proteins cannot transport through membrane by passive or active transport discussed so far. These are packed into membrane bound vesicles and transported across cell membrane.
- Endocytosis is the bulk transport into the cell. If solid material including prey is brought in as Food Vacuole, the process is called Phagocytosis. For example, white blood cells eating bacteria. When cell brings in liquid bound in sac the process is called Pinocytosis.
- Exocytosis: When the cells releases solid or liquid in sacs the process is called exocytosis. For example Amoeba throws excess water outside to maintain required concentration (osmoregulation).

1.3 CELL MEMBRANE- ACTION POTENTIAL

The membrane potential (V_m) is defined as

$V_m = V_{in} – V_{out}$

Many ion transport systems were discovered in cell membranes. One of them, denoted as sodium-potassium pump (Na/K pumpor Na^+-K^+-ATP-ase) has an extraordinary importance for production of membrane voltage. It removes Na-ions from the cell and interchanges them with K-ions. Thus, the concentrations of these ions in the intracellular and extracellular medium (they are denoted as [Na+], [K+] and distinguished by indexes i, e) are different. We can write:

$$[Na^+]_e >> [Na^+]_i , \qquad [K^+]_i >> [K^+]_e .$$

- Working *Na/K* pump requires constant energy supply. This energy is delivered to the transport molecules by the adenosine triphosphate (ATP) which is present in the intracellular medium.

Principle of the sodium-potassium pump

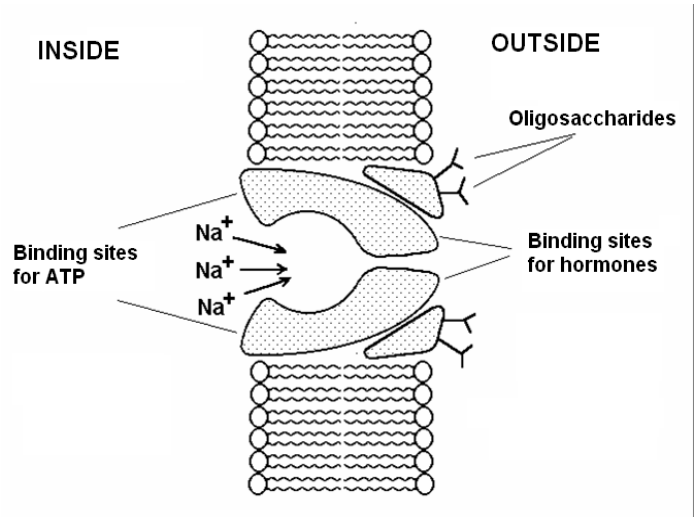


Fig 1.6 Sodium potassium pump

The sodium ions are released on the outer side of the membrane. Following conformation change of the ion pump molecule enables binding of potassium ions which are carried inside the cell.

Action potential

- The concept of action potential denotes a fast change of the resting membrane potential caused by over-threshold stimulus which propagates into the adjacent areas of the membrane.
- This potential change is connected with abrupt changes in sodium and potassium ion channels permeability.
- The action potential can be evoked by electrical or chemical stimuli which cause local decrease of the resting membrane potential.

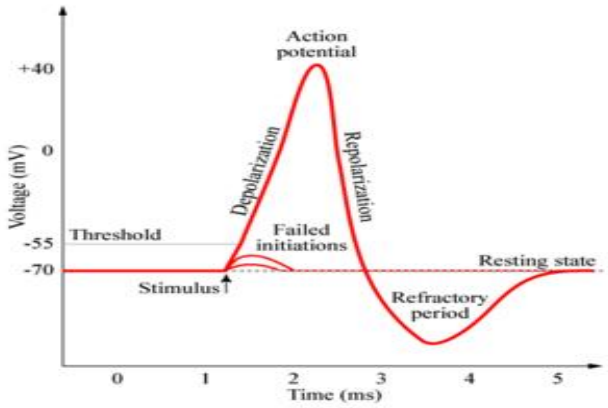


Fig 1.7 Action potential graph

The main physiological characteristics of the AP

- Obeys the law of "all or nothing." This means that:

AP occurs when the stimulus, the power which is no less than certain thresholds;

Physical characteristics of the AP (amplitude, duration, shape) does not depend on the power of stimulus.

- Ability to autospread along the cell membrane without damping, ie without changing their physical characteristics.
- AP accompanied with refractory.
- AP is no capable to summation.

1.4 TISSUE STRUCTURE AND FUNCTION

- Cells combine to form four primary tissues
  - Epithelial tissue
  - Connective tissue
  - Muscle tissue
  - Nervous tissue

1.4.1 Epithelium

- Two types:
  - membranous epithelia
    - form the coverings or linings of organs
  - glandular epithelia
    - form exocrine and endocrine glands

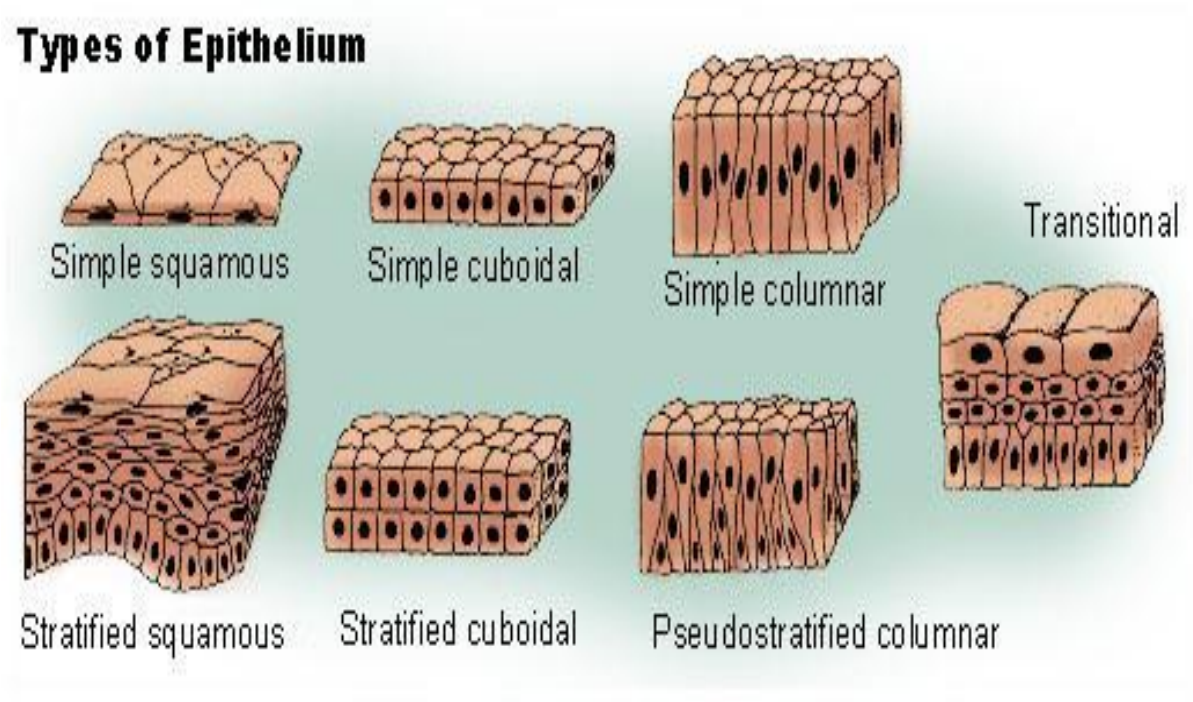


Fig 1.8 Structure ofepithelial tissues

1.4.2 Connective Tissue

- Binds the cells and organs of the body together
  - All connective tissues consist of two basic components: cells and extracellular fibers
- Two types of connective tissue are:
  - Connective tissue proper
  - Specialized connective tissue

Specialized Connective Tissues

- Perform specific functions essential to homeostasis

- The body contains three types of specialized connective tissue:
    - Cartilage
    - Bone
    - Blood
- Cartilage
    - Consists of specialized cells embedded in a matrix of extracellular fibers and other extracellular material
- Blood
    - Contains blood cells, platelets, plasma
- **Bone** (Osseous tissue)
    - Consists of bone cells (osteocytes) and a calcified cartilage matrix
        - Two types of bone tissue exist: spongy and compact

Cartilage

- 3 Types: hyaline, elastic, fibrocartilage
- All three are composed of chondrocytes
- They differ based on their fiber composition

Hyaline Cartilage

- A rubbery type of cartilage
- Contains more cartilage than elastic but less than fibrocartilage
- This is the human version of rubber
- Found on the ends of long bones, the sternal ends of the ribs, the larynx, trachea, bronchi

Elastic Cartilage

- Contains chondrocytes
- Similar to hyaline but has much more elastin
- Found in the ear lobe, Eustachian tube, larynx, epiglottis
- This is the most flexible of the three types of cartilage

Fibrocartilage

- Contains chondrocytes

- Has the highest amount of collagen in the ECM
- Found in areas of the body that need to withstand compressive force
- Knee (menisci), intervertebral disks, pubic symphysis

Bone

- The hardest and most highly specialized of all connective tissues
- Minerals mix within the ECM gels and cause this tissue to become hard
- Contains osteocytes, osteoblasts, osteoclasts
- Functions: physical protection, mineral storage, mineral homeostasis, pH balance, hematopoiesis

Blood

- Considered a connective tissue because of the mixing of plasma proteins and cells (cells and gels)
- Contains erythrocytes, leukocytes and platelets
- Functions: gas transport, pH balance, nutrient transport, immunity, hemostasis

Vascular tissue

- Erythrocytes: Red Blood Cells – carry oxygen
- Leucocytes: White Blood Cells – part of the immune system
- Platelets - clotting

1.4.3 Muscle Tissue

- Consists of specialized cells that contract when stimulated
- The body has three types of muscle tissue:
    - **Skeletal** (voluntary)
    - **Cardiac** (involuntary)
    - **Smooth muscle** (involuntary)

1.4.4 Nervous Tissue

- Contains specialized cells that conduct impulses

- Conducting cells, called **neurons**, transmit impulses from one region of the body to another.
- Nonconducting cells, **neuroglia,** are a type of nervous system connective tissue.

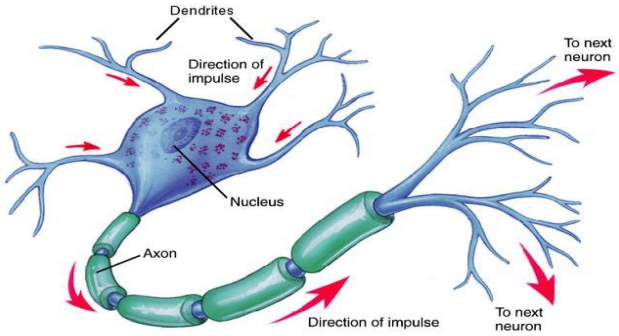


Fig 1.9 Structure of neuron

1. BLOOD COMPOSITION

What is Blood?

- Blood is a connective tissue
- Its volume is 5-6 L in males and 4-5 L in females
- It is slightly alkaline, with a pH of ~ 7.4
- Its color varies from bright to dark red
- It has a salty metallic taste

3.1 Function

3 major functions

- Transportation
- Regulation
- Protection

Transportation

- Respiratory

Red blood cells or erythrocytes transport Oxygen from lungs to cells and Carbon dioxide from cells to lungs

- Nutritive

Blood absorb nutrients from digested foods in gastrointestinal tract and transport to all the cells in body

- Excretory

Metabolic wastes, excess water and ions , and other molecules not needed by the body are carried by the blood to the kidneys and excreted in the urine

Regulation

- Hormonal

Blood carries hormones from their site of origin to distant target tissues , where they perform the regulatory functions

- Temperature

Blood is responsible to carry body heat to the surface in high temperature environment as well as to keep body heat in within low temperature environment

Protection

- Clotting

The clotting mechanism protects against blood loss when vessels are damaged

- Immune

The immune function of blood is performed by the leukocytes that protects against many disease causing agents

3.2 Composition of the Blood

- Blood consists of formed elements that are suspended and carried in a fluid called plasma
- The formed elements

- Erythrocytes Oxygen transport
- Leukocytes Immune defence

- Platelets Blood clotting

Plasma

- Straw colored fluid made of water (~90%), other contents include:
- Proteins make the bulk of the solutes:

Albumins (60%), manufactured in the liver are the most abundant

Globulins (36%) are immune bodies

Fibrinogen (4%) for blood clotting

- Nutrients: glucose, amino acids, lipids, cholesterol
- Electrolytes: Na^+, K^+, Ca^{++}, Mg^{++}, H^+, Cl^-, HCO_3^-, PO_4^{--}, SO_4^{--}
- Waste: urea, creatinine, uric acid, bilirubin
- Gases: O_2 , CO_2 , N_2
- Protein bound hormones
- Plasma without clotting factors is called "serum"

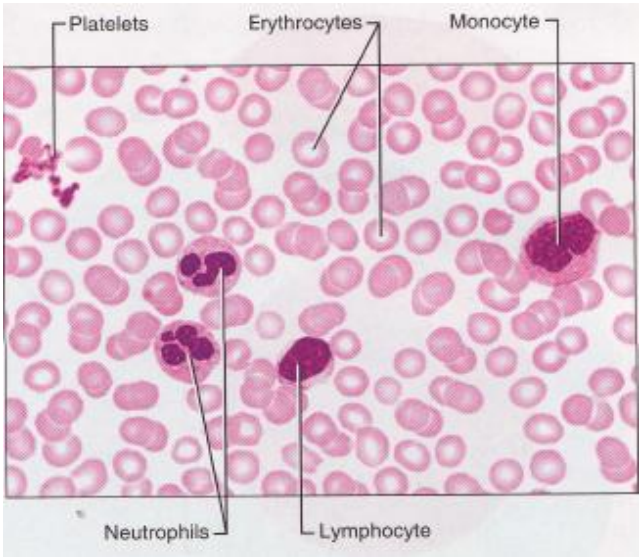


Fig 3.1 Blood cells

RBC/ ERYTHROCYTES

FUNCTIONS OF RBC:

- An RBC is a 7.5 micron disc shaped body with a central depression
- The cell is without a nucleus or mitochondria
- AN RBC contains hemoglobin and filamentous proteins attached to the cell wall to impart flexibility on it
- Life span 120 days
- Erythrocytes are produced in bone marrow
- Older erythrocytes are removed from the circulation by phagocytic cells in the liver, spleen and bone marrow.
- Antigens are embedded in the cell membrane, they decide the blood group
- The RBC cytoplasm provides energy to maintain intracellular homeostasis
- This energy is generated mostly through anaerobic glycolysis
- RBCs function is gas exchange: O_2 to the tissues and CO_2 to the lungs

White Blood Cells/Leukocytes

WBC TYPES AND THEIR FUNCTIONS

- Leukocytes contain nuclei and mitochondria and can move in an amoeboid fashion
- Because of their amoeboid ability, leukocytes can squeeze through pores in capillary walls and move to a site of infection.
- Produced in bone marrow and destructed in spleen

Types

- The total number of WBCs is 4000 to 11,000/mm^3
- There two main types of WBCs: granulucytes and agranulocytes

Granulocytes, are of three types:

Neutrophils (polymorphs) 50-70%, destroy bacteria

Eosinophils, 2-4% bilobed nuclei, attack parasites

Basophils, 1% in peripheral blood, reside in the tissues, contain histamine, involved in hypersensitivity reaction

Agranulocytes are of two types

Lymphocytes, the smallest and second most abundant

T cells (80%) mediate cellular immunity

B cells mediate humoral immunity

Monocytes, the largest, migrate to the tissues and become macrophages involved in cellular immunity

Platelets

- Platelets are only about 20% of the diameter of red blood cells, the most numerous cell of the blood.
- The normal platelet count is 150,000-350,000 per microliter of blood
- Platelets are produced in bone marrow and destroyed in the spleen and liver
- Life span 5 to 9 days
- They are fragments of cells called megakaryocytes, they have no nuclei but like leukocytes are capable of amoeboid movements
- Platelets play an important role in blood clotting
- They constitute most of the mass of the clot, and phospholipids in their cell membranes activate the clotting factors in plasma that result in threads of fibrin, which reinforce the platelet plug.

- Platelets that attach together in a blood clot release serotonin , a chemical that stimulates constriction of blood vessel.

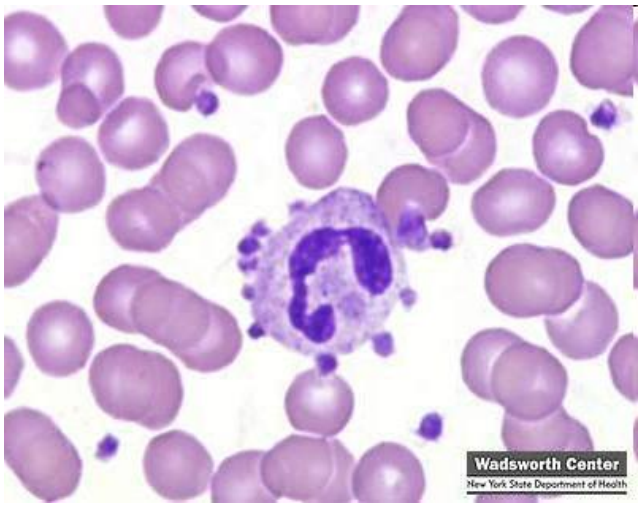


Fig .3.2 Platelets

3.3 BLOOD GROUPS:

History:

- Experiments with blood transfusions have been carried out for hundreds of years. Many patients have died and it was not until 1901, when the Austrian Karl Landsteiner discovered human blood groups, that blood transfusions became safer.
- He found that mixing blood from two individuals can lead to blood clumping. The clumped RBCs can crack and cause toxic reactions. This can be fatal.
- Karl Landsteiner discovered that blood clumping was an immunological reaction which occurs when the receiver of a blood transfusion has antibodies against the donor blood cells.
- Karl Landsteiner's work made it possible to determine blood types and thus paved the way for blood transfusions to be carried out safely. For this discovery he was awarded the Nobel Prize in Physiology or Medicine in 1930.

Of What is Blood Made?

- An adult human has about 4–6 liters of blood circulating in the body.
- Blood consists of several types of cells floating around in a fluid called plasma.

  The red blood cells (RBCs) contain haemoglobin, a protein that binds oxygen. RBCs transport oxygen to, and remove carbon dioxide from the tissues.

The white blood cells fight infection.

The platelets help the blood to clot, if you get a wound for example.

The plasma contains salts and various kinds of proteins.

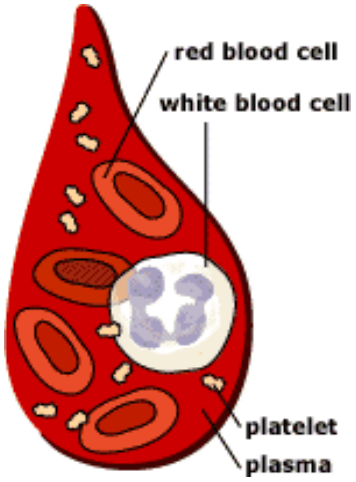


Fig 3.3 Blood

What are the different blood groups?

- The differences in human blood are due to the presence or absence of certain protein molecules called antigens and antibodies.
- The antigens are located on the surface of the RBCs and the antibodies are in the blood plasma.
- Individuals have different types and combinations of these molecules.
- The blood group you belong to depends on what you have inherited from your parents.
- There are more than 20 genetically determined blood group systems known today
- The **AB0** and **Rhesus (Rh)** systems are the most important ones used for blood transfusions.
- Not all blood groups are compatible with each other. Mixing incompatible blood groups leads to blood clumping or agglutination, which is dangerous for individuals.

ABO blood grouping system

According to the ABO blood typing system there are four different kinds of blood types: A, B, AB or O (null).

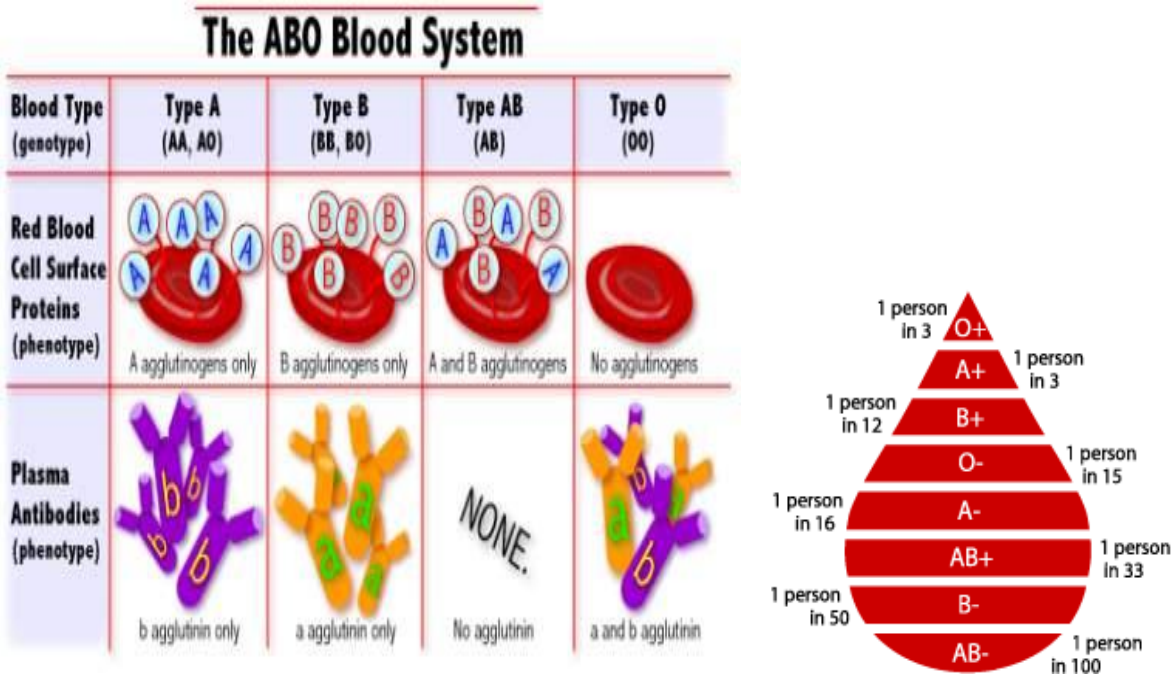


Fig 3.4 ABO blood grouping system

Blood group A

If you belong to the blood group A, you have A antigens on the surface of your RBCs and B antibodies in your blood plasma.

Blood group B

If you belong to the blood group B, you have B antigens on the surface of your RBCs and A antibodies in your blood plasma.

Blood group AB

If you belong to the blood group AB, you have both A and B antigens on the surface of your RBCs and no A or B antibodies at all in your blood plasma.

Blood group O

If you belong to the blood group O (null), you have neither A or B antigens on the surface of your RBCs but you have both A and B antibodies in your blood plasma.

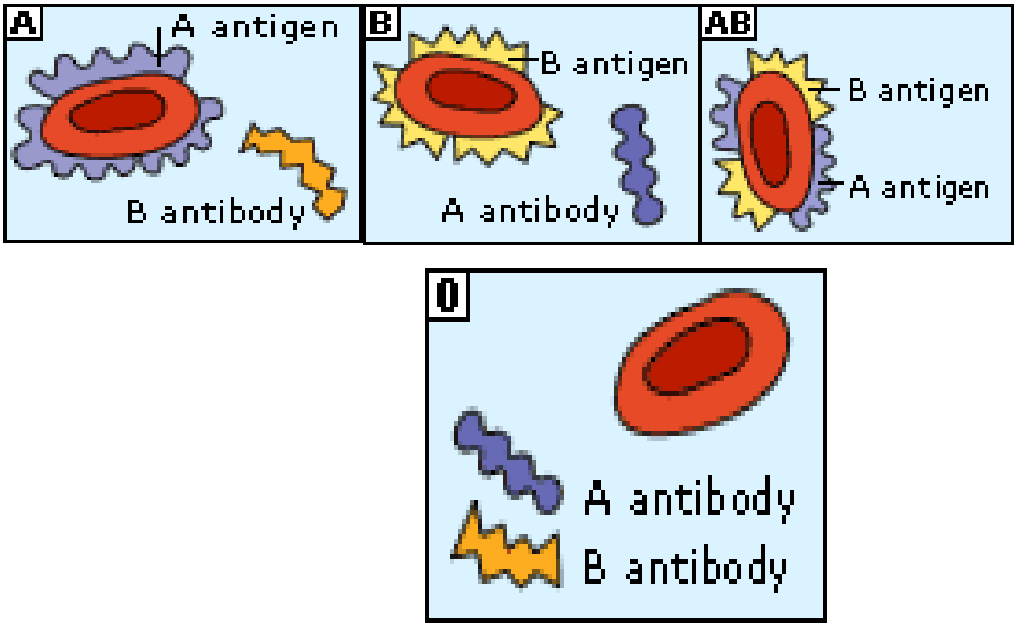


Fig 3.5 Blood groups

18BEBME306 ANATOMY AND HUMAN PHYSIOLOGY

UNIT II
CARDIAC AND NERVOUS SYSTEM

STRUCTURE OF HEART:

Functions to pump blood to all parts of the body
Muscle tissue = myocardium
Size of a closed fist
5" long and 3.5" wide
Weighs about 12-13 oz

- Located in the Thoracic Cavity between the lungs, in front of the thoracic vertebrae and above the diaphram.

Lies centrally located, but the apex is slightly to the left midline

Structures

- Pericardium
- Myocardium
- Endocardium
- Ventricular Septum
- 4 chambers: R&L atria

R&L ventricles

- Pericardium: double layer of fibrous tissue (outer layer)
- Myocardium: cardiac muscle tissue (middle layer)
- Endocardium: smooth muscle tissue lining the interior

Structures leading to and from the heart

- Superior & Inferior Vena Cava: large veins which brings deoxygenated blood to the R atrium from all parts of the body.
- Pulmonary Artery: takes blood away from the R ventricle to the to the lungs for oxygen.
- Pulmonary veins: which bring oxygenated blood to the heart from the lungs.
- Aorta: takes blood away from the L ventricle to the rest of the body.

Valves of the Heart

- Tricuspid Valve: structure that is positioned between the R atrium and R ventricle. It has this name because there are 3 cusps (points) of attachment.

It allows blood to flow from the R atrium into the R ventricle, but not in the opposite direction.

- Mitral Valve: located between the L atrium and L ventricle. Blood flows from the L atrium to the L ventricle, while backflow from the ventricle to the atrium is prevented.
- Closing of the valves produces heart sounds "lubb-dubb"

Semilunar Valves

- Aortic Semilunar Valve: is at the orafice of the aorta. This valve permits blood flow out of the L ventricle to the aorta, but not backwards into the L ventricle.
- Pulmonary Semilunar Valve: is found at the orafice of the pulmonary artery. It lets blood flow from the R ventticle into the pulmonary artery, and then into the lungs.

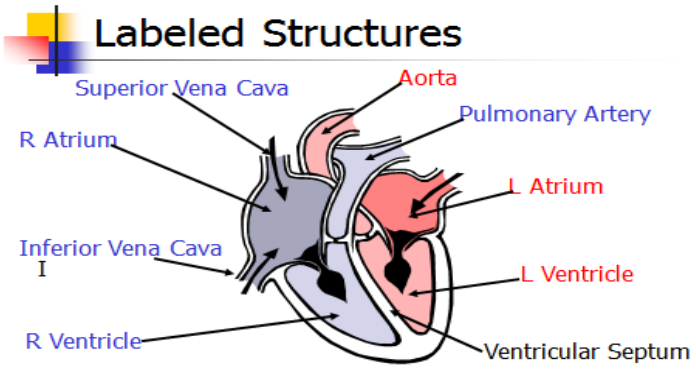


Fig 3.6 Structure of Heart

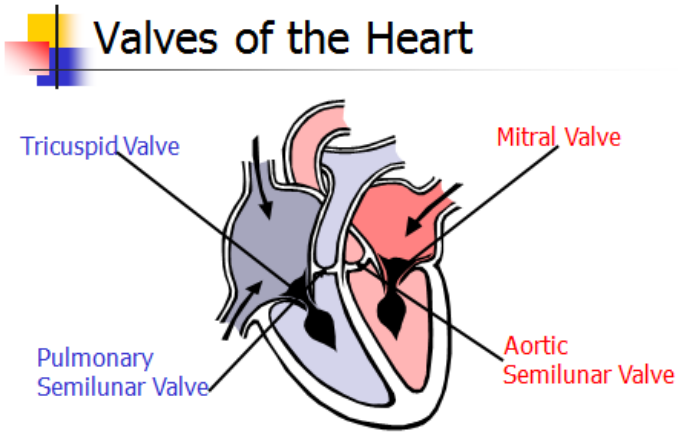


Fig 3.7 Valves of Heart

3.5 Properties of Cardiac muscle

Histological Properties of Cardiac Muscle Fibers

- Exhibit branching
- Adjacent cardiac cells are joined end to end by specialized structures known as intercalated discs
- Within intercalated discs there are two types of junctions
    - Desmosomes
    - Gap junctions..allow action potential to spread from one cell to adjacent cells.
- Heart function as syncytium
- when one cardiac cell undergoes an action potential, the electrical impulse spreads to all other cells that are joined by gap junctions so they become excited and contract as a single functional syncytium.

Atrial syncytium and ventricular syncytium

THE CARDIAC MUSCLE

- Contractile muscle fibres (myocardium 99%)

Atrial muscle fibres& Ventricular muscle fibres

- Both contract same as in sk. Muscle
- Duration of contraction much longer
    - Excitatory & conductive muscle fibres (autorhythmic 1%)
- Few contractile fibrils (v.weak contraction)
- Exhibit either automatic rhythmic discharge(AP)

OR

Conduction of the AP through heart

Properties of Cardiac Muscle Fibers

1. Autorhythmicity: The ability to initiate a heart beat continuously and regularly without external stimulation
2. Excitability: The ability to respond to a stimulus of adequate strength and duration (i.e. threshold or more) by generating a propagated action potential
3. Conductivity: The ability to conduct excitation through the cardiac tissue
4. Contractility: The ability to contract in response to stimulation

3.6 Conducting System of Heart

Physiology of Cardiac Conduction:

- The excitatory & electrical conduction system of the heart is responsible for the contraction and relaxation of the heart muscle.
- The sinoatrial node (SA node) is the pacemaker where the electrical impulse is generated.

