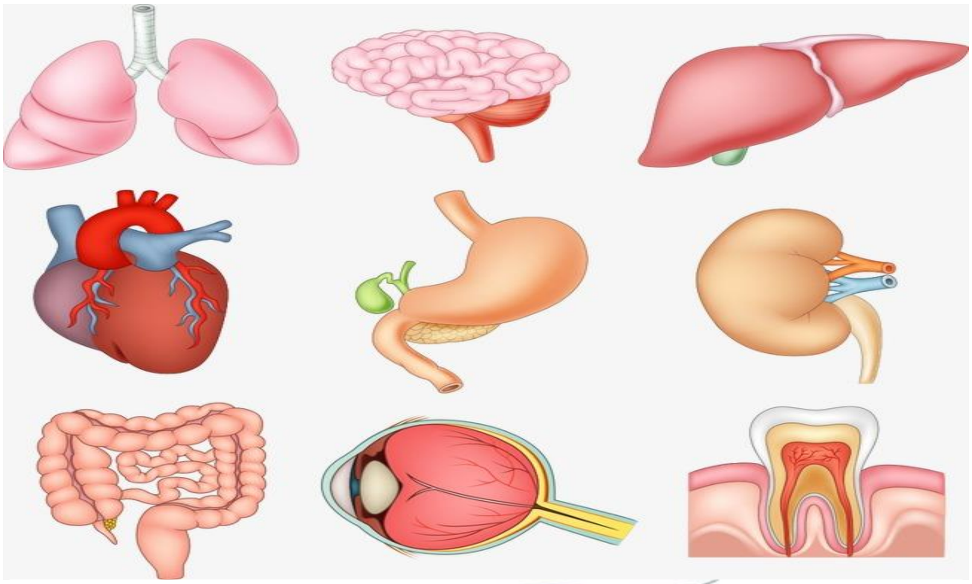
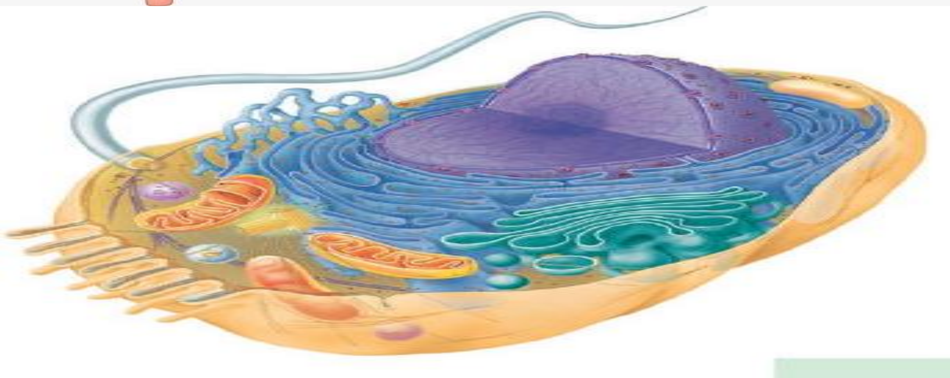
Zoology (1)

Cell Structure &Function, Tissues and Organ system





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For geological &biological sciences &: basic Science students

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CONTENTS

CHAPTER 1

THE CELL

THE CELL

The cell is the smallest structural unit of a living organism. So, everything that we are able to do is possible because of the 10 trillion cells present in our body, which were made by Allah. The number is huge and of course, the function performed by them is even bigger.

The introduction to cell began back in the year 1655 when a revolutionary observation was made by scientist **Robert Hook**. This observation made by him was so huge that it went on to change the basic biological theory and research forever. So, how was the cell discovered?

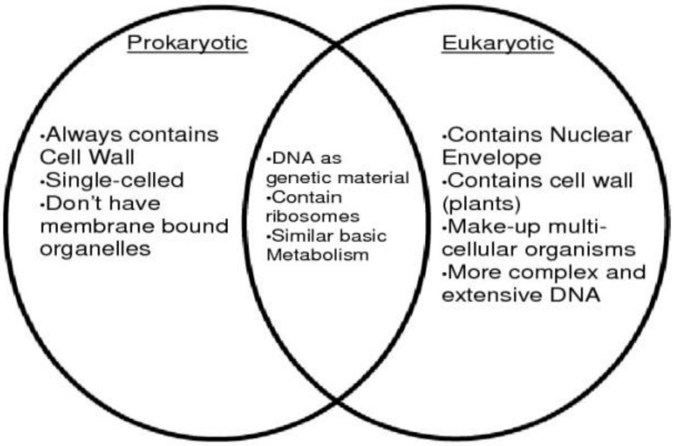
Robert Hook was examining a dried section of the cork tree using a crude light microscope. In this analysis, he observed multiple small chambers which he named the cells. Thereafter, over the next 175 years, several kinds of research were made which led to the formation of the cell theory that we know today. The first such theory was proposed by the German botanist Matthias Jacob **Schleiden** and the German physiologist Theodore **Schwann** in 1838. This theory was formalized in the year 1858 by the German researcher Rudolf **Virchow**.

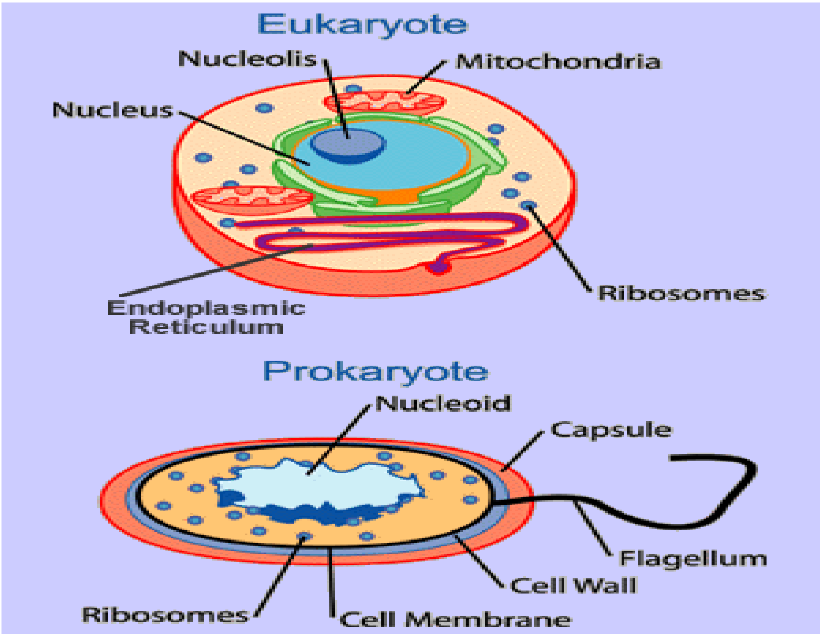
Cell Theory

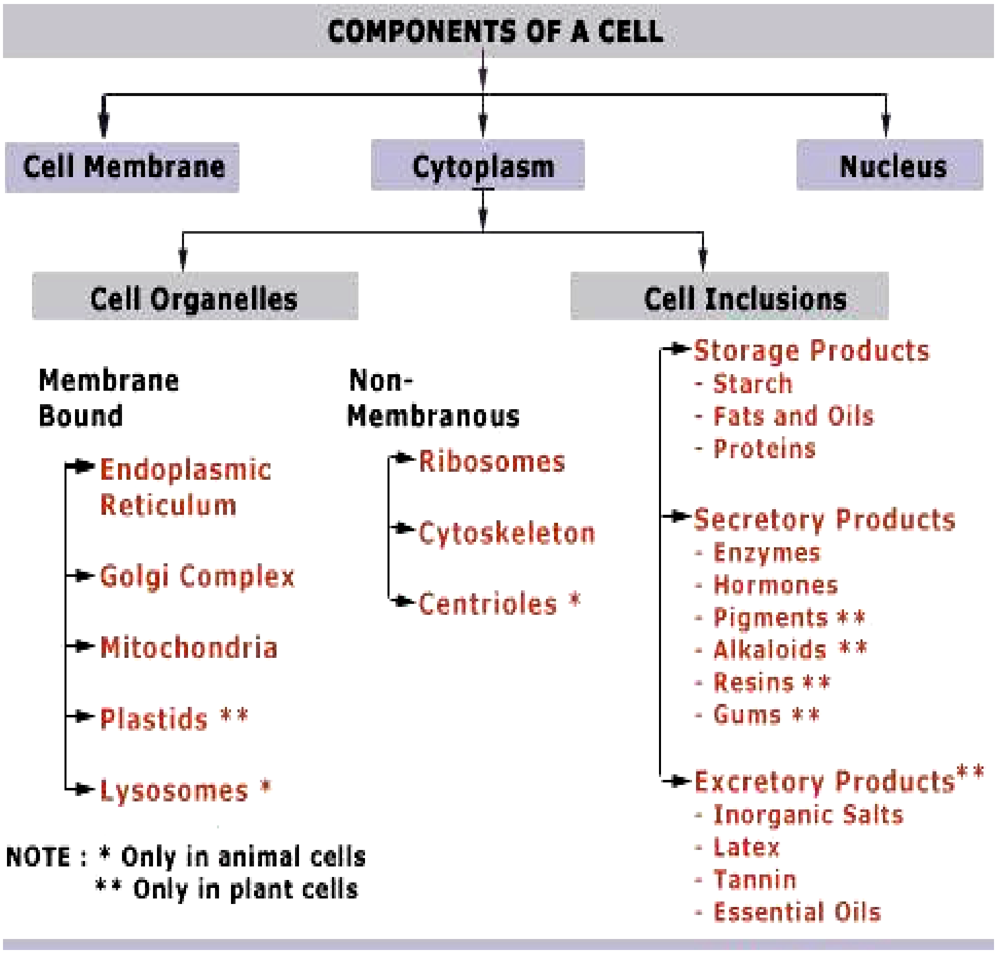
- The cell is the basic functional and structural unit of life. All the living organisms are composed of cells.
- All cells are formed by the division of the already existing cells which in terms of biology means reproduction. Every cell of our body comprises of genetic material which is passed down during the process.
- All the basic physiological and chemical functions i.e. the growth, repair, movement, communication, immunity and digestions are performed inside the cells.
- All the activities of the cell depend mainly on the activities of the sub cellular structures that lie within the cell.

Types of cell

Broadly, there are two key types of cells i.e. the Prokaryotic Cell and the Eukaryotic Cell. The difference between the two is defined mainly by the presence or the absence of the nuclear membrane. Let’s know more about the two types of cells.


Prokaryotic
Eukaryotic
·Always contains Cell Wall
·Single-celled
·Don't have membrane bound organelles
·DNA as genetic material
·Contain ribosomes
·Similar basic Metabolism
·Contains Nuclear Envelope
·Contains cell wall (plants)
·Make-up multi-cellular organisms
·More complex and extensive DNA


Eukaryote
Nucleolis
Mitochondria
Nucleus
Ribosomes
Endoplasmic Reticulum
Prokaryote
Nucleoid
Capsule
Flagellum
Cell Wall
Ribosomes
Cell Membrane



The **plasma membrane that surrounds and keeps** the cell intact and regulates what enters and exits a cell. The plasma membrane is a phospholipids bilayer that is said to be selective permeable because it allows certain molecules but not others to enter the cell the **nucleus is a large, centrally located structure** that can often be seen with a light microscope. The nucleus contains the chromosomes and is the control center of the cell. It controls the metabolic functioning and structural characteristics of the cell. The **nucleolus is a region inside the nucleus.** The **cytoplasm is**

the portion of the cell between the nucleus and the plasma membrane. The matrix of the cytoplasm is a semi fluid medium that contains water and various types of molecules suspended or dissolved in the medium. The presence of proteins accounts for the semi fluid nature of the matrix the cytoplasm contains various **organelles.** Organelles are small membranous structures that can usually only be seen with an electron microscope. Each type of organelle has a specific function. Cells also have a **cytoskeleton, a network of** interconnected filaments and microtubules that occur in the cytoplasm. The name cytoskeleton is convenient in that it allows us to compare the cytoskeleton to the bones and muscles of an animal. Bones and muscle give an animal structure and produce movement. Similarly, the elements of the cytoskeleton maintain cell shape and allow the cell and its contents to move. Some cells move by using cilia and flagella, which are also made up of microtubules.

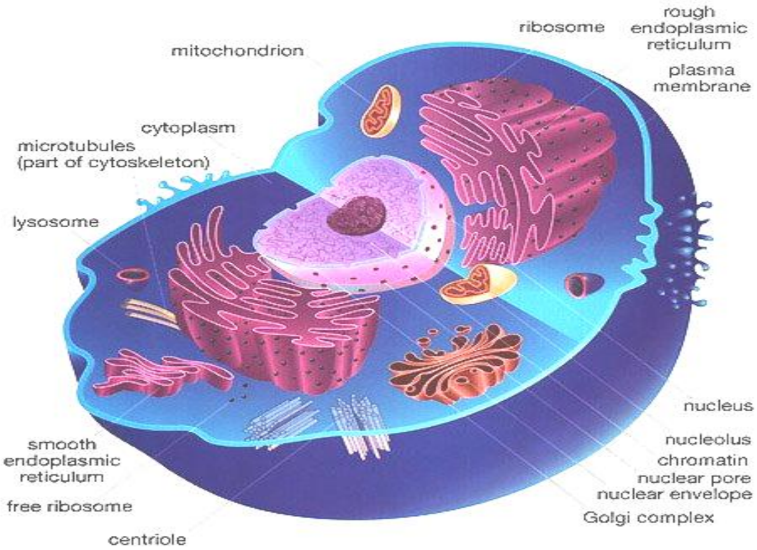
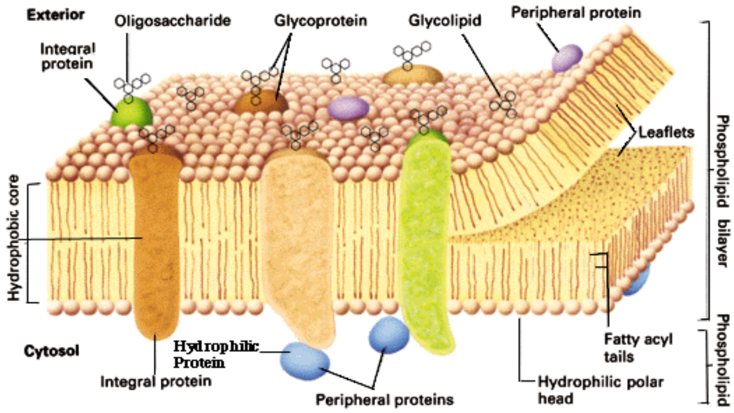


Fig. of a typical animal cell

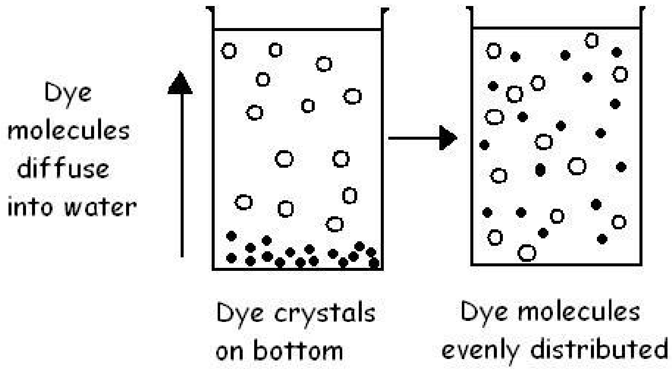
The structure of Plasma Membrane

An animal cell is surrounded by an outer plasma membrane. The plasma membrane marks the boundary between the outside of the cell and the inside of the cell. The plasma membrane is a phospholipids bilayer with attached or embedded proteins. The structure of phospholipids is such that the molecule has a polar head and nonpolar tails. The polar heads, being charged, are hydrophilic (water loving) and face outward, toward the cytoplasm on one side and the tissue fluid on the other side. The nonpolar tails are hydrophobic (not attracted to water) and face inward toward each other, where there is no water. Fluid-mosaic model, a working description of membrane structure, says that the protein molecules have a changing pattern (form a mosaic) within the fluid phospholipid bilayer. Cholesterol lends support to the membrane. Short chains of sugars are attached to the outer surface of some protein and lipid molecules (called glycoprotein and glycolipids, respectively). It is believed that these carbohydrate chains, specific to each cell, help mark it as belonging to a particular individual. They account for why people have different blood types, for example. Other glycoproteins have a special configuration that allows them to act as a receptor for a chemical messenger like a hormone. Some plasma membrane proteins form channels through which certain substances can enter cells; others are carriers involved in the passage of molecules through the membrane



Transport in plasma membrane

How substances move across the Plasma Membrane?



Substances need to pass through the membrane to enter or leave the cell and they do so in a number of ways. Some of these processes require no energy i.e. they are passive, while
others require energy i.e. they are active. Passive processes include: a) diffusion and b) osmosis, while active processes include: c) active transport, d) phagocytosis, e) pinocytosis and f) exocytosis. These will be described below.

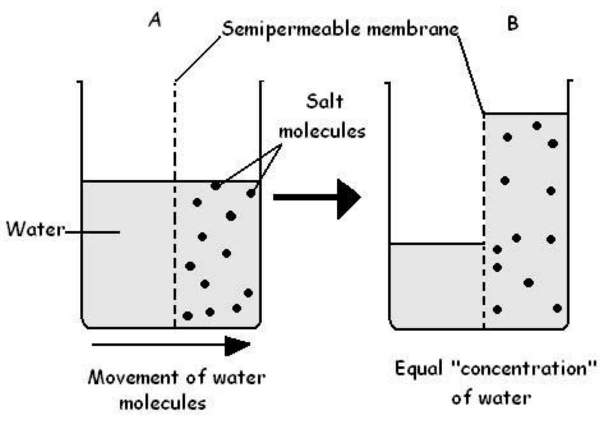
a) Diffusion

Although you may not know it, you are already familiar with the process of diffusion. It is diffusion that causes a smell (expensive perfume or smelly socks) in one part of the room to gradually move through the room so it can be smelt on the other side. Diffusion occurs in the air and in liquids.

The up picture shows what happens when a few crystals of a dark purple dye called potassium permanganate are dropped into a beaker of water. The dye molecules diffuse into the water moving from high to low concentrations so they become evenly distributed throughout the beaker. In the body, diffusion causes molecules that are in a high concentration on one side of the cell membrane to move across the membrane until they are present in equal concentrations on both sides. It takes place because all molecules have an in-built vibration that causes them to move and collide until they are become evenly distributed. It is an absolutely natural process that requires no added energy. Small molecules like oxygen, carbon dioxide, water and ammonia as well as fats, diffuse directly through the double fat layer of the membrane. The small molecules named above as well as a variety of charged particles (ions) also diffuse through the protein-lined channels.

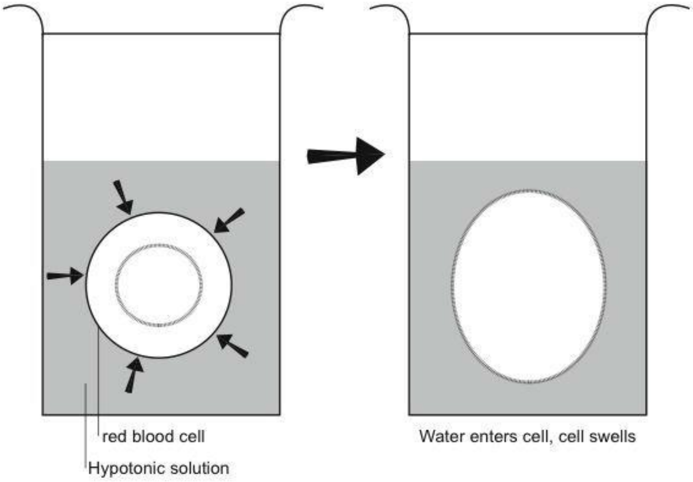
Larger molecules like glucose attach to a carrier molecule that aids their diffusion through the membrane. This is called facilitated diffusion.

In the animal's body diffusion is important for moving oxygen and carbon dioxide between the lungs and the blood, for moving digested food molecules from the gut into the blood and for the removal of waste products from the cell.