Cardiac conduction pathway

1. SA node fires to the AV node through gap jxn's
2. AV node delays 0.1 s for atrial diastole
3. AV node fires to the AV bundle (HIS)
4. AV bundle depolarizes through right & left bundle branches
5. Bundle branches carry impulses through Purkinje fibers to the ventricular myocardium for ventricular systole
   Total time of conduction = 0.22 s

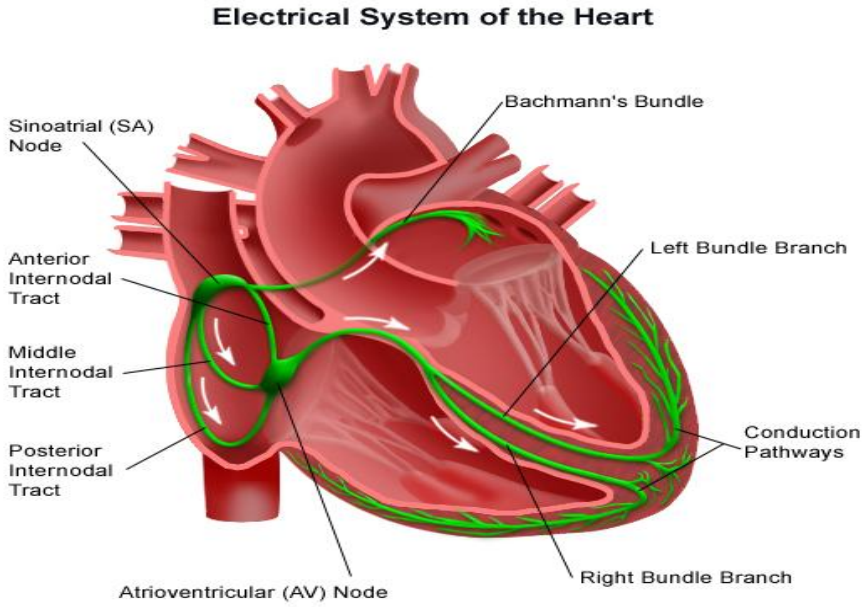


Fig 3.8 Electrical System Of Heart

Nodal Firing Rates

- Sa node = 75 b.p.m.
- AV node = 50 b.p.m.
- AV bundle = 30 b.p.m.
- Purkinje fibers = 30 b.p.m.

3.7 Cardiac cycle:

ATRIAL SYSTOLE-The end of diastole

- Prior to atrial systole, blood has been flowing passively from the atrium into the ventricle through the open AV valve.
- During atrial systole the atrium contracts and tops off the volume in the ventricle with only a small amount of blood. Atrial contraction is complete before the ventricle begins to contract.

Pressures & Volumes

- The "a" wave occurs when the atrium contracts, increasing atrial pressure (yellow).
- Blood arriving at the heart cannot enter the atrium so it flows back up the jugular vein, causing the first discernible wave in the jugular venous pulse.
- Atrial pressure drops when the atria stop contracting.
- During atrial systole the atrium contracts and tops off the volume in the ventricle with only a small amount of blood.
- Atrial contraction is complete before the ventricle begins to contract.

ECG

- An impulse arising from the SA node results in depolarization and contraction of the atria (the right atrium contracts slightly before the left atrium).
- The P wave is due to this atrial depolarization.
- The PR segment is electrically quiet as the depolarization proceeds to the AV node.
- This brief pause before contraction allows the ventricles to fill completely with blood.

Heart Sounds

- A fourth heart sound (S4) is abnormal and is associated with the end of atrial emptying after atrial contraction.
- It occurs with hypertrophic congestive heart failure, massive pulmonary embolism, tricuspid incompetence, or corpulmonale.

ISOVOLUMETRIC CONTRACTION- The Beginning of systole

- The atrioventricular (AV) valves close at the beginning of this phase.
- Electrically, ventricular systole is defined as the interval between the QRS complex and the end of the T wave (the Q-T interval).

- Mechanically, ventricular systole is defined as the interval between the closing of the AV valves and the opening of the semilunar valves (aortic and pulmonary valves).

Pressures & Volumes

- The AV valves close when the pressure in the ventricles (red) exceeds the pressure in the atria (yellow).
- As the ventricles contract isovolumetrically -- their volume does not change (white) -- the pressure inside increases, approaching the pressure in the aorta and pulmonary arteries (green).

ECG

- The electrical impulse propagates from the AV node through the His bundle and Purkinje system to allow the ventricles to contract from the apex of the heart towards the base.
- The QRS complex is due to ventricular depolarization, and it marks the beginning of ventricular systole. It is so large that it masks the underlying atrial repolarization signal. the ventricles to fill completely with blood.

Heart Sounds

- The first heart sound (S1, "lub") is due to the closing AV valves and associated blood turbulence.

RAPID EJECTION

Heart

- The semilunar (aortic and pulmonary) valves open at the beginning of this phase.

Pressures & Volumes

- While the ventricles continue contracting, the pressure in the ventricles (red) exceeds the pressure in the aorta and pulmonary arteries (green); the semilunar valves open, blood exits the ventricles, and the volume in the ventricles decreases rapidly (white).
- As more blood enters the arteries, pressure there builds until the flow of blood reaches a peak.
- The "c" wave of atrial pressure is not normally discernible in the jugular venous pulse. Right ventricular contraction pushes the tricuspid valve

into the atrium and increases atrial pressure, creating a small wave into the jugular vein. It is normally simultaneous with the carotid pulse.

ECG

- No Deflections

Heart Sounds

- None

REDUCED EJECTION- The end of systole

Heart

- At the end of this phase the semilunar (aortic and pulmonary) valves close.

Pressures & Volumes

- After the peak in ventricular and arterial pressures (red and green), blood flow out of the ventricles decreases and ventricular volume decreases more slowly (white).
- When the pressure in the ventricles falls below the pressure in the arteries, blood in the arteries begins to flow back toward the ventricles and causes the semilunar valves to close. This marks the end of ventricular systole mechanically.

ECG

- The T wave is due to ventricular repolarization. The end of the T wave marks the end of ventricular systole electrically.

Heart Sounds

- None

ISOVOLUMETRIC RELAXATION-The beginning of Diastole

Heart

- At the beginning of this phase the AV valves are closed.

Pressures & Volumes

- Throughout this and the previous two phases, the atrium in diastole has been filling with blood on top of the closed AV valve, causing atrial pressure to rise gradually (yellow).
- The "v" wave is due to the back flow of blood after it hits the closed AV valve. It is the second discernible wave of the jugular venous pulse.
- The pressure in the ventricles (red) continues to drop.
- Ventricular volume (white) is at a minimum and is ready to be filled again with blood.

ECG

- No Deflections

Heart Sounds

- The second heart sound (S2, "dup") occurs when the semilunar (aortic and pulmonary) valves close. S2 is normally split because the aortic valve closes slightly earlier than the pulmonary valve.

RAPID VENTRICULAR FILLING

Heart

- Once the AV valves open, blood that has accumulated in the atria flows rapidly into the ventricles.

Pressures & Volumes

- Ventricular volume (white) increases rapidly as blood flows from the atria into the ventricles

ECG

- No Deflections

Heart Sounds

- A third heart sound (S3) is usually abnormal and is due to rapid passive ventricular filling. It occurs in dilated congestive heart failure, severe hypertension, myocardial infarction, or mitral incompetence.

REDUCED VENTRICULAR FILLING-(Diastasis)

Heart

- Rest of blood that has accumulated in the atria flows slowly into the ventricles.

Pressures & Volumes

- Ventricular volume (white) increases more slowly now. The ventricles continue to fill with blood until they are nearly full.

ECG

- No Deflections

Heart Sounds

- None

3.8 Volume And Pressure Changes And Regulation Of Heart Rate

- Each tissue regulates its own local blood flow based on its needs, which include:

  - Deliver O_2, glucose, amino acids, and fatty acids.

  - Remove CO_2 and H^+ ions.

  - Maintain proper [ion]s.

  - Transport hormones and other nutrients.

Local and Humoral Control of Blood Flow

- Local Control

- Acute control rapid (seconds to minutes) changes in vasodilation or vasoconstriction.

- Long-term local control - change in the physical size or numbers of blood vessels, occurs over days to months.

- Humoral Control

- Substances secreted or absorbed into the body fluids that cause vasoconstriction or vasodilation, *e.g.*, hormones, peptides and ions.

Vascular Theory for Local Control of Blood Flow

Vasodilator Theory –

As metabolism and O_2 consumption increase, vasodilators are produced and released from the tissue. These act on precapillary sphincters, metarterioles and arteries. Some vasodilators are:Adenosine, CO_2, ATP compounds, histamine, K^+ ions and H^+ ions.Many think adenosine is the most important.

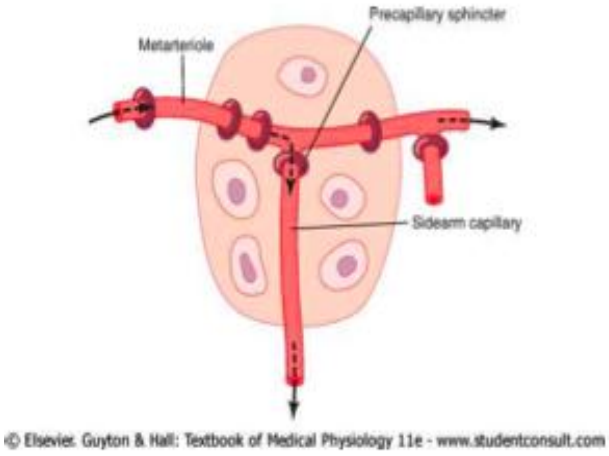


Fig 3.9Vasodilator Theory

Reactive and Active Hyperemia

These are examples of vasodilation and nutrient-lack theory (metabolic control).

- Reactive hyperemia is an increase of blood flow after the flow to a tissue has been blocked (think of nutrient-lack theory).
- Active hyperemia is an increase in blood flow in response to increased activity.

Myogenic Theory

Another example of local control of blood flow.

Arterial Pressure causes increased blood flow → less than a min → BF normalizes even though arterial Pressure stays high.

The Myogenic theory for this is that stretching of small blood vessels causes the smooth muscle of the vessel wall to contract. Conversely, at low pressures, the muscles relax.

Nitric Oxide

- Increased blood flow in arterioles causes the release of NO (endothelium relaxing factor). This causes small arteries upstream to relax.

Long-term Local Regulation of Blood Flow

- Works by changing the vascularity (number and size of arterioles and capillaries) to match the needs of a tissue.
- Degree of vascularity is determined by the maximum blood flow needed.
- Important peptides that increase vascularity are vascular endothelial growth factor (VEGF), fibroblast growth factor, and angiogenin.

Humoral Control of Circulation

- Controlled by substances secreted or absorbed into the body fluids.

  - Vasoconstriction

  - Vasodilation

Humoral Vasoconstriction

- Sympathetic and adrenal release of norepinephrine and epinephrine.
- Angiotensin II (more on this when we discuss renal mechanisms).
- Vasopressin (ADH) – very potent vasoconstrictor secreted by the posterior pituitary. Also increases renal H_2O reabsorption.
- Endothelin A – released from damaged vessels.

Humoral Vasodilation

- Bradykinin – powerful arteriolar dilation and increased permeability of the capillaries.

- Histamine – released from damaged or inflamed tissue; also during an allergic reaction. Also cases arteriolar dilation and increased permeability of the capillaries.

3.9 Coronary Circulation:

- Heart is supplied by TWO CORONARY arteries:

1- Right coronary artery---(RCA)

2- Left coronary artery---(LCA)

- These coronary arteries arise at the root of the aorta.

Coronary artery & their branches

- LCA---- -Lt Anterior Descending (LAD)

  -Marginal Artery

  -Circumflex Artery

- RCA ---- -Marginal Artery

-Posterior descending branch

Left coronary artery (LCA) –Divides in

Anterior Descending (LAD)

Circumflex artery

- LAD--- Supplies anterior and apical parts of heart ,and Anterior 2/3rd of interventricular septum.
- Circumflex branch-- supplies the lateral and posterior surface of heart.
- Right coronary artery(RCA) supplies:
- Right ventricle
- Part of interventricular septum (posterior 1/3rd)
- Inferior part of left ventricle

- AV Node

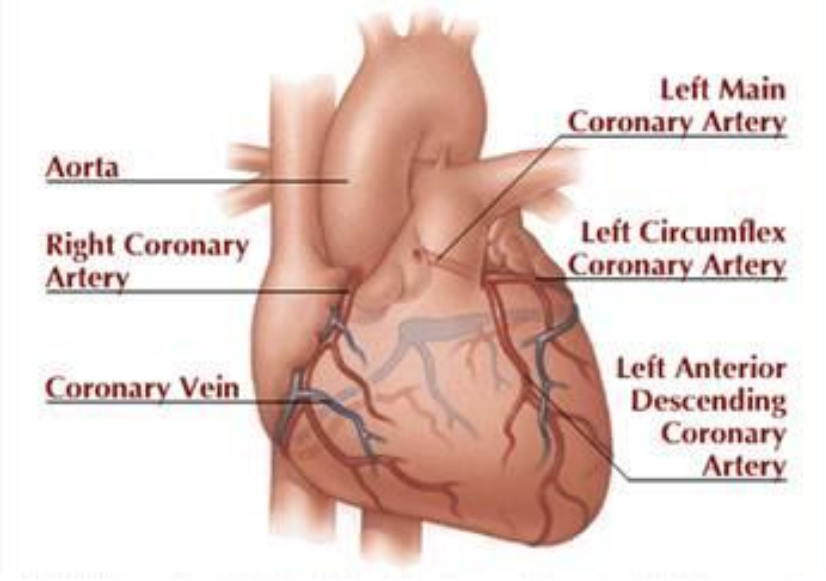


Fig 3.10 Heart

Venous return of Heart

Most of the venous blood return to heart occurs through the coronary sinus and anterior cardiac veins, which drain into the right atrium

Blood flow to Heart during Systole & Diastole

- During systole when heart muscle contracts it compresses the coronary arteries therefore blood flow is less to the left ventricle during systole and more during diastole.
- To the subendocardial portion of Left ventricle it occurs only during diastole
- As we know blood flow to subendocardial surface of left ventricle during systole is not there, therefore, this region is prone to ischemic damage and most common site of Myocardial infarction.
- Coronary blood flow to the right side is not much affected during systole.

Reason---Pressure difference between aorta and right ventricle is greater during systole than during diastole, therefore more blood flow to right ventricle occurs during systole.

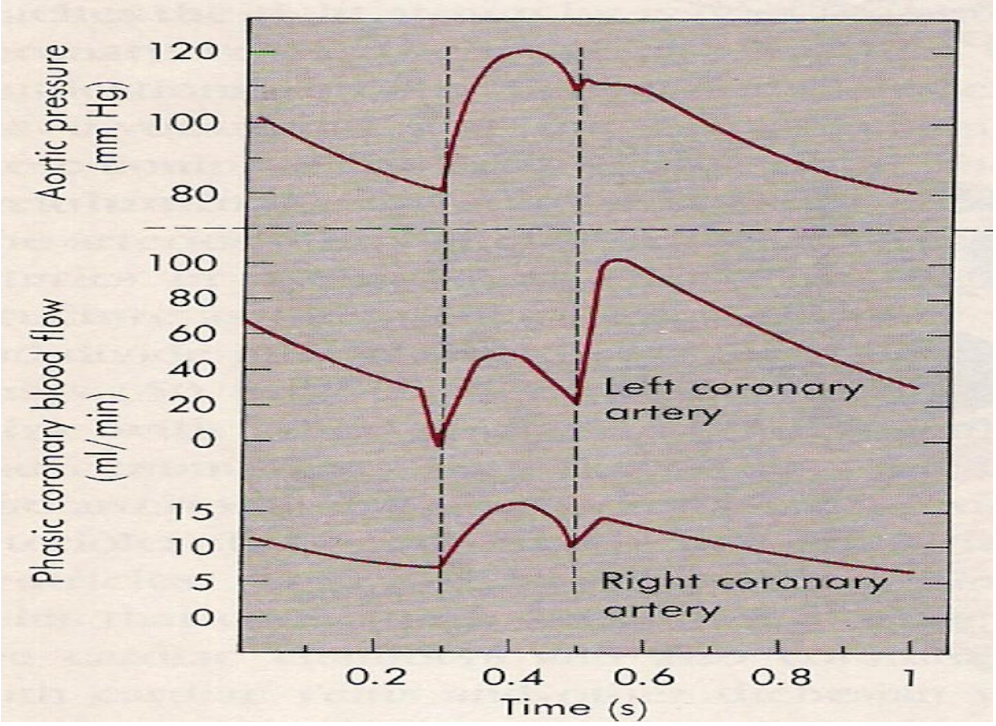


Fig 3.11 Coronary Blood Flow During Systole And Diastole

3.10 Factors regulating Blood flow

Redistribution of Blood Flow During Exercise

- Increased blood flow to working skeletal muscle

At rest, 15–20% of cardiac output to muscle

Increases to 80–85% during maximal exercise

• Decreased blood flow to less active organs

Liver, kidneys, GI tract

• Redistribution depends on metabolic rate

Exercise intensity

Regulation of Local Blood Flow During Exercise

Skeletal muscle vasodilation

– Autoregulation

Blood flow increased to meet metabolic demands of tissue

Due to changes in O2 tension, CO2 tension, nitric oxide,potassium, adenosine, and pH

Vasoconstriction to visceral organs and inactive tissues

SNS vasoconstriction

NERVOUS SYSTEM

5. Structure of a Neuron – Types of Neuron:

5.1 The Neuron

- The neuron is the basic building block of the nervous system
- They are often grouped in bundles called nerves.

4 parts of the neuron

1. Dendrites are specialized to receive signals from neighboring neurons and carry them back to the cell body
    - Thin, bushy-like structures that receive information from outside the neuron
    - Relays the information into the cell body
2. The Cell body contains the cell nucleus
   The cell body relays the information down to the axon
3. Axon: A thin, long structure that transmits signals from the cell body to the axon terminal.
4. Axon Terminal is the last step for the relay of information inside the neuron.

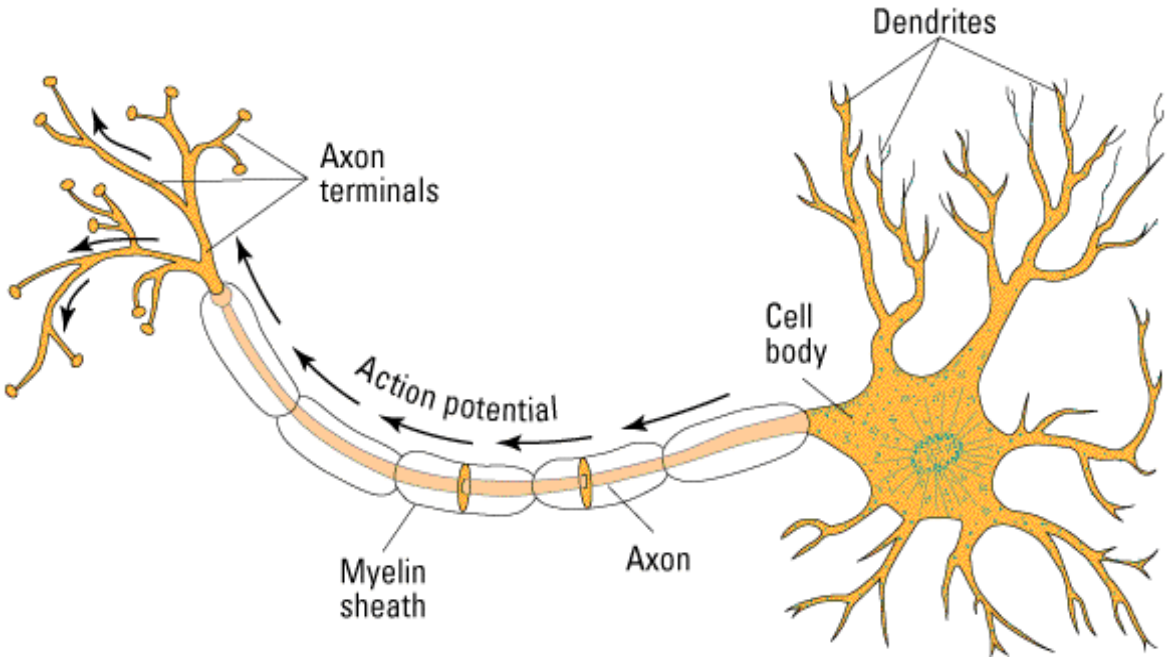


Fig 5.1 Structure of Neuron

Three main types of neurons

- Sensory Neurons
- Interneurons
- Motor Neurons

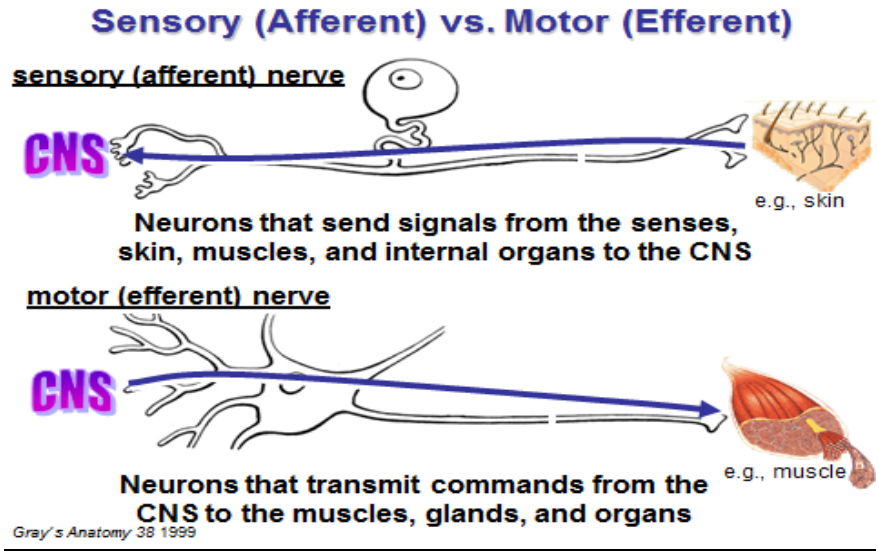


Fig 5.2 Neuron types

5.2 Synapses and types

- Neurons communicate by transmitting chemicals at junctions called "synapses"

In 1906, Charles Scott Sherrington coined the term synapse to describe the specialized gap that existed between neurons

- Sherrington observed that repeated stimuli over a short period of time produced a stronger response.
- Led to the idea of temporal summation or that repeated stimuli can have a cumulative effect and can produce a nerve impulse when a single stimuli is too weak.

Two Kinds of Synapses

1. Chemical
2. Electrical

- Both types of synapses relay information, but do so by very different mechanisms.
- Much more is known about chemical than about electrical synapses.

Electrical Synapses

- Symmetrical morphology.
- Bidirectional transfer of information, but can be unidirectional.
- Pre- and postsynaptic cell membranes are in close apposition to each other (~ 3.5 vs. ~ 20 nm in other cells), separated only by regions of cytoplasmic continuity, calledgap junctions.

- Ions can flow through these gap junctions, providing low-resistance pathway for ion flow between cells without leakage to the extracellular space: signal transmission = electrotonic transmission.

- Instantaneous, fast transfer from 1 cell to the next (< 0.3 msec), unlike the delay seen with chemical synapses.

Putative Functions

- Synchronization of the electrical activity of large populations of neurons;

- e.g., the large populations of neurosecretory neurons that synthesize and release biologically active peptide neurotransmitters and hormones are extensively connected by electrical synapses.

- e.g., Synchronization may be required for neuronal development, including the development of chemical synapses.

- e.g., Synchronization may be important in functions that require instantaneous responses, such as reflexes and pacemakers**.**

Chemical Synapses

- Asymmetric morphology with distinct features found in the pre- and postsynaptic parts.
- Enlarged extracellular space with no cytoplasmic continuity = Synaptic cleft is ~ 200-300 A wide.
- CHO moities intersperse the synapse.
- Most presynaptic endings are axon terminals.
- Most postsynaptic elements in the CNS are dendrites**.**
- Convergence.
- Divergence.
- Presynaptic ending:

  - swelling of the axon terminal.

    - mitochondria.

    - a variety of vesicular structures, clustered at/near the very edge of the axon terminal.

- Postsynaptic element

    - comprised largely of an electron-dense structure, called the postsynaptic density (PSD).

  Function of PSD?

    - Anchor receptors for neurotransmitters in the postsynaptic membrane.

- Involved in the conversion of a chemical signal into an electrical one = transduction.

- Associated with the morphological asymmetry is that chemical synapses are, for the most part, unidirectional.
- There is a delay of ~0.3 – 5 msec between the arrival of information at the presynaptic terminal and its transfer to the postsynaptic cell.

  This delay may reflect the several steps required for signal transmission= the release and action of a chemical neurotransmitter, which is usually Ca^{2+}-dependent.

  The response of the postsynaptic neuron may be sustained (long-lasting), much longer than the presynaptic signal the evoked it.

  This may reflect long-lasting changes in the target (receiving) cell.
- The most common type of synapse in the vertebrate nervous system.

5.3 Conduction of action potential in neuron

- They are initiated in an all-or-none manner when the summed graded potential exceed threshold voltage.
- They remain the same size as they travel along the axon over long distances.
- They are identical to one another.
- Occurs upon alteration of the permeability of Na^+ and K^+ ions through voltage-gated channels.

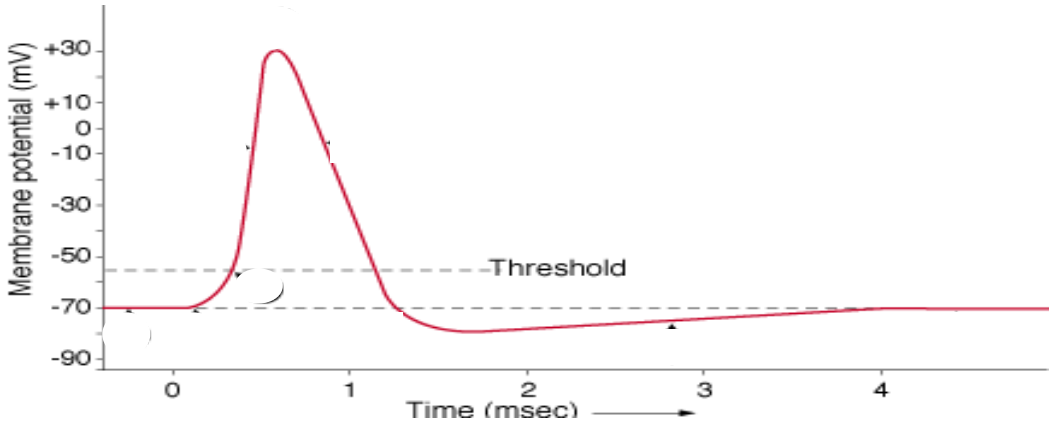


Fig 5.3 Action Potential

Action Potential Conduction

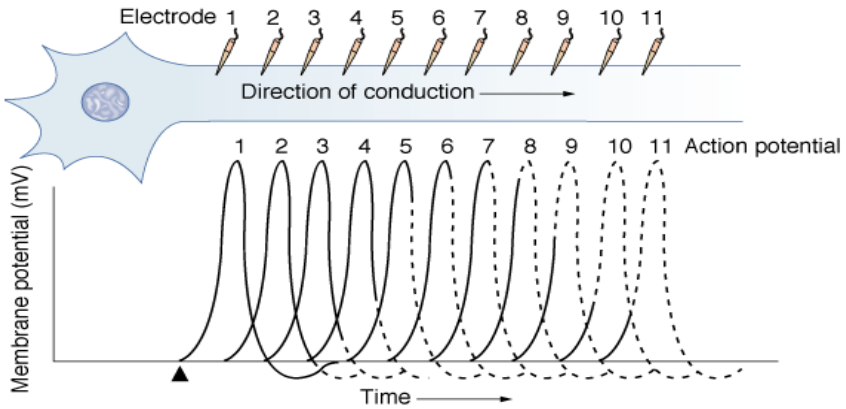


Fig 5.4 Action Potential Conduction

- Movement of the AP along the axon at high speed is called <u>conduction</u>.
- A wave of action potentials travel down the axon.
- Each section of the axon is experiencing a different phase of the AP (see figure).

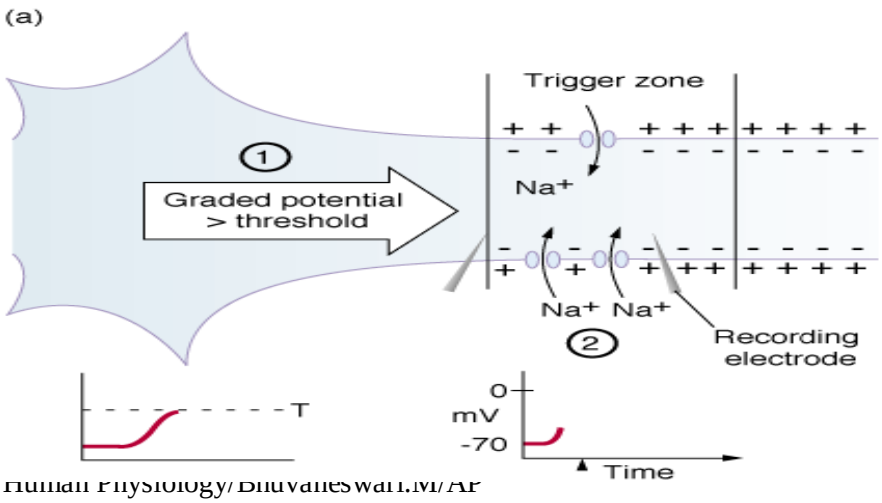


Fig 5.5 Action Potential phases

- Graded potential triggers AP. Opens voltage-gated Na^+ channels.

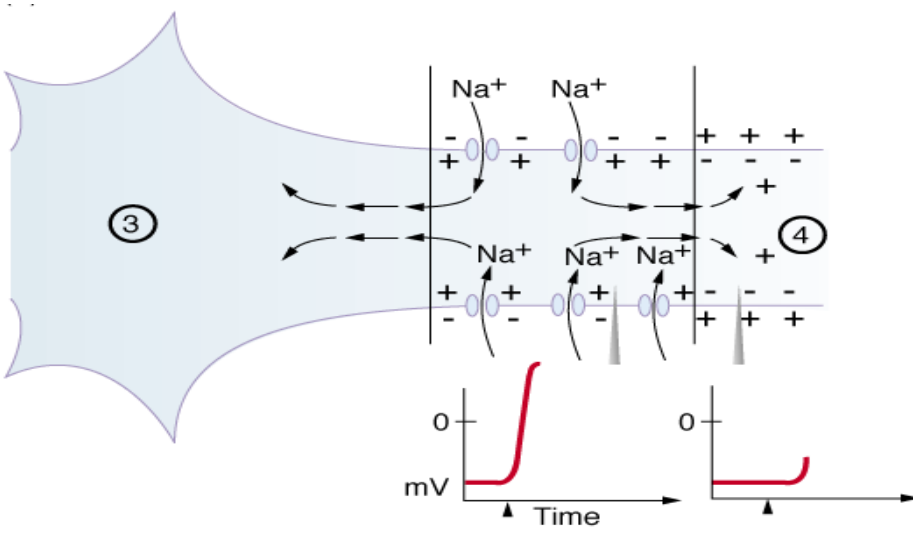


Fig 5.6 Graded Potential

- The Na^+ spreads in all directions attracted by the -ve ions in adjacent regions (3,4). Opens Na^+ channels and initiates AP in the adjacent region along the axon (4), but not in the cell body where there are no voltage-gated Na^+ channels (3).

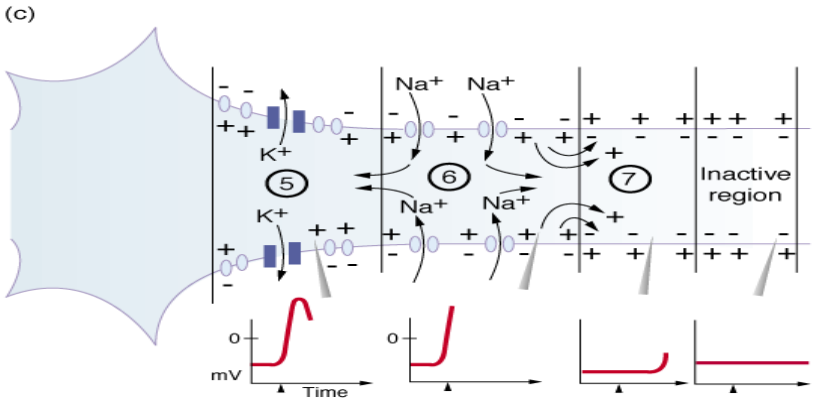


Fig 5.7 Graded Potential

- K^+ channels have opened in the initial segment (5) and the Na^+ (6) ions cannot trigger an AP in that region since its absolutely refractory. Na^+ ions initiate action potentials in segment (7).

5.4 Brain – Divisions of brain lobes

Lobes of the Brain :

- Frontal
- Parietal
- Occipital
- Temporal

Lobes of the Brain – Frontal

- The Frontal Lobe of the brain is located deep to the Frontal Bone of the skull.
- It plays an integral role in the following functions/actions:
  - Memory Formation
  - Emotions
  - Decision Making/Reasoning
  - Personality
- Frontal Lobe - Cortical Regions **Primary Motor Cortex (Precentral Gyrus)** – Cortical site involved with controlling movements of the body.

- **Broca's Area** – Controls facial neurons, speech, and language comprehension. Located on **Left** Frontal Lobe.
    - **Broca's Aphasia** – Results in the ability to comprehend speech, but the decreased motor ability (or inability) to speak and form words.
- **Orbitofrontal Cortex** – Site of Frontal Lobotomies

Desired Effects:

- Diminished Rage
- Decreased Aggression
- Poor Emotional Responses

Possible Side Effects:

- Epilepsy
- Poor Emotional Responses
- Perseveration (Uncontrolled, repetitive actions, gestures, or words)

Lobes of the Brain - Parietal Lobe

- The Parietal Lobe of the brain is located deep to the Parietal Bone of the skull.
- It plays a major role in the following functions/actions:

  - Senses and integrates sensation(s)

  -Spatial awareness and perception

  (Proprioception - Awareness of body/ body parts in space and in relation to each other)

Parietal Lobe - Cortical Regions

- **Primary Somatosensory Cortex (Postcentral Gyrus)** – Site involved with processing of tactile and proprioceptive information.
- **Somatosensory Association Cortex -** Assists with the integration and interpretation of sensations relative to body position and orientation in space. May assist with visuo-motor coordination.

- **Primary Gustatory Cortex** – Primary site involved with the interpretation of the sensation of Taste.

Lobes of the Brain – Occipital Lobe

- The Occipital Lobe of the Brain is located deep to the Occipital Bone of the Skull.
- Its primary function is the processing, integration, interpretation, etc. of VISION and visual stimuli.

Occipital Lobe – Cortical Regions

- **Primary Visual Cortex** – This is the primary area of the brain responsible for sight -recognition of size, color, light, motion, dimensions, etc.
- **Visual Association Area** – Interprets information acquired through the primary visual cortex.

Lobes of the Brain – Temporal Lobe

- The Temporal Lobes are located on the sides of the brain, deep to the Temporal Bones of the skull.
- They play an integral role in the following functions:
    - Hearing
    - Organization/Comprehension of language
    - Information Retrieval (Memory and Memory Formation)

Temporal Lobe – Cortical Regions

- **Primary Auditory Cortex** – Responsible for hearing
- **Primary Olfactory Cortex** – Interprets the sense of smell once it reaches the cortex via the olfactory bulbs. (Not visible on the superficial cortex)
- **Wernicke's Area** – Language comprehension. Located on the ***Left*** Temporal Lobe.

Wernicke's Aphasia – Language comprehension is inhibited. Words and sentences are not clearly understood, and sentence formation may be inhibited or non-sensical.

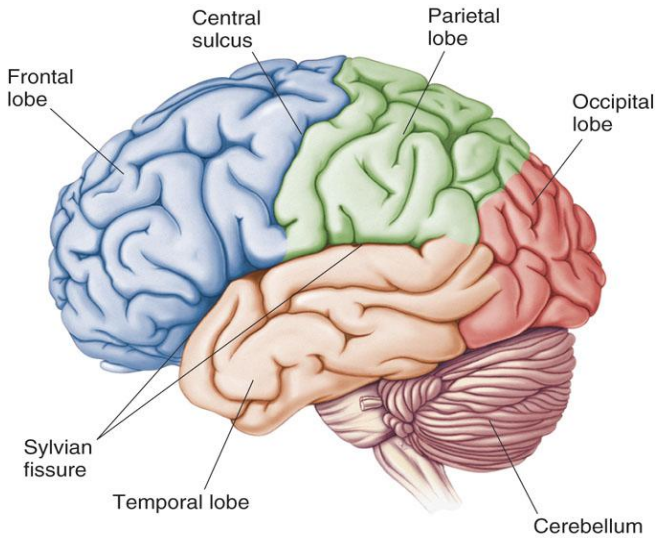


Fig 5.8 Lobes of Brain

Cortical Localizations And Functions

Sensory area

primary sensory area

secondary sensory area

Motor area

primary motor area

secondary motor area

supplementary motor area

Association area

parietal, occipital and temporal cortex

- conceptual elaboration of sensory data

prefrontal (frontal) cortex

- judgement, foresight

Disorders of Association Cortex

- **Agnosia**

Tactile agnosia

Visual agnosia

Alexia

Auditory agnosia

- **Apraxia**
- **Aphasia**

Wernicke's (receptive) aphasia

Broca's (Motor) aphasia

conduction aphasia

global aphasia

5.5 EEG-ELECTROENCEPHALOGRAPHY

The electroencephalogram (EEG) is a recording of the electrical activity of the brain from the scalp.

The first recordings were made by Hans Berger in 1929

Origin of EEG waves

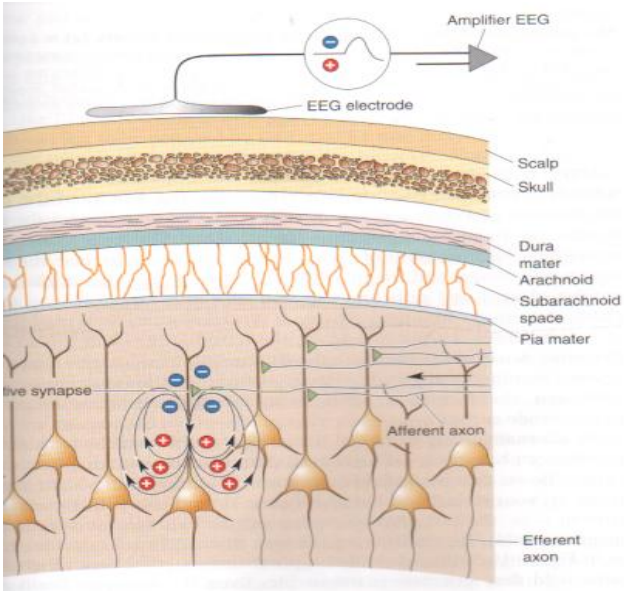


Fig 5.9 Origin of EEG waves

- EEG is the record of electrical activity of brain(superficial layer i.e. the dendrites of pyramidal cells) by placing the electrodes on the scalp.

Procedure of EEG recording

- A standard EEG makes use of 21 electrodes linked in various ways (Montage).
- Ask the subject to lie down in bed.
- Apply electrode according to 10/20% system.
- Check the impedance of the electrodes.

10 /20 % system of EEG electrode placement

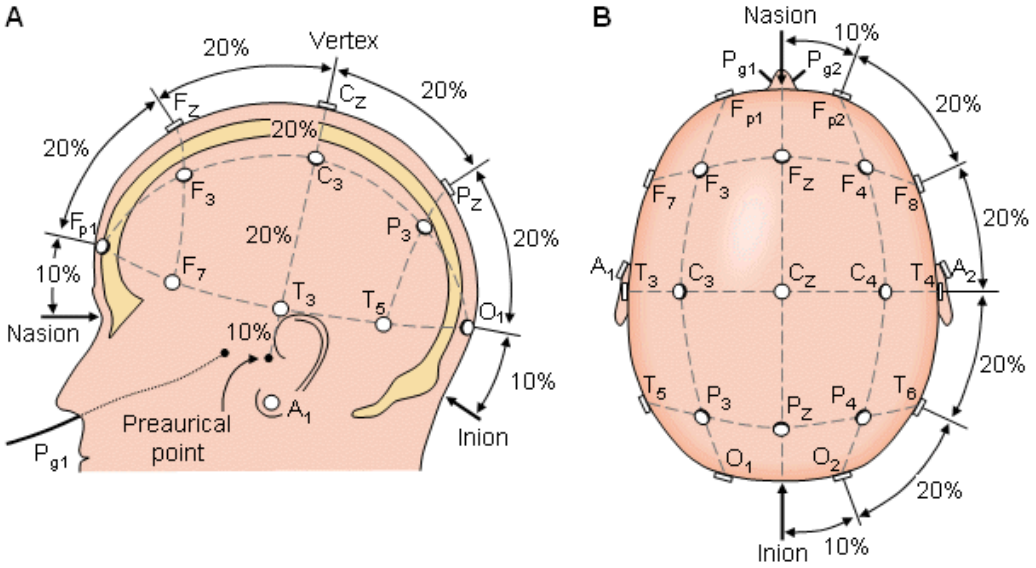


Fig 5.10 Electrode System

- Ask the subject to close his/her eyes.
- Select a montage.
- Press run switches on to run the paper.
- Press the calibration knob to check voltages & time constant.
- Always observe subject for any abnormal muscle activity.
- Ask the subject to open eyes for 10 sec.and ask him/her to close eyes. (do this procedure for several times in each montage)

EEG Electrodes

- Each electrode site is labeled with a letter and a number.
- The letter refers to the area of brain underlying the electrode e.g. F - Frontal lobe and T - Temporal lobe.
- Even numbers denote the right side of the head and
- Odd numbers the left side of the head.

Two types of recording

- Bipolar – both the electrodes are at active site
    - Bipolar montage areparasagital montage.

- Unipolar – one electrode is active and the other is indifferent kept at ear lobe.
    - Always watch for any abnormal muscle activity.
    - Ask the subject to open eyes for 10 sec. then ask them to close the eyes.

EEG Waves

- Alpha wave -- 8 – 13 Hz.
- Beta wave -- >13 Hz. (14 – 30 Hz.)
- Theta wave -- 4 – 7.5 Hz.
- Delta waves – 1 – 3.5 Hz.
    - D T A B

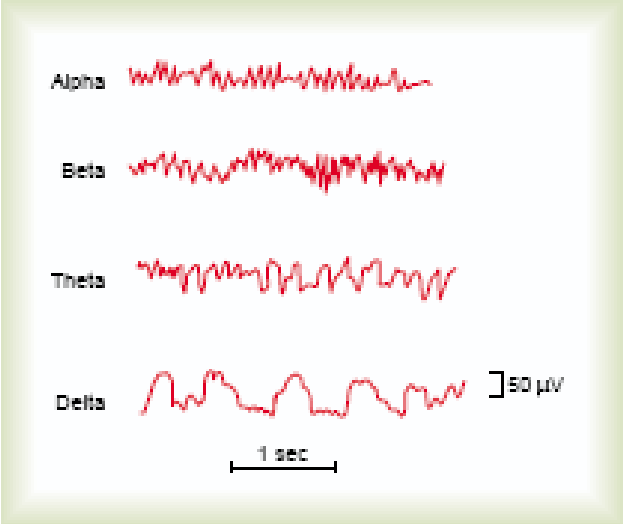


Fig 5.11 ECG waves

Alpha wave

- rhythmic, 8-13 Hz
- mostly on occipital lobe
- 20-200 µ V
- normal,
- relaxed awake rhythm with eyes closed

Beta wave

- irregular, 14-30 Hz
- mostly on temporal and frontal lobe
- mental activity
- excitement

Theta wave

- rhythmic, 4-7 Hz
- Drowsy, sleep

Delta wave

- slow, < 3.5 Hz
- in adults
- normal sleep rhythm

Factor influencing EEG

- Age
  - Infancy – theta, delta wave
  - Child – alpha formation.
  - Adult – all four waves.
- Level of consciousness (sleep)
- Hypocapnia(hyperventilation) slow & high amplitude waves.
- Hypoglycemia
- Hypothermia
- Low glucocorticoids

NORMAL EEG CHANGES

Desynchronization or Alpha block

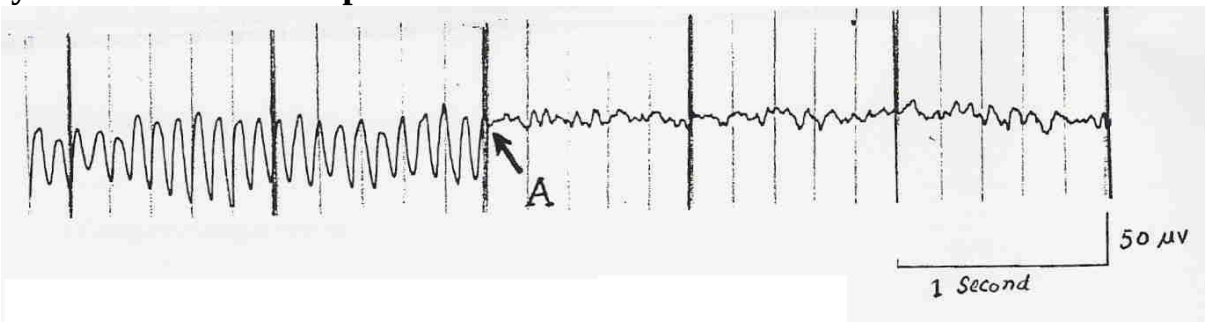


Fig 5.12 Desynchronization(1)

Cause:

- Eyes opening (after closure)
- Thinking by the subject (mathematicacalculation)
- Sound (clapping)

Eye opening

- Alpha rhythm changes to beta on eye opening (desynchronization / α- block)

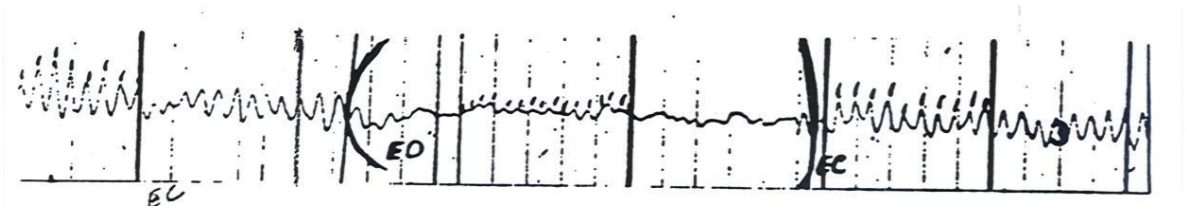


Fig 5.13 Desynchronization(2)

Thinking

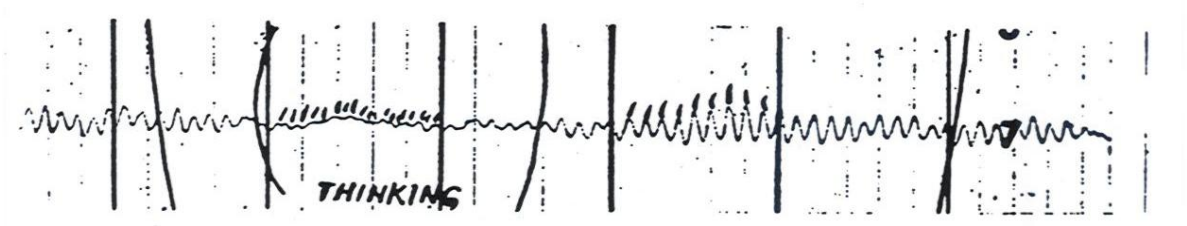


Fig 5.14Desynchronization(3)

Provocation test

- Intermittent photic stimulation
  - Increase rate & decrease amplitude
- Hyperventilation
  - **Decrease rate & increase in amplitude**

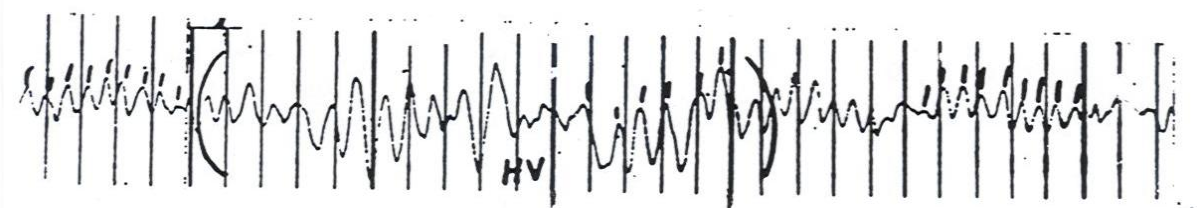


Fig 5.15Desynchronization(4)

Use of EEG

- Epilepsy
  - Generalized (grandmal) seizures.
  - Absence (petitmal) seizures.
- Localize brain tumors.
- Sleep disorders (Polysomnography)
  - Narcolepsy
  - Sleep apnea syndrome
  - Insomnia and parasomnia
- Helpful in knowing the cortical activity, toxicity, hypoxia and encephalopathy &
- Determination of brain death.

- Flat EEG(absence of electrical activity) on two records run 24 hrs apart.

5.6 Spinal cord –Tracts of spinal cord

It is covered by three membrane lies loosely in the vertebral canal. The covering of spinal cord are membranes in nature and are called meninges .The meninges are duramater and arachnoid membrane. These meninges are responsible for protection is nourishment to nervous tissues. The length of spinal cord is 45cm in males is 43cm in females.The spinal cord is cylindrical in shape with two enlargement.

- Cervicals
- Lumbae

Spinal cord made of 31 segment namely

- Cervicals
- Thorascic
- Lumbas
- Sacrum
- Coceyx

The neutral substance of spinal cord is divided into

- Inner gray mater
- Outer white matter

Gray matter is collection of nerve cells bodies dendrites is parts of axons. It is placed centrally in form of wings of butterfly and it resembles the letter "h". In the centre of gray matter there is a canal called spinal cord.White matter is collection of myelinated and on myelinated nerve fibres.

Track of spinal cord

The different collection of nerve fibres passing through the spinal cord are known as tracts of spinalcord.

Divided into two types;

- Short tracts
- Long tracts

Short tracts

The fibres of short tracts connect different part of spinal cord itself.

There are two types of short tracts namely

- Association or intrinsic (connects adjacent segment of spinal cord).
- Commissural (connect the opposite segment of spinal cord).

Long tracts or projection tracts

Which connects spinal cord with other parts of central nervous system.

There are two types namely;

- Ascending tracts (which carry sensory impulses from spinal cord to brain).
- Descending tracts(which carry motor impulses from brain to spinal cord).

5.7 Reflex mechanism – Types of reflex:

- Reflexes are automatic, unconscious to changes, either inside or outside the body.

a. Reflexes maintain homeotasis (autonomic reflexes) – heart rate, breathing rate, bp, digestion.
b. Reflexes also carry out the automatic actions of swallowing, sneezing, coughing, vomiting.
c. Reflexes maintain balance and posture; *e.g*., spinal reflexes control trunk and limb muscles.
d. Brain reflexes involve reflex center in brainstem; *e.g*., reflexes for eye movement.

Reflex Arc

- The reflex arc governs the operation of reflexes. Nerve impulses follow nerve pathways as they travel through the nervous system. The simplest of

these pathways, which include only a few neurons, is called the *reflex arc*. Reflexes whose arc passes through the spinal cord are called *spinal reflexes.*

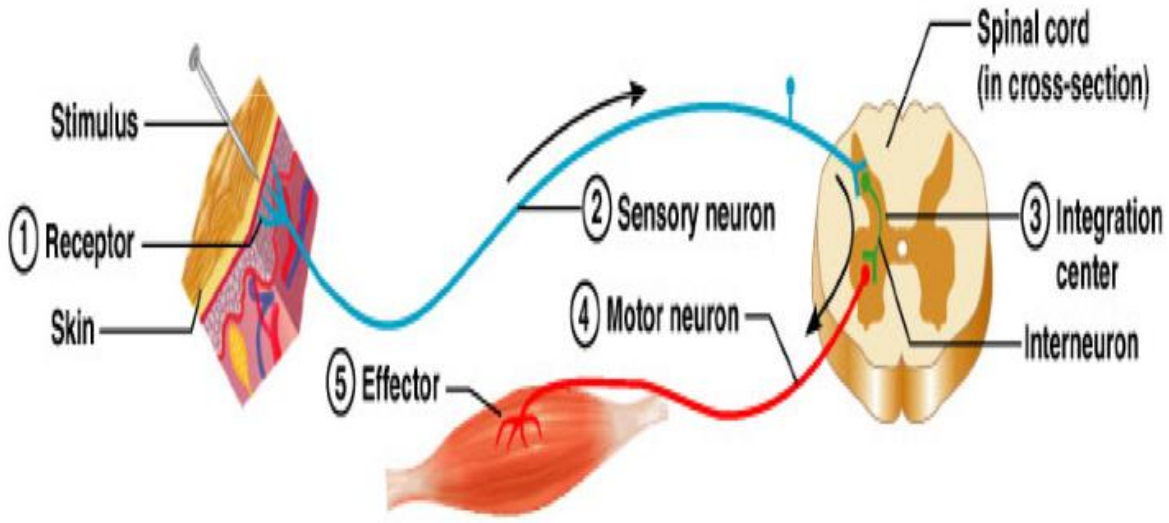


Fig 5.16 Reflex arc

Parts of the Reflex Arc

1. Receptor – detects the stimulus. a) Description: the receptor end of a particular dendrite or a specialized receptor cell in a sensory organ. b) Function: sensitive to a specific type of internal or external change.
2. Sensory neuron – conveys the sensory info. to brain or spinal cord. a. Description: Dendrite, cell body, and axon of a sensory neuron. b. Function: transmit nerve impulses from the receptor into the brain or spinal cord.
3. 3. Interneuron: relay neurons. a. Description: dendrite, cell body, and axon of a neuron within the brain or spinal cord. b. Function: serves as processing center, conducts nerve impulses from the sensory neuron to a motor neuron.
4. 4. Motor neuron: conduct motor output to the periphery. a. Description: Dendrite, cell body, and axon of a motor neuron. b. Function: transmits nerve impulse from the brain or spinal cord out to an effecter.
5. 5. Effector: a. Description: a muscle or gland. b. Function: Response to stimulation by the motor neuron and produces the reflex or behavioral action.

Spinal Reflexes

The Myotatic Reflex

- Stretch reflex: Muscle pulled→ tendency to pull back
- Feedback loop

- Discharge rate of sensory axons: Related to muscle length
- Monosynaptic
- Example: knee-jerk reflex

Reverse myotatic reflex

- Regulate muscle tension
- Golgi tendon organs

Stretch and Deep Tendon Reflexes

For skeletal muscles to perform normally:

- The Golgi tendon organs (proprioceptors) must constantly inform the brain as to the state of of the muscle.
- Stretch reflexes initiated by muscle spindles must maintain healthy muscle tone.

Stretch Reflex

- Stretching the muscle activates the muscle spindle.
- Excited g motor neurons of the spindle cause the stretched muscle to contract.
- Afferent impulses from the spindle result in inhibition of the antagonist inhibition of the antagonist.
- Example: patellar reflex.

Tapping the patellar tendon stretches the quadriceps and starts the reflex action.

The quadriceps contract and the antagonistic hamstrings relax.

Golgi Tendon Reflex

- The opposite of the stretch reflex.
- Contracting the muscle activates the Golgi tendon organs.
- Afferent Golgi tendon neurons are stimulated, neurons inhibit the contracting muscle, and the antagonistic muscle is activated.
- As a result, the contracting muscle relaxes and the antagonist muscle contracts.

Monosynaptic Stretch Reflex

- Simplest reflex because it has only 1 synapse in the path of its arc.
- Muscle spindles contain the sensory receptors for the stretch reflex.
- Each spindle contains modified muscle fibers called spindle or intrafusal fibers (inside spindle), innervated by γ efferent fibers.
- The middle segment of each spindle fiber acts as a mechanical stretch receptor that is connected to a sensory afferent nerve to the spinal cord.
- Stretching of the muscle stretches the spindle fibers activating the muscle spindle stretch receptors and the associated sensory fibers.

- The terminals of the spindle sensory fibers make direct excitatory synaptic contact with alpha motor neurons serving the ordinary muscle fiber (extrafusal fibers).
- Contraction of these fibers shorten the muscle and relaxes the spindle fibers terminating the stretch reflex and muscle contraction.

The Deep Tendon Reflex

- If you tap on the tendon of a muscle, it contracts. Its synergists contract and its antagonists are inhibited. - polysynaptic reflex.
- A tap on the patellar tendon stretches the extensor muscle and its spindles**.**
- The spindle discharges and excites the associated sensory fibers that excite the motor neurons to the extensor muscle.
- - Contraction of the extensor muscle extends the lower leg (knee - jerk).
- - Ipsilateral flexor muscle relax for extensors to function.
- - Branches of the sensory fibers from muscle spindle activate inhibitory interneuron, which in turn, inhibit the motor neuron to the flexor muscle.

The Withdrawal Reflex (Flexor Reflex)

- The automatic withdrawal of an extremity from a painful stimulus.
- A polysynaptic reflex.
- Sensory pain signals excite motor neurons to the flexor muscles, eliciting flexion and withdrawal of the leg.
- Motor neurons to the extensor muscles are inhibited via inhibitory interneurons.
- This would relax the extensors of the same leg.

The Crossed Extensor Reflex

- A polysynaptic reflex.
- *E.g.,* Painful stimulation of one foot causes flexion (withdrawal) of the ipsilateral leg as well as the extension of the contralateral leg, to stabilize the posture; thus the ipsilateral leg flexors are activated and the extensors are inhibited and *vice versa* in the contralateral leg.

5.8 Autonomic nervous system and its function:

Responsible for control of involuntary or visceral bodily functions visceral functions

- cardiovascular
- respiratory
- digestive

- urinary
- reproductive functions reproduce
- Key role in the bodies response to stress Key stress

Sympathetic nervous system

- allow body to function under stress allow stress
- fight or flight

Parasympathetic nervous system

- controls vegetative functions
- feed or breed or rest and repose
- constant opposition to sympathetic system

Sympathetic Effects

- Fight, Fright or flight response
- Release of Neurotransmitters (NT)-
  - Norepinephrine (NT) from postganglionic fibers
  - Epinephrine (NT) from adrenal medulla
- Mass activation prepares for intense activity
  - Heart rate (HR) increases
  - Bronchioles dilate
  - Blood [glucose] increases
- GI motility decreases
- Contraction of sphincters
- Relaxation of
  - Detrusor muscle
  - Ciliary muscle
- Mydriasis

Parasympathetic Effects

- Normally not activated as a whole
  - Stimulation of separate parasympathetic nerves.
- Release ACh as NT
- Relaxing effects-
  - Decreases HR.
  - Dilates visceral blood vessels.
  - Increases digestive activity.
- Bronchonstriction
- GI motility increases

- Relaxation of sphincters
- Contraction of
  - Detrusor muscle
  - Ciliary muscle
- Miosis

UNIT-3

RESPIRATORY SYSTEM AND MUSCULO SKELETAL SYSTEM

1. Skeletal System:

- Parts of the skeletal system
    - Bones (skeleton)
    - Joints
    - Cartilages
    - Ligaments (bone to bone)(tendon=bone to muscle)

3.1 Functions of Skeletal System

- SUPPORT: Hard framework that supports and anchors the soft organs of the body.
- PROTECTION: Surrounds organs such as the brain and spinal cord.
- MOVEMENT: Allows for muscle attachment therefore the bones are used as levers.
- STORAGE: Minerals and lipids are stored within bone material.
- BLOOD CELL FORMATION: The bone marrow is responsible for blood cell production.

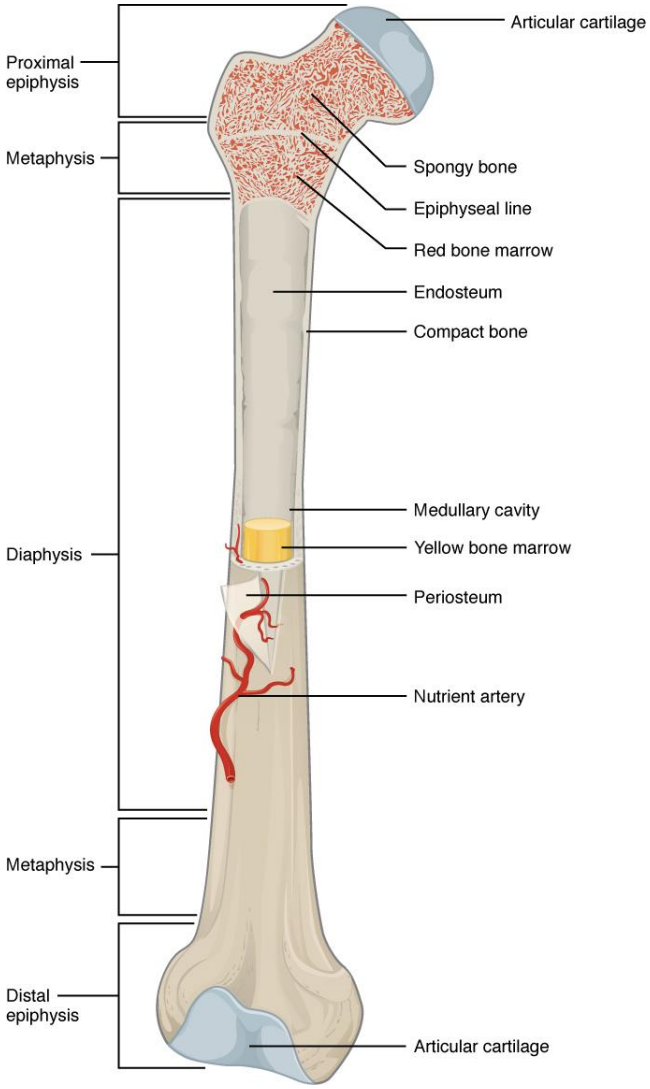
3.3 BONES

Gross Anatomy of Bone

The structure of a long bone allows for the best visualization of all of the parts of a bone ([link]). A long bone has two parts: the **diaphysis** and the **epiphysis**. The diaphysis is the tubular shaft that runs between the proximal and distal ends of the bone. The hollow region in the diaphysis is called the **medullary cavity**, which is filled with yellow marrow. The walls of the diaphysis are composed of dense and hard **compact bone**.