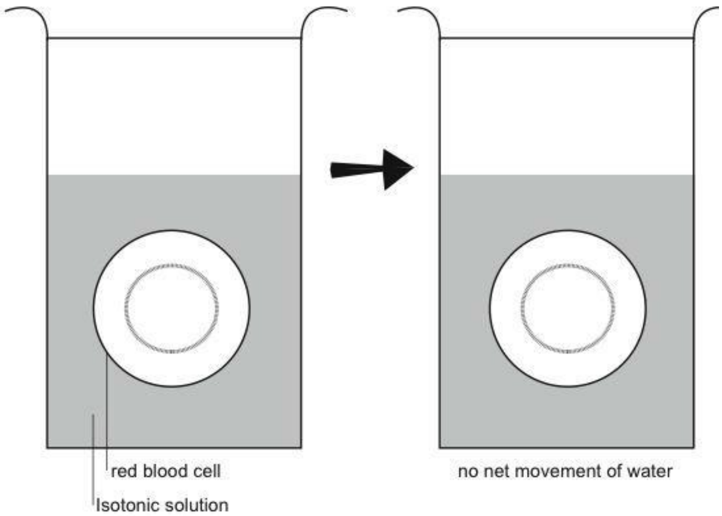
b) Osmosis

Although the word may be unfamiliar, you are almost certainly acquainted with the effects of osmosis. It is osmosis that plumps out dried fruit when you soak it before making a fruit cake or makes that wizened old carrot look almost like new when you soak it in water. Osmosis is in fact the diffusion of water across a membrane that allows water across but not larger molecules. This kind of membrane is called a semi-permeable membrane. Take a look at side A of diagram 3.6. It shows a container divided into two parts by an artificial semi-permeable membrane. Water is poured into one part while a solution containing salt is poured into the other part. Water can cross the membrane but the salt cannot. The water crosses the semi-permeable membrane by diffusion until there is an equal amount of water on both sides of the membrane. The effect of this would be to make the salt solution more diluted and cause the level of the liquid in the right-hand side of the container to rise so it looked like side B of diagram 3.6. This movement of water across the Semi-permeable membrane is called osmosis. It is a completely natural process that requires no outside energy. Although it would be difficult to do in practice, imagine that you could now take a plunger and push down on the fluid in the right-hand side of container B so that it flowed back across the semi-permeable membrane until the level of fluid on both sides was equal again. If you could measure the pressure required doing this, this would be equal to the osmotic pressure of the salt solution. (This is a rather advanced concept at this stage but you will meet this term again when you study fluid balance later in the course).



The plasma membrane of cells acts as a semi-permeable membrane. If red blood cells, for example, are placed in water, the water crosses the membrane to make the amount of water on both sides of it equal. This means that the water moves into the cell causing it to swell. This can occur to such an extent that the cell actually bursts to release its contents. This bursting of red blood cells is called hemolysis. In a situation such as this when the solution on one side of a semi-permeable membrane has a lower concentration than that on the other side, the first solution is said to be hypotonic to the second.

Now think what would happen if red blood cells were placed in a salt solution that has a higher salt concentration than the solution within the cells. Such a bathing solution is called a hypertonic solution. In this situation the "concentration" of water within the cells would be higher than that outside the cells. Osmosis (diffusion of water) would then occur from the inside of the cells to the outside solution, causing the cells to shrink.

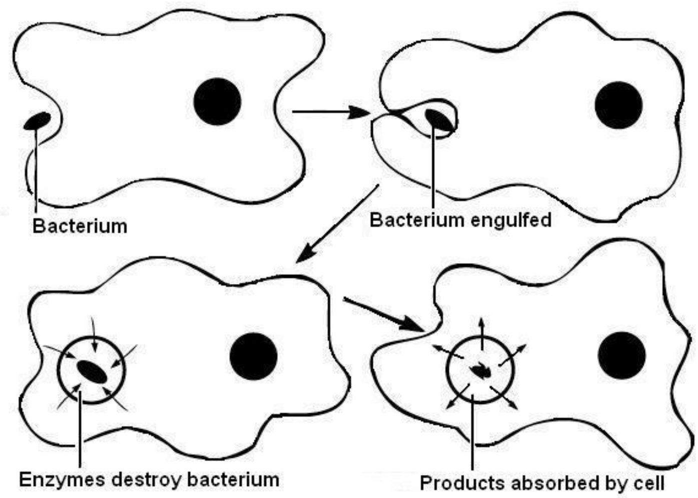


Red cells placed in an isotonic solution, a solution that contains 0.9% salt has the same concentration as body fluids and the solution within red cells. Cells placed in such a solution would neither swell nor shrink.

This solution is called an isotonic solution. This strength of salt solution is often called normal saline and is used when replacing an animal’s body fluids or when cells like red blood cells have to be suspended in fluid. Remember - osmosis is a special kind of diffusion. It is the diffusion of water molecules across a semi-permeable membrane. It is a completely passive process and requires no energy. Sometimes it is difficult to remember which way the water molecules move. Although itis not strictly true in a biological sense, many students use the phrase “SALT SUCKS” to help them remember which way water moves across the membrane when there are two solutions of different salt concentrations on either side. As we have seen water moves in and out of the cell by osmosis. All water movement from the intestine into the blood system and between the blood capillaries and the fluid around the cells (tissue or extra cellular fluid) takes place by osmosis. Osmosis is also important in the production of concentrated urine by the kidney.

c) Active transport

When a substance is transported from a low concentration to a high concentration i.e. uphill against the concentration gradient, energy has to be used. This is called active transport. Active transport is important in maintaining different concentrations of the ions sodium and potassium on either side of the nerve cell membrane. It is also important for removing valuable molecules such as glucose, amino acids and sodium ions from the urine.



d) Phagocytosis

Phagocytosis is sometimes called “cell eating”. It is a process that requires energy and is used by cells to move solid particles like bacteria across the plasma membrane. Finger-like projections from the plasma membrane surround the bacteria and engulf them as shown in the diagram. Once within the cell, enzymes produced by the lysosomes of the cell (described later) destroy the bacteria. The destruction of bacteria and other foreign substance by white blood cells by the process of phagocytosis is a vital part of the defense mechanisms of the body.

e) **Pinocytosis**

Pinocytosis or “cell drinking” is a very similar process to phagocytosis but is used by cells to move fluids across the plasma membrane. Most cells carry out pinocytosis (note the pinocytotic vesicle in the up diagram.

f) **Exocytosis**

Exocytosis is the process by means of which substances formed in the cell are moved through the plasma membrane **into the** fluid outside the cell (or extra-cellular fluid). It occurs in all cells but is most important in secretory cells (e.g. cells that produce digestive enzymes) and nerve cells.

The Cytoplasm

Within the plasma membrane is the cytoplasm. It consists of a clear jelly-like fluid called the a) cytosol or intracellular fluid in which b) cell inclusions, c) organelles and d) microfilaments and microtubules are found.

a) **Cytosol**

The cytosol consists mainly of water in which various molecules are dissolved or suspended. These molecules include proteins, fats and carbohydrates as well as sodium, potassium, calcium and chloride ions. Many of the reactions that take place in the cell occur in the cytosol.

b) **Cell inclusions**

These are large particles of fat, glycogen and melanin that have been produced by the cell. They are often large enough to be seen with the light microscope. For example, the cells of adipose tissue (as in the insulating fat layer under the skin) contain fat that takes up most of the cell.

c) **Organelles**

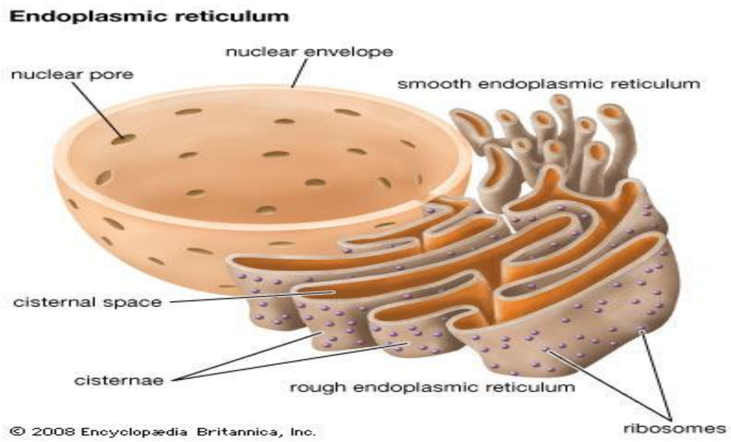
Organelles are the “little organs” of the cell - like the heart, kidney and liver are the organs of the body. They are structures with characteristic appearances and specific “jobs” in the cell. Most cannot be seen with the light microscope and so it was only when the electron microscope was developed that they were discovered. The main organelles in the cell are the ribosome, endoplasmic reticulum, mitochondrion, Golgi complex and lysosomes.

Ribosomes

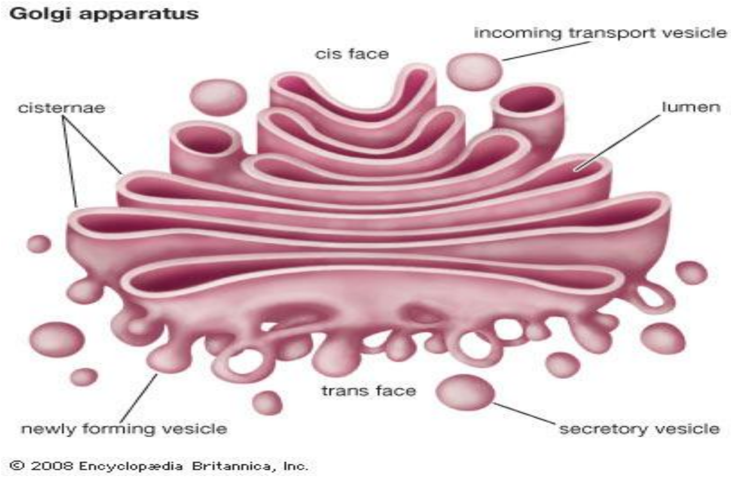
Ribosomes are composed of two subunits, one large and one small. Each subunit has its own mix of proteins and rRNA. Protein synthesis occurs at the ribosomes. Ribosomes are found free within the cytoplasm either singly or in groups called polyribosomes. Ribosomes are often attached to the endoplasmic reticulum, a membranous system of saccules and channels. Proteins synthesized by cytoplasmic ribosomes are used inside the cell for various purposes. Those produced by ribosomes attached to endoplasmic reticulum may eventually be secreted from the cell.

Membranous Canals and Vesicles

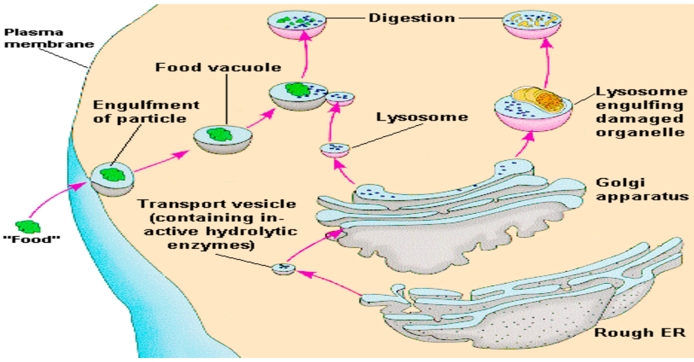
The endomembrane system consists of the nuclear envelope, the vesicles (tiny membranous sacs). This system compartmentalizes the cell so that particular enzymatic reactions are restricted to specific regions The Endoplasmic Reticulum the endoplasmic reticulum (ER), a complicated system of membranous channels and saccules (flattened vesicles), is physically continuous with the outer membrane of the nuclear envelope. Rough ER is studded with ribosomes on the side of the membrane that faces the cytoplasm Here proteins are synthesized and enter the ER interior where



Processing and modification begin. Smooth ER, which is continuous with rough ER, does not have attached ribosomes. Smooth ER synthesizes the phospholipids that occur in membranes and has various other functions depending on the particular cell. In the testes, it produces testosterone, and in the liver, it helps detoxify drugs. Smooth ER also forms vesicles in which large molecules are transported to other parts of the cell. Often these vesicles are on their way to the plasma membrane or the Golgi apparatus. ER is involved in protein synthesis. Golgi Apparatus consists of a stack of three to twenty slightly curved saccules whose appearance can be compared to a stack of pancakes in animal cells, one side of the stack (the inner face) is directed toward the ER, and the other side of the stack (the outer face) is directed toward the plasma membrane. Vesicles can frequently be seen at the edges of the saccules The Golgi apparatus receives protein and/or lipid-filled vesicles that bud from the ER. The Golgi apparatus contains enzymes that modify proteins and lipids. For example, it can add a chain of sugars to proteins, thereby making them glycoproteins and glycolipids, which are molecules found in the plasma membrane the vesicles that leave the Golgi apparatus move about the cell. Some vesicles proceed to the plasma membrane, where they discharge their contents. Because this is secretion, it is often said that the Golgi apparatus is involved in processing, packaging, and secretion. Other vesicles that leave the Golgi apparatus are lysosomes.



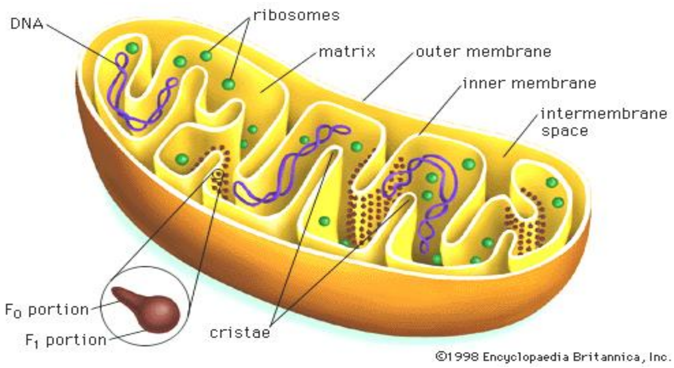
Lysosomes, vesicles produced by the Golgi apparatus, contain hydrolytic digestive enzymes. Sometimes macromolecules are brought into a cell by vesicle formation at the plasma membrane When a lysosome fuses with such a vesicle, its contents are digested by lysosomal enzymes into simpler subunits that then enter the cytoplasm Even parts of a cell are



digested by its own lysosomes (called autodigestion). Auto digestion is also important during development. For example, when a tadpole becomes a frog, lysosomes digest away the cells of the tail. The fingers of a human embryo are at first webbed, but they are freed from one another as a result of lysosomal action occasionally, a child is born with Tay-Sachs disease, a metabolic disorder involving a missing or inactive lysosomal enzyme. In these cases, the lysosomes fill to capacity with macromolecules that cannot be broken down. The cells become so full of these lysosomes that the child dies.

Mitochondria

Most mitochondria (sing., mitochondrion) are between 0.5 µm and 1.0 µm in diameter and about 7 µm in length, although the size and the shape can vary. Mitochondria are bounded by a double membrane.

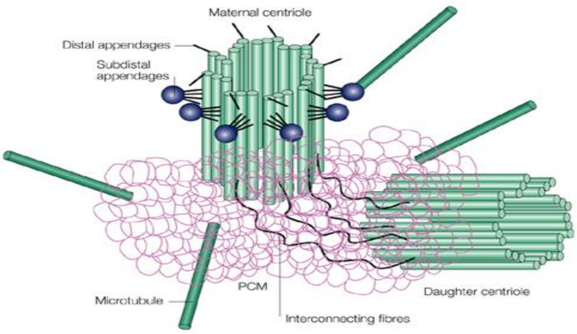


The inner membrane is folded to form little shelves called cristae, which project into the matrix, an inner space filled with a gel like fluid Mitochondria are the site of ATP (adenosine triphosphate) production involving complex metabolic pathways. ATP molecules are the common carrier of energy in cells. The mitochondria convert the chemical energy of glucose products into the chemical energy of ATP molecules. In the process mitochondria use up oxygen and give off carbon dioxide and water mitochondria carry on cellular respiration. The matrix of a mitochondrion contains enzymes for breaking down glucose products, ATP production then occurs. Every cell uses a certain amount of ATP energy to synthesize molecules, but many cells use ATP to carry out their specialized function. For example, muscle cells use ATP for muscle contraction, which produces movement, and nerve cells use it for the conduction of nerve impulses, which make us aware of our environment.

The Cytoskeleton

Several types of filamentous protein structures form a cytoskeleton that helps maintain the cell's shape and either anchors the organelles or assists their movement as appropriate. The cytoskeleton includes microtubules and actin filaments; Microtubules are shaped like thin cylinders and are several times larger than actin filaments. Each cylinder contains 13 rows of tubule, a globular protein, arranged in a helical fashion. Remarkably, microtubules can assemble and disassemble. In many cells, the regulation of microtubule assembly (helping to maintain the shape of the cell and acting as tracks along which organelles move. It is well known that during cell division, microtubules form spindle fibers, which assist the movement of chromosomes actin filaments are long, extremely thin fibers that usually occur in bundles or other groupings. Actin filaments have been isolated from various types of cells, especially those in which movement occurs. Microvilli, which project from certain cells and can shorten and extend, contain actin filaments. Actin filaments, like microtubules, can assemble and disassemble

Centrioles



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There are nine outer microtubule triplets and no center microtubules there is always one pair of centrioles lying at right angles to one another near the nucleus. Before a cell divides, the centrioles duplicate, and the members of the new pair are also at right angles to one another. During cell division, the pairs of centrioles separate so that each daughter cell gets one pair of centrioles. Centrioles are part of a microtubule organizing center that also includes other proteins and substances. Microtubules begin to assemble in the center, and then they grow outward, extending through the entire cytoplasm. In addition, centrioles may be involved in other cellular processes that use microtubules, such as movement of material throughout the cell or formation of the spindle, a structure that distributes the chromosomes to daughter cells during cell division. Their exact role in these processes is uncertain, however. Centrioles also give rise to basal bodies that direct the formation of cilia and flagella.

Functions of the Cytoskeleton:

• Intermediate filaments determine cell shape.
• Microtubules and microfilaments assemble and disassemble, causing cell movement.
• Microtubules and microfilaments move organelles within the cell.
• Microfilaments form centrioles, the spindle that apportions the genetic material during cell division.

The Nucleus

The nucleus, which has a diameter of about 5 μm, is a prominent structure in the eukaryotic cell. The nucleus is of primary importance because it stores genetic information that determines the characteristics of the body's cells and their metabolic functioning. Every cell contains complex copy of genetic information, but each cell type has certain genes, or segments of DNA, turned on, and others turned off. Activated DNA, with RNA acting as an intermediary, specifies the sequence of amino acids during protein synthesis. The proteins of a cell determine its structure and the functions it can perform.

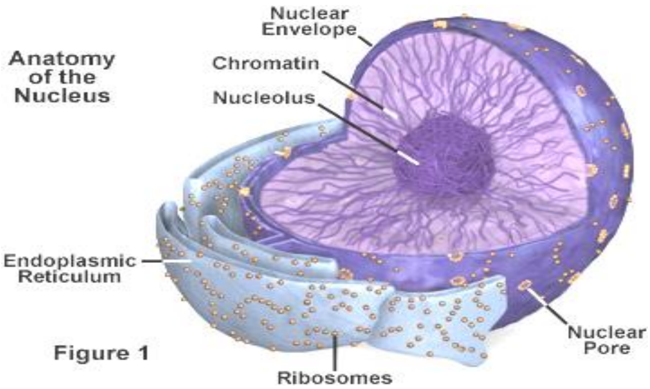


Figure 1

when you look at the nucleus, even in an electron micrograph, you cannot see DNA molecules but you can see chromatin. Chromatin looks grainy, but actually it is a thread like material that undergoes coiling into rod like structures called chromosomes just before the cell divides. Chemical analysis shows that chromatin, and therefore chromosomes, contains DNA and much protein, as well as some RNA. Chromatin is immersed in a semi fluid medium called the nucleoplasm. A difference in pH between the nucleoplasm and the cytoplasm suggests that the nucleoplasm has a most likely; too, when you look at an electron different composition micrograph of a nucleus, you will see one or more regions that look darker than the rest of the chromatin. These are nucleoli (sing., nucleolus) where another type of RNA, called ribosomal RNA (rRNA), is produced and where rRNA joins with proteins to form the subunits of ribosomes. (Ribosomes are small bodies in the cytoplasm that contain rRNA and proteins.)

The nucleus is separated from the cytoplasm by a double membrane known as the nuclear envelope, which is continuous with the endoplasmic reticulum discussed on the next page. The nuclear envelope has nuclear pores of sufficient size (100 nm) to permit the passage of proteins into the nucleus and ribosomal subunits out of the nucleus.