Anatomy of a Long Bone

A typical long bone shows the gross anatomical characteristics of bone.



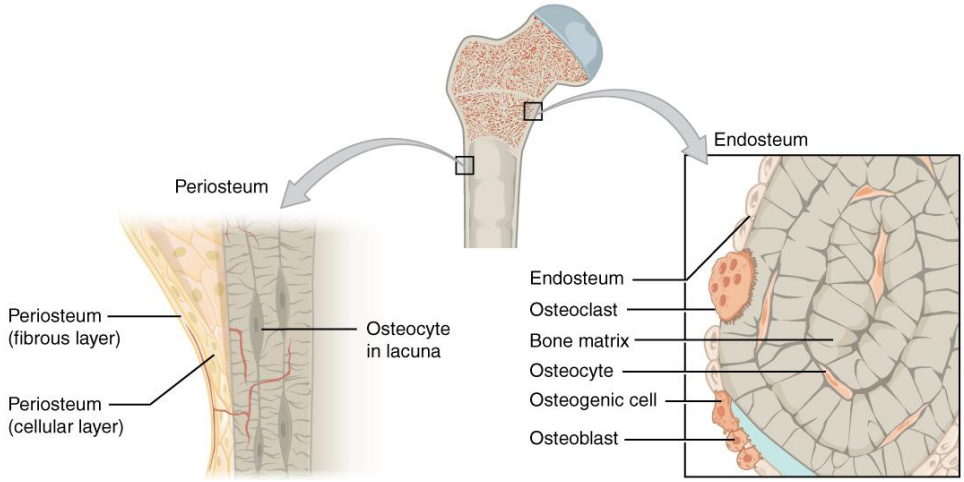
The wider section at each end of the bone is called the epiphysis (plural = epiphyses), which is filled with spongy bone. Red marrow fills the spaces in the spongy bone. Each epiphysis meets the diaphysis at the metaphysis, the narrow area that contains the **epiphyseal plate** (growth plate), a layer of hyaline (transparent) cartilage in a growing bone. When the bone stops growing in early adulthood (approximately 18–31 years), the cartilage is replaced by osseous tissue and the epiphyseal plate becomes an epiphyseal line.

The medullary cavity has a delicate membranous lining called the **endosteum** (end- = "inside"; oste- = "bone"), where bone growth, repair, and remodeling occur. The outer surface of the bone is covered with a fibrous membrane called the **periosteum** (peri– = "around" or "surrounding"). The periosteum contains blood vessels, nerves, and lymphatic vessels that nourish

compact bone. Tendons and ligaments also attach to bones at the periosteum. The periosteum covers the entire outer surface except where the epiphyses meet other bones to form joints ([link]). In this region, the epiphyses are covered with **articular cartilage**, a thin layer of cartilage that reduces friction and acts as a shock absorber.

Periosteum and Endosteum

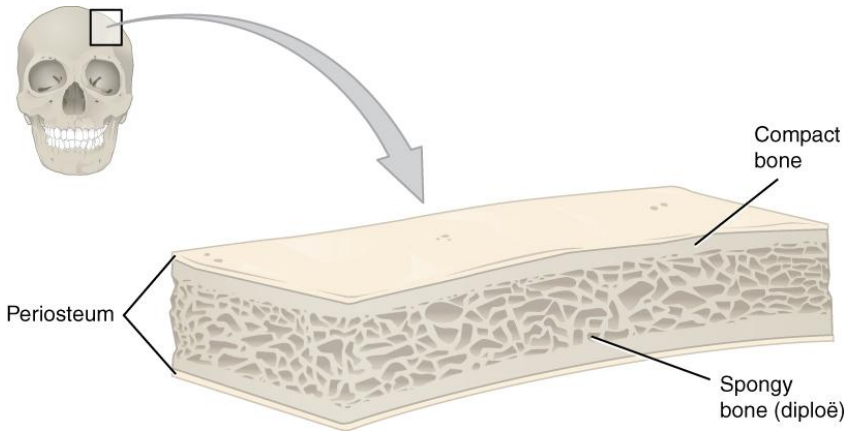
The periosteum forms the outer surface of bone, and the endosteum lines the medullary cavity.



Flat bones, like those of the cranium, consist of a layer of **diploë** (spongy bone), lined on either side by a layer of compact bone ([link]). The two layers of compact bone and the interior spongy bone work together to protect the internal organs. If the outer layer of a cranial bone fractures, the brain is still protected by the intact inner layer.

Anatomy of a Flat Bone

This cross-section of a flat bone shows the spongy bone (diploë) lined on either side by a layer of compact bone.



Bone Markings

The surface features of bones vary considerably, depending on the function and location in the body. [link] describes the bone markings, which are illustrated in ([link]). There are three general classes of bone markings: (1) articulations, (3) projections, and (3) holes. As the name implies, an **articulation** is where two bone surfaces come together (articulus = "joint"). These surfaces tend to conform to one another, such as one being rounded and the other cupped, to facilitate the function of the articulation. A **projection** is an area of a bone that projects above the surface of the bone. These are the attachment points for tendons and ligaments. In general, their size and shape is an indication of the forces exerted through the attachment to the bone. A **hole** is an opening or groove in the bone that allows blood vessels and nerves to enter the bone. As with the other markings, their size and shape reflect the size of the vessels and nerves that penetrate the bone at these points.

Bone Markings		
Marking	**Description**	**Example**
Articulations	Where two bones meet	Knee joint

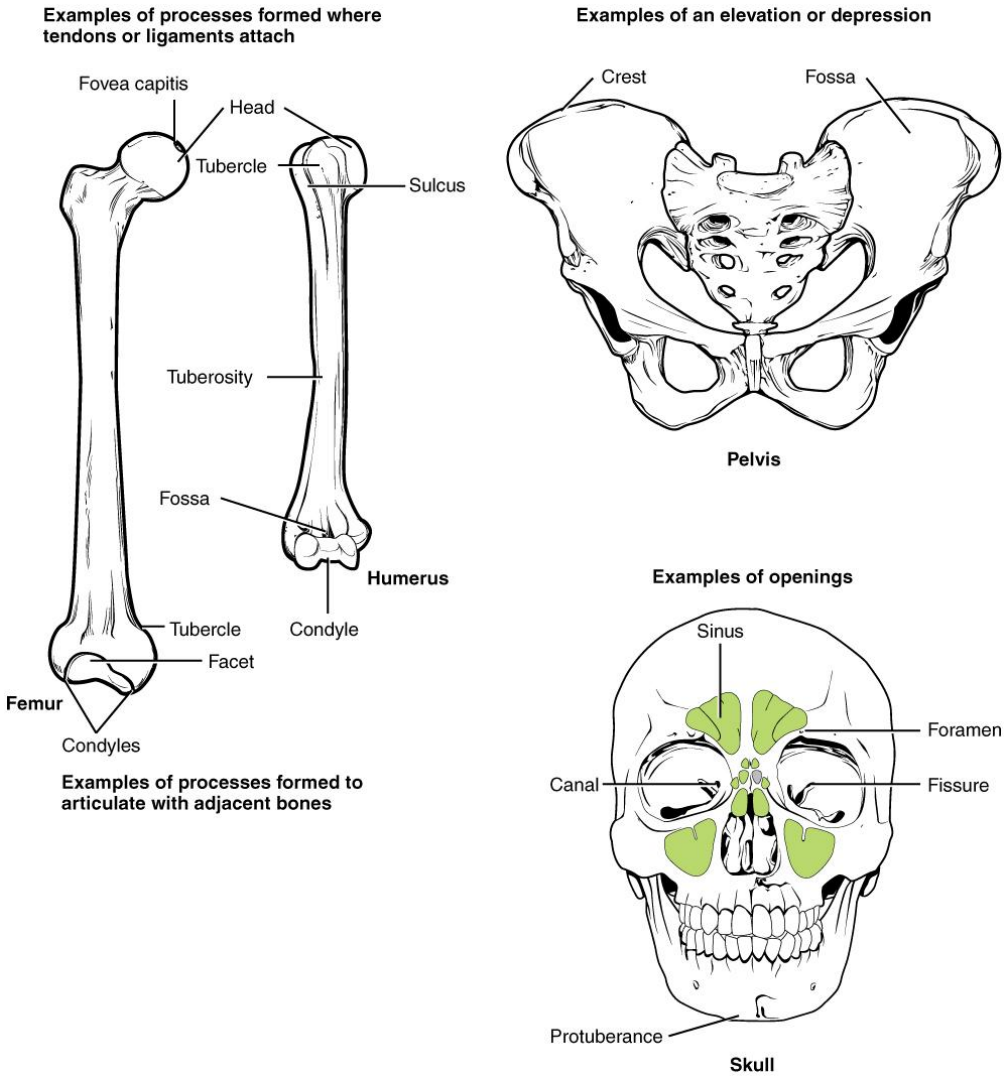
Bone Markings		
Marking	**Description**	**Example**
Head	Prominent rounded surface	Head of femur
Facet	Flat surface	Vertebrae
Condyle	Rounded surface	Occipital condyles
Projections	Raised markings	Spinous process of the vertebrae
Protuberance	Protruding	Chin
Process	Prominence feature	Transverse process of vertebra
Spine	Sharp process	Ischial spine

Bone Markings		
Marking	**Description**	**Example**
Tubercle	Small, rounded process	Tubercle of humerus
Tuberosity	Rough surface	Deltoid tuberosity
Line	Slight, elongated ridge	Temporal lines of the parietal bones
Crest	Ridge	Iliac crest
Holes	Holes and depressions	Foramen (holes through which blood vessels can pass through)
Fossa	Elongated basin	Mandibular fossa
Fovea	Small pit	Fovea capitis on the head of the femur

Bone Markings		
Marking	**Description**	**Example**
Sulcus	Groove	Sigmoid sulcus of the temporal bones
Canal	Passage in bone	Auditory canal
Fissure	Slit through bone	Auricular fissure
Foramen	Hole through bone	Foramen magnum in the occipital bone
Meatus	Opening into canal	External auditory meatus
Sinus	Air-filled space in bone	Nasal sinus

Bone Features

The surface features of bones depend on their function, location, attachment of ligaments and tendons, or the penetration of blood vessels and nerves.



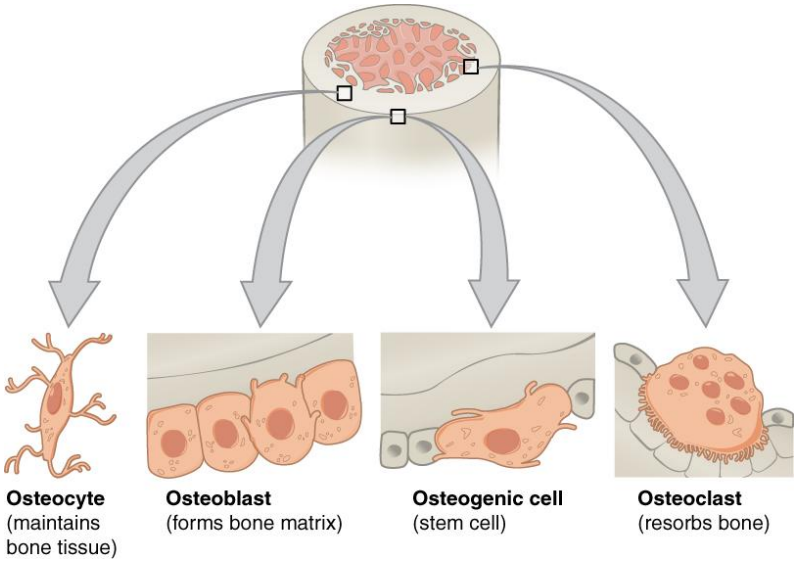
Bone Cells and Tissue

Bone contains a relatively small number of cells entrenched in a matrix of collagen fibers that provide a surface for inorganic salt crystals to adhere. These salt crystals form when calcium phosphate and calcium carbonate combine to create hydroxyapatite, which incorporates other inorganic salts like magnesium hydroxide, fluoride, and sulfate as it crystallizes, or calcifies, on the collagen fibers. The hydroxyapatite crystals give bones their hardness and strength, while the collagen fibers give them flexibility so that they are not brittle.

Although bone cells compose a small amount of the bone volume, they are crucial to the function of bones. Four types of cells are found within bone tissue: osteoblasts, osteocytes, osteogenic cells, and osteoclasts ([link]).

Bone Cells

Four types of cells are found within bone tissue. Osteogenic cells are undifferentiated and develop into osteoblasts. When osteoblasts get trapped within the calcified matrix, their structure and function changes, and they become osteocytes. Osteoclasts develop from monocytes and macrophages and differ in appearance from other bone cells.



The **osteoblast** is the bone cell responsible for forming new bone and is found in the growing portions of bone, including the periosteum and endosteum. Osteoblasts, which do not divide, synthesize and secrete the collagen matrix and calcium salts. As the secreted matrix surrounding the osteoblast calcifies, the osteoblast become trapped within it; as a result, it changes in structure and becomes an **osteocyte**, the primary cell of mature bone and the most common type of bone cell. Each osteocyte is located in a space called a **lacuna** and is surrounded by bone tissue. Osteocytes maintain the mineral concentration of the matrix via the secretion of enzymes. Like osteoblasts, osteocytes lack mitotic activity. They can communicate with each other and receive nutrients via long cytoplasmic processes that extend through **canaliculi** (singular = canaliculus), channels within the bone matrix.

If osteoblasts and osteocytes are incapable of mitosis, then how are they replenished when old ones die? The answer lies in the properties of a third category of bone cells—the **osteogenic cell**. These osteogenic cells are undifferentiated with high mitotic activity and they are the only bone cells that

divide. Immature osteogenic cells are found in the deep layers of the periosteum and the marrow. They differentiate and develop into osteoblasts.

The dynamic nature of bone means that new tissue is constantly formed, and old, injured, or unnecessary bone is dissolved for repair or for calcium release. The cell responsible for bone resorption, or breakdown, is the **osteoclast**. They are found on bone surfaces, are multinucleated, and originate from monocytes and macrophages, two types of white blood cells, not from osteogenic cells. Osteoclasts are continually breaking down old bone while osteoblasts are continually forming new bone. The ongoing balance between osteoblasts and osteoclasts is responsible for the constant but subtle reshaping of bone. [link] reviews the bone cells, their functions, and locations.

Bone Cells

Cell type	Function	Location
Osteogenic cells	Develop into osteoblasts	Deep layers of the periosteum and the marrow
Osteoblasts	Bone formation	Growing portions of bone, including periosteum and endosteum
Osteocytes	Maintain mineral concentration of matrix	Entrapped in matrix
Osteoclasts	Bone resorption	Bone surfaces and at sites of old, injured, or unneeded bone

Compact and Spongy Bone

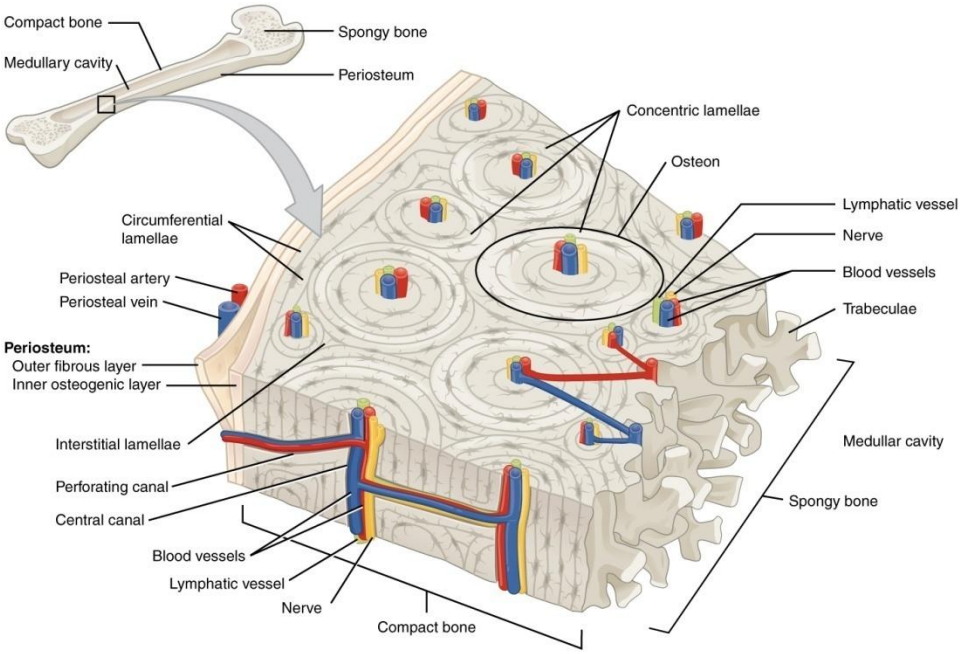
The differences between compact and spongy bone are best explored via their histology. Most bones contain compact and spongy osseous tissue, but their distribution and concentration vary based on the bone's overall function. Compact bone is dense so that it can withstand compressive forces, while spongy (cancellous) bone has open spaces and supports shifts in weight distribution.

Compact Bone

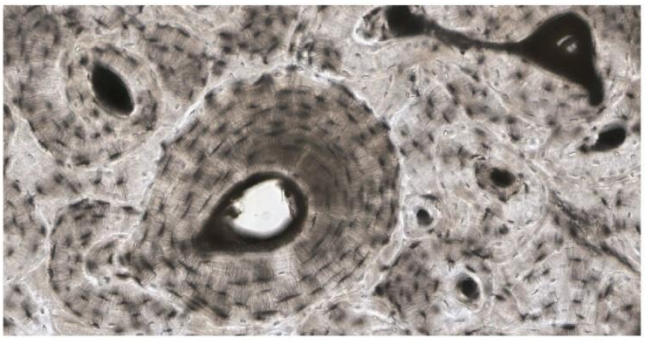
Compact bone is the denser, stronger of the two types of bone tissue ([link]). It can be found under the periosteum and in the diaphyses of long bones, where it provides support and protection.

Diagram of Compact Bone

(a) This cross-sectional view of compact bone shows the basic structural unit, the osteon. (b) In this micrograph of the osteon, you can clearly see the concentric lamellae and central canals. LM × 40. (Micrograph provided by the Regents of University of Michigan Medical School © 3013)



(a)



(b)

The microscopic structural unit of compact bone is called an **osteon**, or Haversian system. Each osteon is composed of concentric rings of calcified matrix called lamellae (singular = lamella). Running down the center of each osteon is the **central canal**, or Haversian canal, which contains blood vessels, nerves, and lymphatic vessels. These vessels and nerves branch off at right angles through a **perforating canal**, also known as Volkmann's canals, to extend to the periosteum and endosteum.

The osteocytes are located inside spaces called lacunae (singular = lacuna), found at the borders of adjacent lamellae. As described earlier, canaliculi connect with the canaliculi of other lacunae and eventually with the central canal. This system

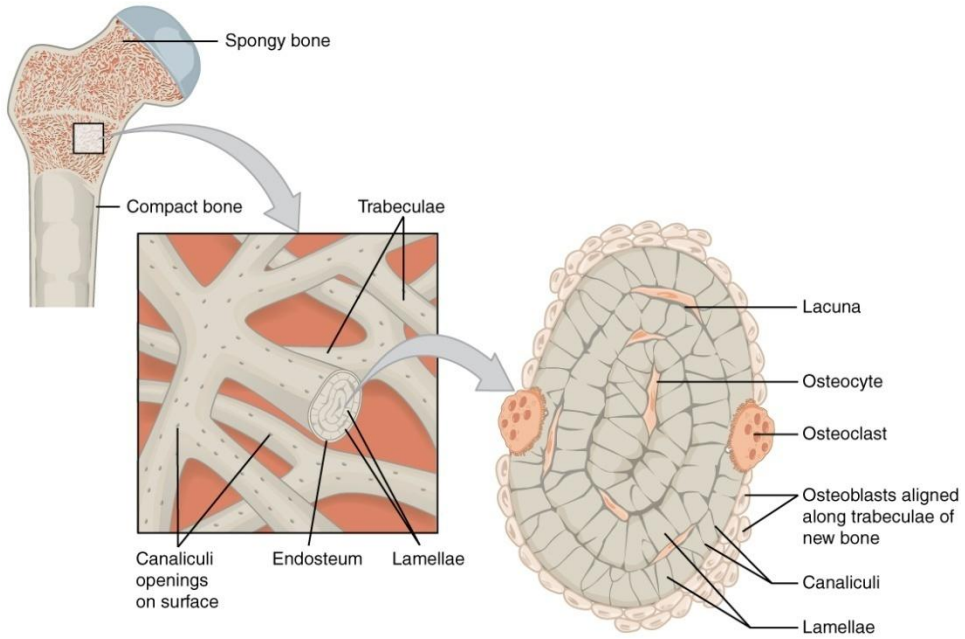
allows nutrients to be transported to the osteocytes and wastes to be removed from them.

Spongy (Cancellous) Bone

Like compact bone, **spongy bone**, also known as cancellous bone, contains osteocytes housed in lacunae, but they are not arranged in concentric circles. Instead, the lacunae and osteocytes are found in a lattice-like network of matrix spikes called **trabeculae** (singular = trabecula) ([link]). The trabeculae may appear to be a random network, but each trabecula forms along lines of stress to provide strength to the bone. The spaces of the trabeculated network provide balance to the dense and heavy compact bone by making bones lighter so that muscles can move them more easily. In addition, the spaces in some spongy bones contain red marrow, protected by the trabeculae, where hematopoiesis occurs.

Diagram of Spongy Bone

Spongy bone is composed of trabeculae that contain the osteocytes. Red marrow fills the spaces in some bones.



Aging and the…

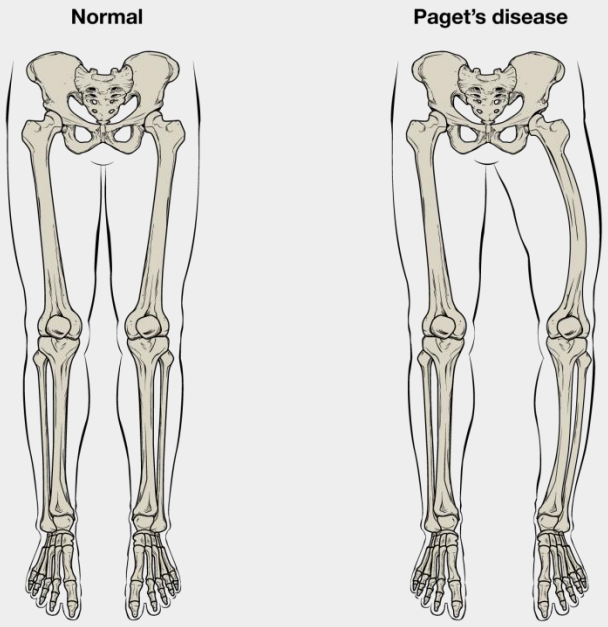
Skeletal System: Paget's Disease

Paget's disease usually occurs in adults over age 40. It is a disorder of the bone remodeling process that begins with overactive osteoclasts. This means more bone is resorbed than is laid down. The osteoblasts try to compensate but the new bone they lay down is weak and brittle and therefore prone to fracture.

While some people with Paget's disease have no symptoms, others experience pain, bone fractures, and bone deformities ([link]). Bones of the pelvis, skull, spine, and legs are the most commonly affected. When occurring in the skull, Paget's disease can cause headaches and hearing loss.

Paget's Disease

Normal leg bones are relatively straight, but those affected by Paget's disease are porous and curved.



What causes the osteoclasts to become overactive? The answer is still unknown, but hereditary factors seem to play a role. Some scientists believe Paget's disease is due to an as-yet-unidentified virus.

Paget's disease is diagnosed via imaging studies and lab tests. X-rays may show bone deformities or areas of bone resorption. Bone scans are also useful. In these studies, a dye containing a radioactive ion is injected into the body. Areas of bone resorption have an affinity for the ion, so they will light up on the scan if the ions

are absorbed. In addition, blood levels of an enzyme called alkaline phosphatase are typically elevated in people with Paget's disease.

Bisphosphonates, drugs that decrease the activity of osteoclasts, are often used in the treatment of Paget's disease. However, in a small percentage of cases, bisphosphonates themselves have been linked to an increased risk of fractures because the old bone that is left after bisphosphonates are administered becomes worn out and brittle. Still, most doctors feel that the benefits of bisphosphonates more than outweigh the risk; the medical professional has to weigh the benefits and risks on a case-by-case basis. Bisphosphonate treatment can reduce the overall risk of deformities or fractures, which in turn reduces the risk of surgical repair and its associated risks and complications.

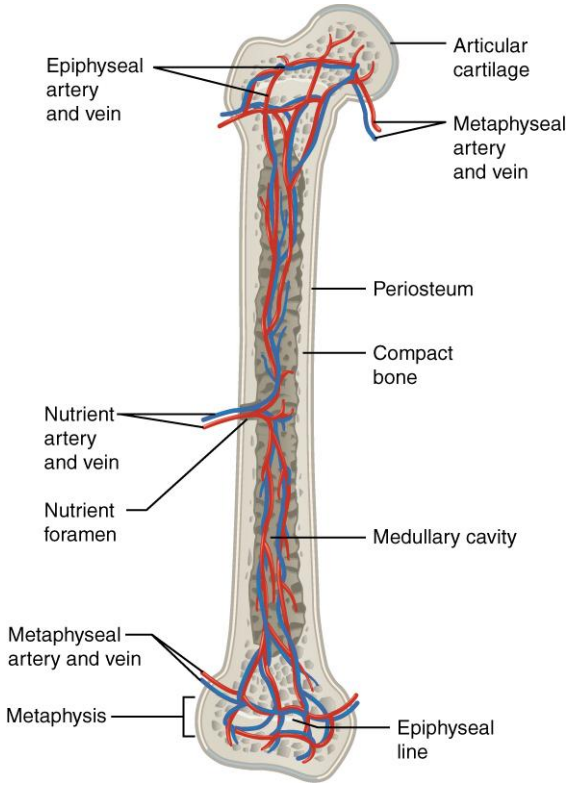
Blood and Nerve Supply

The spongy bone and medullary cavity receive nourishment from arteries that pass through the compact bone. The arteries enter through the **nutrient foramen** (plural = foramina), small openings in the diaphysis ([link]). The osteocytes in spongy bone are nourished by blood vessels of the periosteum that penetrate spongy bone and blood that circulates in the marrow cavities. As the blood passes through the marrow cavities, it is collected by veins, which then pass out of the bone through the foramina.

In addition to the blood vessels, nerves follow the same paths into the bone where they tend to concentrate in the more metabolically active regions of the bone. The nerves sense pain, and it appears the nerves also play roles in regulating blood supplies and in bone growth, hence their concentrations in metabolically active sites of the bone.

Diagram of Blood and Nerve Supply to Bone

Blood vessels and nerves enter the bone through the nutrient foramen.



3.3.1 Functions of Bones

- Support of the body
- Protection of soft organs
- Movement due to attached skeletal muscles
- Storage of minerals and fats
- Blood cell formation

Bones of the Human Body

- The skeleton has 306 bones
- Two basic types of bone tissue
  - Compact bone
    - Homogeneous
  - Spongy bone
    - Small needle-like pieces of bone
    - Many open spaces

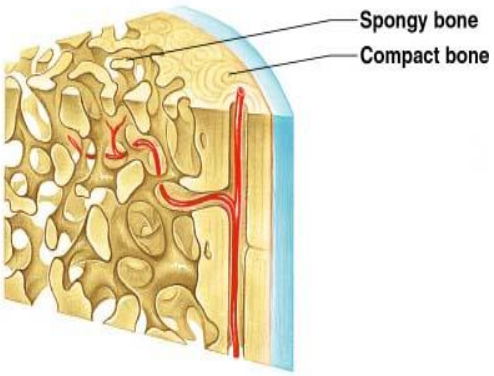


Fig 3.1 Skeletal System

3.3.3 Classification of bones by their shape

1. long
2. short
3. flat
4. irregular

Long bones

- Typically longer than wide
- Have a shaft with heads at both ends
- Contain mostly compact bone
- Examples: Femur, humerus

Short bones

- Generally cube-shape
- Contain mostly spongy bone
- Examples: Carpals, tarsals

Flat bones

- Thin and flattened
- Usually curved
- Thin layers of compact bone around a layer of spongy bone
- Examples: Skull, ribs, sternum

Irregular bones

- Irregular shape
- Do not fit into other bone classification categories
- Example: Vertebrae and hip

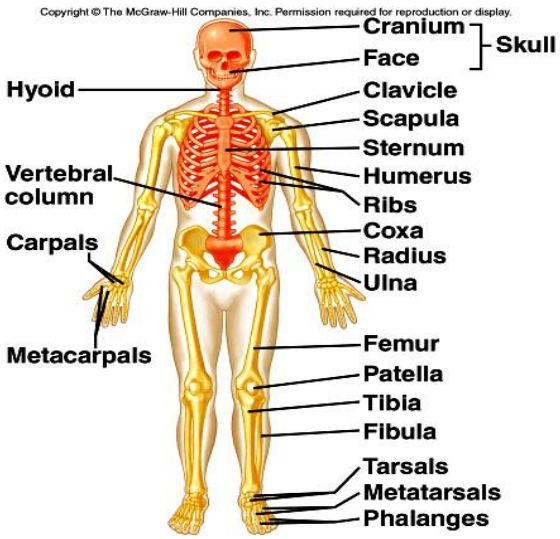


Fig 3.3 Skeletal System

3.3 JOINTS

3.3.1 FUNCTION

- Holds bones together
- Allows bones to move
- All bones articulate with at least one other bone except the hyoid**.**

FIBROUS JOINTS

- Fibrous joints connect bones without allowing any movement.
- The bones of your skull and pelvis are held together by fibrous joints.

CARTILAGINOUS JOINTS

- Cartilaginous joints are joints in which the bones are attached by cartilage.

- These joints allow for only a little movement, such as in the spine or ribs.

SYNOVIAL JOINTS

- Synovial joints allow for much more movement than cartilaginous joints.
- Cavities between bones in synovial joints are filled with synovial fluid.
- This fluid helps lubricate and protect the bones. Bursa sacks contain the synovial fluid.
- A joint, or articulation, is the place where two bones come together.
- There are three types of joints classified by the amount of movement they allow:
    - Immovable
    - slightly movable
    - freely movable

Types of Joints

Classification of Joints

According to the structural classification of joints, they are divided into 3 types, namely:

Fibrous Joints / Fixed Joints

Fixed joints, also called immovable joints, are found where bones are not flexible. In such joints, bones have been fused together in such a way that they are fixed to that part, most commonly to create a structure. A prominent example of a fixed joint is the skull, which is made up of a number of fused bones. Other examples include the upper jaw, rib cage, backbone, and pelvic bone, etc.

Cartilaginous Joints / Slightly Moveable Joints

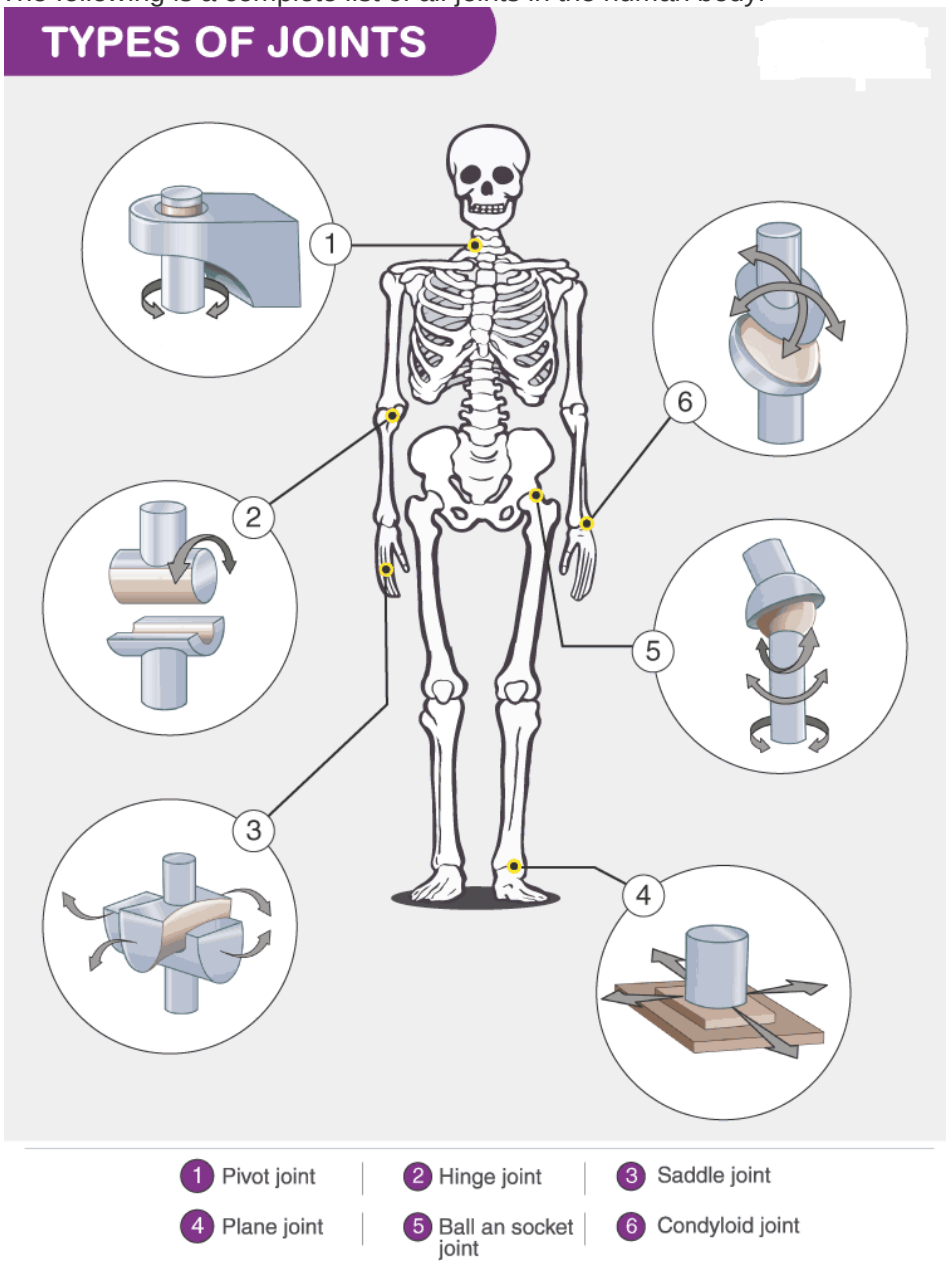
Cartilaginous joints are partly movable joints comprising of symphysis or synchondrosis joints. These joints occur only in those regions where the connection between the articulating bones is made up of cartilage. Synchondrosis are temporary cartilaginous joints which are present in young children and last until the end of their puberty. For example, the epiphyseal plates present at each end of the long bones is responsible for bone growth in children. The symphysis or the secondary cartilaginous joints (the place where bones join) is permanent. Examples include the pubic symphysis. Other examples of cartilaginous types of joints include the spinal column and the ribcage.

Synovial Joints / Freely Movable Joints

The synovial joints are the most common type of joint because this joint helps us to perform a wide range of motions such as walking, running, typing and more. Synovial joints are flexible, movable, can slide over one another, rotatable and so on. These joints are found in our shoulder joint, neck joint, knee joint, wrist joint, etc. There are six types of freely movable joint and are mentioned below with with the examples:

Types of Joints: A list of Joints in the Human Body

The following is a complete list of all joints in the human body.



Types of Joints and their range of motions

Ball and Socket Joints

Here, one bone is hooked into the hollow space of another bone. This type of joint helps in rotatory movement. An example ball and socket joint are the shoulders.

Pivotal Joints

In this type of joint, one bone has tapped into the other in such a way that full rotation is not possible. This joint aid in sideways and back-forth movement. An example of a pivotal joint is the neck.

Hinge Joints

Hinge joints are like door hinges, where only back and forth movement is possible. Example of hinge joints is the ankle, elbows, and knee joints.

Saddle Joints

Saddle joint is the biaxial joint that allows the movement on two planes– flexion/extension and abduction/adduction. For example, the thumb is the only bone in the human body having a saddle joint.

Condyloid Joints

Condyloid joints are the joints with two axes which permit up-down and side-to-side motions. The condyloid joints can be found at the base of the index finger, carpals of the wrist, elbow and the wrist joints. This joint is also known as a condylar, or ellipsoid joint.

Gliding Joints

Gliding joints are a common type of synovial joint. It is also known as a plane or planar joint. This joint permit two or more round or flat bones to move freely together without any rubbing or crushing of bones. This joint is mainly found in those regions where the two bones meet and glide on one another in any of the directions. The lower leg to the ankle joint and the forearm to wrist joint are the two main examples of gliding joints.

Cartilage and functions.

- Cartilage- A strong, flexible connective tissue.
    - Different types of cartilage line the surface of bones at joints allowing smooth movement.
    - Other functions include cushioning the vertebrae and supporting the ear and nose.

- A baby's skeletal system is mostly made up of cartilage.
- As the baby grows, the cartilage is replaced with bone minerals and cells through ossification.
    - Ossification- the process by which bone is formed, renewed, and repaired.

3.4 RESPIRATORY SYSTEM: Components of respiratory system

3.4.1 Basic functions of the respiratory system

- BREATHING (PULMONARY VENTILATION) – movement of air in and out of the lungs
    - Inhalation (inspiration) draws gases into the lungs.
    - Exhalation (expiration) forces gases out of the lungs.

GAS CONDITIONING – as gases pass through the nasal cavity and paransal sinuses, inhaled air becomes turbulent. The gases in the air are

- warmed to body temperature
- humidified
- cleaned of particulate matter

GAS EXCHANGE - RESPIRATION

- Supplies body with oxygen
- Disposes of carbon dioxide
- Produces Sounds
- Protects respiratory surfaces
- Site for olfactory sensation

Respiration – four distinct processes must happen

- Pulmonary ventilation – moving air into and out of the lungs
- External respiration – gas exchange between the lungs and the blood

- Transport – transport of oxygen and carbon dioxide between the lungs and tissues
- Internal respiration – gas exchange between systemic blood vessels and tissues

3.4.3 Functional Anatomy of the Respiratory System

Respiratory organs

- Nose, nasal cavity, and paranasal sinuses
- Pharynx, larynx, and trachea
- Bronchi and smaller branches
- Lungs and alveoli

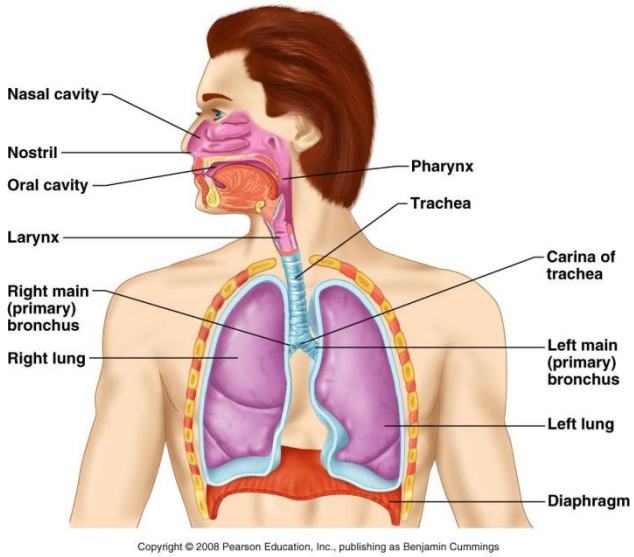


Fig 3.3 Respiratory system

The Nose

- Provides an airway for respiration
- Moistens and warms air

- Filters inhaled air
- Resonating chamber for speech
- Houses olfactory receptors
- Skin is thin – contains many sebaceous glands

The Nasal Cavity

- External nares – nostrils
- Divided by – nasal septum
- Vestibule - anterior opening
- Continuous with nasopharynx
- Two types of mucous membrane
    - Olfactory mucosa - Near roof of nasal cavity, houses olfactory (smell) receptors
    - Respiratory mucosa - Lines nasal cavity

The Paranasal Sinuses

Hollow portions of bones surrounding the nasal cavity

- Paranasal sinuses
    - Air-filled spaces within the skull bones
        - Open into the nasal cavity
    - Reduce the weight of the skull
    - Equalizes pressure
    - Gives the voice its certain tone

The Pharynx

- Funnel-shaped passageway
- Connects nasal cavity and mouth
- Shared by the digestive and respiratory systems

- Divided into three sections by location
    - Nasopharynx – superior portion,
    - Oropharynx – continuous with the oral cavity
    - Laryngopharynx – between the hyoid bone and the esophagus

The Nasopharynx

- Superior to the point where food enters
- Only an air passageway
- Closed off during swallowing
- Epithelium consists of ciliated pseudostratified epithelium that moves mucus

The Oropharynx

- Arch-like entranceway – fauces
    - Extends from soft palate to the epiglottis
- Epithelium - stratified squamous epithelium
- Two types of tonsils in the oropharynx
    - Palatine tonsils – in the lateral walls of the fauces
    - Lingual tonsils – covers the posterior surface of the tongue

The Laryngopharynx

- Passageway for both food and air
- Epithelium - stratified squamous epithelium
- Continuous with the esophagus and larynx

The Trachea

- Descends into the mediastinum
- C-shaped cartilage rings keep airway open

- Carina - marks where trachea divides into two primary bronchi
- Epithelium - pseudostratified ciliated columnar

Bronchi

- Bronchial tree - extensively branching respiratory passageways
  - Primary bronchi (main bronchi)
    - Largest bronchi
    - Right main bronchi - wider and shorter than the left
  - Secondary (lobar) bronchi
    - Three on the right
    - Two on the left
  - Tertiary (segmental) bronchi - branch into each lung segment
  - Bronchioles - little bronchi, less than 1 mm in diameter
  - Terminal bronchioles - less than 0.5 mm in diameter

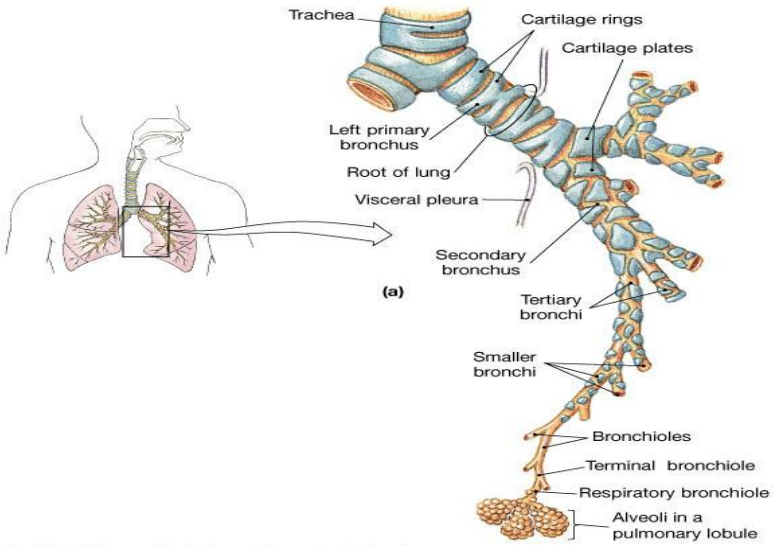


Fig 3.4 Structure of bronchi

Lobes and Surfaces of the lungs

- Lungs

  - Cone-shaped organs
  - Right lung – three lobes
  - Left lung – two lobes
  - Pleura – membranes surrounding the lungs
  - Right lung has three lobes
- Left lung has two lobes
- Bronchi enter the lungs at the hilus

The Pleurae

- A double-layered sac surrounding each lung
  - Parietal pleura
  - Visceral pleura
- Pleural cavity - potential space between the visceral and parietal pleurae
- Pleurae help divide the thoracic cavity
  - Central mediastinum
  - Two lateral pleural compartments

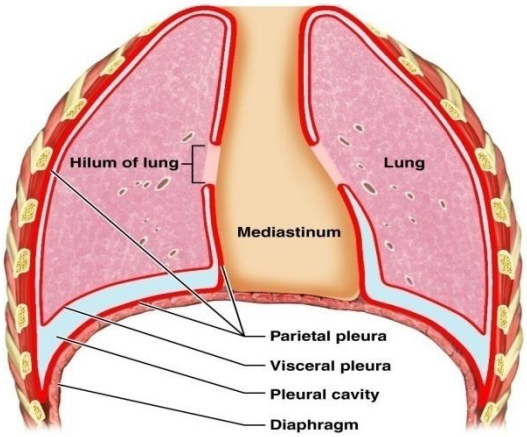


Fig 3.5 Pleurae

Structures of the Respiratory Zone

- Consists of air-exchanging structures
- Respiratory bronchioles – branch from terminal bronchioles

Lead to alveolar ducts

- Lead to alveolar sacs

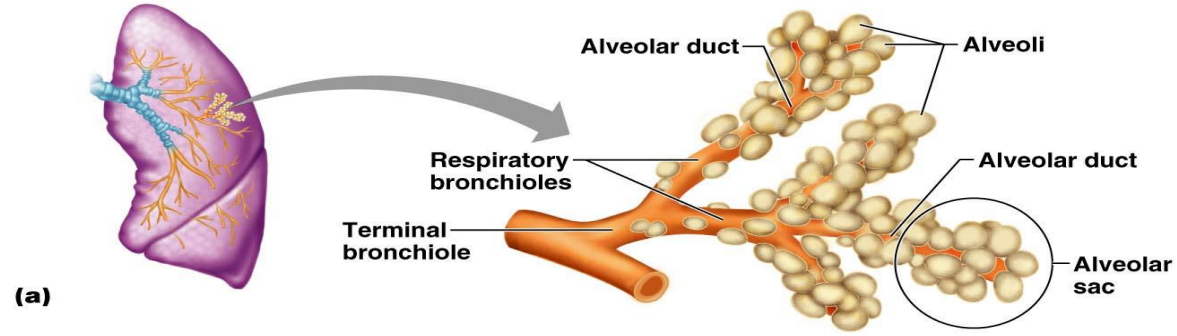


Fig 3.6 Structure of Alveoli

Features Of Alveoli

- Alveoli cell types
  - Type I cells site of gas exchange and
  - Type II cells - secrete surfactant
  - Macrophages
- Surrounded by basal laminae and elastic fibers
- Interconnect by way of alveolar pores
- Internal surfaces - site for free movement of alveolar macrophages

3.5 RESPIRATORY MECHANISM

Inspiration

- Diaphragm and intercostals muscles contract
  - Diaphragm moves inferiorly and flattens during contraction, causing height of thoracic cavity to increase
  - Intercostals contraction lifts the ribcage and thrusts sternum forward, increasing anterioposterior and lateral dimensions (circumference)

- Lungs adhere tightly to the thorax walls (due to surface tension of fluid between pleural membranes), they are stretched to the new, larger size of the thorax.
- As intrapulmonary volume increases, gases with in the lungs spread out to fill the larger space.
- Resulting decrease in the gas pressure in the lungs produces a partial vacuum (pressure less than atmospheric pressure), which sucks the air into the lungs.

Events of Inspiration

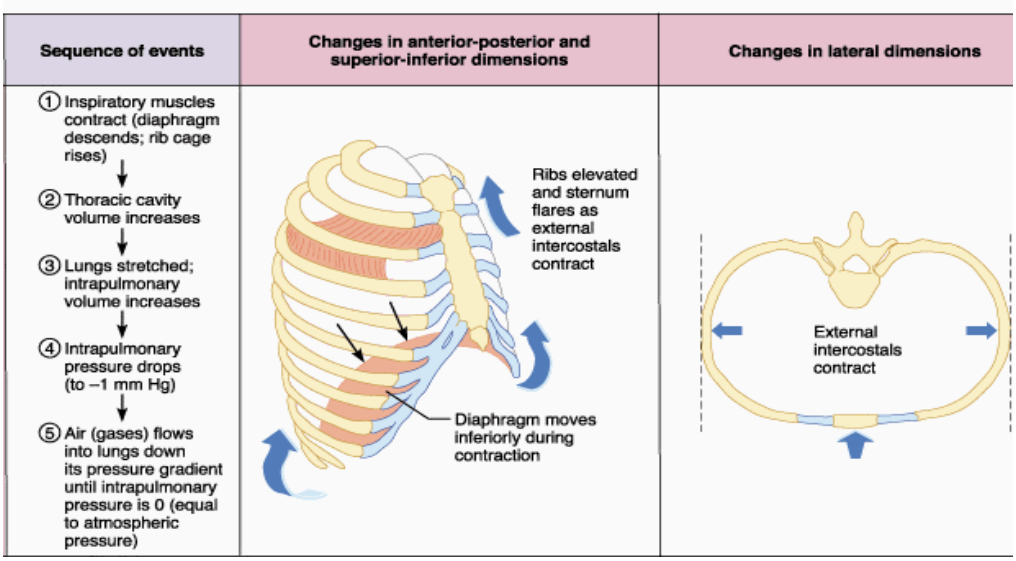


Fig 3.7 Events of Inspiration

Expiration

- Passive process that depends mostly on natural elasticity of the lungs than on muscle contraction.

- As inspiratory muscles relax and resume normal resting length, rib cage descends and lungs recoil.
- As the thoracic and pulmonary volume to decrease, gases inside the lungs are forced closer together and intrapulmonary pressure rises to above atmospheric pressure.
- This causes gases to flow out to equalize pressure inside and outside of the lungs.
- Normally this is a passive process, but if passageways are narrowed due to spasms of bronchioles (asthma) or clogged with mucus/fluid (bronchitis/pneumonia), it becomes an active process, using intercostal muscles to help depress rib cage and abdominal muscles to help squeeze air out of lungs.

Events of Expiration

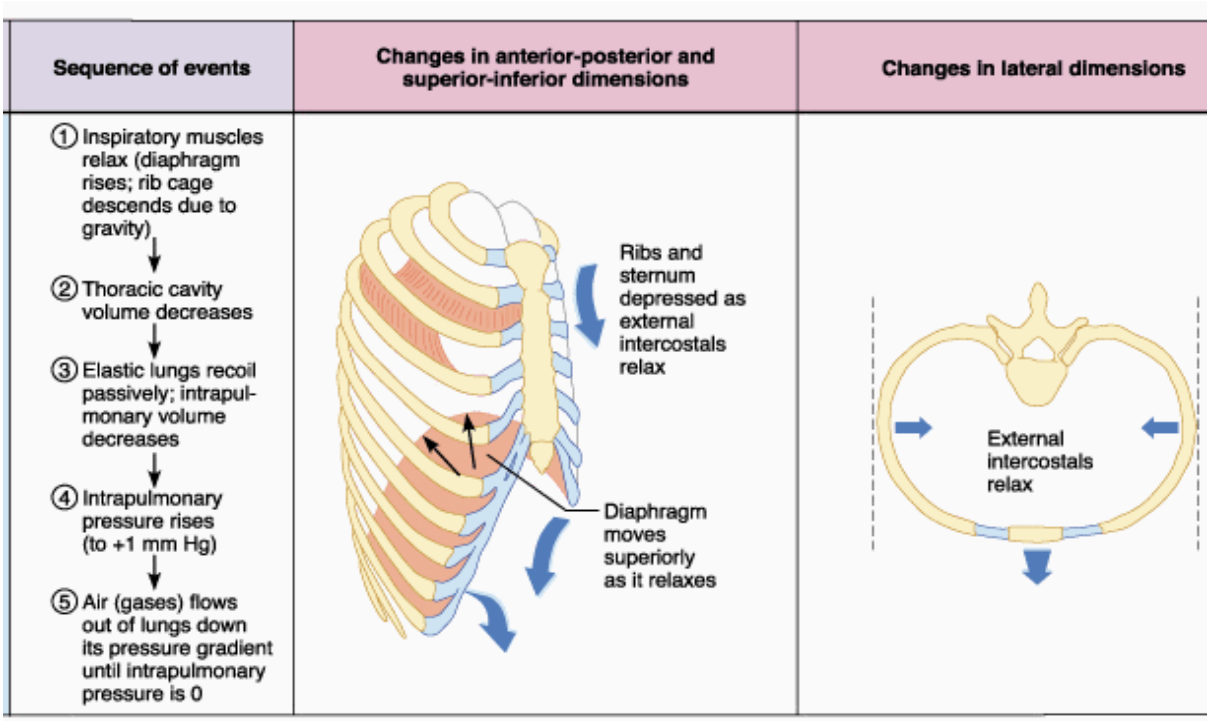


Fig 3.8 Events of Expiration

3.6 Oxygen And Carbon Dioxide Transport

Oxygen Transport

- O_3 is transported by the blood either,
  - Combined with haemoglobin (Hb) in the red blood cells (>98%) or,
  - Dissolved in the blood plasma (<3%).
- The resting body requires 350ml of O3 per minute.
- We have four to six billion haemoglobin containing red blood cells.
- The haemoglobin allows nearly 70 times more O_3than dissolved in plasma.

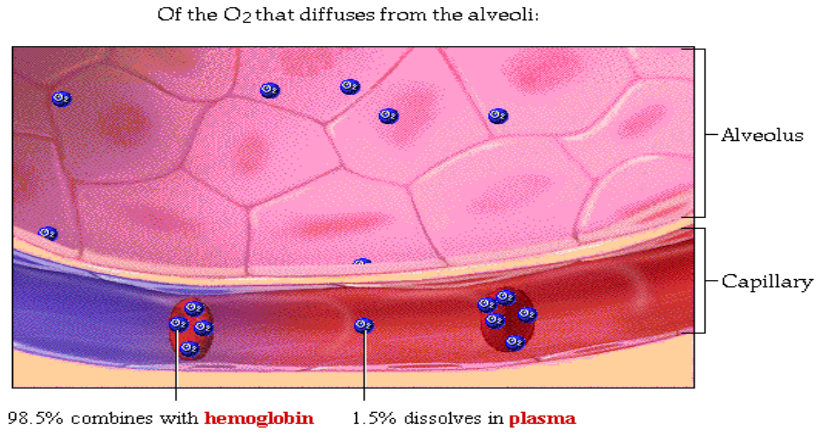


Fig 3.9 O_3 Transport

Haemoglobin

- Haemoglobin saturation is the amount of oxygen bound by each molecule of haemoglobin
- Each molecule of haemoglobin can carry four molecules of O3.
- When oxygen binds to haemoglobin, it forms OXYHAEMOGLOBIN;

- Haemoglobin that is not bound to oxygen is referred to as DEOXYHAEMOGLOBIN.
- The binding of O_3 to haemoglobin depends on the PO_3 in the blood and the bonding strength, or affinity, between haemoglobin and oxygen.
- The graph on the following page shows an oxygen dissociation curve, which reveals the amount of haemoglobin saturation at different PO_3 values.

The Oxygen Dissociation Curve

- Reveals the amount of haemoglobin saturation at different PO_3 values.
- In the lungs the partial pressure is approximately 100mm Hg at this Partial Pressure haemoglobin has a high affinity to 03 and is 98% saturated.
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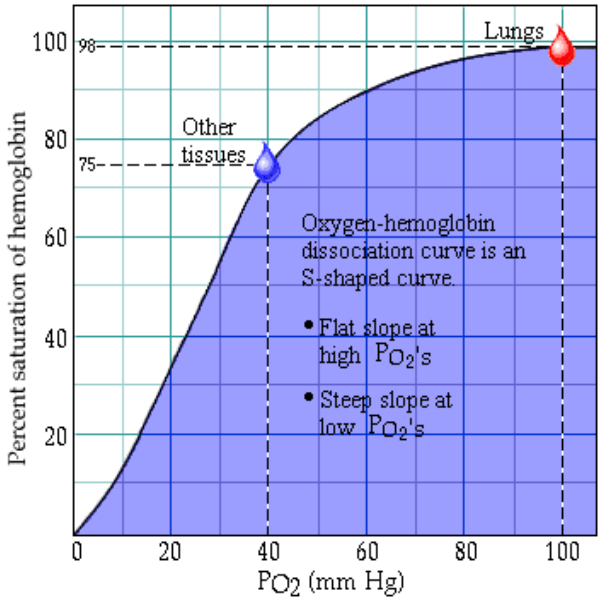


Fig 3.10 Oxygen Saturation Curve

- In the lungs the partial pressure is approximately 100mm Hg at this Partial Pressure haemoglobin has a high affinity to 03 and is 98% saturated.

- In the tissues of other organs a typical PO3 is 40 mmHg here haemoglobin has a lower affinity for O3 and releases some but not all of its O3 to the tissues. When haemoglobin leaves the tissues it is still 75% saturated.

Factors Affecting Haemoglobin Saturation

- Blood acidity…
- Blood temperature…
- Carbon Dioxide concentration

Carbon Dioxide Transport

- Carbon dioxide also relies on the blood fro transportation. Once carbon dioxide is released from the cells, it is carried in the blood primarily in three ways…
- Dissolved in plasma,
- As bicarbonate ions resulting from the dissociation of carbonic acid,
- Bound to haemoglobin.

Dissolved Carbon Dioxide

- Part of the carbon dioxide released from the tissues is dissolved in plasma. But only a small amount, typically just 7 – 10%, is transported this way.
- This dissolved carbon dioxide comes out of solution where the PCO_3 is low, such as in the lungs.
- There it diffuses out of the capillaries into the alveoli to be exhaled.

3.7 Types Of Respiration

- Respiration is the process in which glucose is converted into energy useable for life processes.
- Respiration involves the important component of breathing but be careful not to confuse respiration as just solely breathing.

There are 3 types of respiration that our bodies use for different activities

Aerobic Respiration

- Aerobic respiration occurs in the presence of oxygen and is summarised by the following equation:
- Glucose + Oxygen → Energy + Carbon Dioxide +Water
- This type of respiration is used when the body continues an activity for a prolonged period of time.
- The energy that is needed to allow this prolonged activity is produced using oxygen.
- In order for the aerobic system to function effectively, there has to be a constant supply of oxygen to the body and the working muscles.
- For any activity that takes place over a long period of time (e.g. Marathon) it is important to have this constant supply of oxygen to the body otherwise the body would be unable to carry out the event.

Anaerobic Respiration

- On the other hand, anaerobic respiration is the process where energy is made in the absence of oxygen.
- The equation for anaerobic respiration is:
- Glucose → Energy + Lactic Acid
- This type of respiration occurs when the body works without sufficient oxygen being delivered to the muscles.
- Without the presence of oxygen, a waste product called lactic acid is produced in the muscles.
- High lactic acid concentrations cause muscles to feel painful and can lead to cramp.
- As oxygen is not being used to generate energy in anaerobic respiration, it can only be used for short bursts e.g. 100m sprint

3.8 ACID-BASE REGULATION

Maintenance of an acceptable pH range in the extracellular fluids is accomplished by **three** mechanisms:

1) Chemical Buffers

- React very rapidly (less than a second)

3) Respiratory Regulation

- Reacts rapidly (seconds to minutes)

3) Renal Regulation

- Reacts slowly (minutes to hours)

Chemical Buffers

- The body uses pH buffers in the blood to guard against sudden changes in acidity
- A pH buffer works chemically to minimize changes in the pH of a solution

Respiratory Regulation

- Carbon dioxide is an important by-product of metabolism and is constantly produced by cells
- The blood carries carbon dioxide to the lungs where it is exhaled
- When breathing is increased, the blood carbon dioxide level decreases and the blood becomes more **Base**
- When breathing is decreased, the blood carbon dioxide level increases and the blood becomes more **Acidic**
- By adjusting the speed and depth of breathing, the respiratory control centers and lungs are able to regulate the blood pH minute by minute

ACIDS

- Acids can be defined as a proton ($\mathbf{H^+}$) donor
- Hydrogen containing substances which dissociate in solution to release $\mathbf{H^+}$
- Physiologically important acids include:
    - **Carbonic acid ($\mathbf{H_3CO_3}$)**

- **Phosphoric acid (H_3PO_4)**
- **Pyruvic acid ($C_3H_4O_3$)**
- **Lactic acid ($C_3H_6O_3$)**

- These acids are dissolved in body fluids

BASES

- Bases can be defined as:
  - A proton (H^+) acceptor
  - Molecules capable of accepting a hydrogen ion (OH^-)
  - Physiologically important bases include:
    - **Bicarbonate (HCO_3^-)**
    - **Biphosphate (HPO_4^{-3})**

UNIT 4

DIGESTIVE AND EXCRETORY SYSTEM

Digestion definition

The energy required for all the processes and activities that take place in our bodies is derived from the foods we ingest. The digestive system allows us to utilize food from such diverse sources as meat from an animal and the roots of a plant, and utilize them as an energy source. Whether it is the ability to coordinate the chewing of the food without injuring our tongue and lips or the propulsion of the food from the stomach into the duodenum while releasing the appropriate enzymes, our digestive system allows us to manage the process without much thought and often while performing other tasks.