Cell division

Cell life cycle

- Cells have two major periods

  Interphase (Cell grows, Cell carries on metabolic processes)

- Cell division (Cell replicates itself, to produce more cells for growth and repair processes)

DNA Replication

- Genetic material duplicated and readies a cell for division into two cells
  - Occurs toward the end of interphase
  - DNA uncoils and each side serves as a template

MITOSIS

- A multicellular organism grows by repeated cell divisions

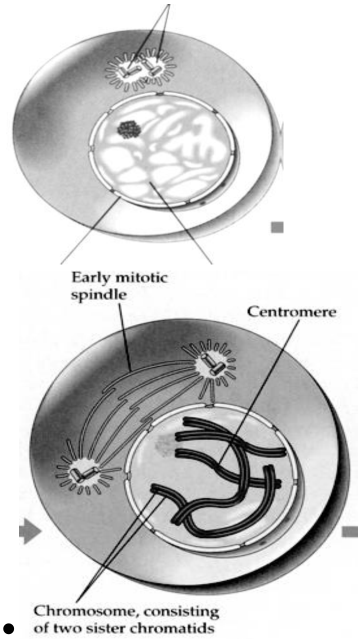
• These occur using the process of mitosis

• Each cell receives an identical set of chromosomes

• Almost any change in chromosome number is lethal there are a few exceptions, one is Down, syndrome where individuals have an extra chromosome 21

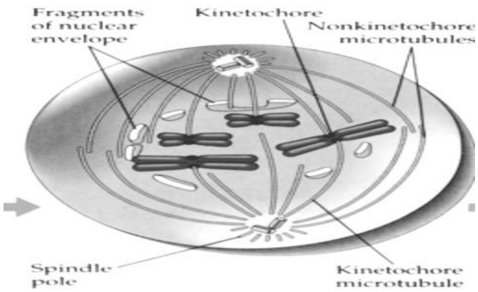
• In humans, each cell contains 23 pairs of chromosomes 23 paternal chromosomes 23 maternal chromosomes (the total46 chromosomes) interphase

• DNA has been replicated but chromosomes not yet visible.



Prophase

- Chromosomes condense and thicken
- Each duplicated chromosome appears as two identical sister chromatids
- The mitotic spindle begins to form

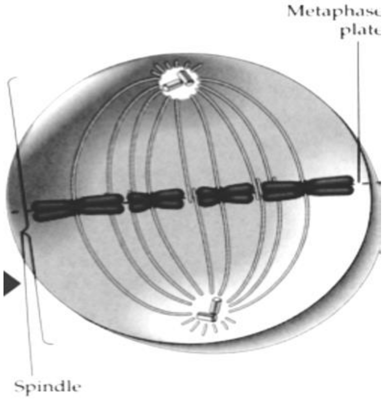


Prometaphase

• The nuclear envelope fragments

• The spindle fibres become attached tothe centre of each chromosome
= kinetochore

Metaphase



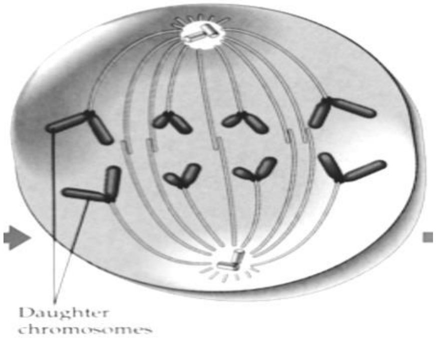
• The chromosomes assemble at the equator = metaphase plate

Anaphase

• The spindle fibers begin to contract

• This starts to pull the sister chromatid separate

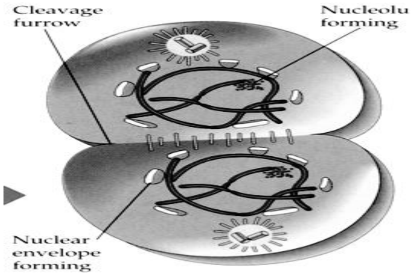
• At the end of anaphase, a complete set of daughter chromosomes is found each pole.



Telophase and Cytokinesis

• Nuclear envelopes begin to form around each set of daughter chromosomes

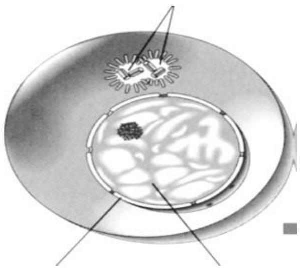
• A cleavage furrow divides the cytoplasm in two = cytokinesis



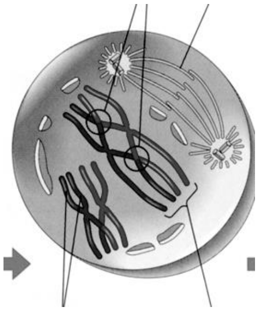
• Mitosis cannot be the only type of cell division!
• If it were, the chromosome number would double in each generation
Parents 46 + 46
F1 Offspring 92
Next generation 92 + 92=184
Remember changes in chromosome number are usually lethal!

The solution: a reduction division called meiosis that halves the number of chromosomes in gametes (i.e. in sperm and eggs)
Female (46) Male (46) (Diploid) meiosis egg + sperm
(23) (23) (Haploid) 46 (Diploid)

MEIOSIS I



Interphase I
• Each chromosome replicates
• The result is two genetically identical sister chromatids

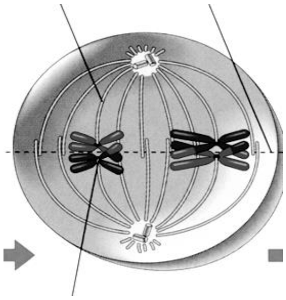


Prophase I (Crossing-over recombination)

• Homologous chromosomes (each consisting of two sister chromatids) come together as pairs

• The structure formed is called a tetrad

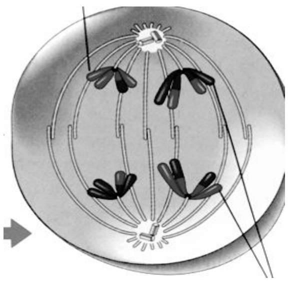
• Chromosome segments are swapped between non-sister chromatids at cross-over points called chiasmata (= crossing-over) called chiasmata (= crossing-over)



Metaphase I

• Chromosomes align on the metaphase plate

• Chromosomes still arranged as: pairs of homologues



Anaphase I

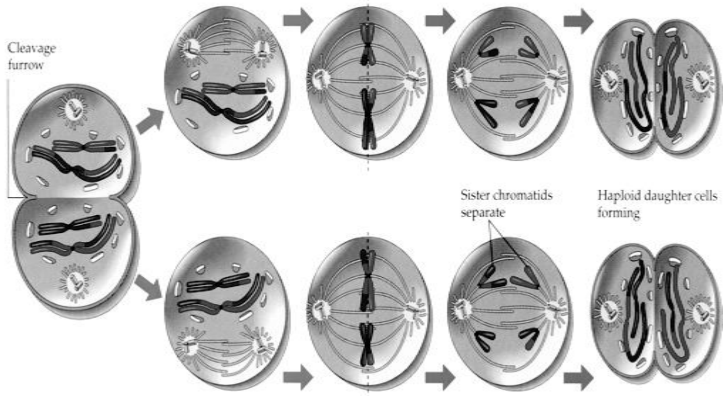
• Sister chromatids remain attached

• But homologous chromosomes move apart to opposite poles

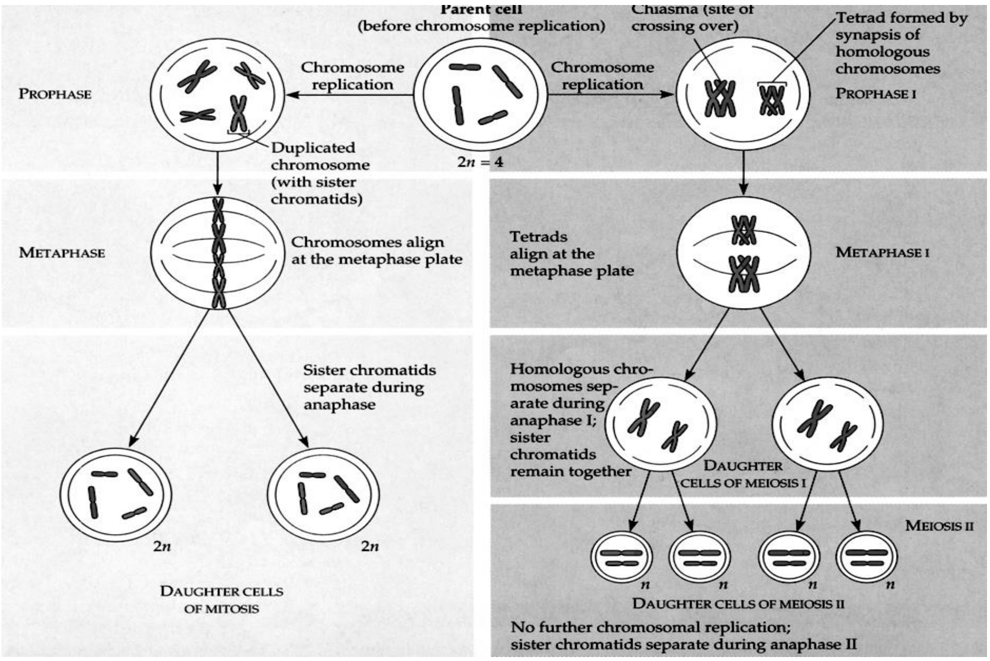
MEIOSIS II –

separation of sister chromatids

Telophase I Prophase II Metaphase II Anaphase II Telophase II

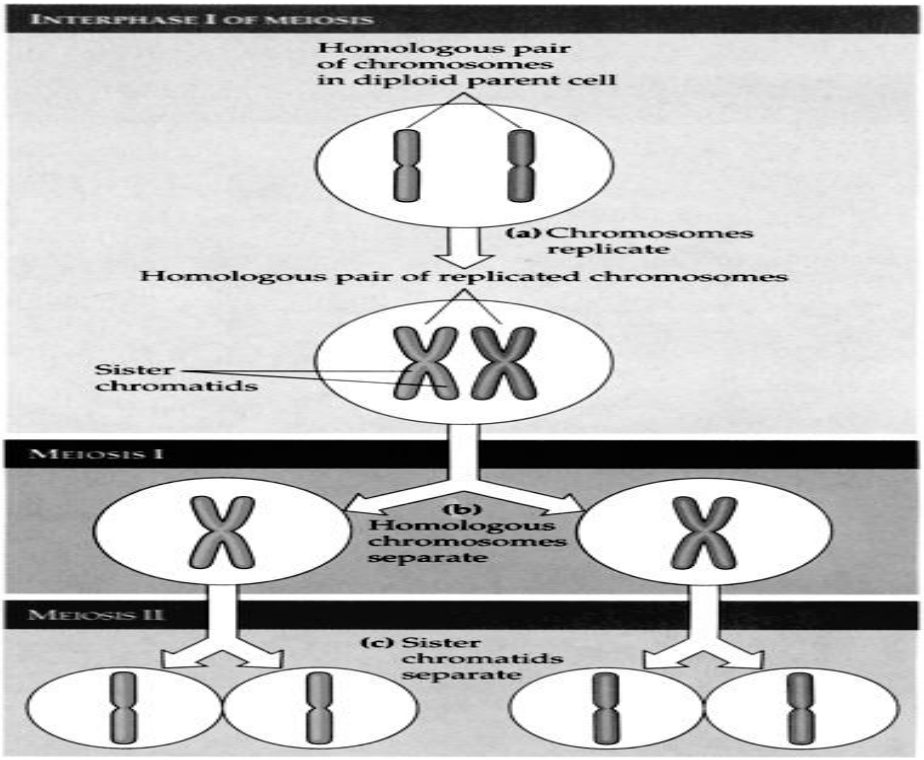


MITOSIS **MEIOSIS**

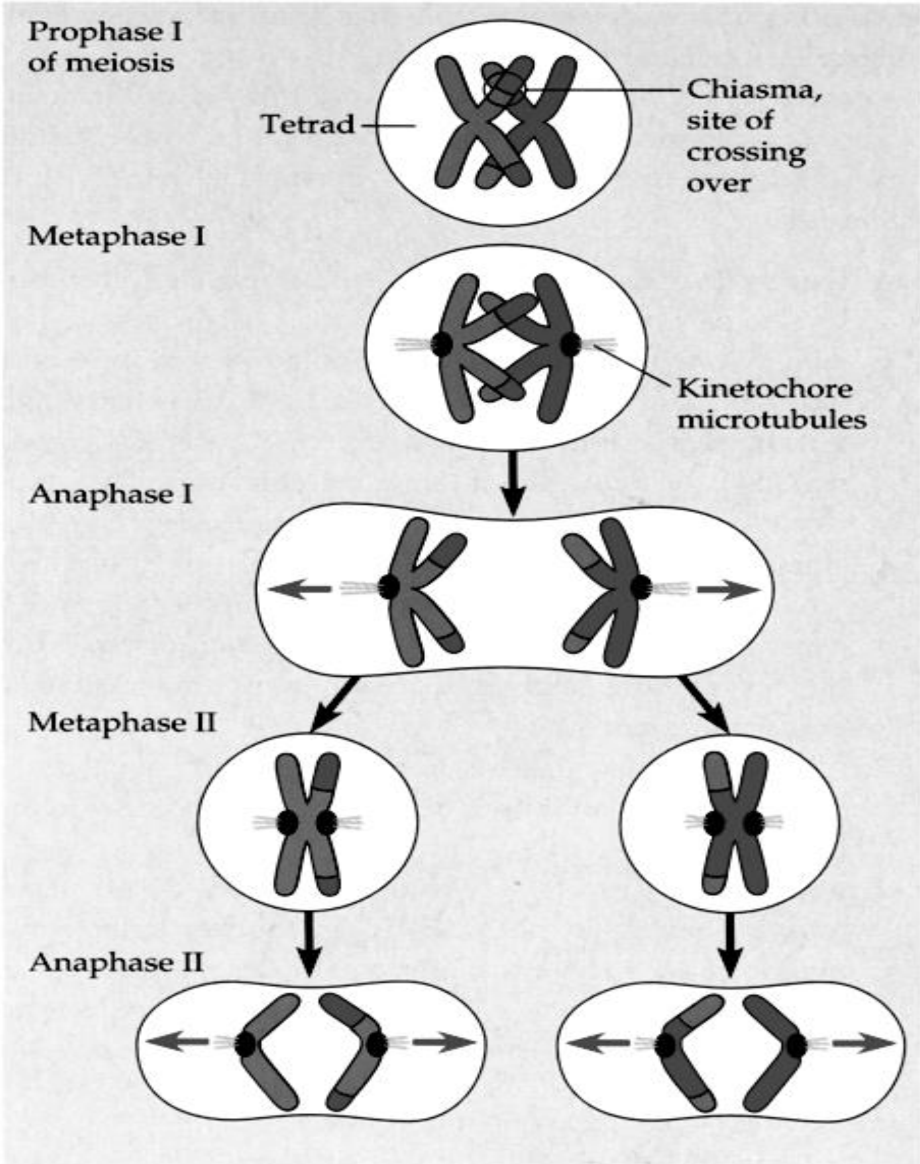


Meiosis: how the chromosome set is halved

A diploid cell
One pair of homologous chromosomes
Replication of each chromosome two sister chromatids
Meiosis I
Each cell receives only one of the homologues
Meiosis II
Each cell receives only one sister chromatid



The consequences of crossing over: recombination



Test Yourself

1-compare between the mitotic and meiosis divisions.
2. Red blood cells placed in a 5% salt solution would:
Swell/stay the same/shrink?

3. Red blood cells placed in a 0.9% solution of salt would be in a: hypotonic/isotonic/hypertonic solution?

4. White blood cells remove foreign bodies like bacteria from the body by engulfing them.

This process is known as ……………………………

5. Match the organelle in the left-hand column of the table below with its function in the right-hand column.

Organelle	**Function**
a. Nucleus	**1. Modifies proteins and fats**
b. Mitochondrion	**2. Makes, modifies and stores proteins**
c. Golgi body	**3. Digests worn out organelles**
d-. Rough endoplasmic reticulum	**4. Makes fats**
e. Lysosome	**5. Controls the activity of the cell proteins**
f. Smooth endoplasmic reticulum	**6. Produces energy**

6. The cell division that causes an organism to grow and repairs tissues is called……...

7. The cell division that produces sperm and ova is called……

8. TWO important differences between the two types of cell division named by you above are:

a.

b.

CHAPTER 2

BODY TISSUES

Living organisms are made from cells which are organized into tissues and these are themselves combined to form organs and systems. Skin cells, muscle cells, skeleton cells and nerve cells, for example. These different types of cells are not just scattered around randomly but similar cells that perform the same function are arranged in groups. These collections of similar cells are known as tissues.

There are four main types of tissues in animals. These are:

Epithelium tissues, Connective tissues, Muscle tissues and Nervous tissue.

I. EPITHELIUM

Functions (jobs):

1) It protects us from the outside world – skin.

2) Absorbs – stomach and intestinal lining (gut)

3) Filters – the kidney

4) Secretes – forms glands

Characteristics (Traits):

1) Closely attached to each other forming a protective barrier.

2) Always has one free (apical) surface opened to outside the body or inside (cavity) an internal organ.

3) Always had one fixed (basal) section attached to underlying connective tissue.

4) Has no blood vessels but can soak up nutrients from blood vessels in connective tissue underneath.

5) Can have lots of nerves in it (innervated).

6) Very good at regenerating (fixing itself). i.e. sunburn, skinned knee.

Classification of Epithelium

• Classified by arrangement of cells into layers

– simple = one cell layer thick

– stratified = two or more cell layers thick

– pseudostratified = cells contact BM but all cells don't reach apical surface

• nuclei are located at multiple levels so it looks multilayered

• Classified by shape of surface cells

– squamous = flat

– cuboidal = cube-shaped

– columnar = tall column

– transitional = shape varies with tissue stretching

Types of Epithelium

• Covering and lining epithelium

– Epidermis of skin

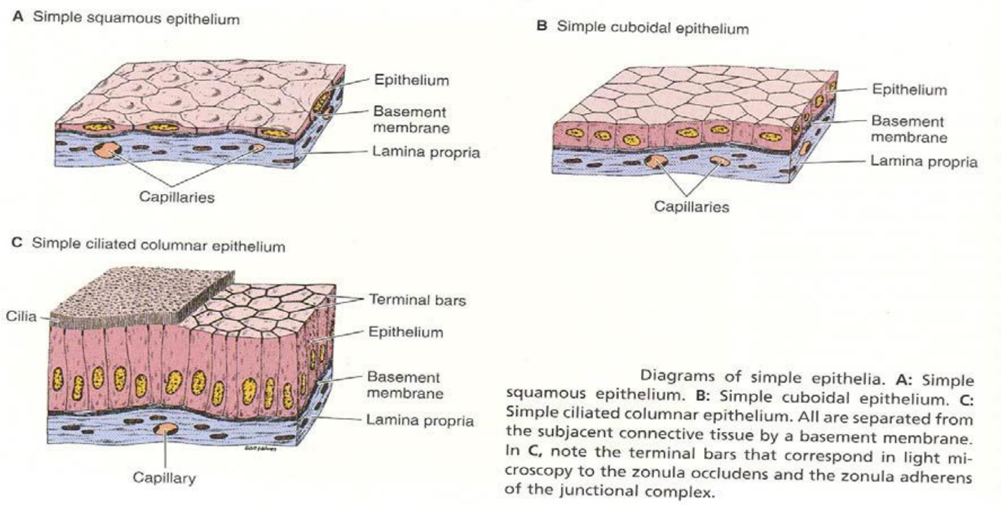
– lining of blood vessels and ducts

– lining respiratory, reproductive, urinary & GI tract

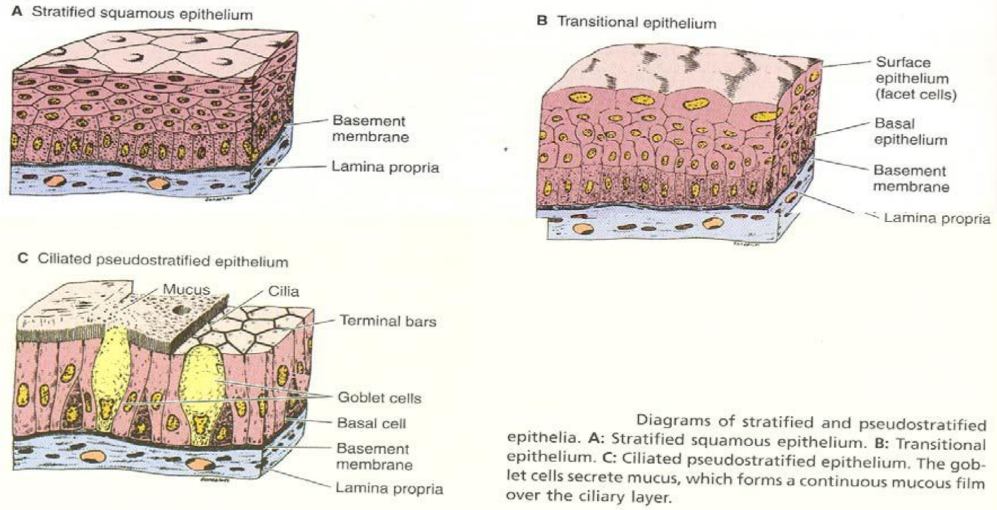
• Glandular epithelium

– secreting portion of glands

– Thyroid, adrenal, and sweat glands



Diagrams of simple epithelia. **A:** Simple squamous epithelium. **B:** Simple cuboidal epithelium. **C:** Simple ciliated columnar epithelium. All are separated from the subjacent connective tissue by a basement membrane. In **C,** note the terminal bars that correspond in light microscopy to the zonula occludens and the zonula adherens of the junctional complex.