What is digestion?

The process of digestion is a fascinating and complex one that takes the food we place in our mouth and turns it into energy and waste products. This process takes place in the gastrointestinal tract, a long, connected, tubular structure that starts with the mouth and ends with the anus. The food is propelled forward within the system, altered by enzymes and hormones into usable particles and absorbed along the way. Other organs that support the digestive process are the liver, gallbladder, and pancreas. The time it takes for food to travel from entering the mouth to be excreted as waste is around 30 to 40 hours.

The mouth

The mouth is the entry point for food, but the digestive system often gets ready before the first piece of food even enters our mouth. Saliva is released by the salivary glands into our oral cavity when we smell food. Once the food enters the mouth, chewing (mastication) breaks food into smaller particles that can be more easily attacked by the enzymes in saliva. Our teeth can perform a cutting as well as grinding function to accomplish this task. The tongue assists in mixing the food with the saliva and then the tongue and roof of the mouth (soft palate) help move the food along to the pharynx and esophagus.

The pharynx and esophagus

The pharynx (throat) is the transition area from the mouth to the esophagus. From the pharynx there are two paths that the food bolus can take; 1) the wrong path, which is down the windpipe into the lungs, or 2) the correct path into the esophagus and then the stomach. The act of swallowing is a complex process that closes the windpipe (to protect our lungs) and moves food into the esophagus. This process is mostly automatic (reflex) but it is also partially under our direct control.

Once it enters the esophagus, food is moved down the esophagus and into our stomach. The esophagus is a muscular tube that contracts in a synchronized fashion (peristalsis) to move food down towards the stomach. While the muscles behind the food product contract, the muscles ahead of the food relax, causing the forward propulsion of the food. Peristalsis is the main mechanism by which food moves through our digestive system.

Once the food approaches the stomach, a muscular valve (the lower esophageal sphincter) relaxes and lets the food pass into the stomach. This sphincter has the important function of closing the stomach so no food or stomach acid reenters the esophagus (and therefore avoiding heartburn or regurgitation).

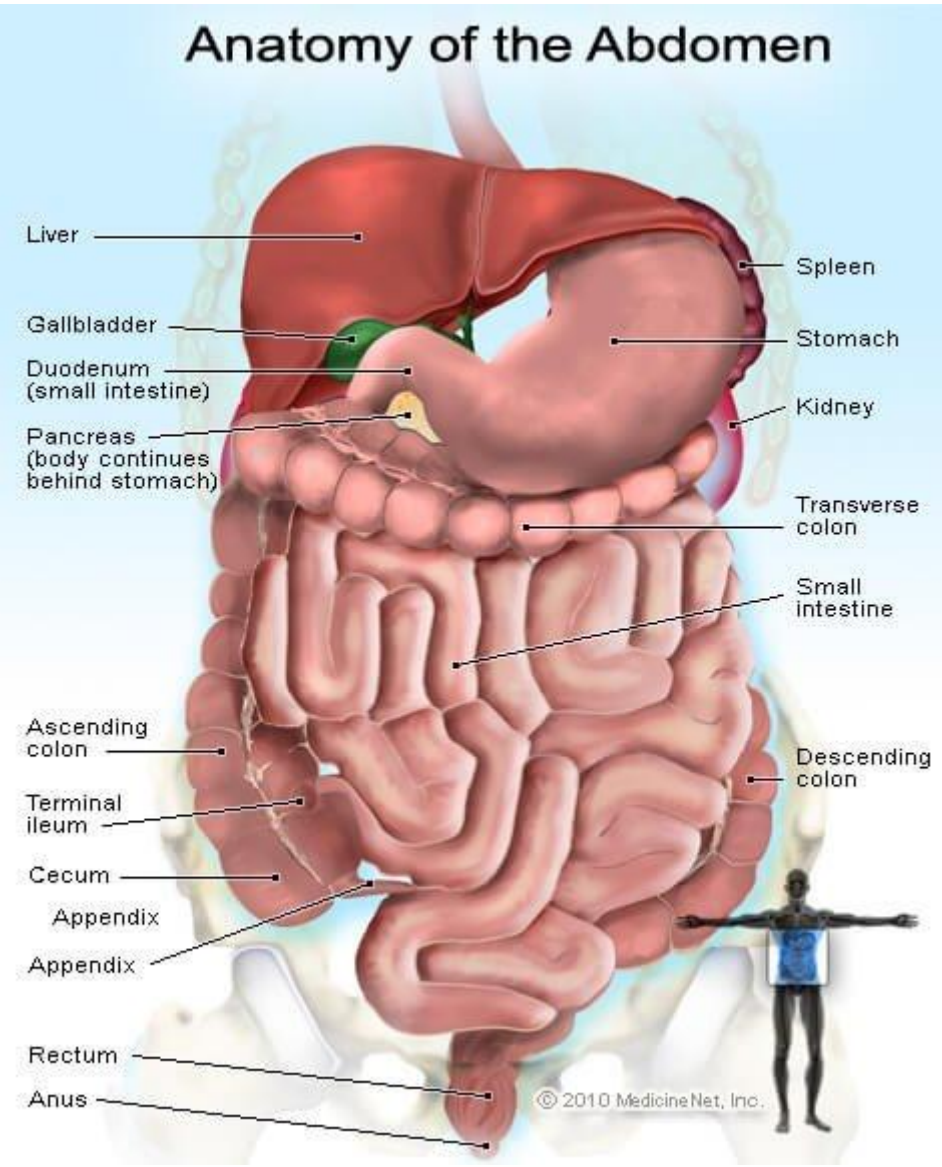
The stomach and small intestine

From glands that line the stomach, acid and enzymes are secreted that continue the breakdown process of the food. The stomach muscles further mix the food. At the end of this process, the food you placed in your mouth has been transformed to a thick creamy fluid called chyme.

This thick fluid is then pushed into the duodenum (the first part of the small intestine). With the help of enzymes from the pancreas and bile from the liver, further breakdown of the food occurs in the small intestine.

The small intestine has three segments. The first segment is the duodenum where further breakdown of the food takes place. The next two parts of the small intestine (jejunum and ileum) are mostly responsible for the absorption of nutrients from the processed food into the bloodstream through the walls of the intestine.

After the small intestine, the leftover waste leaves the upper gastrointestinal tract (upper GI tract) which is made up of everything above the large intestine, and moves into the large intestine or colon (the beginning of the lower GI tract).



The colon, rectum, and anus

The role of the lower GI tract is to solidify the waste product (by absorbing water), store the waste product until it can be evacuated (going to the bathroom) and help with the evacuation process.

The large intestine (colon) has four parts:

1. ascending colon,
2. transverse colon,
3. descending colon and
4. sigmoid colon.

All together the colon is approximately 7 feet long and connects to the rectum. Here as in most other parts of the GI system, the waste product is moved along by peristalsis. As the waste product passes through the colon, water is absorbed and stool is formed.

The stool from the colon is stored in the rectum. The anal sphincter provides the control over releasing stool or holding it. Once stool arrives in the rectum, a feedback to the brain makes the person aware of the need for a bowel movement. Voluntary control over the anal sphincter lets us hold the stool until we go to the toilet.

Three accessory digestive organs (pancreas, liver, gallbladder)

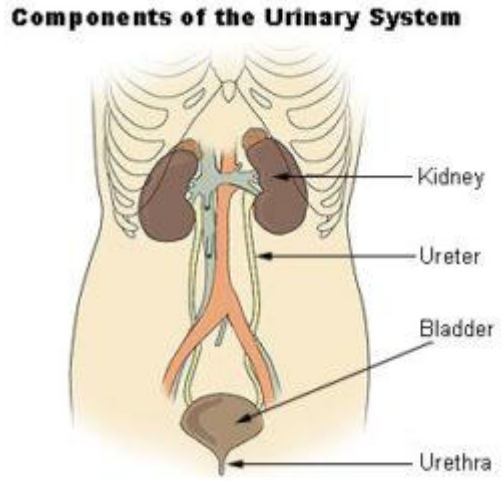
Three other organs are instrumental in the digestive process.

1. Pancreas: Although the pancreas is mostly known for its blood sugar regulatory function with the production of insulin (as part of the endocrine system -- he insulin goes directly from the gland into the bloodstream), it is the main producer of digestive enzymes as part of the exocrine system (the enzymes produced by the gland pass through a duct into the intestines). These enzymes are released into the duodenum and help with the digestion of fats, proteins, and carbohydrates..
2. Liver: The liver produces bile for fat digestion and elimination. In addition, nutrients are stored in the liver, and toxins and chemicals are filtered by liver.
3. Gallbladder: Bile is stored and released from the gallbladder. When fatty food enters the duodenum, the gallbladder contracts and releases bile.

The Human Excretory System

Every living organism generates waste in its body and has a mechanism to expel it. In humans, waste generation and disposal are taken care of by the human excretory system. The human excretory system comprises of the following structures:

- 2 Kidneys
- 2 Ureters
- 1 Urinary bladder
- 1 Urethra



Kidneys

Kidneys are the main organ of the human excretory system. The kidneys are paired organs in each individual. They are the primary excretory organ in humans and are located one on each side of the spine at the level of the liver. They are divided into three regions- the renal cortex which is the outer layer, the renal medulla which is the inner layer and the renal pelvis which is responsible for carrying the urine from the kidney to the ureter. The functional unit of a kidney is called the nephron.

Ureters

There is one ureter that comes out of each kidney as an extension of the renal pelvis. The ureter is a thin muscular tube that carries urine from the kidneys to the bladder.

Urinary Bladder

It is a sac-like structure that is lined with smooth muscle layer and is responsible for storage of urine till it is expelled from the body by micturition. Micturition is the act of expelling urine from the body. The bladder receives urine from the ureters, one from each kidney. The level of the urinary bladder placement in the body differs in men and women.

What are the Different Stages of Micturition?

Urethra

This is a tube that arises from the urinary bladder and functions to expel urine to the outside by micturition. The urethra is shorter in females and longer in the males. In males, the urethra functions as a common path for sperms and urine. The opening of the urethra is guarded by a sphincter that is autonomically controlled.

Other Excretory Organs

Apart from the above mentioned excretory organs, there are other organs that also perform some form of excretion.

Skin

The skin is the largest organ in the body. Its primary function is to protect the different organs of the body. However, the skin helps in excretion by the way of sweat. The skin eliminates compounds like NaCl, some amount of urea etc.

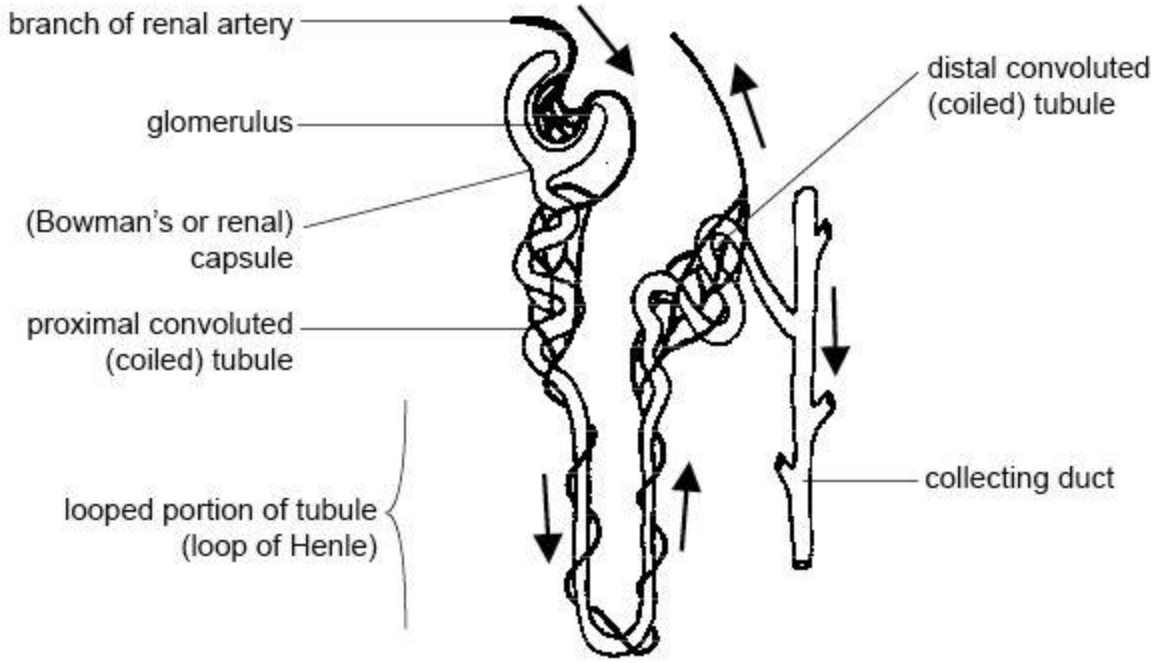
Lungs

Lungs are the primary respiratory organs and they help take in oxygen and expel carbon dioxide. But, in this process, they also function to eliminate some amount of water in the form of vapour.

Liver

The liver has an important function in excretion. It is said to be the first line of defence when it comes to hormones, fats, alcohol, and drugs. Most drugs undergo a first pass metabolism which occurs in the liver. Few drugs are eliminated directly by the kidneys. The liver is said to play a role in the elimination of excess fats and cholesterol that is essential to the health of the body.

Structure of a Nephron



What is the Formation Process of Urine?

The structural and functional unit of the kidney is the nephrons. Each kidney consists of millions of nephrons that are all functioning together to filter urine and expel the waste products. Each kidney consists of the following parts:

- **Bowman's capsule**– is the first part of the nephron which is a cup-shaped structure and receives the blood vessels. The glomerular filtration occurs here. The blood cells and proteins remain in the blood.
- **Proximal Convoluted Tubule**– The Bowman's capsule extends downwards to form the proximal tubule. Water and reusable materials from the blood are now reabsorbed back into it.
- **The loop of Henle**– The proximal tubule leads to the formation of a u-shaped loop called the Loop of Henle. The Loop of Henle has three parts: The descending limb, the u-shaped bend, and the ascending limb. It is in this area that the urine becomes concentrated as water is reabsorbed. The descending limb is freely permeable to water whereas the ascending limb is impermeable to it.
- **Distal Convoluted Tubule**– The Loop of Henle leads into the distal convoluted tubule which is where the kidney hormones cause their effect. And the distal convoluted tubule leads to the collecting ducts.
- **Collecting Duct**– The distal convoluted tubule of each nephron leads to the collecting ducts. The collecting ducts together form the renal pelvis through which the urine passes into the ureter and then into the urinary bladder.

Functions of the Excretory System

The excretory system performs many functions such as:

- Helps eliminate waste products such as urea, uric acid ammonia, and other products via urine.
- It helps maintain the osmotic level of blood and plasma
- It helps maintain the electrolyte balance in the body
- And it also helps in the metabolism of those drugs that do not get metabolized in the liver.

4.

4.Kidney

4.1 Structure of Kidney

Kidneys Are located on either side of the vertebral column

- Left kidney lies superior to right kidney
- Superior surface capped by suprarenal (adrenal) gland
- Position is maintained by:

  Overlying peritone

  Contact with adjacent visceral organs

  Supporting connective tissues

Kidney Function: Urinary System Structure

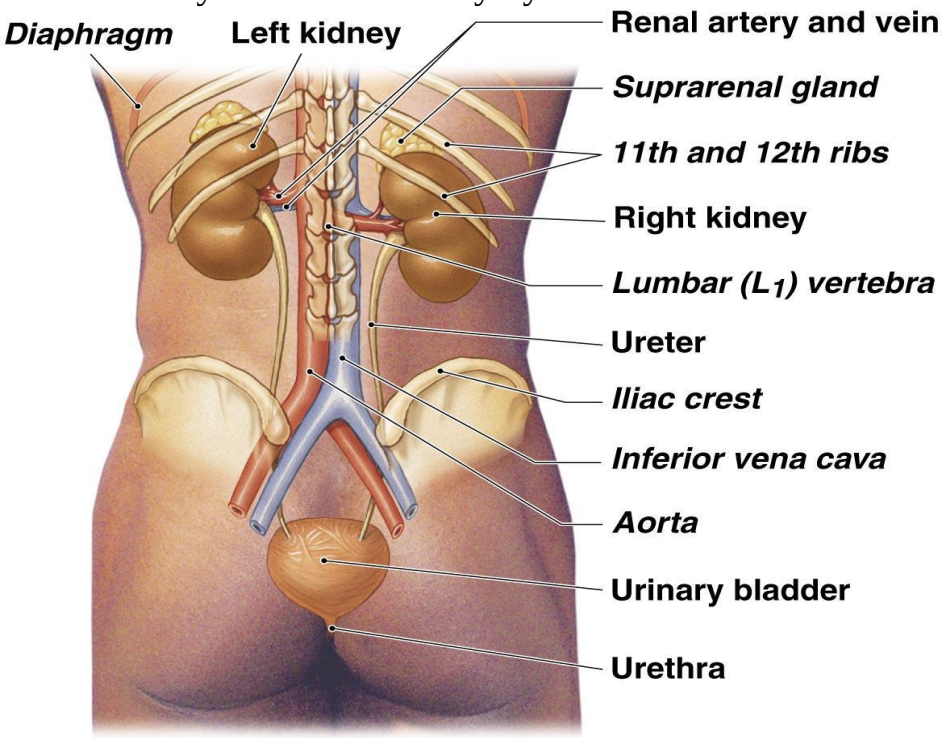


Fig 4.1 Structure of Kidney

Typical Adult Kidney

- Is about 10 cm long, 5.5 cm wide, and 3 cm thick (4 in. 2.2 in. 1.2 in.)

Weighs about 150 g (5.25 oz)

Hilum

- Point of entry for renal artery and renal nerves
- Point of exit for renal vein and ureter

Sectional Anatomy of the Kidneys

Renal sinus

- Internal cavity within kidney
- Lined by fibrous renal capsule
- bound to outer surfaces of structures in renal sinus
- stabilizes positions of ureter, renal blood vessels, and nerves

Renal Cortex

- Superficial portion of kidney in contact with renal capsule
- –Reddish brown and granular

Renal Pyramids

- 6 to 18 distinct conical or triangular structures in renal medulla
- •Base abuts cortex
- •Tip (renal papilla) projects into renal sinus

Renal Columns

- Bands of cortical tissue separate adjacent renal pyramids
- Extend into medulla
- Have distinct granular texture

Renal Papilla

- Ducts discharge urine into minor calyx,a cup-shaped drain

Major Calyx

Formed by four or five minor calyces

Renal Pelvis

- Large, funnel-shaped chamber
- Consists of two or three major calyces
- Fills most of renal sinus
- Connected to ureter, which drains kidney

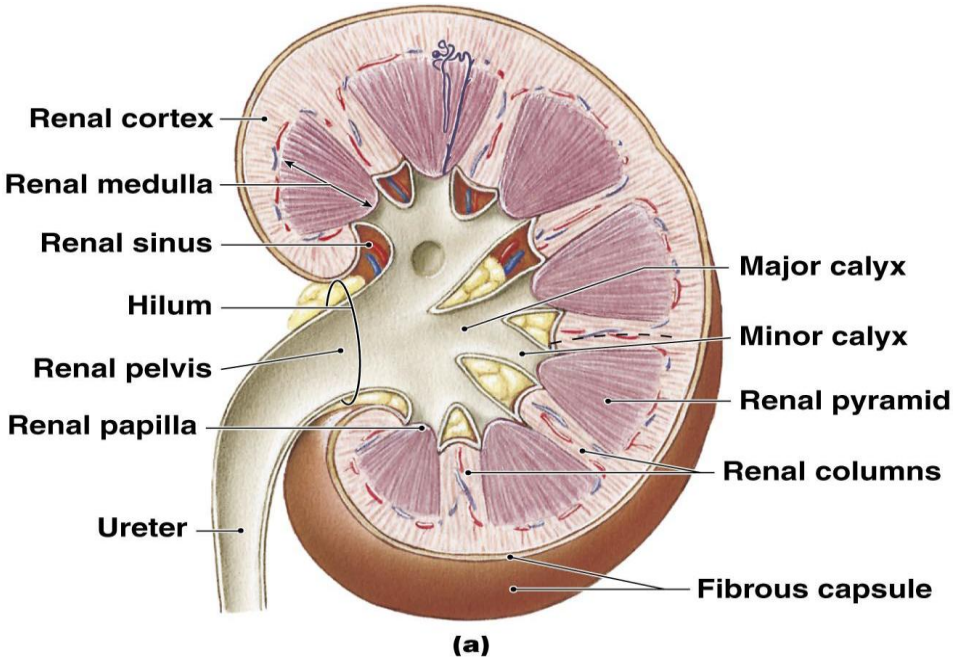


Fig 4.2 Kidney

4.2 STRUCTURE OF NEPHRON

Consists of renal tubule andrenal corpuscle

- Renal tubule

Long tubular passageway
Begins at renal corpuscle

- Renal corpuscle

Spherical structure consisting of glomerular capsule(Bowman's capsule)
•cup-shaped chamber
•capillary network (glomerulus)

Glomerulus

- Consists of 50 intertwining capillaries
- Blood delivered via afferent arteriole
- Blood leaves in efferent arteriole:
- Flows into peritubular capillaries
- Which drain into small venules
- And return blood to venous system

Three Functions of Renal Tubule

1.Reabsorb useful organic nutrients that enter filtrate
2.Reabsorb more than 90% of water in filtrate
3.Secrete waste products that failed to enter renal corpuscle through filtration at glomerulus

Segments of Renal Tubule

Located in cortex:

Proximal convoluted tubule (PCT)
•Distal convoluted tubule (DCT)
Separated by nephron loop(loop of Henle):
•U-shaped tube
•Extends partially into medulla

Organization of the Nephron

Traveling along tubule, filtrate (tubular fluid) gradually changes composition
Changes vary with activities in each segment of nephron

Each Nephron

Empties into the collecting system:
•A series of tubes that carries tubular fluid away from nephron

Collecting Ducts

Receive fluid from many nephrons
Each collecting duct:

•Begins in cortex
•Descends into medulla
•Carries fluid to papillary ductthat drains into a minor calyx

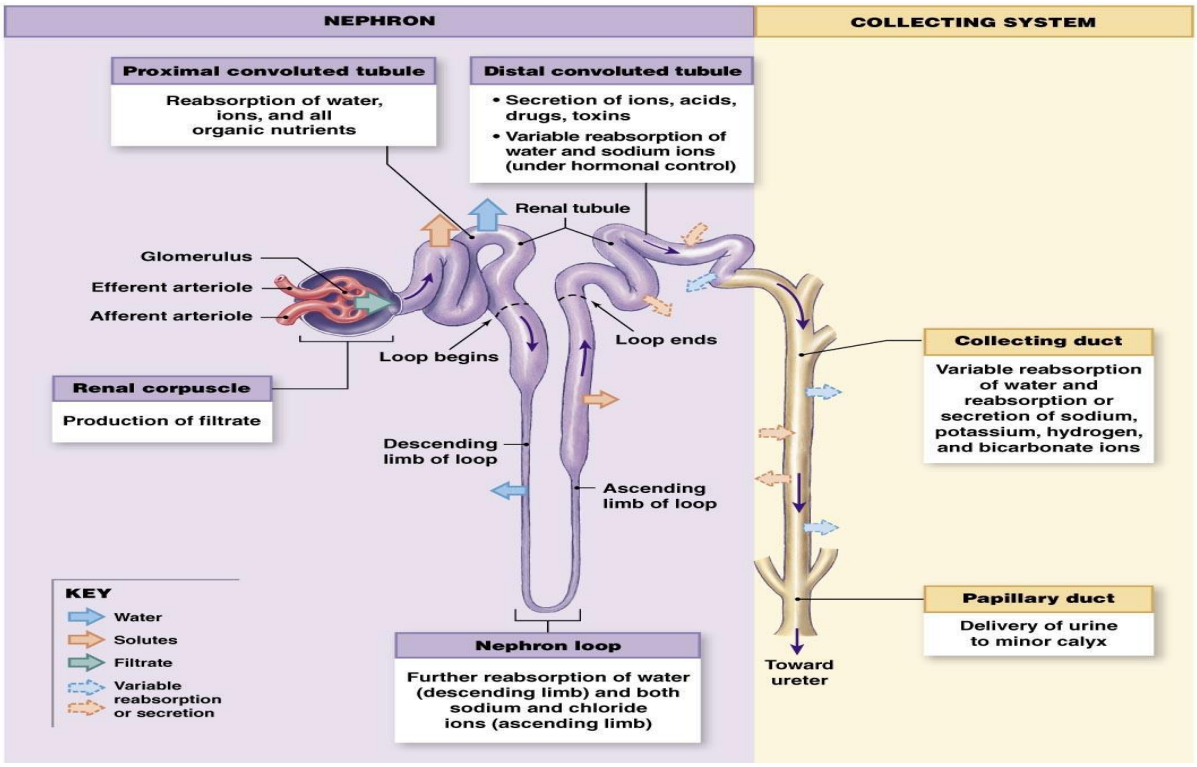


Fig 4.3 Nephron process

4.3 Urine Formation

- Hormones and neurotransmitters ensure urine composition and release are matched to the physiological needs of the animal.
- Regulatory factors affect the 4 processesinvolved in urine formation:

- ➢ Filtration
- ➢ Reabsorption
- ➢ Secretion
- ➢ Excretion

Filtration in the Glomerulus

- Wall of the glomerular capillary is complex biological filter:
- retains blood cells and large macromolecules
- allows liquid components of blood to escape into lumen of Bowman's capsule.

Reabsorption & Secretion

- As fluid passes into the lumen of the tubule, a filtrate is formed = *primary urine*
- As fluid passes through the tubule, about99% of the volume is recovered.
- Remodeling of primary urine occurs as itpasses through successive regions of tubuleand results in the production of final urine.

Reabsorption

- **Reabsorption** = Recovery of substances from the lumen of the tubule Requires both favorable electrochemical gradients and transport capacities.
- Most molecules are reabsorbed through combination of facilitated diffusion and active transport.

Secretion

Secretion = transferring solutes fromthe blood into the tubule lumen.

- Uses transporters found in the cells thatline the lumen.
- Most important secretory products areK+, NH4+, and H+.

4.4 ACID BASE REGULATION

- Excess acid is excreted by the kidneys, largely in the form of ammonia
- The kidneys have some ability to alter the amount of acid or base that is excreted, but this generally takes several days
- Nephron regulates pH of urine by
- transport of H+, HCO3-, and ammonia.
- ◦ Na+/H+ exchangers recover Na+ and extrudeH+, acidifying the urine
- ◦ Cl-/HCO3
- - exchangers recover Cl-, whilealkalinizing primary urine
- Exchangers occur throughout differentparts of tubule.

4.5 URINARY REFLEX

Micturition (Voiding or Urination)

- Voiding:
- Activation by visceral afferent fibers

- Stimulates Pontine Micturation center which then:
- Stimulates contraction of detrusor muscle
- Inhibits contraction of internal sphincter
- Inhibits sympathetic & somatic fibers allowing relaxation of external sphincter
- Voluntary contraction of external sphincter can postpone voiding

4.6 Homeostasis and blood pressure regulation by urinary system

Homeostasis

- The urinary system maintains homeostasis in several ways:
    - Removal of urea (nitrogenous waste) from the bloodstream.
    - Control of water and salt balance in the bloodstream.
    - Involved in blood pressure regulation.

Urea removal

Amino acid metabolism

- Amino acids are the building blocks of protein. If not needed for building protein, then can be metabolized for energy, or broken apart and the carbon chains used to make fat.
- Metabolism requires removal of the amine unit (NH3).

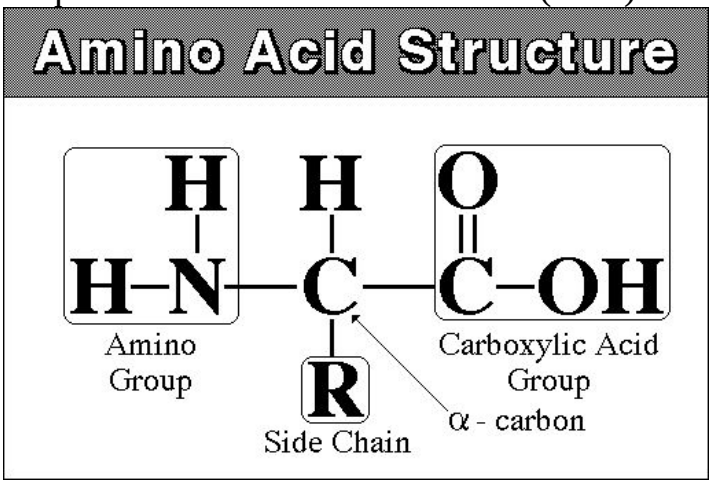


Fig 4.4 Amino Acid Structure

Ammonia and Urea

- Ammonia is toxic and highly water soluble.
- The liver turns ammonia into urea, which is less toxic and less soluble.

Blood pressure

Renin:

- Renin is an enzyme released by the kidneys in response to a drop in blood pressure.
- Renin catalyzes the production of angiotensin, a hormone that causes arterioles to constrict, raising blood pressure. This also causes water retention. How does this maintain homeostasis of blood pressure?

Erythropoietin:

- A second response to low blood pressure is the release of erythropoietin, another hormone.
- Erythropoietin travels to the bone marrow and stimulates the production of new blood cells.

• Sweat Glands

• Introduction

- Sweat glands are appendages of the integument. There are eccrine and apocrine sweat glands. They differ in embryology, distribution, and function. Eccrine sweat glands are simple, coiled, tubular glands present throughout the body, most numerously on the soles of the feet. Thin skin covers most of the body and contains sweat glands, in addition to hair follicles, hair arrector muscles, and sebaceous glands. Exceptions are the vermillion border of the lips, external ear canal, nail beds, glans penis, clitoris, and labia minora, which do not contain sweat glands. The thick skin covering the palms of hands and soles of feet lack all skin appendages except sweat glands.
- Apocrine sweat glands, also referred to as odoriferous sweat glands, are known for producing malodorous perspiration. They are large, branched glands that are mostly confined to the axillary and perineal regions, including the perianal region, labia majora in women, and the scrotum and prepuce in men. Apocrine sweat glands are also present in the nipples and areolar tissue surrounding the nipples.