Diagrams of stratified and pseudostratified epithelia. **A:** Stratified squamous epithelium. **B:** Transitional epithelium. **C:** Ciliated pseudostratified epithelium. The goblet cells secrete mucus, which forms a continuous mucous film over the ciliary layer.

Simple Squamous Epithelium

• Single layer of flat cells

– very thin --- controls diffusion, osmosis and filtration

• found in lungs and kidneys

• blood vessel lining (endothelium) and lining of body cavities (mesothelium)

– nuclei are centrally located

– cells are in direct contact with each other

Simple Cuboidal Epithelium

• Single layer of cube-shaped cells viewed from the side

– nuclei are round and centrally located

– lines tubes of kidney

– adapted for absorption or secretion

Simple Columnar Epithelium

• Consists of a single layer of column-like cells and can exist in two forms

– Non-ciliated *simple columnar epithelium* contains microvilli

• increase surface area and the rate of secretion and absorption

– Ciliated simple columnar epithelium contains cells with hair-like processes called cilia

• provides motility and helps to move fluids or particles along a surface

Pseudostratified Columnar Epithelium

• Appears to have several layers because the nuclei are at various levels.

• All cells are attached to the basement membrane but some do not reach the apical surface.

• Found in respiratory system, male urethra & epidermis

Stratified Epithelium

• Epithelia have at least two layers of cells

– more durable and protective

– name depends on the shape of the **surface** (apical) cells

• Stratified squamous epithelium consists of several layers of

– top layer of cells is flat

– deeper layers of cells vary cuboidal to columnar

– basal cells replicate by mitosis

• **Keratinized stratified squamous epithelium**

– a tough layer of keratin (a protein resistant to friction and repels bacteria) is deposited in the surface cells.

• **Nonkeratinized epithelium remains moist**

Stratified Epithelium

• Stratified cuboidal epithelium

– rare tissue consisting of two or more layers of cube shaped cells whose function is mainly protective

• **Stratified columnar epithelium**

– consists of layers of cells

– top layer is columnar

– somewhat rare

– adapted for protection and secretion

• **Transitional epithelium**

– consists of several layers of variable shape

– capable of stretching / permits distention of an organ

– lines the urinary bladder

– lines portions of the ureters and the urethra

Transitional Epithelium•

Multilayered

– surface cells varying in shape

• round to flat (if stretched)

– lines hollow organs that expand from within (urinary bladder)

Glandular Epithelium

Gland:

– A single cell or a mass of epithelial cells adapted for secretion

• Exocrine glands

– Cells that secrete---sweat, ear wax, saliva, digestive enzymes onto free surface of epithelial layer

– connected to the surface by tubes (ducts)

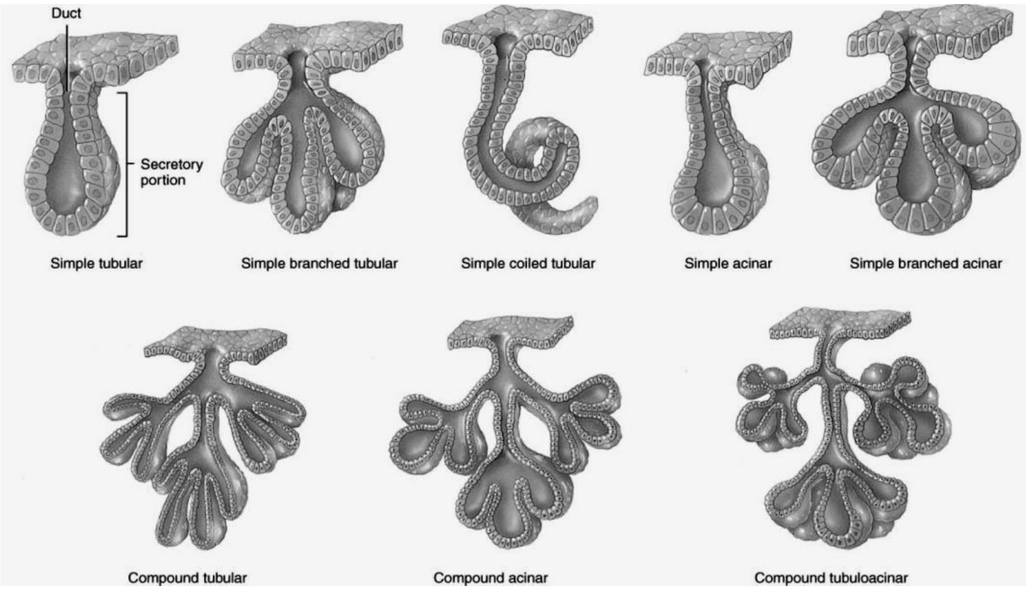
– unicellular glands (goblet cells) or multicellular glands

• Endocrine glands

– secrete hormones into the bloodstream

– Ductless

– Hormones help maintain homeostasis



Structural Classification of Exocrine Glands

• Unicellular (single-celled) glands

– goblet cells

• Multicellular glands

– branched (compound) or unbranched (simple)

– tubular or acinar (flask-like) shape

Exocrine Glands – Functional

II. CONNECTIVE TISSUE

Functions (jobs):

1) Wraps around and cushions and protects organs

2) Stores nutrients

3) Internal support for organs

4) As tendon and ligaments protects joints and attached muscles to bone and each other

5) Runs through organ capsules and in deep layers of skin giving strength

The 3 Elements of Connective Tissue:

1) Ground substance – gel around cells and fibers

2) Fibers – provide strength, elasticity and support

3) Cells

2 Kinds of Connective Tissue:

1) Loose Connective Tissue:

a) Areolar Connective Tissue – cushion around organs, loose arrangement of cells and fibers.

b) Adipose Tissue – storehouse for nutrients, packed with cells and blood vessels

c) Reticular Connective Tissue internal supporting framework of some organs, delicate network of fibers and cells

2) Dense Connective Tissue:

a) Dense Regular Connective Tissue – tendons and ligaments, regularly arranged bundles packed with fibers running same way for strength in one direction.

b) Dense Irregular Connective Tissue – skin, organ capsules, irregularly arranged bundles packed with fibers for strength in all directions.

II a. SPECIAL CONNECTIVE TISSUES

<u>1) Cartilage</u>

Functions (jobs):

1) provides strength with flexibility while resisting wear, i.e. epiglottis, external ear, larynx

2) cushions and shock absorb where bones meet, i.e. intervertebral discs, joint capsules

2) Bone

<u>Functions (jobs):</u>

1) provides framework and strength for body

2) allows movement

3) stores calcium

4) contains blood-forming cells

3) Blood

<u>Functions (jobs):</u>

1) transports oxygen, carbon dioxide, and nutrients around the body

2) immune response

III. NERVOUS TISSUE

Functions (jobs):

1) Conducts impulses to and from body organs via neurons

The 3 Elements of Nervous Tissue

1) Brain

2) Spinal cord

3) Nerves

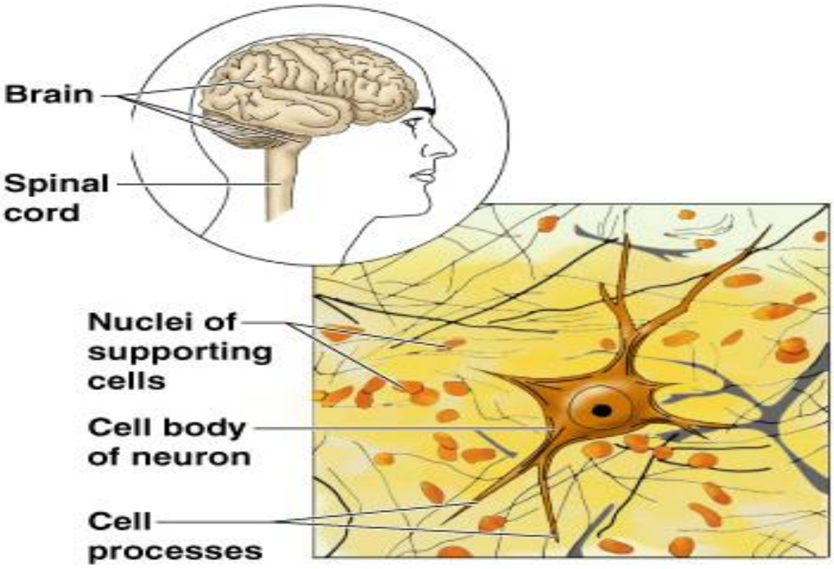


Diagram: Nervous tissue

IV. MUSCLE TISSUE

Functions (jobs):

1) Responsible for body movement

2) Moves blood, food, waste through body's organs

3) Responsible for mechanical digestion

The 3 Types of Muscle Tissue

4) Smooth Muscle – organ walls and blood vessel walls, involuntary, spindle-shaped cells for pushing things through organs

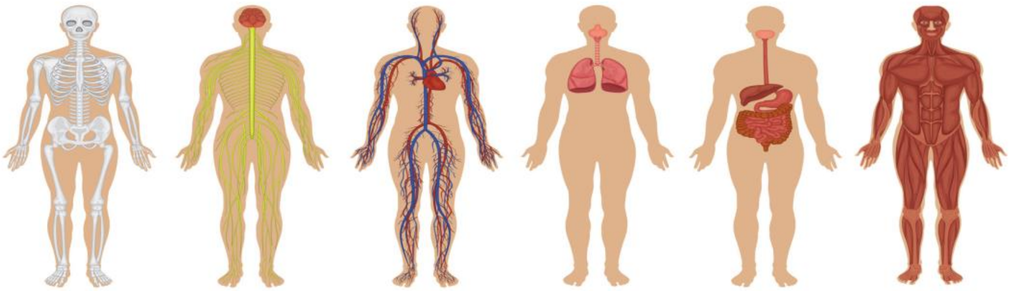
5) Skeletal Muscle – large body muscles, voluntary, striated muscle packed in bundles and attached to bones for movement

6) Cardiac Muscle – heart wall, involuntary, striated muscle with intercalated discs connecting cells for synchronized contractions during heartbeat.

CHAPTER 3
Organs and Organ Systems

Organs and Organ Systems

Your body is an amazing machine! Tissues are organized into organs and organs are organized into organ systems.



Systems are made up of individual parts that work together and are usually connected to one or more other systems. If one part of the system is damaged, the system will not function well or may not function at all. These characteristics are true of systems in the human body. The human body is a complex system of interdependent parts that work together—understanding how these parts work helps us to understand the whole system.

Cell Organization

In a multicellular organism, such as humans, cells are specialized and organized to work together. Groups of similar **cells** that have a common function form a **tissue**. Tissue cells are often stuck together with fibers or other sticky material.

Groups of tissues having a common function are organized into **organs**. Many organs are made up of several different types of tissues. Some examples of organs in your body include the heart, lungs, kidney, liver, skin, eye, brain, and ears. Some examples of organs in plants are the roots, stems leaves, stamens, and ovaries.

Groups of organs having a common function form an **organ system**. The human body is made up of many systems 12 major systems including:

Digestive system

Respiratory system

Cardiovascular system

Lymphatic and immune systems

Excretory system

Endocrine system

Reproductive system

Nervous system

Muscular system

Skeletal system

MUSCULAR SYSTEM

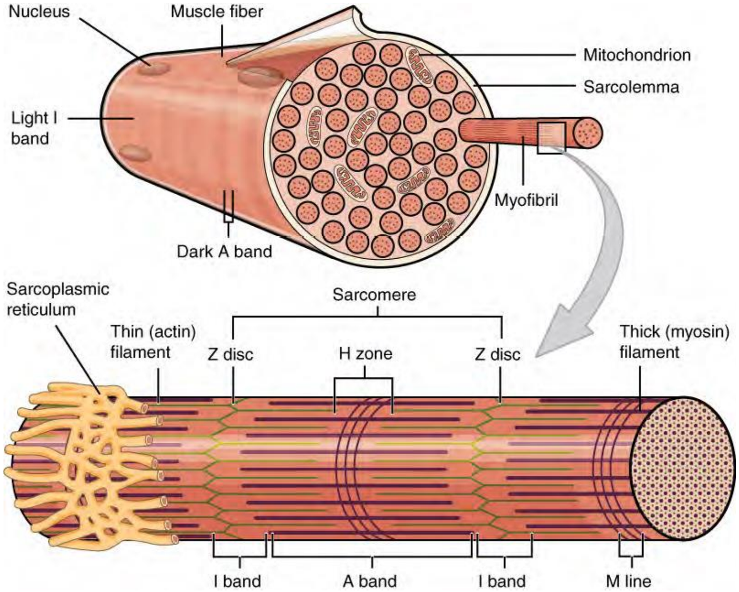
Muscle is one of the four primary tissue types of the body, and the body contains three types of muscle tissue: skeletal muscle, cardiac muscle, and smooth muscle. All three muscle tissues have some properties in common; they all exhibit a quality called **excitability** as their plasma membranes can change their electrical states (from polarized to depolarized) and send an electrical wave called an action potential along the entire length of the membrane. While the nervous system can influence the excitability of cardiac and smooth muscle to some degree, skeletal muscle completely depends on signaling from the nervous system to work properly. On the other hand, both cardiac muscle and smooth muscle can respond to other stimuli, such as hormones and local stimuli.

The muscles all begin the actual process of contracting (shortening) when a protein called actin is pulled by a protein called myosin. This occurs in striated muscle (skeletal and cardiac) after specific binding sites on the actin have been exposed in response to the interaction between calcium ions (Ca++) and proteins (troponin and tropomyosin) that "shield" the actin-binding sites. Ca++ also is required for the contraction of smooth muscle, although its role is different: here Ca++activates enzymes, which in turn activate myosin heads. All muscles require adenosine triphosphate (ATP) to continue the process of contracting, and they all relax when the Ca++ is removed and the actin-binding sites are re-shielded.

A muscle can return to its original length when relaxed due to a quality of muscle tissue called **elasticity**. It can recoil back to its original length due to elastic fibers. Muscle tissue also has the quality of **extensibility**; it can stretch or extend. **Contractility** allows muscle tissue to pull on its attachment points and shorten with force. Differences among the three muscle types include the microscopic organization of their contractile proteins—actin and myosin. The actin and myosin proteins are arranged very regularly in the cytoplasm of individual muscle cells (referred to as fibers) in both skeletal muscle and cardiac muscle, which creates a pattern, or stripes, called striations. The striations are visible with a light microscope under high magnification. **Skeletal muscle** fibers are multinucleated structures that compose the skeletal muscle. **Cardiac muscle** fibers each have one to two nuclei and are physically and electrically connected to each other so that the entire heart contracts as one unit (called a syncytium). Because the actin and myosin are not arranged in such regular fashion in **smooth muscle**, the cytoplasm of a smooth muscle fiber (which has only a single nucleus) has a uniform, nonstriated appearance (resulting in the name smooth muscle). However, the less organized appearance of smooth muscle should not be interpreted as less efficient. Smooth muscle in the walls of arteries is a critical component that regulates blood pressure necessary to push blood through the circulatory system; and smooth muscle in the skin, visceral organs, and internal passageways is essential for moving all materials through the body.

Skeletal Muscle Fibers

Because skeletal muscle cells are long and cylindrical, they are commonly referred to as muscle fibers. Skeletal muscle fibers can be quite large for human cells, with diameters up to 100 μm and lengths up to 30 cm (11.8 in) in the Sartorius of the upper leg. During early development, embryonic myoblasts, each with its own nucleus, fuse with up to hundreds of other myoblasts to form the multinucleated skeletal muscle fibers. Multiple nuclei mean multiple copies of genes, permitting the production of the large amounts of proteins and enzymes needed for muscle contraction. Some other terminology associated with muscle fibers is rooted in the Greek *sarco*, which means "flesh." The plasma membrane of muscle fibers is called the **sarcolemma**, the cytoplasm is referred to as **sarcoplasm**, and the specialized smooth endoplasmic reticulum, which stores, releases, and retrieves calcium ions (Ca++) is called the **sarcoplasm.** As will soon be described, the functional unit of a skeletal muscle fiber is the sarcomere, a highly organized arrangement of the contractile myofilaments actin (thin filament) and myosin (thick filament), along with other support proteins.

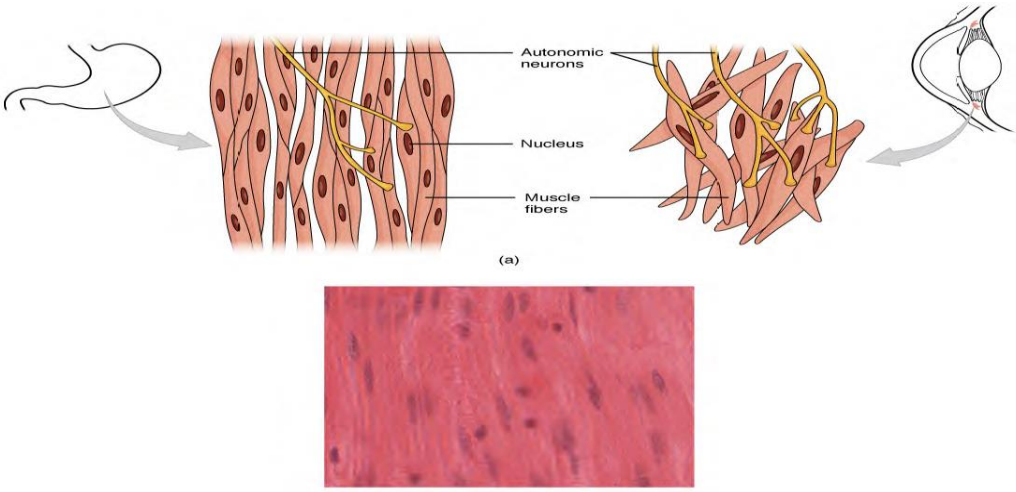


Cardiac Muscle Tissue

Cardiac muscle is only found in the heart. Highly coordinated contractions of cardiac muscle pump blood into the vessels of the circulatory system. Similar to skeletal muscle, cardiac muscle is striated and organized into sarcomeres, possessing the same banding organization as skeletal muscle. However, cardiac muscle fibers are shorter than skeletal muscle fibers and usually contain only one nucleus, which is located in the central region of the cell. Cardiac muscle fibers also possess many mitochondria and myoglobin, as ATP is produced primarily through aerobic metabolism. Cardiac muscle fibers cells also are extensively branched and are connected to one another at their ends by intercalated discs. An **intercalated disc** allows the cardiac muscle cells to contract in a wave-like pattern so that the heart can work as a pump

Smooth Muscle

smooth muscle (so-named because the cells do not have striations) is present in the walls of hollow organs like the urinary bladder, uterus, stomach, intestines, and in the walls of passageways, such as the arteries and veins of the circulatory system, and the tracts of the respiratory, urinary, and reproductive systems. Smooth muscle is also present in the eyes, where it functions to change the size of the iris and alter the shape of the lens; and in the skin where it causes hair to stand erect in response to cold temperature or fear.



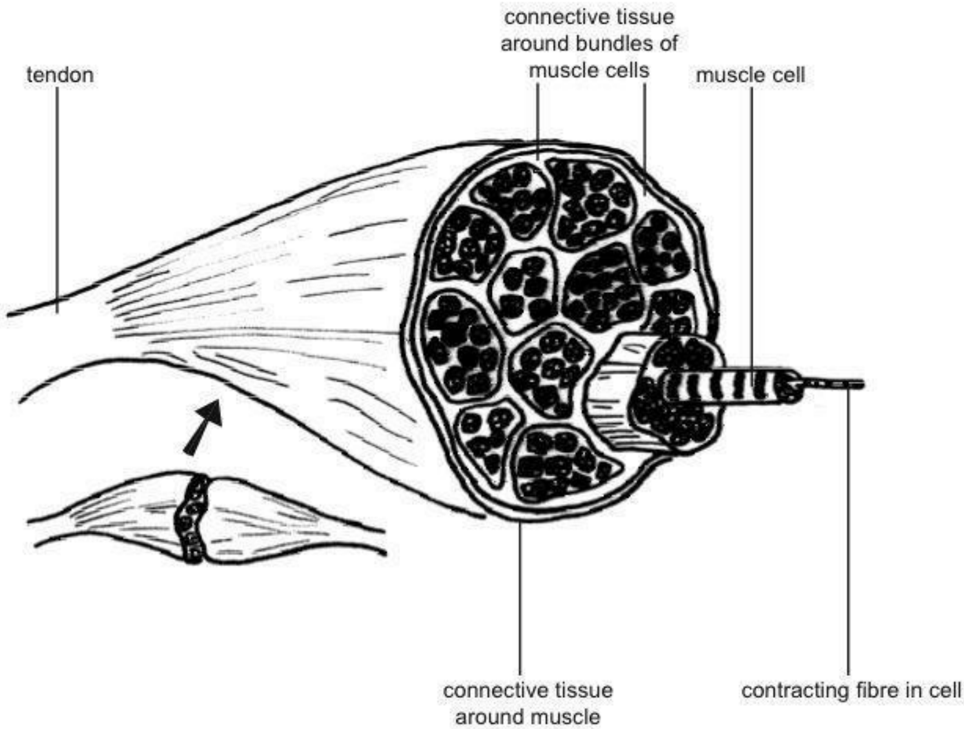
(b)

Smooth muscle fibers are spindle-shaped (wide in the middle and tapered at both ends, somewhat like a football) and have a single nucleus; they range from about 30 to 200 μm (thousands of times shorter than skeletal muscle fibers), and they produce their own connective tissue, endomysium. Although they do not have striations and sarcomeres, smooth muscle fibers do have actin and myosin contractile proteins, and thick and thin filaments. These thin filaments are anchored by dense bodies. A **dense body** is analogous to the Z-discs of skeletal and cardiac muscle fibers and is fastened to the sarcolemma. Calcium ions are supplied by the SR in the fibers and by sequestration from the extracellular fluid through membrane indentations called alveoli.

Muscle contraction

Muscle contraction requires energy and muscle cells have numerous mitochondria. However, only about 15% of the energy released by the mitochondria is used to fuel muscle contraction.
The rest is released as heat. This is why exercise increases body temperature and makes animals sweat or pant to rid them of this heat.

What we refer to as a muscle is made up of groups of muscle fibers surrounded by connective tissue. The connective tissue sheaths join together at the ends of the muscle to form tough white bands of fiber called tendons. These attach the muscles to the bones. Tendons are similar in structure to the ligaments that attach bones together across a joint (see figure below)

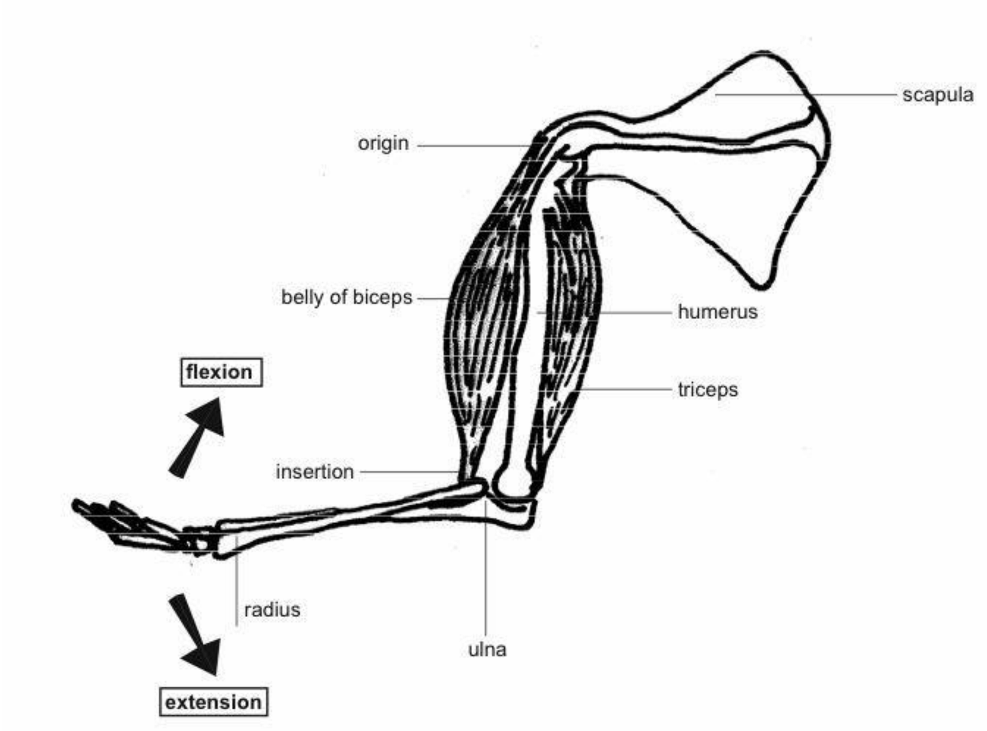


Tendons Tie muscles to bones and Ligaments Link bones at joints

Structure of a muscle

A single muscle is fat in the middle and tapers towards the ends. The middle part, which gets fatter when the muscle contracts, is called the belly of the muscle. If you contract your biceps muscle in your upper arm you may feel it getting fatter in the middle. You may also notice that the biceps is attached at its top end to bones in your shoulder while at the bottom it is attached to bones in your lower arm. Notice that the bones at only one end move when you contract the biceps. This end of the muscle is called the insertion.

The other end of the muscle, the origin , is attached to the bone that moves the least



Antagonistic muscles

Skeletal muscles usually work in pairs. When one contracts the other relaxes and vice versa.

Pairs of muscles that work like this are called antagonistic muscles. For example the muscles in the upper forearm are the biceps and triceps (see diagram 7.3). Together they bend the elbow. When the biceps contracts (and the triceps relaxes) the lower fore arms raised and the angle of the joint is reduced. This kind of movement is called flexion.

When the triceps is contracted (and the biceps relaxes), the angle of the elbow increases.

The term for this movement is extension.

When you or animals contract skeletal muscle it is a voluntary action. For example, you make a conscious decision to walk across the room, raise the spoon to your mouth or smile.

There is however, another way in which contraction of muscles attached to the skeleton happens that is not under voluntary control. This is during a reflex action, such as jerking your hand away from the hot stove you have touched by accident. This is called are flex arc and will be described in detail in nervous system

Test Yourself

1. What kind of muscle tissue:

a) moves bones:

b) makes the heart pump blood:

c) pushes food along the intestine:

d) makes your mouth form a smile:

e) makes the hair stand up when cold:

f) makes the diaphragm contract for breathing in:

2. What structure connects a muscle to a bone?

3. What is the insertion of a muscle?

4. Which muscle is antagonistic to the biceps?

5. Name 3 other antagonistic pairs and tell what they do.

6. When you bend your knee what movement are you making?

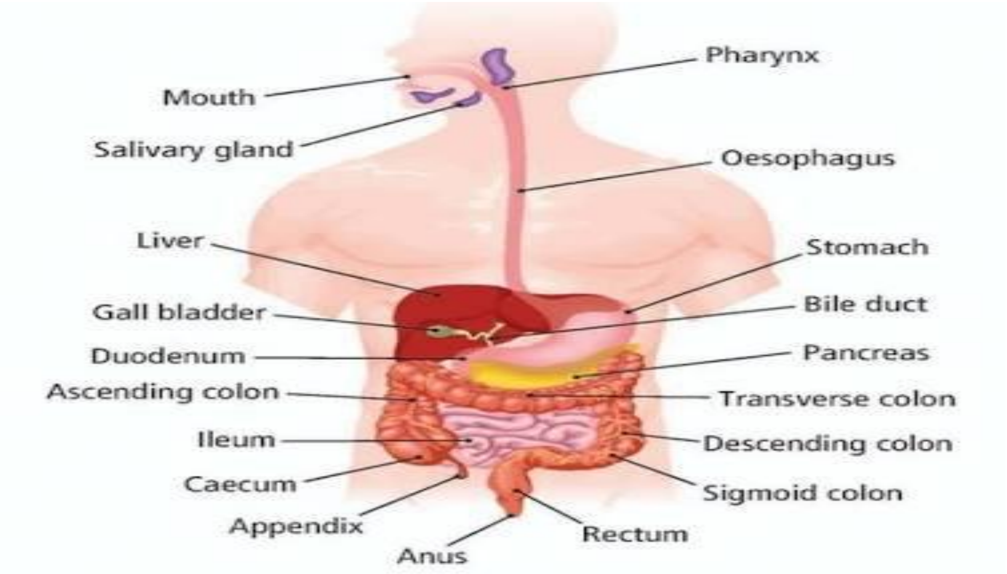
7. When you straighten your ankle joint what movement happens?

8. What organelles provide the energy that muscles need?

9. State the difference between a tendon and a ligament.

The digestive system

Every cell in our body does work. Work requires energy, which is supplied by the food we eat. Food also supplies the small molecules that are the building blocks for cell maintenance, growth, and function. Digestion breaks down food into materials the body can use:



Functions of the Digestive System

<u>ingestion</u>– the oral cavity allows food to enter the digestive tract and have mastication (chewing) occurs, and the resulting food bolus is swallowed.

<u>Digestion:</u>

Mechanical digestion – muscular movement of the digestive tract (mainly in the oral cavity and stomach) physically breakdown food into smaller particles. Chemical digestion – hydrolysis reactions aided by enzymes (mainly in the stomach and small intestine) chemically break down food particles into nutrient molecules, small enough to be absorbed

<u>Secretion</u> – enzymes and digestive fluids secreted by the digestive tract and its accessory organs facilitate chemical digestion.

<u>Absorption</u> – passage of the end – products (nutrients) of chemical digestion from the digestive tract into blood or lymph for distribution to tissue cells.

<u>Elimination</u> – undigested material will be released through the rectum and anus by defecation.

Organization of the Digestive System

□□Organs of the digestive system are divided into 2 main group: the **gastrointestinal tract (GI tract)** and **accessory structures.**

□□GI tract is a continuous tube extending through the ventral cavity from the mouth to the anus – it consists of the mouth, oral cavity, or oropharynx, esophagus, stomach, small intestine, large intestine, rectum, and anus.

□□Accessory structures include the teeth, tongue (in oral cavity), salivary glands, liver, gallbladder, and pancreas.

Muscular movement of the GI tract

Peristalsis– wavelike movement that occurs from the oropharynx to the rectum, allowing GI tract to push food particles toward the anus.

Mixing—mixing motion in the oral cavity and stomach that allows the GI tract to repeatedly breakdown food into smaller particles, using mechanical digestion.

Segmentation– regions of the small intestine contracting and relaxing independently, allowing the small intestine to digestive and absorb more efficiently.

Mouth & Oral Cavity

Food enters the GI tract by ingestion.

Food is broken down by mechanical digestion, using mastication

One chemical digestive process occur where **amylase** enzyme in saliva breaks down polysaccharide into disaccharides.

The **tongue**, made of skeletal muscle, manipulates the food during mastication. it also contains taste buds to detect taste sensations(intrinsic).

Food particles are mixed with saliva during mastication, resulting in a moist lump called **bolus** for easier passage into or pharynx.

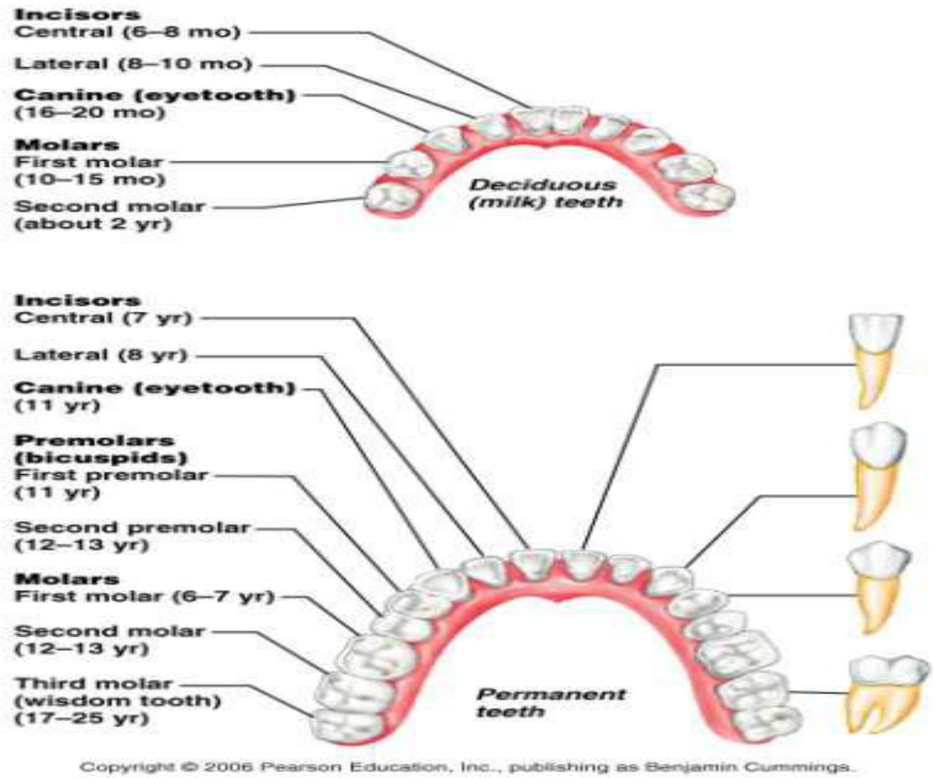
Teeth

□□Adapted for **mechanical digestion** (mastication) in the oral cavity.

□20 deciduous or primary teeth before the age of 6.

□□By age 7, 32 permanent or secondary teeth are developed & are divided into4 types: **incisors** (for cutting), **Canines** (for tearing),

Premolars (for crushing), and **Molars** (for grinding). these teeth follow the human dental formula of 2-1-2-3.

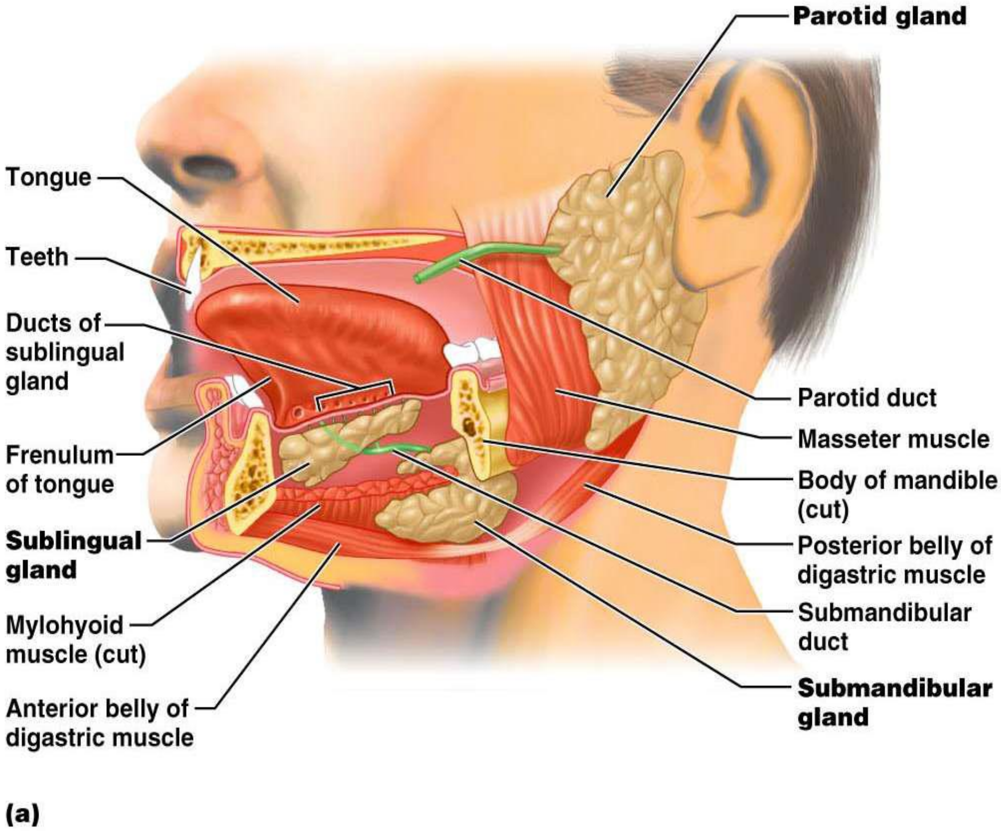


Salivary Glands

3 pairs of salivary glands called parotid, sub mandibular, and sublingual gland secrete most of the saliva in the oral cavity, using salivary ducts.

Saliva helps moisten the food during mastication, dissolve the food in forming the bolus, and help cleanse the teeth.

Saliva consists of 99.5% water, the remaining 0.5% is dissolved substances including amylase enzyme (for chemically digesting carbohydrate), bicarbonate ion (HCO3-; maintains pH of saliva at 6.5-7.5), and many electrolytes.

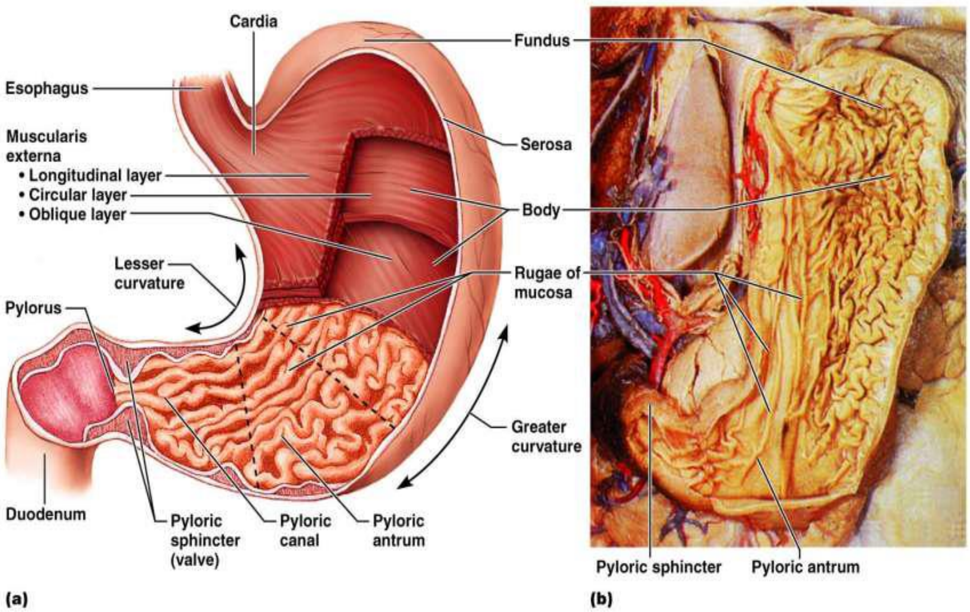


Stomach

A pouch-like organ primarily designed for food storage (for 2-4hours), some mechanical and chemical digestion also occur. Contains two sphincters at both ends to regulate food movement – **cardiac sphincter** near the esophagus, and **pyloric sphincter** near the small intestine.

Divided into 4 regions: **cardiac stomach** (or cardiac), **fundic stomach** (or funded), **body of stomach**, and **pyloric stomach** (or Pylorus).

Contain thick folds called **ruga e**at its layer, for providing larger surface area for expansion, secretion, digestion, and some absorption.



Gastric Secretory Cells

-Chief cells: secrete pepsinogen (an inactive enzyme).

-Parietal cells: secrete hydrochloric and (HCl) and

"intrinsic factor" (which helps absorption of vitaminB12 in the intestines).

- **Mucous cells:** secrete mucus and alkaline substances to help neutralize HCl in the gastric juice.