• Structure and Function

- Eccrine sweat glands serve a thermoregulatory function via evaporative heat loss. When the internal temperature of the body rises, sweat glands release water to the skin surface. There, it quickly evaporates, subsequently cooling the skin and blood beneath. This is the most effective means of thermoregulation in humans. Eccrine sweat glands also participate in ion and nitrogenous waste excretion. In response to emotional or thermal stimuli, sweat glands can produce at least 500 mL to 750 mL in a day. Apocrine sweat glands start to function at puberty under the stimulation of sex hormones. They are associated with hair follicles in the groin and axillary region. The viscous, protein-rich product is initially odorless but may develop an odor after exposure to bacteria. Modified apocrine sweat glands include the wax-producing ceruminous glands of the external auditory meatus, the Moll glands found at the free margins of the eyelids, and the mammary glands of the breast.
- Sweat glands play a regenerative role in skin damage. In second-degree cutaneous burns, which extend into the reticular dermis, regeneration of the epithelium occurs via skin appendages including hair follicles, sebaceous glands, and sweat glands. The epithelial cells surrounding these appendages produce more epithelial cells that progress to form a new epithelium, a process that can take 1 to 3 weeks.

• Embryology

- Both eccrine and apocrine sweat glands originate from the epidermis. Eccrine glands begin as epithelial cellular buds that grow into the underlying mesenchyme. The glandular secretory components are then formed by elongation of the gland and coiling of the ends. Primordial sweat ducts are formed by epithelial attachments of the developing gland. Finally, the central cells degenerate to form the lumen of the sweat duct. Cells on the periphery of the gland differentiate into secretory and myoepithelial cells. Myoepithelial cells are thought to be specialized smooth muscle cells that function

to expel sweat from the gland. Eccrine sweat glands first appear on the palms and soles during the fourth month of gestation; they become functional soon after birth.

- On the other hand, apocrine sweat glands do not function until hormonal stimulation during puberty, and their ducts do not open onto the skin surface. This is because these glands originate from the stratum germinativum of the epidermis. Therefore, down-growth does not produce a duct open to the skin surface. Instead, the ducts open into hair follicles and sweat is released through the hair opening in the skin. The canals of these apocrine sweat gland ducts enter the hair follicle superficial to the sebaceous gland, which results in a protein-rich sweat rather than the watery sweat associated with eccrine sweat glands.

• Blood Supply and Lymphatics

- Sweat glands along with all other skin appendages receive blood supply from cutaneous perforators of underlying source vessels. The perforators may branch directly from the source as septocutaneous or fasciocutaneous perforators or from muscular branches as musculocutaneous perforators. Once these perforators reach the skin, they form extensive networks called dermal and subdermal plexuses. Interconnections between these plexuses form via connecting vessels that run perpendicular to the skin surface, forming a continuous vascular plexus in the skin.
- Lymphatic drainage parallels the blood supply, starting with blind-ended lymphatic capillaries in the dermal papillae. These drain into dermal and deep dermal plexuses that eventually coalesce to form larger lymphatic vessels.

• Nerves

- Eccrine sweat glands receive sympathetic innervation via cholinergic fibers that send impulses in response to changes in core body temperature. Sympathetic innervation to the sweat glands is mediated by the thermoregulatory center of the hypothalamus. A short

preganglionic cholinergic fiber is originating from the thoracolumbar region of the spinal cord synapses with the postganglionic neuron via nicotinic acetylcholine. The postganglionic fiber releases acetylcholine, which differs from all other sympathetic postganglionic fibers that release norepinephrine. Cholinergic stimulation of muscarinic receptors induces sweating. Apocrine sweat glands receive adrenergic sympathetic innervation. Because apocrine sweat glands respond to norepinephrine, they are involved in emotional sweating due to stress, fear, pain, and sexual stimulation.

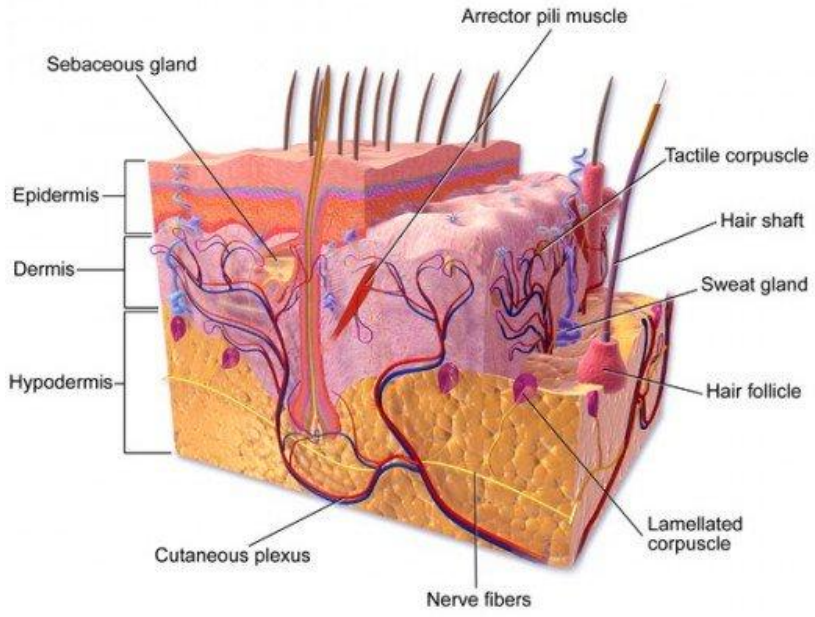
• Clinical Significance

- Given the role of sweat glands in thermoregulation, both eccrine and apocrine glands are associated with various diseases ranging from mild and discomforting to life-threatening. Disorders of sweating can have emotional, social, and professional implications. Hyperhydrosis is the excessive excretion of sweat above the quantity needed for thermoregulation. It can be idiopathic or due to another endocrine, neurologic, or infectious disorders. Treatment options include topical medications, oral medications, surgical procedures, or botulinum toxin injection. Bromhidrosis is a similar disorder that presents with excessive malodorous perspiration. It can involve either apocrine or eccrine sweat glands; apocrine bromhidrosis tends to develop after puberty, while eccrine bromhidrosis may develop at any age. It is caused by excessive perspiration that secondarily becomes malodorous by bacterial breakdown. Because poor hygiene most often aggravates bromhidrosis, an effective treatment is improving personal hygiene. Surgical approaches, antibacterial agents, and antiperspirants are treatment options as well.
- The sweat glands of patients with cystic fibrosis (CF) are ineffective at reabsorbing salt which has major implications. CF is an autosomal recessive congenital disease in which the cystic fibrosis transmembrane regulator (CFTR) that normally inhabits the apical membrane of epithelial cells is defective. CFTR is a transmembrane protein that functions as part of a cAMP-regulated chloride ion

channel; in normal sweat glands, the ductal epithelium reabsorbs sodium and chloride ions in response to aldosterone so that sweat is hypotonic. In CF patients, the sweat glands fail to reabsorb chloride which affects sodium reabsorption resulting in salty sweat and an inability of sweat glands to participate in ion regulation. Disruption of the same membrane proteins in the respiratory and gastrointestinal epithelium result in accumulations of thick mucus.

- Another autosomal recessive congenital disorder that affects sweat glands is lamellar ichthyosis. Infants present with persistent scaling skin and growth of hair may be curtailed. Impairment of sweat gland development often causes infants to suffer in severely hot weather as they cannot maintain thermoregulation through sweating.
- Hidradenitis suppurativa is a chronic, inflammatory disease affecting the hair follicles. This ailment has classically been associated with the apocrine sweat glands as it manifests after puberty in the apocrine-gland concentrated areas of the body. However, the pathophysiology involves follicular occlusion rather than an apocrine disorder as previously thought. Patients often present with tender, suppurative subcutaneous nodules and abscesses in the axillae and groin. The lesions can form sinus tracts and extensive scarring.
- Hypohydrotic ectodermal dysplasia is a disease characterized by hypotrichosis (decreased growth of scalp and body hair), hypodontia (congenital absence of teeth), and hypohidrosis. The term "hypohidrotic" indicates impairment in the ability to perspire. Patients born with hipohydrotic ectodermal dysplasia have difficulty regulating body temperature and therefore must learn to modify their environment in order to control exposure to heat.

Human Skin: Structure, Functions



The Components of the Integumentary System

The skin is a very impressive organ that has many vital functions. Skin acts as an enclosure that stops water from entering the body, reduces the loss of water, and protects the body from infection. It also helps to regulate body temperature, produces a vitamin D precursor, protects us from damage by ultraviolet light, and detects information in the environment. In addition, the skin contains cells that belong to the immune system and resident bacteria that help us in a variety of ways.

Although skin prevents the entry of water and many other substances into the body, it isn't a complete barrier between the body and the outside world. This is why some medicines can be absorbed through the skin, which is beneficial for us, and why some chemicals in cosmetics can also be absorbed through the skin, which may harm the body. In addition, some of our skin pores allow water to leave the body during perspiration. This process helps us to maintain a constant body temperature.

Structure of the Skin: An Overview

The skin consists of two layers—the outer, thinner epidermis and the inner, thicker dermis. Underneath the dermis is the hypodermis, also called the subcutaneous layer, which is where fat is stored. The hypodermis isn't considered to be part of the skin, although the bases of the hair follicles and sweat glands may extend into the hypodermis.

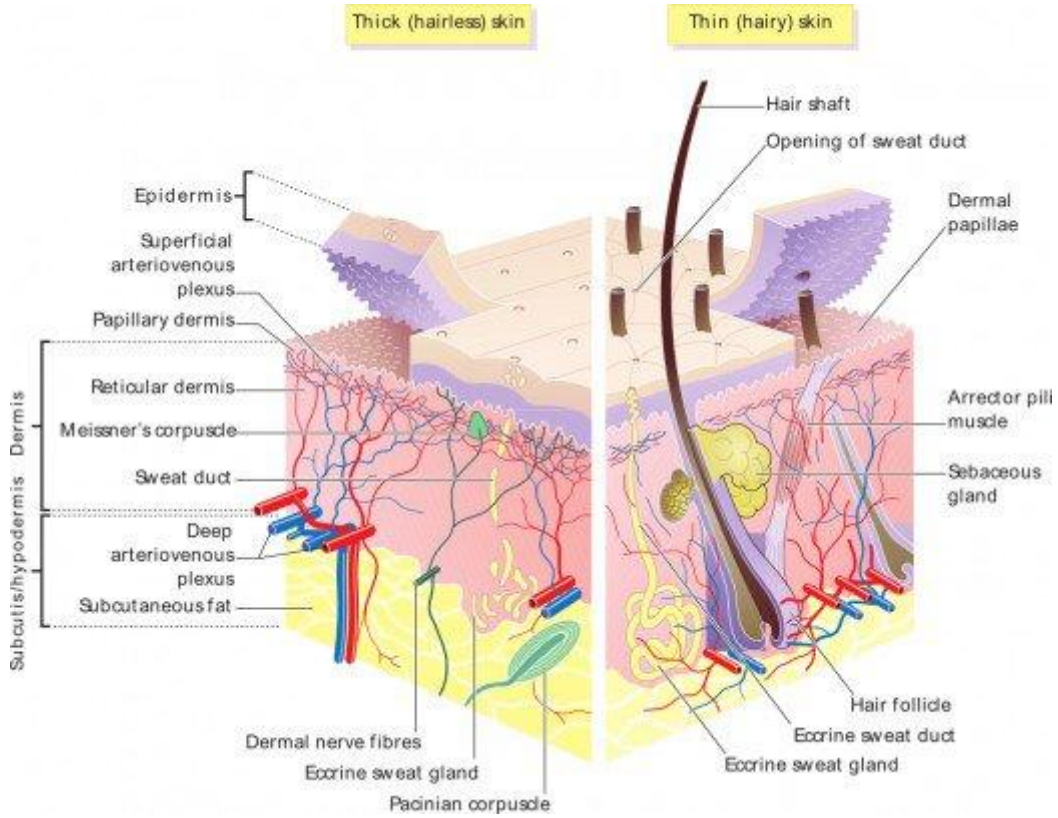
The Epidermis

The most abundant cells in the epidermis are the keratinocytes, which are arranged in layers. The keratinocytes in the upper part of the epidermis contain a protein called keratin. Keratin makes the epidermis strong and waterproof. Cells called melanocytes, which produce a protective pigment named melanin, are also present in the epidermis. In addition, Merkel cells, which detect light touches to the skin, and Langerhans cells, which are part of the immune system, are located in the epidermis.

The Dermis

The dermis contains collagen and elastin fibers, hair follicles, sebaceous glands, the coiled sections of the sweat glands, blood and lymph vessels, nerves, sensory receptors, and cells from the immune system. The sebaceous glands produce an oily substance called sebum. Most sebaceous glands are connected to a hair follicle.

Attached to each hair follicle is an arrector pili muscle which causes the hair to become erect when the skin is cold or when we experience strong emotions. The erect hairs produce a "goose bumps" or "goose flesh" appearance on the surface of the skin.



Resident Bacteria on the Surface of the Skin

It may be surprising to learn that bacteria are an important part of our skin. The bacteria that make their home there are known as resident bacteria, as opposed to temporary visitors which are known as transient bacteria.

Resident bacteria are generally harmless or even helpful. They produce acidic wastes. The bacterial wastes and the lactic acid in our sweat cause the skin surface to have a low pH of around 4 to 5. This pH is fine for the normal bacteria that we carry around but is too low for many harmful bacteria and fungi. Our bacteria population therefore helps to protect us from injury by other microbes. The bacteria may also boost the activity of the immune system in the skin and fight pathogens (microbes that cause disease) in other ways.

Keratinocytes and Keratin in the Epidermis

At the base of the epidermis are cells called keratinocytes. These cells divide to make new keratinocytes. The new cells slowly migrate upwards through the epidermis until they reach the top layer, or the stratum corneum. The migration process takes about a month.

As the keratinocytes migrate, they gradually manufacture a chemical called keratin. Keratin is a fibrous protein that forms hair and nails as well as being present in skin cells. It makes the skin tough and contributes to its ability to block water movement through the skin. By the time the migrating keratinocytes reach the surface of the epidermis they have a flattened, hexagonal shape and their keratin is fully formed.

In the stratum corneum the keratinocytes die, although their tough keratin still protects the skin. Eventually the dead cells fall off. This loss is usually balanced by the production of new cells. The cells that leave the body make up a large part of household dust.

The Epidermis and Vitamin D Production

The process of vitamin D production in the body is a multistep process. The basic steps are follows.

- A chemical in the epidermis called 7-dehydrocholesterol is struck by ultraviolet light from the sun.
- The 7-dehydrocholesterol is converted into an inactive form of vitamin D called cholecalciferol.
- The cholecalciferol is converted into calcidiol in the liver.

- The calcidiol is converted into calcitriol in the kidneys. Calcitriol is the active form of vitamin D.

Vitamin D is necessary for the absorption of calcium in the small intestine. The calcium is sent to the bones and keeps them strong. The vitamin may also boost the activity of the immune system.

Melanocytes, Langerhans Cells, and Merkel Cells

Melanocytes

Melanocytes are found in the bottom layer of the epidermis. These cells make melanin, a pigment which gives color to the skin. The pigment is transported to other epidermal cells. Melanin absorbs ultraviolet light, preventing it from damaging the body. It's important to realize that melanin doesn't completely protect us from UV light, however. An additional form of protection is needed when we are exposed to sunlight.

Langerhans and Merkel Cells

The epidermis also contains Langerhans and Merkel cells. Langerhans cells are classified as a type of dendritic cell because they have extensions called dendrites at some point in their life. They are part of the immune system, but it's not completely clear how they function. Their biology is an active area of research. Merkel cells are located at the base of the epidermis. They lie close to nerve endings and are sensitive to light touch.

Other Cells and Chemicals

The dermis contains other sensory cells as well as a variety of chemicals. These chemicals include lipids and antimicrobial peptides (short chains of amino acids that fight pathogens). The epidermis doesn't contain blood vessels. Nutrients for the epidermal cells are supplied by the blood vessels in the dermis, which also remove waste substances made by the cells.

Glands in the Dermis

Sebaceous Glands

The dermis contains three types of skin glands—sebaceous glands, eccrine or merocrine glands, and apocrine glands. Sebaceous glands are usually attached to hair follicles. They secrete sebum, an oily substance that contains a mixture of lipids. Sebum lubricates and waterproofs the skin and hair. The greatest amount of sebum is secreted during puberty.

Eccrine Glands

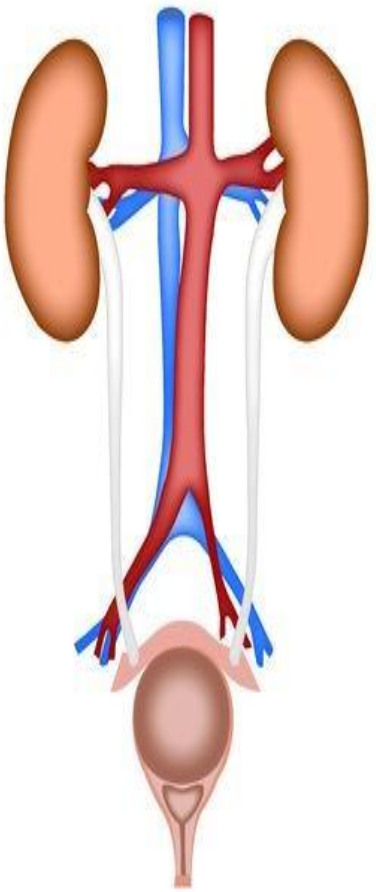
Our skin contains two types of sweat glands, or sudoriferous glands. Eccrine glands are found over most of the body and release sweat directly to the surface of the skin. This sweat is watery and almost odorless. It contains many dissolved chemicals, including water, urea (a waste substance produced from protein metabolism), lactic acid, and sodium chloride.

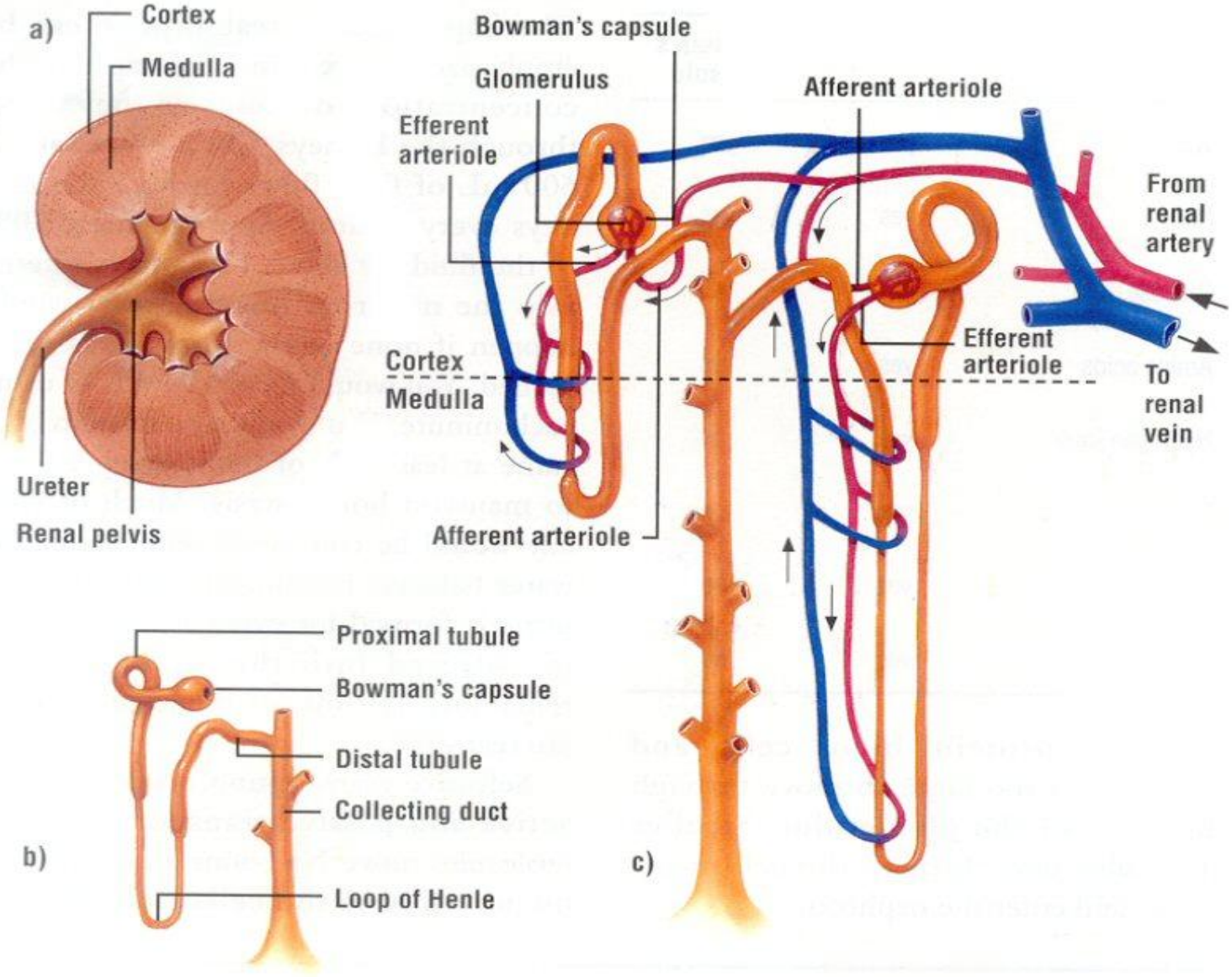
Apocrine Glands

Apocrine glands are found only in certain areas, such as the armpits. They become active at puberty and release a thick, milky, and fatty liquid into a hair follicle. Certain conditions, such as stress, stimulate the release of liquid from apocrine glands. When the odorless liquid reaches the surface of the skin, bacteria break it down, producing odoriferous compounds. The function of apocrine glands is unknown. It's been suggested that in the past (and perhaps in the present) their secretion contained a pheromone, which is a chemical that attracts the opposite gender.

The Human Excretory System

The function of the excretory system is to excrete (get rid of) wastes that are not helpful to the body.




a)
Cortex
Medulla
Ureter
Renal pelvis
Bowman's capsule
Glomerulus
Afferent arteriole
Efferent arteriole
From renal artery
Cortex
Medulla
Efferent arteriole
To renal vein
Afferent arteriole
b)
Proximal tubule
Bowman's capsule
Distal tubule
Collecting duct
Loop of Henle
c)

Waste

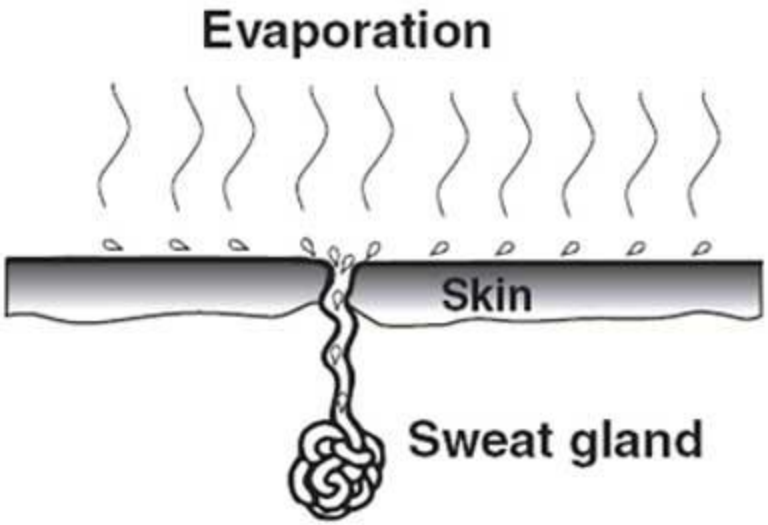
- Wastes that are removed include carbon dioxide, water, salt, urea and uric acid.
- **All** excreted wastes travel at some time in the blood.

Structures of the Excretory System

1. Skin
2. Lungs
3. Liver
4. Large intestine
5. Urinary System

Skin

Wastes such as excess <u>water, salt, urea and uric acid</u> are removed from the body in <u>sweat</u>.



Lungs

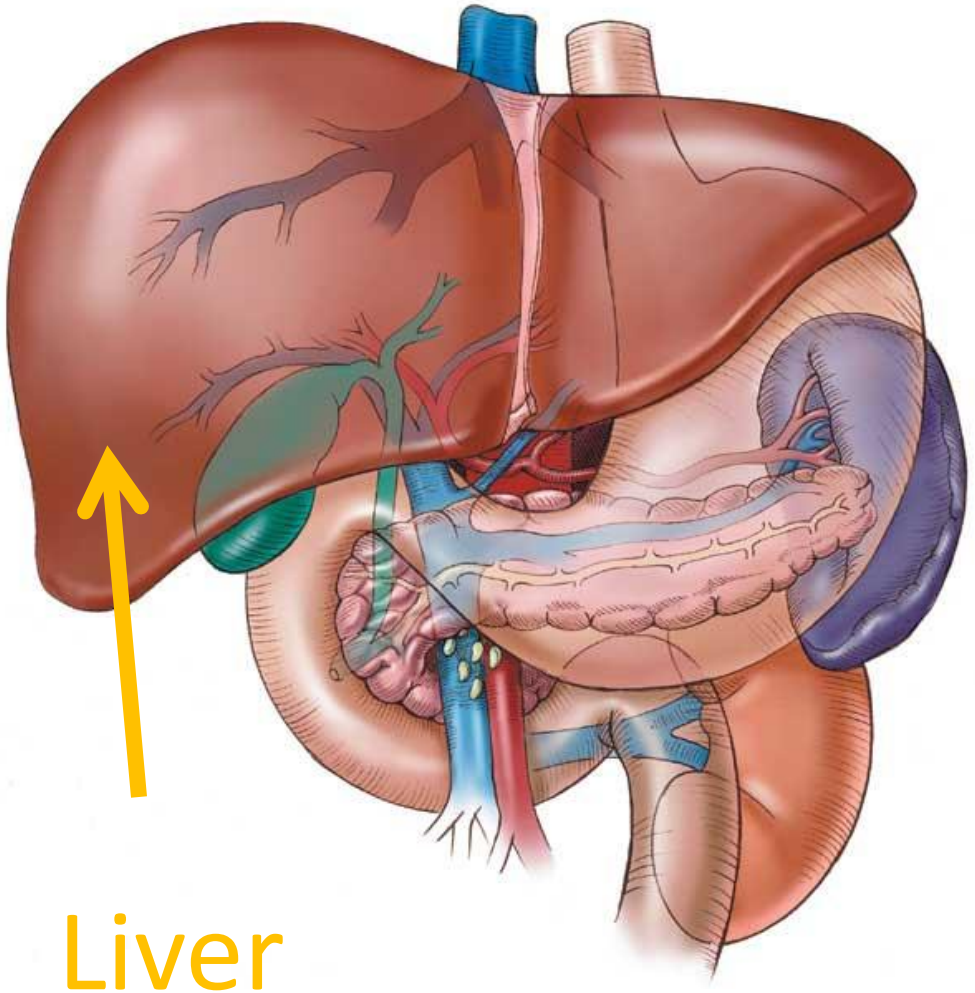
Excess carbon dioxide and water vapor waste is removed from the body when we exhale.

CO_2

Liver

The liver is a part of what other system?

The digestive system

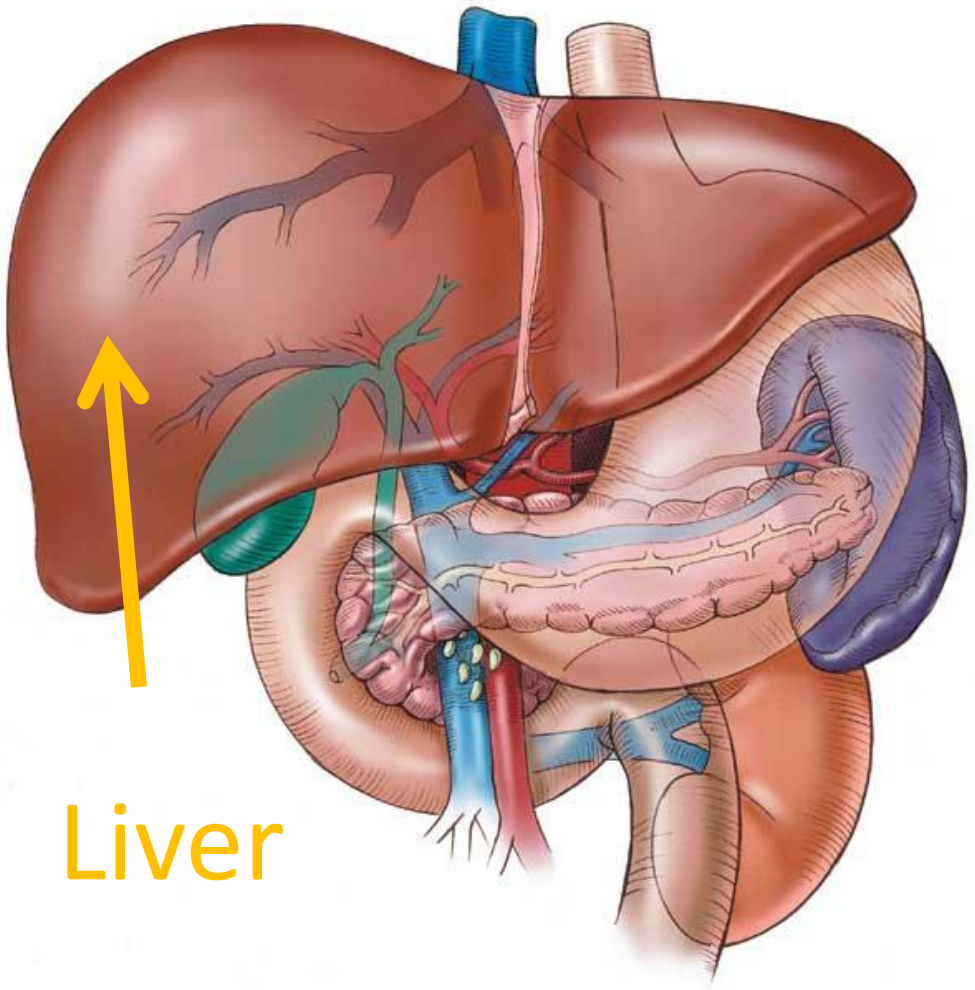


The liver has many functions, including (but not limited to):

1. to produce substances that break down fats
2. produce urea (the main substance of urine)
3. make certain amino acids (the building blocks of proteins)
4. filter harmful substances from the blood (such as alcohol)
5. The liver is also responsible for producing cholesterol. It produces about 80% of the cholesterol in your body.