-G cells: secrete a hormone called gastrin, which stimulates the parietal cells and overall gastric secretion.

Chemical digestion & absorption in the stomach

- Carbohydrate digestion is continued with gastric amylase, resulting in disaccharides.

- Protein digestion begins with pepsin (activation of pepsinogen by HCl), resulting in peptides (small chains of protein).

- Lipid digestion begins with gastric lipases which can only break down certain lipids such as butter fat, resulting in fatty acids.

-Absorption in the stomach is limited, where only small and fat-soluble substances can be absorbed—water, alcohol, aspirin, and certain drugs.

-The result of all these mixing, chemical digestion, secretion, and absorption is a yellowish paste called chyme, which will be passed on to the small intestine.

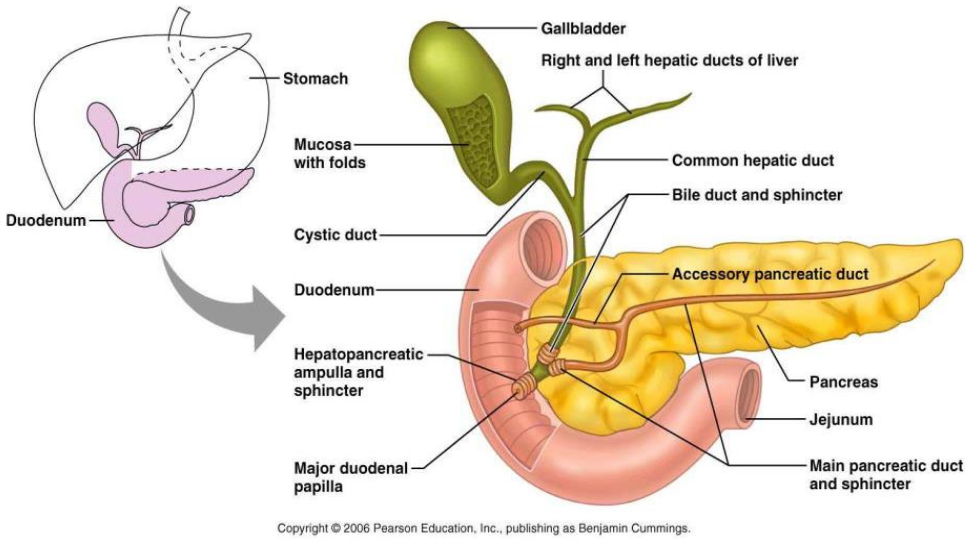
Pancreas

Pancreas: most pancreatic enzymes are produced as inactivate molecules, or zymogens, so that the risk of self – digestion within the pancreas is minimized.

- More than 98% of the pancreas mass is devoted to its exocrine function: the secretion of pancreatic juice by the pancreatic acini and their ductile cells. Ductile cells produce Sodium bicarbonate which helps neutralize the acidic gastric contents.

Acinar cells of the exocrine pancreas produce a variety of digestive enzymes to break down food substances into smaller absorbable molecules.

Only 2% of pancreas mass is devoted to the islets of Langerhans, which produce insulin and glucagon, hormones that regulate blood sugar and carbohydrate metabolism (they have opposite effects).



Major pancreatic Enzymes

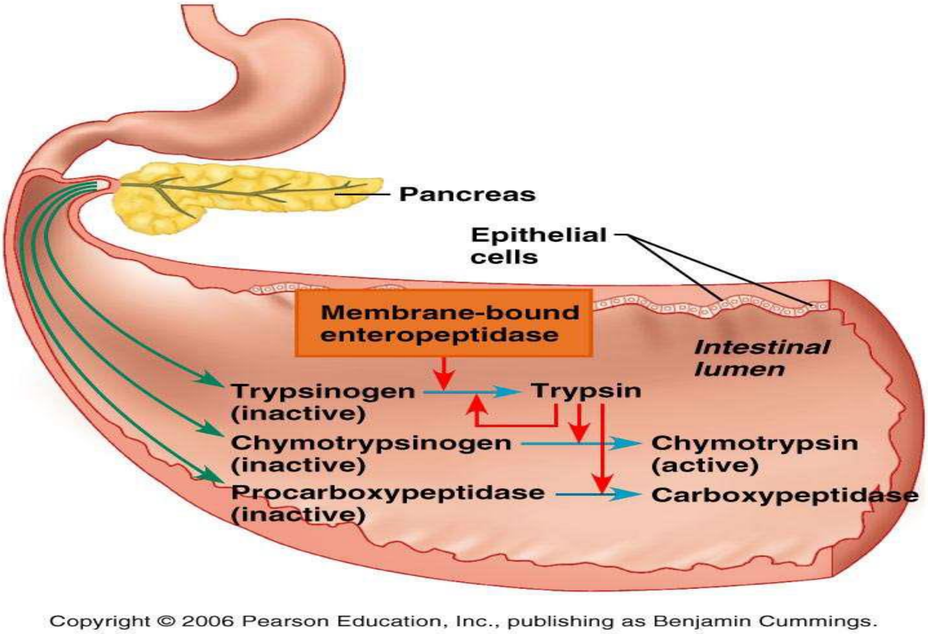
-pancreatic amylase: digest polysaccharides into disaccharides

- **pancreatic lipases** digest triglycerides into fatty acids.

- **pancreatic nucleases** digest nucleic acids into nucleotides.

-Pancreatic proteinases (all secreted in their inactive forms) digest peptides into amino acids:

Trypsinogen is activated by enterokinase (secreted by duodenum) into **trypsin**, which in turn activates the other 3 enzymes – **chymo trypsinogen** becomes **chymotrypisn**, **proamino peptidase** becomes **aminopeptidase**, **and procarboxy peptidase.**



Functions of The Liver

 Important in carbohydrate metabolism where hepatic cells conduct **glycogenesis** (converting glucose into glycogen)**,** and **Glycogenolysis** (breaking glycogen down to glucose)**.**

- Also, is critical in lipid metabolism where hepatic cells produce **bile** (for fat emulsification), oxidize fatty acids, synthesize various forms of lipids, and convert glucose to fatty acids (**lipogenesis**).

Other functions of the liver include:

- Storage of glycogen, iron, and vitamins A, D, B12.

-Contains phagocytes to destroy damaged erythrocytes and foreignsubstances, using phagocytosis .

-Detoxifies harmful substances in the blood.

-Serves as a blood reservoir (contains 7% of blood volume).

Gall Bladder

 A small sac located on the inferior, visceral surface of the liver.
 Stores and concentrates bile secreted by the liver.
 Regulation of Bile Release:
 1.**Chyme**with fat enters small intestine.
 2. Cells of intestinal mucosa secrete the hormone **Cholecystokinin**(CCK) into the blood stream.
 3.**CCK** stimulates muscular layer of gallbladder wall to contract.
 4.**Bile** passes down the cystic duct and common bile duct toduodenum .
 5.Hepatopancreatic sphincter relaxes and **bile** enters duodenum.

Small Intestine

 A long tube, with a small diameter (about 1 inch), extending from pyloric sphincter to the ileocecal valve.
 Divided into Duodenum, Jejunum, and ileum.

 1. Secretions of small intestine:

 a. Intestinal glands secrete a watery fluid that lack digestive enzymes but provides a vehicle for moving chyme to villi. Intestinal enzymes include: maltase digests maltose into glucose. sucrose digests sucrose into glucose and fructose .lactase digests sucrose into glucose and glucose. peptidases digest peptides into amino acids. lipases digest triglycerides into fatty acids and glycerol. Nucleases digest nucleotides into nitrogenous bases. Enterokinase converts trypsinogen into trypsin.

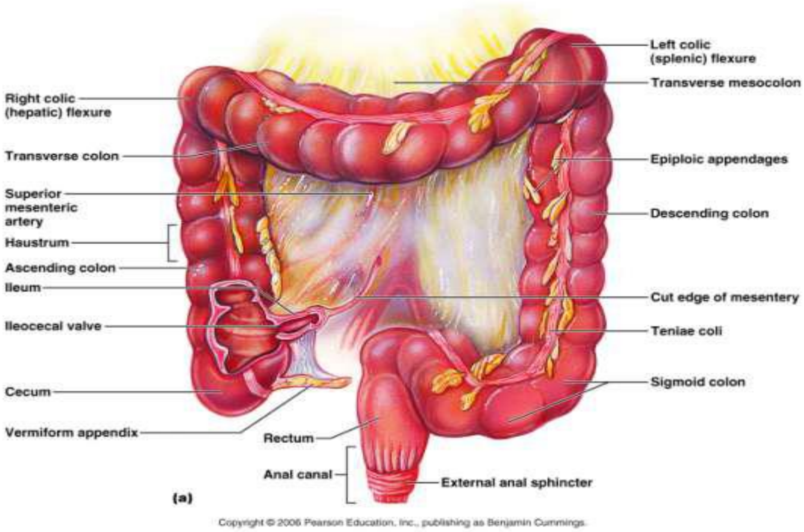
b. Digestive enzymes embedded in the surfaces of microvilli split molecules of sugars, proteins and fats.

 c. Regulation of small intestine secretions: secretion is stimulated by gastric juice, chyme, and reflex stimulated by distension of the small intestinal wall.

Large intestine

 The last segment of the GI tract, with a large diameter (2-3inches), extending from the ileocecal valve to the anus.

 Divided into cecum, ascending colon, transverse colon ,descending colon ,sigmoid colon ,rectum , anal canal, and anus.



The large intestine has little or no digestive function, although its secretes mucus. Its mucosa has no villa or microvillus but contains numerous **goblet cells** for secreting mucus to aid in the formation of feces and maintain an alkaline condition.

 mechanical stimulation and parasympathetic impulses control the rate of mucus secretion.

 The large intestine only absorbs **water**, electrolytes and some vitamins.

 Many **bacteria** inhabit the large intestine, where they break down certain indigestible substances and synthesize certain vitamins.

 feces are formed and stored in the large intestine. **Defecation** involves a reflex mechanism aided by voluntary contraction of the diaphragm, abdominal muscles, and the external anal sphincter.

Major Hormones of The Digestive Tract

 1. Gastrin: (Gastric & intestinal) : released by Gastric cells , in response to the presence of food. Causes Gastric glands to increase their secretory activity.

 2. Somatostatin: (Gastric inhibitory peptides - GIP): Inhibits secretion of acid by parietal cells.

 3. Cholecystokinin: released by intestinal wall cells, in response to the presence of proteins and fats in the small intestine. It causes gastric glands to decrease their secretory activity and inhibits gastric motility; stimulation of pancreas to secrete digestive enzyme; stimulates gall – bladder to contract and release bile.

 4. Secretin: released by cells in the duodenal wall, in response to acidic chyme entering the small intestine.

Salivary enzyme: Begins carbohydrates digestion by breaking down starch and glycogen to disaccharides

 Gastric enzymes: Pepsin, from Gastric glands – Begins protein
digestion. Lipase, from Gastric glands – Begins fat digestion.

 Pancreatic enzymes: Amylase, from pancreas – breaks down starch and glycogen into disaccharides. Lipase, from pancreas – breaks down fats into fatty acids and glycerol.

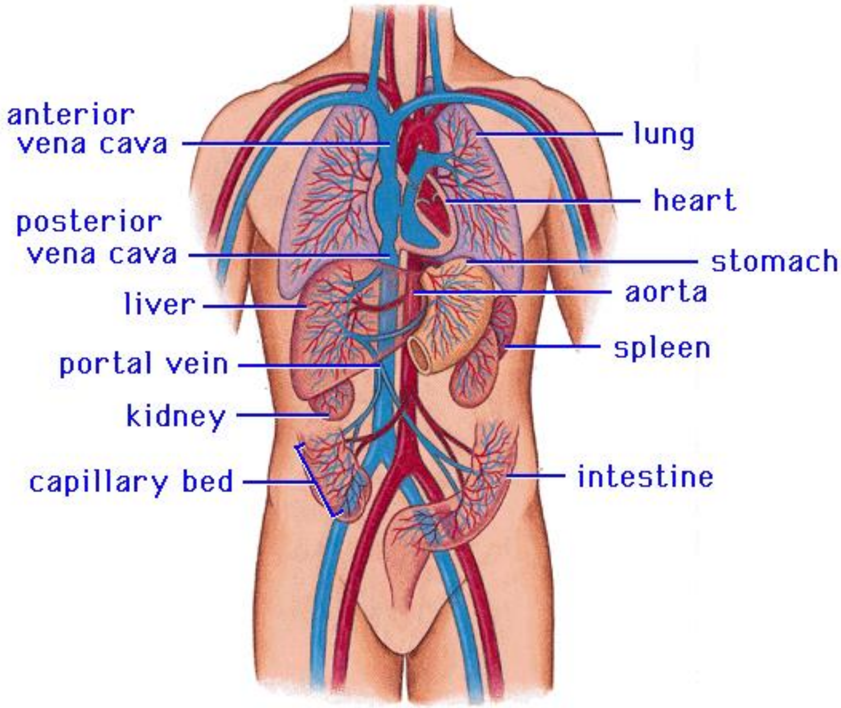
 Proteolytic enzymes:

 Trypsin, Chymotrypsin, and Carboxypeptidase from pancreas breaks down peptides into amino acids. Nucleases, from pancreas breaks down nucleic acids into nucleotides.

Intestinal Enzymes: Peptidase, from mucosal cells, breaks down peptides into amino acids. Sucrase, maltase, and lactase, from mucosal cells, breaks down disaccharides into monosaccharides. Lipase, from mucosal cells, breaks down fats into fatty acid and glycerol. Enterokinase, from mucosal cells, (breaks down) converts trypsinogen into trypsin.

THE CIRCULATORY SYSTEM and the LYMPHATIC SYSTEM

Most of the cells in the human body are not in direct contact with the external environment, so rely on the circulatory system to act as a transport service for them. Two fluids move through the circulatory system: **blood** and **lymph**. The blood, heart, and blood vessels form the **Cardiovascular System**. The lymph, lymph nodes and lymph vessels form the **Lymphatic System**. The Cardiovascular System and the Lymphatic System collectively make up the circulatory system.



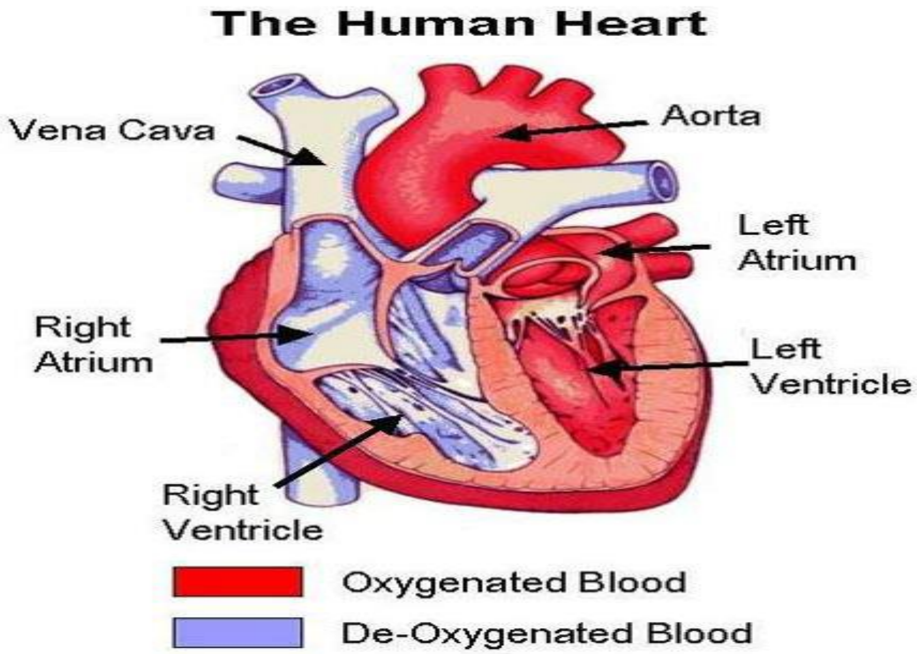
1. Vertebrates have a **closed circulatory system,** meaning the blood is repeatedly cycled throughout the body inside a system of pipes.

2. It was in 1628, when the English Dr. William Harvey showed that blood circulated throughout the body in one-way vessels. According to him, blood was pumped out of the heart and into the tissues through one type of vessel and back to the heart through another type of vessel. The blood, in other words, moved in a closed cycle through the body.

3. Blood is the body's internal transportation system. Pumped by the heart, blood travels through a network of blood vessels, carrying nutrients (O_2, glucose) and hormones **to** the cells and removing waste products (CO_2. urea) **from** the 10^{12} (= 100 trillion) cells of our bodies.

THE HEART

1. The central organ of the cardiovascular system is the heart. This is a hollow, muscular organ that contracts at regular intervals, forcing blood through the circulatory system.



2. The heart is cone-shaped, about the size of a fist, and is located in the center of the thorax, between the lungs, directly behind the **sternum** (breastbone). The heart is tilted so that the base is tilted to the left.

3. The walls of the heart are made up of **three** layers of tissue:

a) The outer and inner layers are **epithelial tissue.**

b) The middle layer, comprising the **cardiac muscle** of the heart itself, is called the **myocardium**.

4. For obvious reasons, the cardiac muscle is not under the conscious control of the nervous system and can generate its own electrical rhythm (**myogenic)**. For the same reasons, cardiac

muscle **cannot respire anaerobically** and so the muscle **cannot get tired** (or develop cramp!)

5. Cardiac muscle has a rich supply of blood, which ensures that it gets plenty of oxygen. This is brought to the heart through the **coronary artery.** Since the heart relies on aerobic respiration to supply its energy needs, cardiac muscle cells are richly supplied with mitochondria.

6. Our hearts beat about once every second of every day of our lives, or over 2.5 million times in an average life span. The only time the heart gets a rest is between beats.

HOW the heart works?

1. The heart can be thought of as two pumps sitting side by side – **each** of which has an upper **atrium** and a lower **ventricle –** a total of 4 chambers. It functions as two pumps inside one.

2. The **right side** of the heart pumps '**deoxygenated blood**' (actually, blood low in oxygen) from the body into the lungs, where **gas exchange** takes place. In that process, carbon dioxide is lost to the air and oxygen is absorbed. This oxygen is almost all carried by the Red Blood Cells (RBC's).

3. The **left side** of the heart pumps oxygenated blood from the lungs to the rest of the body.

4. The heart is enclosed in a protective membrane-like sac called the **pericardium**, which surrounds the heart and secretes a fluid that reduces friction as the heart beats.

5. The **atria** (upper chambers) of the heart receive blood coming into the heart. Then have thin walls, so allowing them to be filled easily. They pump the blood into the **ventricles** (lower chambers), thus filling them.

6. The ventricles pump blood out of the heart and the **left ventricle has the thickest walls** of the heart because it has to do most of the work to pump blood to all parts of the body. **This is where the blood has the highest pressure**.

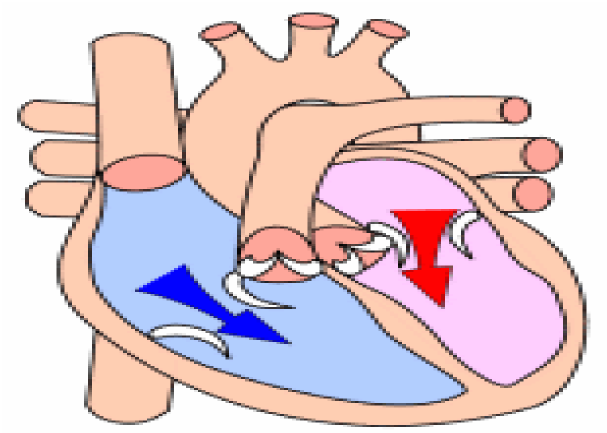
7. Vertically dividing the two sides of the heart is a wall, known as the **septum.** The septum prevents the mixing of oxygenated (left side) and deoxygenated (right side) blood.

8. It also carries electrical signals instructing the ventricles when to contract. These impulses pass down specially-modified muscle cells (**Purkinje fibers**), collectively known as the **Bundle of His**.

THE RIGHT SIDE OF THE HEART

1. Deoxygenated blood from the body enters the right side of the heart through **two** large veins called the **vena cava.** The **superior** vena cava returns blood from the head and arms; the **inferior** vena cava from the rest of the body (except, of course, the lungs!)

2. Both empty into the **right atrium**. **This is where the blood pressure is lowest** (even negative). When the heart relaxes (between beats), pressure in the circulatory system causes the right atrium to fill with blood.



3. When the atria contract, pressure inside it rises, the **right atrio-ventricular (AV) valve opens,** and blood is squeezed from the right atrium into the right ventricle. This valve is also known as the **tricuspid valve.** The closing of this valve makes a sound – 'lub'.

4. When the atrium is empty, the pressure inside it falls, and the pressure inside the ventricle begins to rise. This causes the a trio-ventricular valve to

shut quickly, preventing the back-flow of blood.

5. The general purpose of all valves in the circulatory and so ensure that blood flows in only one direction.

6. When the right ventricle contracts, blood is forced out through the **semi-lunar valve** (also known as the **pulmonary valve**), into the pulmona**l** arteries to carry deoxygenated blood.

7. When the right ventricle is empty, the pressure inside falls **below** that in the pulmonary artery, and this causes the semi-lunar valve to snap shut, the closing of these valves also causes a sound- dup A normal heart-beat is thus 'lub…dup.

THE LEFT SIDE OF THE HEART

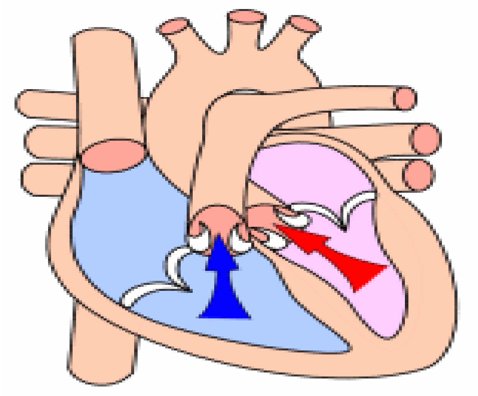
1. Oxygenated blood leaves the lungs and returns to the heart through the **pulmonary veins.** These are the **only** veins to carry oxygenated blood.

2. This blood enters the **left atrium,** which, when full, forces blood into the left ventricle, filling it. The valve which opens is called the **left atrio-ventricular** (AV) **valve**, (or **bicuspid** or **mitral** valve). As on the right side of the heart, this valve clos begins to rise in the ventricle.

3. From the left ventricle, blood is forced at very high pressure through another **semi-lunar valve** (the **aortic valve**), into th blood throughout the body (apart from the lungs!).

4. This surge of blood from the ventricles causes the walls of the aor expand and the muscles within to stretch – we can detect this as a **pulse**. 5. When the ventricle is almost empty, the pressure begins to fall below that in the aorta, and this causes the semi-

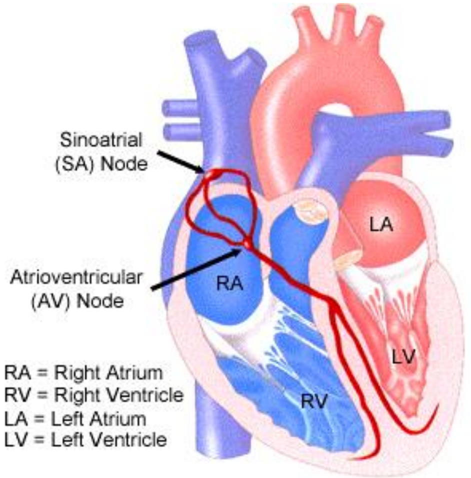
lunar valve to snap shut, **as the elastic walls of the aorta recoil**, thus preventing back-flow of blood into the heart.



Ventricles contract system is to prevent the back-flow of blood, arteries, where it goes to the lungs. These are the t. The closing of these valves also causes a sound – up'. A normal heart-beat is thus 'lub…dup'. ees when the atrium is empty and pressure e **aorta**, which carries ta to p shut, **as the elastic walls of the aorta recoil**, thus preventing back-flow of blood into the heart.

THE CARDIAC CYCLE

1. The **cardiac cycle** is the sequence of events in one heartbeat. In its simplest form, the cardiac cycle is the simultaneous contraction of **both** atria, followed a fraction of a second later by the simultaneous contraction of **both** ventricles.



2. The heart consists of cardiac muscle cells that connect with each other – they are branched – and so when one contracts, they stimulate their neighbors and they all contract. The heart is an 'all-or-nothing' muscle, getting its rest between beats. It can **only** respire aerobically.

3. A heartbeat has two phases:

A. **Phase 1 - Systole** is the term for contraction. This occurs when the ventricles contract, closing the A-V valves and opening the Semi-Lunar valves to pump blood into the two major vessels leaving the heart.

B. **Phase 2 – Diastole** is the term for relaxation. This occurs when the ventricles relax, allowing the back pressure of the blood to close the semi-lunar valves and opening the A-V valves.

4. The cardiac cycle also creates the heart sounds: each heartbeat produces **two** sounds, often called **lub-dup**, that can be heard

with a stethoscope. The first sound is caused by the contraction of the ventricles (**ventricular systole**) closing the A-V valves. The second sound is caused by the snapping shut of the Aortic and Pulmonary Valves (Semi-lunar valves). If any of the valves do not close properly, an extra sound called a **heart murmur** may be heard.

5. Although the heart is a single muscle, it does not contract all at once. The contraction spreads over the heart like a wave, beginning in a small region of specialized cells in the **right atrium** called the **Sino-Atrial Node (SAN).** This is the hearts natural **pacemaker,** and it initiates each beat

6. The impulse spreads from the SAN through the cardiac muscle of the right and left atrium, causing **both atria** to contract almost simultaneously.

7. When the impulse reaches another special area of the heart, right in the centre of the septum, known as the **Atrio-Ventricular (**or **AV) Node**, the impulse is delayed for approximately 0.2 s. **This allows time for the ventricles to fill completely.**

8. The AV Node relays the electrical impulse **down the septum,** along the **Bundle of His,** to the **base** of the ventricles. The ventricles then contract simultaneously, **from the bottom upwards,** thus allowing them to empty completely with each beat.

9. The heartbeat is initiated by the Sino-Atrial Node and passes through the Atrio-Ventricular Node, remaining at the same rhythm until nerve impulses cause it to speed up or to slow down. Unlike other muscles, it does **not** require a new nerve impulse for each contraction.

10. The **autonomic nervous** system controls heart rate. The **accelerator nerve** of the sympathetic nervous system **increases** heart rate and the **vagus nerve** of the **parasympathetic nervous system decreases** heart rate.

11. For most people, their resting heart rate is between 60 and 80 b.p.m. During exercise that can increase to as many as 200 beats per minute for an athlete; for the rest of us, 150 b.p.m. is about all we can safely manage!

BLOOD VESSELS (ARTERIES, VEINS and CAPILLARIES)

1. The Circulatory System is known as a **closed system** because the blood is contained within either the heart or blood vessels at all times – always flowing in one direction. The path is the same –

heart (ventricles) → arteries → arterioles → organ (capillaries) → veins → heart (atrium)

2. **Except** for the capillaries, all blood vessels have **walls made of 3 layers of tissue.** This provides for both strength and elasticity:

A. The inner layer is made of **epithelial tissue.**

B. The middle layer is **smooth muscle.**

C. The outer layer is **connective tissue.**

ARTERIES and ARTERIOLES

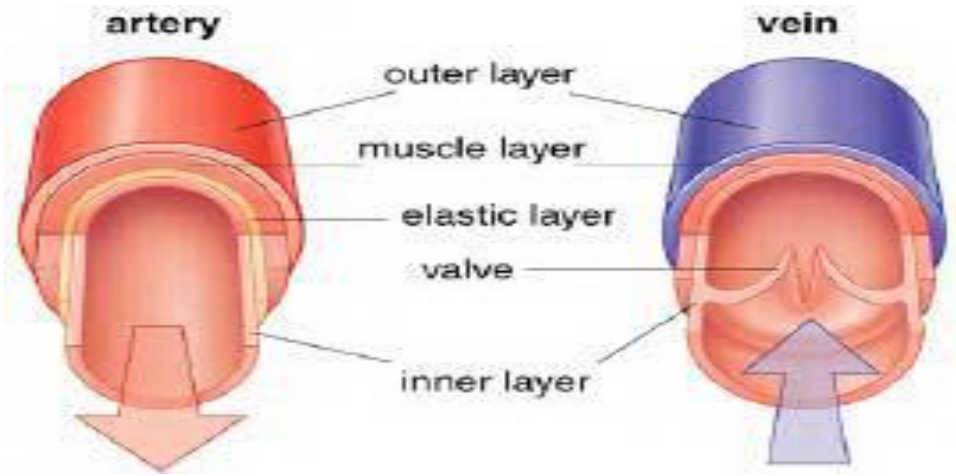
1. Arteries carry blood **from** the heart to the capillaries of the organs in the body.

2. The walls of arteries are **thicker** than those of veins. The smooth muscle and elastic fibers that make up their walls enable them to withstand the high pressure of blood as it is pumped from the heart. The force that blood exerts on the walls of blood vessels is known as **blood pressure** and it cycles with each heart-beat (see below).

3. Each artery **expands** when the pulse of blood passes through and **the elastic recoil** of the fibers cause it to **spring back** afterwards, thus helping the blood along. This is known as **secondary circulation**, and it reduces the load on the heart.

4. Other than the **pulmonary arteries, all** arteries carry oxygenated blood.

5. The **aorta** carries oxygenated blood from the **left ventricle** to all parts of the body **except** the lungs. It has the largest diameter (25mm) and carries blood at the highest pressure.



6. As the aorta travels away from the heart, it branches into smaller arteries so that all parts of the body are supplied. The smallest of these are called arterioles.

7. Arterioles can **dilate** or **constrict** to alter their diameter and so alter the flow of blood through the organ supplied by that arteriole. Examples include muscles (when running) and skin (when hot or blushing). Since the **volume** of blood remains the same, if **more** blood flows through one organ, **less** must flow through another.

8. Two organs which **always** have the same blood flow are the brain and the kidneys. Popular organs to have blood flow reduced are the guts (between meals), muscles (when resting) and skin (when cold).

CAPILLARIES

1. Arterioles branch into networks of very small blood vessels – the capillaries. These have a **very large surface** area and **thin walls** that are only one (epithelial) cell thick.

2. It is in the capillaries that exchanges take place between the blood and the tissues of the body.

3. Capillaries are also **narrow**. This **slows the blood down** allowing time for diffusion to take occur. In most capillaries, blood cells must flow in single file.

4. **Tissue fluid** is formed in the capillaries, for their walls are leaky (see below).

VEINS

1. After leaving the capillaries, the blood enters a network of small venules, which feed into veins. These, in turn, carry the blood back to the atria of the heart.

2. Like arteries, the walls of veins are lined with epithelium and contain smooth muscle. The walls of veins are thinner and less elastic than arteries, but they are also more flexible.

3. Veins tend to run **between** the muscle blocks of the body and nearer to the surface than arteries.

4. The larger veins contain valves that maintain the direction of blood-flow. This is important where blood must flow against the force of gravity.

5. The flow of blood in veins is helped by contractions of the skeletal muscles, especially those in the arms and legs. When muscles contract they squeeze against the veins and help to force the blood back towards the heart. Once again, this is known as secondary circulation.

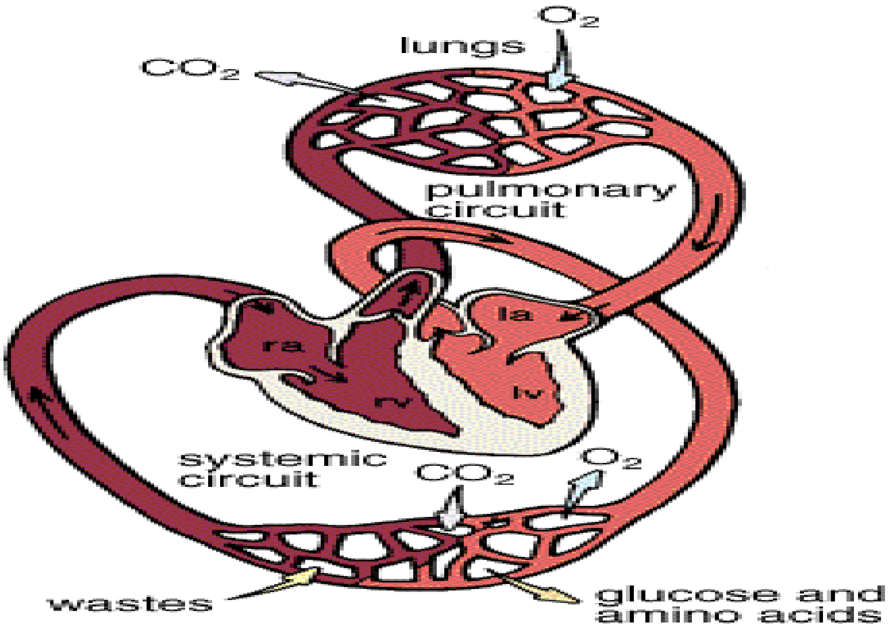
PATTERNS OF CIRCULATION

1. Blood moves through the body in a continuous fashion:

Left ventricle → systemic circulation (body) → right atrium → right ventricle → pulmonary circulation (lungs) → left atrium → left ventricle.

2. Deoxygenated blood is pumped from the right ventricle into the lungs through the pulmonary arteries – the only arteries to carry deoxygenated blood.

3. Blood returns to the heart through the pulmonary veins, the only veins to carry oxygenated blood.



4. The **systemic circulation** starts at the left ventricle and ends at the right atrium. It carries blood to and from the rest of the body.

5. The heart itself receives its supply of blood from the **two coronary arteries** leading from the aorta. Blood enters into capillaries that lead to veins through which blood returns to the right atrium.

6. There are **three** parts of the systemic circulation that you need to know:

A. **coronary circulation -** supplying blood to the heart muscle (**coronary artery**).

B. **renal circulation** – supplying blood to the kidneys (**renal artery**). Nearly 25% of the blood leaving the heart flows to the kidneys, which are pressure filters for waste.

C. **hepatic portal circulation-** nutrients picked up by capillaries in the small intestines are transported directly to the liver in the **hepatic portal vein**, where excess nutrients are stored. This is about 70% of the liver's blood supply. The liver **also** receives oxygenated blood from the **hepatic artery**, which branches off the aorta, and provides 30% of its blood. All blood leaves the liver through the hepatic vein.

BLOOD PRESSURE

1. Blood moves through our circulation system because it is under pressure, caused by the contraction of the heart and by the muscles that surround our blood vessels. The measure of this force is **blood pressure.**

2. Blood pressure will always be highest in the two main arteries, just outside the heart, but, because the pulmonary circulation is inaccessible, blood pressure is measured in the systemic circulation **only**, i.e. blood leaving the left ventricle only – normally in the upper arm.

3: To measure blood pressure:

a) Ensure the patient is relaxed and has not taken any exercise for at least 10 mins.

b) A cuff is inflated around a persons arm - stopping the flow of blood through the artery.

c) The pressure in the cuff is slowly released – whilst listening for the first sounds of blood passing through the artery. This means that the ventricles are pumping with enough force to overcome the pressure exerted by the cuff. This is the **systolic pressure.**

d) Normal systolic pressure is about 120 mm Hg for males; 110mm Hg for females. Average systolic pressure rises with age so 100+ your age is a safe maximum.

e) The pressure continues to be released – now listening for the **disappearance** of sound - indicating a steady flow of blood. This is the **diastolic pressure**, when the pressure of the blood is sufficient to keep the arteries open even when the ventricles relax.

f) Normal diastolic pressure is about 80 mm Hg for males and 70 mm Hg for females.

g) Blood pressure readings are given as **two** numbers – the systolic (higher) figure over the diastolic (lower) figure e.g. 120/80mm Hg.

h) **Hypertension** (high blood pressure) is diagnosed when the **diastolic** pressure is >10mm Hg above the norm; the systolic pressure is of less concern.

4. Blood pressure is maintained by:

a) **The kidneys**, which regulate blood pressure by removing excess water (and salt) from the body. The higher the blood pressure, the more water is forced out in the nephrons; this reduces the volume of lymph and lowers the blood pressure. **But** it makes the blood thicker (thus more likely to clot).

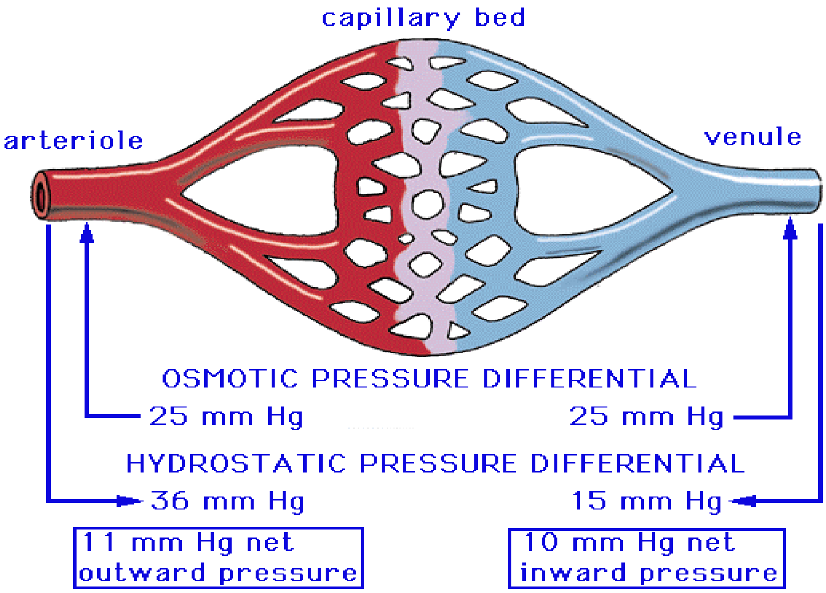
b) **The nervous system**, which regulates heart rate. The level of CO_2 in the blood is monitored in the **carotid artery** and the aorta and this information is sent to the **cardiovascular centre**in the brain. This sends impulses down either the **accelerator nerve** (of the **sympathetic nervous system**), which speeds up heart rate, or down the **vagus nerve** (of the **parasympathetic nervous system**), which slows it down. Both nerves lead to the **sino-atrial node (SAN).**

c) **Stretch receptors** in the walls of the heart. When exercising, more blood is returned to the heart, causing the walls to stretch more than normal. The heart responds to this by beating faster and harder.

5) Blood pressure that is too high (risk of thrombosis) or too low (risk of fainting) are undesirable.

TISSUE FLUID and the LYMPHATIC SYSTEM

1. As blood passes through the capillaries, about 10% of its fluid leaks into the surrounding tissues. This is known as **tissue fluid**.



2. This fluid carries chemicals such as glucose and hormones **to** the cells of the body that are not next to the capillary, and **removes** waste products, such as urea and CO_2.

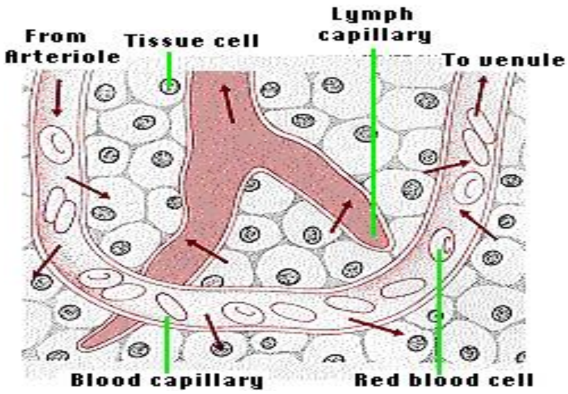
3. The mechanism behind the formation of this fluid is a common question!

a) The high blood pressure ('hydrostatic pressure') at the arteriole end of the capillary bed is much greater than the solute potential ('osmotic pressure') of the surrounding cells. Thus, fluid is forced out of the capillary.

b) at the venous end of the capillary bed, the blood pressure ('hydrostatic pressure') is low, whilst the solute potential ('osmotic pressure') of the blood is much stronger, since the blood is more concentrated. [The proteins in the blood are generally too big to leave the capillaries, whilst the blood cells (and their proteins) **all** remain behind]. This causes **some** water to be returned to the blood in the capillaries by osmosis. (see diagram above)

c) The overall effect is to ensure that the tissue fluid is constantly on the move and so every cell in the body receives a fresh supply of nutrients.

4. **Not all** of the fluid forced out of the capillaries is returned by osmosis (which anyway only moves water – what about the other chemicals?) and a network of vessels known as the **lymphatic system** collects this excess fluid and returns it to the circulatory system.



5. This fluid – **lymph** – flows through wider and wider vessels which contain valves to ensure a one-way flow, before it is returned to the blood in the vena cava, just outside the right atrium (where blood pressure is lowest).