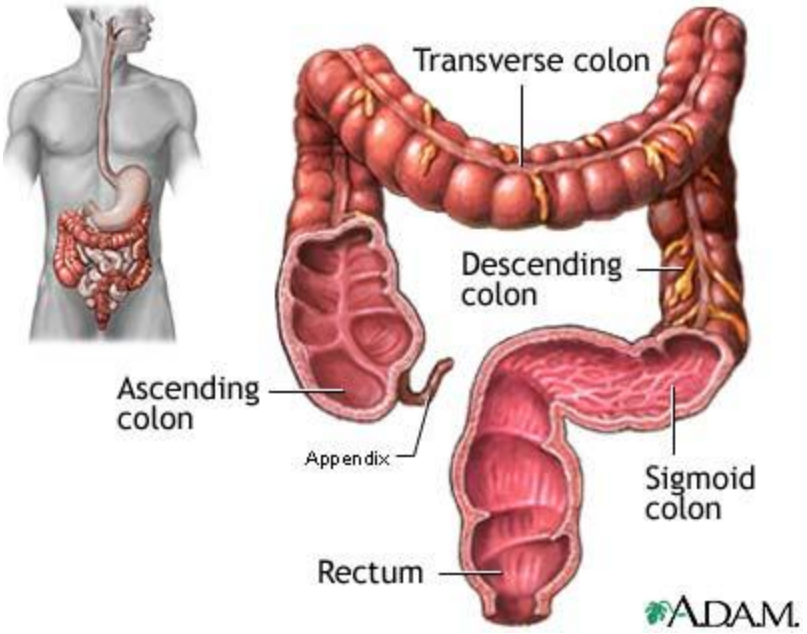
The Liver and Waste

- The liver produces urea and uric acid as a by-product of the breakdown of proteins.
- Urea and uric acid are sent to the kidneys to be processed.



Large Intestine

- The large intestine removes solid, undigested food from the body after it passes through the digestive system.
- Waste is stored in rectum until it is excreted from the body as solid waste.



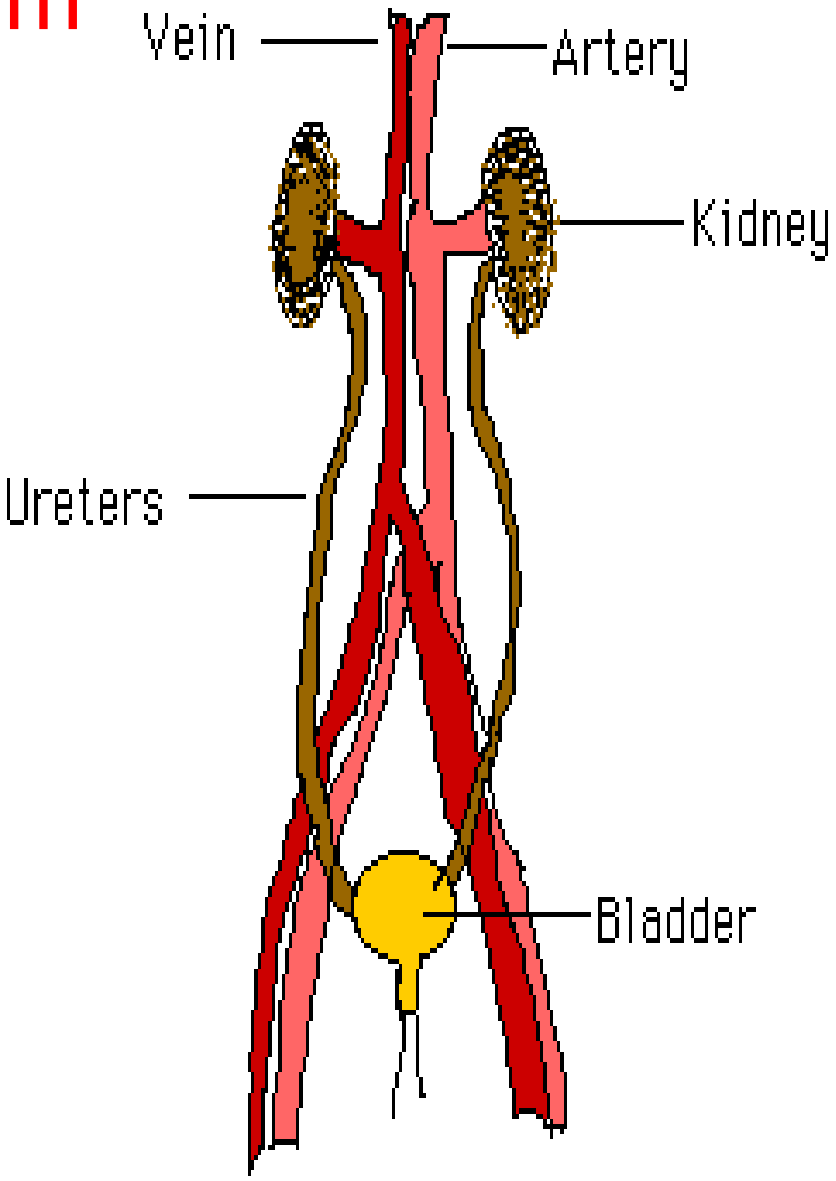
The Urinary System

Kidneys – filter wastes and excess water from the blood.

Ureters – tubes that take urine from the kidney to the urinary bladder.

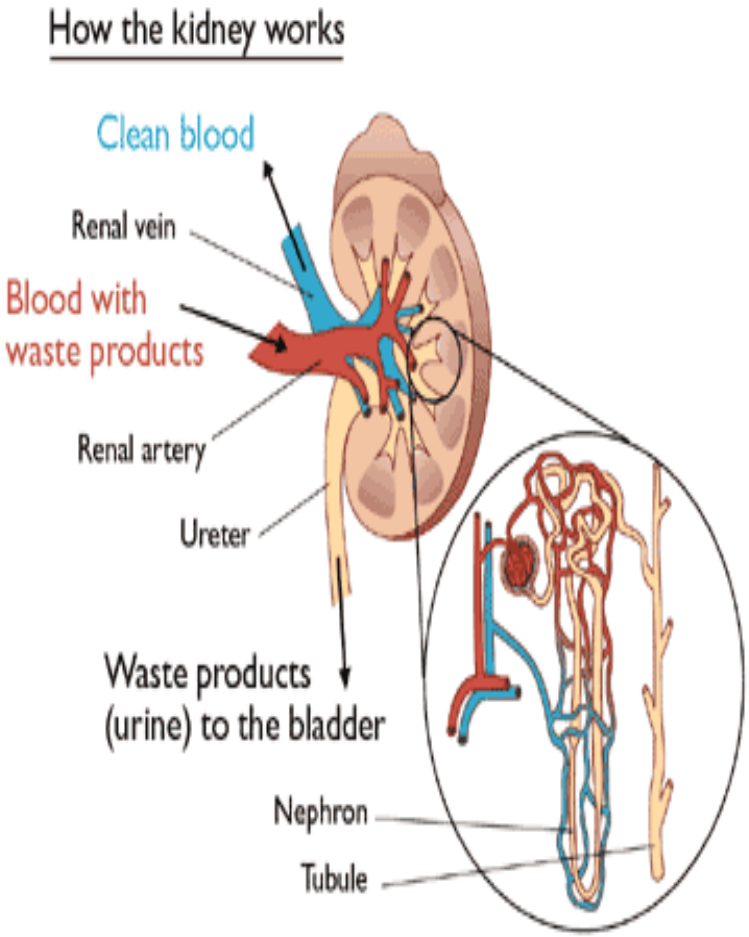
Urinary Bladder – a sack that stores urine.

Urethra – small tube that leads urine out of the body.

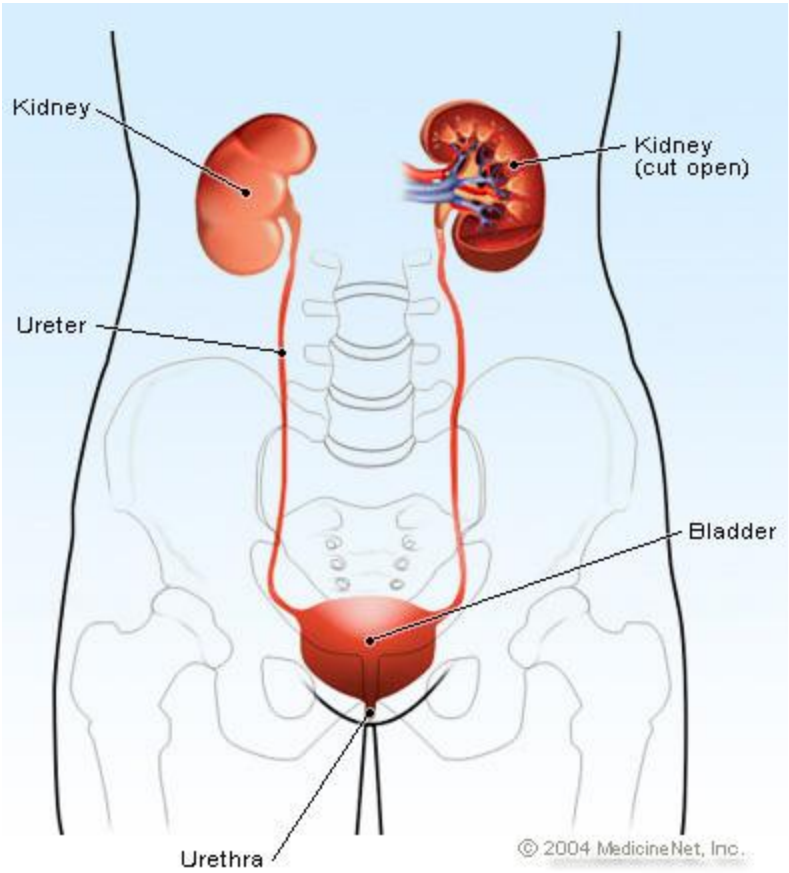


The Kidneys

- Every drop of blood in your body is filtered by your kidneys more than 300 times per day!
- Kidneys eliminate urea, minerals and excess water.
- Kidneys regulate the amount of water we need to maintain in our bodies.



Urine from the kidneys goes to the Ureter, then moves to bladder to be expelled from the body.



Doctors analyze urine for disease;

- Normal urine contains water, urea and trace minerals.
- Sugar in urine indicates Diabetes
- Protein in urine indicates the kidneys are not working and the person, or animal, is very sick.

Micturition

- Micturition or urination is the process of expelling urine from the bladder. This act is also known as voiding of the bladder. The excretory system in humans includes a pair of kidneys, two ureters, a urinary bladder and a urethra. The kidneys filter the urine and it is transported to the urinary bladder via the ureters where it is stored till its expulsion. The process of micturition is regulated by the nervous system and the muscles of the bladder and urethra. The urinary bladder can store around 350-400ml of urine before it expels it out.

- **Stages of Micturition**
- The urinary bladder has two distinct stages or phases:
- Resting or filling stage
- Voiding stage
- Resting or Filling Stage
- It is in this phase of the bladder that the urine is transported from the kidneys via the ureters into the bladder. The ureters are thin muscular tubes that arise from each of the kidneys and extend downwards where they enter the bladder obliquely.
- detrusor muscle, is relaxing
- Voiding Stage
- During this stage, both the urinary bladder and the urethra come into play together. The detrusor muscle of the urinary bladder which was relaxing so far starts to contract once the bladder's storage capacity is reached.
- The internal and external urethral sphincters. The internal sphincter is a smooth muscle whereas the external one is skeletal. Both these sphincters are in a contracted state during the filling stage.

Questions	opt1	opt2	opt3	opt4	Answer
The _____ of a cell is the most critical factor in determining its function.	size	shape	age	chromosome number	shape
The _____ of the cell directs its overall activities as well as houses its genetic material.	nucleolus	endoplasmic reticulam	nucleus	centrosome	nucleus
Molecules that are soluble in _____ can pass through the fatty acid portion of the cell membrane unassisted.	water	cholesterol	gases	lipids	lipids
The type of proteins that guide cells on the move in the bloodstream to their destination at a wound site are _____.	cell adhesion molecules	desmosomes	gap junctions	tight junctions	cell adhesion molecules
_____ provide(s) both structural support and the enzymes needed to make proteins from amino acid building blocks	peroxisomes	golgi apparatus	ribosomes	mitochondria	ribosomes
The tubular transport system that moves molecules throughout the cell is/are the _____.	mitochondria	endoplasmic reticulam	ribosomes	peroxisomes	endoplasmic reticulam
Choose the organelle that consists of microtubules and functions both in distributing chromosomes during cell division and in forming portions of cilia and flagella	lysosome	mitochondria	vesicle	centrosome	centrosome
In what part of the nucleus does ribosome production occur?	within nuclear pores	in chromatin	in nucleolus	not in nucleus	within nuclear pores
By which process does a glucose molecule move through a cell membrane protein carrier from a region of greater concentration to one of lower concentration?	diffusion	facilatated diffusion	active transport	filtration	facilitated diffusion
Cells use up to 40% of their daily energy expenditure engaged in what important process?	active transport	endocytosis	exocytosis	facilatated diffusion	active transport
During what phase of the cell cycle does DNA replication occur?	mitosis	prophase of mitosis	G2 phase	S phase	S phase
Chromosomes align midway between centrioles during what phase of mitosis?	prophase	metaphase	anaphase	telophase	metaphase
Which types of genetic control normally holds mitosis in check?	oncogenes	cell adhesion molecules	tumor suppressor genes	epidermal growth factors	tumor suppressor genes
The _____ of the cell has a function directly related to the synthesis of proteins.	mitochondrion	lysosome	ribosomes	centriole	lysosome
The _____ is a system of membranes designed to transport molecules within and out of cells.	vacuole	chromatin	nucleolus	endoplasmic reticulam	endoplasmic reticulam
The organelle termed the _____ produces the microtubules important in cell division.	centrosome	nucleus	golgi apparatus	cilium	centrosome
DNA can be found within chromosomes during division but prior to division DNA exists as long thin _____ strands.	RNA	chromatin	chromosome	flagellar	chromatin
Which chemicals on the surface of cells function to attach to and recognize hormones?	phospholipids	carbohydrates	proteins	steroids	proteins
The term _____ can be used to imply all of the chemical reactions within a cell.	metabolism	respiration	anabolism	catabolism	metabolism
The cristae are structures found within the _____ organelle.	ribosome	lysosome	mitochondrion	endoplasmic reticulam	mitochondrion
Which of the following does not belong with others?	diffusion	osmosis	active transport	passive transport	active transport
The movement of particles from an area of higher to lower concentration is called _____.	osmosis	diffusion	filtration	active transport	diffusion
The base sequence termed the anticodon is found on molecules of _____.	DNA	tRNA	mRNA	rRNA	tRNA
The production of mRNA from a DNA template is termed _____.	transcription	translation	replication	mutation	transcription
Which of the following is not a compatible base pairing in DNA?	adenine-uracil	adenine-thymine	cytosine-guanine	guanine-cytosine	adenine-uracil
Genes are functional regions found within molecules of _____.	ribonucleic acid	adenosinetriphosphate	adenine and guanine	deoxyribonucleic acid	deoxyribonucleic acid
Which reaction must occur before a triglyceride is to be used for energy?	beta oxidation	hydrolysis	glycolysis	liponeogenesis	hydrolysis
Which molecule represents the storage form of glucose in the liver?	glycoger	glucagon	disaccharide	lactic acid	glycoger
What are the final end products of the electron transport chain?	ATP and NADH	ATP and water	ADP and hydrogen	ATP oxygen	ATP and water
What are the direct end products of the Citric Acid Cycle?	carnondioxide and water	ATP and heat	ADP and heat	citric acid	carnondioxide and water

UNIT II

Questions	opt1	opt2	opt3	opt4	Answer
Branched nerve fibers that convey impulses toward the cell body of a neuron are called _____.	axons	dendrites	axon collaterals	axon terminals	dendrites
Myelin sheaths on the outsides of many axons are contributed by _____.	the axon itself	secretory vesicles	Schwann cells	the cell bodies of the neuron	Schwann cells

A neuron with many nerve fibers arising from its cell body and that carries impulses away from the brain would be classified as _____.	multipolar	bipolar	unipolar and sensory	multipolar and motor	multipolar and motor
Which types of neurons are likely to increase muscular activities?	accelerator neurons	inhibitory neurons	bipolar neurons	sensory neurons	accelerator neurons
The _____ are the types of neuroglial cells that provide myelin in the central nervous system.	oligodendrocytes	astrocytes	microglia	ependyma	oligodendrocytes
Which type of neuroglial cells help regulate the composition of cerebrospinal fluid?	oligodendrocytes	astrocytes	microglia	ependyma	ependyma
When a neuron reaches action potential, it depolarizes and repolarizes in an amount of time on the order of _____.	milliseconds	seconds	microseconds	nanoseconds	milliseconds
Excessive sleeping is most likely due to the presence of too much of which neurotransmitter?	GABA	norepinephrine	serotonin	dopamine	GABA
Myasthenia gravis reflects a deficiency in communication by _____ because receptors for this neurotransmitter have been destroyed.	GABA	norepinephrine	acetylcholine	dopamine	acetylcholine
The levels of which neurotransmitter are affected by the mood-elevator, cocaine?	GABA	norepinephrine	acetylcholine	serotonin	norepinephrine
Fibers that originate from different parts of the nervous system and lead to the same neuron are exhibiting _____.	facilitation	convergence	divergence	neuromodulation	convergence
Which term does not belong with the others?	brain	spinal cord	CNS	spinal nerve	spinal nerve
Which items should not be grouped together?	cranial nerve	spinal cord	PNS	spinal nerve	spinal cord
The cells that conduct messages towards the brain are the:	motor neurons	sensory neurons	interneurons	neuroglia	sensory neurons
Nerves impulses always travel to the brain through _____ fibers.	neuron	dentria	nerve	axon	axon
The layer of the heart that forms a smooth, protective lining of the heart chambers and valves is the _____.	endocardium	myocardium	epicardium	parietal pericardium	endocardium
The bicuspid valve _____.	is located on the left side of the heart	guards the auricles of the heart	guards the entrance to the aorta	guards the entrance to the pulmonary trunk	is located on the left side of the heart
Which artery supplies blood to the ilium and muscles of the lower back?	aorta	common iliac artery	internal iliac artery	iliolumbar artery	iliolumbar artery
A deep wound to the upper thigh might damage the _____ artery.	femora	poplitea	anterior tibial	peroneal	femora
Blood is drained from the face, scalp, and superficial regions of the neck by the _____.	carotid arteries	external jugular veins	internal jugular veins	brachiocephalic veins	external jugular veins
A unique venous system, called the _____, carries blood directly from the intestines to the liver for processing rather than directly into the inferior vena cava.	hepatic portal system	superior mesenteric vein	saphenous vein	gonadal vein	hepatic portal system
The inability of the left ventricle to pump blood adequately to the body's cells is indicative of _____.	an embolus	cardiac tamponade	congestive heart failure	asystole	congestive heart failure
Which membrane is closest to the heart muscle?	pericardial sac	fibrous pericardium	parietal pericardium	visceral pericardium	visceral pericardium
How many openings are there in the right atrium?	1	2	3	5	3
The _____ valve lies between the right atrium and right ventricle.	bicuspid	aortic semilunar	pulmonary semilunar	tricuspid	tricuspid
The pulmonary semilunar valve prevents a back-flow of blood into the _____.	pulmonary artery	right ventricle	left ventricle	right atrium	right ventricle
The aortic semilunar valve prevents blood from returning to the _____.	left ventricle	aorta	right ventricle	left atrium	left ventricle
Which structure contains the lowest amount of oxygen?	pulmonary vein	aorta	vena cava	right ventricle	vena cava
The first heart sound is caused by closure of the _____ valves.	pulmonary semiluna	atrioventricular	aortic semilunar	mitral	atrioventricular
The last in the cardiac conduction sequence is the _____.	SA node	AV node	AV bundle	Purkinje fibers	Purkinje fibers

UNIT III

Questions	opt1	opt2	opt3	opt4	Answer
Thin-walled outpouchings of the alveolar ducts of the lungs are the _____.	respiratory bronchioles	alveolar ducts	alveolar sacs	alveoli	alveolar sacs
What is the first structure in this respiratory sequence?	lungs	trachea	larynx	pharynx	pharynx
Which structures play the greatest role in warming and humidifying air?	ethmoid sinus	soft palate	conchae	frontal sinus	conchae
The area directly superior to the soft palate is the _____.	larynx	nasopharynx	oral cavity	oropharynx	nasopharynx
Which sinuses are not paranasal sinuses?	mastoid	ethmoid	sphenoid	frontal	mastoid
Where are the pharyngeal tonsils located?	larynx	nasopharynx	oral cavity	oropharynx	nasopharynx
Which passageway serves as a common route for food or air?	laryngopharynx	nasopharynx	oral cavity	oropharynx	laryngopharynx

What is the opening to the larynx called?	trachea	epiglottis	laryngopharynx	glottis	glottis
What is the Adam's apple directly part of?	thyroid cartilage	tracheal rings	cricoid cartilage	epiglottis	thyroid cartilage
The only structures that allow gas diffusion across them are the _____.	alveolar ducts	alveoli	bronchioles	bronchi	alveoli
Compact bone is made up of _____ cemented together.	osteocytes	perforating canals	osteons	trabeculae	osteons
The cells that tear down and remodel bone are the _____.	osteoblasts	osteocytes	osteoclasts	macrophages	osteoclasts
A soft spot in a newborn's skull is called a _____.	fontanel	fovea	foramen	fissure	fontanel
The _____ suture joins the temporal and parietal bones of the skull.	lambdoidal	squamosal	coronal	sagittal	squamosal
The membranes that surround the skull attach to the crista galli, found on the _____ bone of the skull.	sphenoid	frontal	parietal	ethmoid	ethmoid
The prominent portions of the cheeks are made up of the _____ bones.	maxillary	palatine	lacrimal	zygomatic	zygomatic
The pectoral girdle is made up of the clavicle and the _____.	humerus	ulna	scapula	sternum	scapula
Another name for the wrist bones is _____.	metacarpals	carpals	phalanges	tarsals	carpals
The femur inserts into the pelvic girdle at the _____.	patella	trochanter	condyle	acetabulum	acetabulum
How many bones are there in the body?	180	80	210	206	206
Which muscle enables you to pucker your lips for a kiss?	epicranius	buccinator	orbicularis oris	orbicularis oculi	orbicularis oris
The muscle that enables you to elevate and adduct your scapula is the _____.	serratus anterior	sternocleidomastoid	splenius capitis	rhomboideus major	rhomboideus major
Which muscle is the strongest flexor of the elbow?	brachialis	biceps brachii	brachioradialis	deltoid	brachialis
The biceps femoris is one hamstring muscle located on the back of the thigh. Which muscle is the other hamstring?	adductor magnus	semitendinosus	gluteus maximus	quadriceps femoris	semitendinosus
Which of the following does not belong with the others?	multinucleated	skeletal	striated	involuntary	involuntary
Each muscle fiber is directly surrounded by connective tissue called the _____.	perimysium	fascia	endomysium	epimysium	endomysium
Which term is the smallest subdivision in this group?	fiber	fibril	filament	actin	actin
Which description of muscle contraction means that all of the fibers within a muscle are fully contracted?	all-or-none law	summation	tetanic	muscle twitching	tetanic
The application of multiple stimuli to a muscle is defined as the process called _____.	tetany	summation	fatigue	treppe	summation
The term _____ refers to the constant state of contraction of a certain number of fibers within a muscle.	atrophy	hypertrophy	summation	tone	tone

UNIT IV

Questions	opt1	opt2	opt3	opt4	Answer
Which gastrointestinal layer is characterized by having tough, fibrous connective tissue?	mucosa	submucosa	muscle	serosa	serosa
Which intestinal layer accounts for the action of the peristaltic waves?	serosa	muscularis	submucosa	mucous	muscularis
The alimentary tube is around _____ meters long.	3	5	7	9	9
The _____ nervous system division usually stimulates and promotes digestion.	parasympathetic	central	sympathetic	somatic	parasympathetic
The processes of chewing are referred to as _____.	churning	mastication	peristalsis	deglutition	mastication
The frenulum is the membrane attached to the inferior surface of the _____.	tongue	stomach	lips	liver	tongue
The following are true of the tongue except which one?	contains skeletal muscle	attaches to hyoid bone	attaches to temporal bone	contains papillae	attaches to temporal bone
The following areas contain tonsils except which one?	around the frenulum	oral pharynx	nasal pharynx	root of tongue	around the frenulum
Which lymphatic areas are most commonly the site of inflammation?	Peyer's patches	palatine tonsils	lingual tonsils	adenoids	palatine tonsils
How many teeth will be produced in an average lifetime?	20	32	50	52	52
The term wisdom tooth refers to the _____ tooth.	incisor	third molar	second bicuspid	first cuspid	third molar
The portion of a tooth which lies within the mandible socket is called the _____.	dentin	crown	root	cementum	root
Which part of a tooth most closely resembles bone tissue?	enamel	cementum	dentin	gingiva	dentin
Which muscles constrict to prevent air from entering the esophagus during breathing?	superior constrictor	middle constrictor	inferior constrictor	esophageal	inferior constrictor
A hiatal hernia is a weakness in the _____ muscle, which allows a portion of the digestive tract to enter the thoracic cavity.	diaphragm	stomach	intestinal	thoracic wall	diaphragm
The outermost covering of the kidney is the _____.	cortex	medulla	pelvis	capsule	capsule
The kidneys are located in the _____ space.	pelvic cavity	peritoneal cavity	abdominal	retroperitoneal	retroperitoneal
The entrance into the kidney is called the _____.	sinus	renal column	hilum	pyramid	hilum
Which structure is the first to collect the urine?	pelvis	calyx	ureter	urethra	calyx

Each minor calyx receives urine from the _____.	renal papillae	pelvis	ureter	columns	renal papillae
The renal pyramids are located within the _____.	column	cortex	medulla	pelvis	medulla
The striated appearance of the pyramids is caused by _____.	parallel blood vessels	microtubules	connective tissue	nerve fibers	microtubules
What is the basic functional unit of the kidney?	alveolus	renal pyramid	renal pelvis	nephron	nephron
The kidney secretes _____ for the purpose of stimulating bone marrow activity.	renin	aldosterone	erythropoietin	somatomedin	erythropoietin
The kidney secretes _____ which is an enzyme-hormone which raises blood pressure.	aldosterone	renin	angiotensinogen	angiotensin II	renin
What is the function of the renal system?	maintain blood pH	regulate blood pressure	control blood concentration	all of these	all of these
How much of the cardiac output passes through the kidneys?	10%	25%	50%	65%	25%
Which blood vessel delivers blood to the cortex?	interlobular artery	arcuate artery	interlobar artery	efferent arteriole	interlobular artery
The renal corpuscle is comprised of a glomerulus and _____.	proximal convoluted tubule	Bowman's capsule	loop of Henle	distal convoluted tubule	distal convoluted tubule
Which section of the nephron follows the ascending limb of the loop of Henle?	descending limb of the loop	proximal convoluted tubule	distal convoluted tubule	collecting duct	

UNIT V

Questions	opt1	opt2	opt3	opt4	Answer
The two systems that act to control all body activities are the nervous and _____ systems.	circulatory	exocrine	endocrine	muscular	endocrine
The _____ system includes the glands that release their secretions directly into the blood.	exocrine	endocrine	circulatory	excretory	endocrine
Which of the following glands does not belong to the endocrine system?	pituitary	thyroid	parathyroid	salivary	salivary
Which of the following is not a chemical class of hormones?	protein	steroid	glycoprotein	carbohydrate	carbohydrate
Which of these is not a steroid?	adrenalin	cholesterol	progesterone	cortisone	adrenalin
Which of the following is the precursor that will result in the synthesis of the others?	testosterone	cholesterol	vitamin D	estrogen	cholesterol
Which of the following does not belong with the others?	amine	epinephrine	cortisone	norepinephrine	cortisone
Which of the following does not chemically belong with the other hormones?	ADH	PTH	GH	LH	ADH
Which of these is not produced by the anterior pituitary?	ACTH	follicle-stimulating hormone	somatostatin	somatotropin	somatostatin
Which of these does not belong with the others?	ICSH	lutropin	LH	follitropin	follitropin
Which of the following is not a pancreatic hormone?	glucagon	aldosterone	insulin	somatostatin	aldosterone
Which of these compounds is produced first?	cAMP	protein kinases	adenylate cyclase	ATP	adenylate cyclase
Which factor inactivates and decreases the levels of cAMP?	adenylate cyclase	phosphodiesterase	ATP conversion to ADP	protein kinases	phosphodiesterase
Which of the following does not employ cAMP second messengers?	cortisol	TSH	FSH	parathormone	cortisol
Which of the following is not a hormone function?	increase cellular oxygen consumption	cause osteoblasts to divide	convert fibroblasts to osteoblasts	alter genetic expression	convert fibroblasts to osteoblasts
Sounds are detected by _____-receptors	chemo	thermo	mechano	photo	mechano
Sensory adaptation occurs when stimuli become _____.	gradually ignored	increased in intensity	lessened in intensity	forgotten	gradually ignored
Pain originating in the parietal pericardium is _____ by the brain.	ignored	referred	usually intensified	felt directly	felt directly
The purpose of the auricle is to _____sound waves.	dampen	increase the intensity of	act as a collector of	vibrate in response to	act as a collector of
The first structure to vibrate in response to sounds is _____.	auricle	malleus	organ of Corti	tympanic membrane	tympanic membrane
The following belong together except which one?	incus	tympanic cavity	middle ear	cochlear duct	cochlear duct
The purpose of the ossicles is to _____ the incoming vibrations.	lessen the intensity of	increase the force of	change the wavelength of	move with	increase the force of
The stapes sends its vibrations to the _____.	incus	tympanic membrane	oval window	round window	oval window
Which of these does not belong with the others?	tympanic reflex	stapedius	increase sound	decrease sound	increase sound
The auditory tube acts to equalize pressure between the middle ear and _____.	throat	inner ear	outer ear	cochlea	throat
The term labyrinth refers to the appearance of the _____.	outer ear	inner ear	middle ear	vestibule	inner ear
The membranous labyrinth contains _____fluid.	cerebrospinal	plasma	endolymph	perilymph	endolymph
The portion of the inner ear, which detects sounds, is the _____.	semicircular canals	osseous labyrinth	vestibule	cochlea	cochlea
Reissner's membrane separates the cochlear duct from the _____.	round window	scala vestibuli	scala tympani	basilar membrane	scala vestibuli
The intensity of sounds is measured in units of _____.	mv	amperes	daltons	dB	dB