6. The lymphatic system **has no pump**, so lymph must be moved through vessels by the squeezing of skeletal muscles.

7. These lymph vessels pass through small bean-shaped enlargements (organs) called **lymph nodes**, which produce one type of white blood cell (**lymphocytes**) which are an important source of antibodies and help us to fight infection. Examples of lymph nodes are the **tonsils**, the **appendix**, the **spleen** and the **thymus gland** (in children only – it disappears from the age of 10 or so).

8. If the blood pressure is too high, or if the person is inactive, the lymph can build up in the tissues, particularly around the ankles and feet. This is known as **oedema** and is common in older people and can also happen on long-distance flights. With the blood now thicker, it is more likely to clot, forming DVT or **deep vein thrombosis.** A simple precaution against this is to take one aspirin tablet, 24 and 12 hours before flying, and also to regularly move your feet and ankles during the flight. However, going for a jog is **not** recommended!

BLOOD

We have between 4 and 6 liters of blood, the **liquid connective tissue** that is the transport medium of the circulatory system. The two main functions of blood are to transport nutrients and oxygen **to** the cells and to carry CO_2, urea and other wastes **away** from the cells. Blood also transfers heat to the body surface and plays a role in defending the body against disease.

1. Blood is composed of 55% liquid - **plasma –** and 45% **cells,** almost all of which are Red Blood Cells (RBC's). together, they transport all the materials around our bodies that every cell needs to function and the hormones that are an important part of coordination.

2. Blood also regulates body temperature, pH, and electrolytes, so it is important in homeostasis.

3. Blood helps to protect us from infection and reduces fluid loss when we are injured.

BLOOD PLASMA

1. Approximately 55% of blood is made up of **plasma,** the straw-colored liquid portion of blood; it is 90% water and 10% dissolved molecules (mainly **plasma proteins).**

2. These can be divided into **three types**:

a) **Albumins -** these help to regulate water potential, by maintaining normal blood volume and pressure. They are the most common plasma protein.

b) **Immunoglobins (antibodies)** – These are very large proteins that target infection and so cause infected or foreign cells to be attacked by white blood cells (WBC's). Together with the WBC's they form the **immune system.**

c) **Fibrinogen** – these are tightly coiled proteins that unwind to form a blood clot.

BLOOD CELLS

These comprise Red Blood Cells RBC's (also known as hemocytes or erythrocytes); White Blood Cells (WBC's) of several different types and platelets. Together, they make up 45% of blood.

RED BLOOD CELLS (RBC's) 1. RBC's are by far the most numerous. One cubic millimeter (one microliter, or 1μl) contains roughly 5 million RBCs. This figure can rise to over 8 million as an adaptation to living at high altitudes – the reason why endurance athletes train at altitude. The liver destroys excess RBC's on returning to sea-level, so training must continue until immediately before the event, if possible.

2. RBC’s are **biconcave** disks about 8 μ across, thus giving them a **larger surface area** (Fick’s Law), and allowing them to fold up and pass through the smallest capillaries.

3. They are produced from stem cells in the bone marrow; are full of hemoglobin; have **no nucleus or mitochondria** and their function is to **transport respiratory** gases. A mature RBC becomes little more than a membrane sac containing hemoglobin and this gives blood its red color.

4. RBC’s stay in circulation for about 120 days before they are destroyed in the liver and spleen, giving a turnover rate of about 2 million per second!

WHITE BLOOD CELLS (WBC)

1. These are outnumbered by RBC's approximately 500 to 1 and their numbers fluctuate, rising during infection and falling at other times. Like the RBC's, they are formed from stem cells in the bone marrow, but may also reproduce in the lymph nodes, thymus and spleen. They are larger than RBC's, almost color less, and do **not** contain hemoglobin.

2. WBC's have a nucleus and whilst most live for a few days, others can live for many months or years, thus providing us with life-long immunity from repeat infections (**memory cells**)

3. WBC's protect us from infection and invasion by foreign cells or substances Whilst **lymphocytes** produce antibodies, the other two types of WBC can also **engulf bacteria**, in a process called **phagocytosis** (a form of active transport!). Granulocytes also produce **histamine**, which is important in allergies. **Appearance**

PLATELETS AND BLOOD CLOTTING

1. **Platelets** are not true cells; they are tiny fragments of other cells – **megakaryocytes -** that were formed in the bone marrow; their life-span

is 7-11 days.

2. Platelets play an important role in blood clotting, by adhering to the site of the wound and releasing clotting factors known as **prothrombin.**

5. Clotting factors are part of a **cascade** reaction which begins with chemicals released by injured cells and ends with a sticky meshwork of **fibrin** stop bleeding by producing a clot.

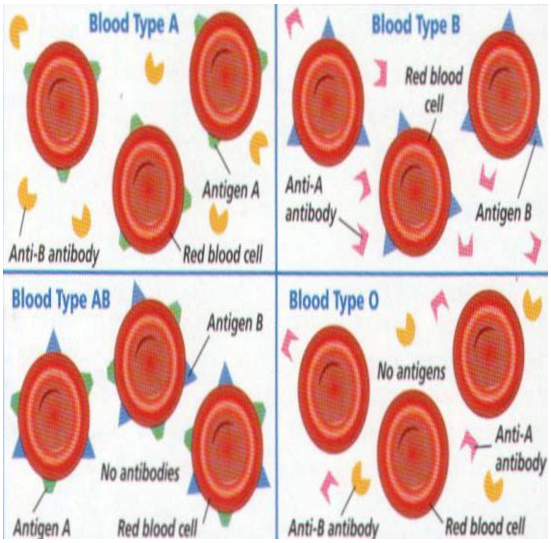
6. A genetic disorder of Factor VII is called **haemophilia**, suffers (all male – why?) may bleed extensively from even a small cut or scrape.

7. Unwanted clotting of blood within blood vessels can block the flow of blood – a **thrombosis**. If this happens in the brain, brain cells may die, causing a **stroke;** in the coronary artery, it may cause the

death of heart cells – a **coronary thrombosis.**

BLOOD TYPES

1. Blood group is determined by the **antigens** present on the surface of RBC's.



2. An **antigen** is a molecule (in this case a carbohydrate) that acts as a signal, enabling the body to recognize foreign substances in the body.

3. Human blood is classified into 4 main groups: A, B, AB and O. Each can be either Rhesus +ve or Rhesus

–ve, giving 8 groups in all.

4. Blood typing is the identification of the antigens in a blood sample. The ABO system is based on the A and B antigens. It classifies blood by the antigens on the surface of the RBC’s and the antibodies circulating in the plasma.

5. An individual's RBC’s may carry an A antigen, a B antigen, both A and B antigens, or no antigen at all. These antigen patterns are called blood types A, B, AB and O, respectively.

6. Type AB is known as a universal recipient, meaning that they can receive any type blood, whilst O is the universal donor, meaning they can donate blood to anyone.

Rhesus system

1. An antigen that is sometimes on the surface of RBC is the **Rh factor** named after the Rhesus monkey in which it was first discovered. Of the UK population, **85% are Rh+ ve**, meaning that Rh antigens are present. The other **15% are Rh-ve**.

2. If an Rh- person receives a transfusion of blood that has Rh+ antigens, anti-Rh+ antibodies will be formed and will react with the Rh+ antigen and agglutination (clumping) will occur.

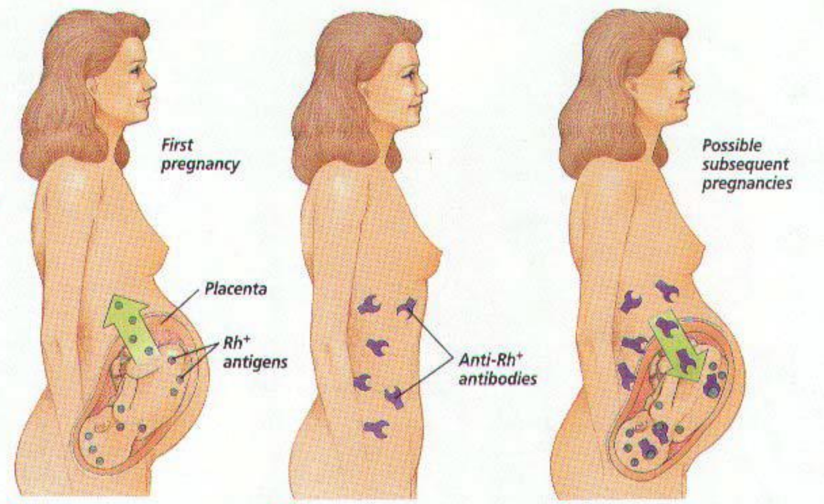
3. The most serious problem with Rh incompatibility occurs during pregnancy. If the mother is Rh- and the father is Rh+, the child may inherit the dominant Rh+ allele (gene) from the father. The baby's Rh+ blood will then get into the mother's blood during delivery, causing her to develop antibodies to the Rh factor.

4. If a **second** Rh+ child is later conceived, the mother's antibodies will cross the placenta and attack the blood of the foetus, causing a

condition known as **rhesus baby syndrome.** The symptoms include damaged liver and so fewer RBC's, brain (due to lack of oxygen) and skin.

5. To prevent this, any Rh- mother will automatically be given an injection of anti-Rh+ antibodies (known, confusingly, as **anti-D**) at childbirth. These antibodies attack and destroy all Rh+ antigens in the mother's blood, thus preventing her from becoming sensitised to the Rh+ antigen. This tricks her body into believing she has not had a Rh+ve child, and so the **next** pregnancy will be protected from attack, since she will have

Figure 37.7 If a baby inherits Rh^+ blood from the father and the mother is Rh^-, problems can develop if the blood cells of mother and baby mix during birth.



A Mother is exposed to Rh antigens at the birth of her Rh^+ baby.

B Mother makes anti-Rh^+ antibodies.

C During the mother's next pregnancy, Rh antibodies can cross the placenta and endanger the fetus.

4- The respiratory system

The major function of the **respiratory system** is to supply the body with oxygen and dispose of carbon dioxide. To accomplish this function, at least four processes, collectively called **respiration**, must happen:

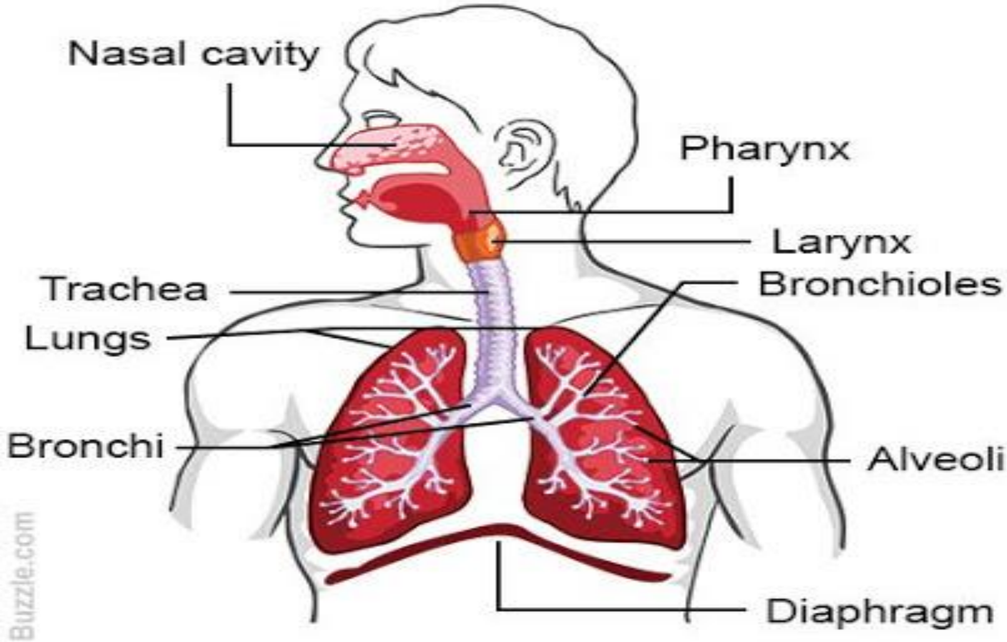
1. Pulmonary ventilation: movement of air into and out of the lungs so that the gases there are continuously changed and refreshed (commonly called breathing).

2. External respiration: movement of oxygen from the lungs to the blood and of carbon dioxide from the blood to the lungs.

3. Transport of respiratory gases: transport of oxygen from the lungs to the tissue cells of the body, and of carbon dioxide from the tissue cells to the lungs. This transport is accomplished by the cardiovascular system using blood as the transporting fluid.

4. Internal respiration: movement of oxygen from blood to the tissue cells and of carbon dioxide from tissue cells to blood.

Only the first two processes are the special responsibility of the respiratory system, but it cannot accomplish its primary goal of obtaining oxygen and eliminating carbon



dioxide unless the third and fourth processes also occur. As you can see, the respiratory and circulatory systems are closely coupled, and if either system fails, the body's cells begin to die from oxygen starvation. The actual use of oxygen and production of carbon dioxide by tissue cells, known as *cellular respiration*, is the cornerstone of all energy-producing chemical reactions in the body. Because it moves air, the respiratory system is also involved with the sense of smell and with speech.

Functions of the Respiratory System

* To allow gases from the environment to enter the bronchial tree through inspiration by expanding the thoracic volume.

*To allow gas exchange to occur at the respiratory membrane, so that oxygen diffuses into the blood while carbon dioxide diffuses into the bronchial tree.

*To permit gases in the lungs to be eliminated through expiration by decreasing the thoracic volume.

Functional Anatomy of the Respiratory System

_ Identify the organs forming the respiratory passageway(s) in descending order until the alveoli are reached.

_ Describe the location, structure, and function of each of the following: nose, paranasal sinuses, pharynx, and larynx.

_ List and describe several protective mechanisms of their respiratory system.

The respiratory system includes the nose, nasal cavity, and paranasal sinuses; the pharynx; the larynx; the trachea; the bronchi and their smaller branches; and the lungs, which contain the terminal air sacs, or alveoli. Functionally, the system consists of two zones. The **respiratory zone**, the actual site of gas exchange, is composed of the respiratory bronchioles, alveolar ducts, and alveoli, all microscopic structures. The **conducting zone** includes all other respiratory passageways, which provide fairly rigid conduits for air to reach the gas exchange sites. The conducting zone organs also cleanse, humidify, and warm incoming air. As a result, air reaching the lungs has fewer irritants (dust, bacteria, etc.) than when it entered the system, and it is warm and damp, like the air of the tropics. In addition to these organs, some authorities also include the respiratory muscles (diaphragm, etc.) as part of this system. Although we will consider how these skeletal muscles bring about the volume changes that promote ventilation, we continue to classify them as part of the muscular system.

Breathing Mechanisms – physical laws

The Gas law states that gas molecules always diffuse from a higher pressure area to a lower pressure area.

The Boyle's law states that pressure and volume are inversely related (with the temperature remains constant), where pressure will increase in a smaller volume of gases, and pressure decreases in a larger volume of gases.

Inspiration (Inhalation)

An active process where nerve impulses from medulla oblongata cause the contraction of diaphragm and external intercostals muscles.

As these muscles contract, thoracic volume increases which decreases the pressure within the
lung (intra alveolar pressure) due to the boyle's law.

When intra alveolar pressure falls below the atmospheric pressure (758 mmHg versus 760mmHg, respectively), the gas law dictates that now gases move from the environment into lungs.

Expiration (exhalation)

a passive process where elastic tissues of the lungs and diaphragm recoil to their original position.

as the diaphragm and external intercostals muscles relax and recoil, thoracic volume decreases which raises the intra alveolar pressure (again due to the
boyle's law).

when intra alveolar pressure is risen above the atmospheric pressure (762 mmHg versus 760mmHg, respectively), gases move from the lungs into the environment (again due to the gas law).

Control of breathing

1. Four major factors that affect normal breathing:

Stretching in the lungs and thoracic walls

O_2 level in the blood

CO_2 level in the blood

H^+ level in the blood

2. Normal breathing is inhibited by stretching of the lungs and thoracic walls, a rise in O_2 level, and a decrease in CO_2 and H^+ levels; while normal breathing is stimulated by relaxing of the lungs and thoracic walls, a decrease in O_2 level, and a rise in CO_2

and H+ levels. Chemicals, and emotional state also affect breathing.

Stretch of tissues: inhibits inspiration by triggering an inflation reflex which reduces the duration of inspiratory movements. This, also prevents over inflation of the lungs during forceful breathing. Hyperventilation decreases carbon dioxide concentration as well.

Low blood PO2: increase alveolar ventilation (peripheral chemoreceptors in the carotid bodies & aortic bodies detect low OO2 concentrations).

High blood Pco2: increase alveolar ventilation.

High CSF, H+ ion concentration: increase breathing rate and alveolar ventilation. CO2 combines with water to form carbonic acid, which in turn, releases H+ ions in CSF.

Gas Exchange

Respiratory membrane is formed by the walls of alveoli and capillaries where they are both made of simple squamous epithelium, thin enough to allow diffusion of gases called **gas exchange** to occur.

Dalton's Law

Gases (particularly O2 and CO2 for this discussion) always diffuse from high pressure to low pressure.

Each gas in a mixture of gases produces its own pressure called **partial pressure (pp or p)**, and the sum of all partial pressure is the total pressure of that gas mixture – a physical law called the **Dalton's law**. Therefore, the directions of diffusion during gas exchange in the lungs and in body tissues are based on the differences in partial pressure of these gases.

External & Internal Respiration

□**External Respiration**: occurs in the lungs to oxygenate the blood and remove CO_2 from the deoxygenated blood. O_2diffuses from the alveoli into capillaries, while CO_2 diffuses from the capillaries into alveoli.

□**Internal respiration** (tissue respiration). occurs in the body tissues to provide O_2 to tissue cells and remove CO_2 from the cells. O is critical in the release of energy molecules (i.e. ATP)

O_2 , a process called **cellular respiration**, while CO_2 is a byproduct of metabolism which can become harmful to tissue cells in large quantities.

□O_2 diffuses from the capillaries into tissue cells, while CO_2diffuses from tissue cells into capillaries.

Alveolar Gas exchange

- Gas exchanges between the air and the blood occur within the alveoli.
- 1. The alveoli are tiny sacs clustered at the distal ends of alveolar ducts.
- 2. The respiratory membrane consists of the alveolar and capillary walls. Gas exchange takes place through these walls.
- 3. Diffusion through the respiratory membrane.
- O_2 diffuses from the alveolar air into the blood; Co_2 diffuses from the blood into the alveolar air.
- Note: the differences in partial pressure determines the diffusion through the respiratory membrane.

<u>Gas Transport - Oxygen</u>

- 98% of O_2 is transported by binding to hemoglobin in erythrocytes [when O_2 binds with hemoglobin (Hb) oxyhemoglobin (oxy-Hb) is formed which shows are a red pigment].
- 2% of O_2 is dissolved in the blood plasma.
- The resulting oxyhemoglobin is relatively unstable and releases its O_2 in regions where Po_2 is low.
- More O_2 is released as the blood conc. of Co_2 increases, as the blood becomes more acidic, and as the blood Temp. increases.
- The efficiency of oxy-Hb releasing O_2 to tissue cells during internal respiration is shown on the O_2-Hb dissociation curve

which shows a distinctive sigmoid shape.

On this curve, as O_2 partial pressure increases, the level of Hb saturation increases (each Hb molecule can bind up to four O_2molecules).

□At about 40 mmHg of O_2, roughly 75% of Hb is saturated.

□At about 80 mmHg of O_2, close to 98% of Hb is saturated, and the curve becomes flattened beyond this point where only about 98 -99% of Hb can be saturated no matter how high the O_2 pressure is.

<u>Gas Transport – carbon dioxide</u>

□7% of CO_2 is dissolved in the blood plasma.

□23% of CO_2 binds with hemoglobin in erythrocytes. [when CO_2binds to Hb, carbaminohemoglobin is formed which shows a bluish pigment].

□70% of CO_2 reacts with water and forms carbonic acid in erythrocytes $CO_2 + H_2O \rightarrow H_2CO_3$

□Carbonic acid is immediately broken down by the enzyme carbonic anhydrase (CA), to become hydrogen ion and bicarbonate ion.

□$H_2CO_3 \rightarrow H^+ + HCO_3^-$

□Where H^+ quickly binds with Hb to prevent it from affecting blood pH too drastically, and HCO_3

- diffuses into blood plasma and maintains an ionic balance with chloride anion (Cl^-).

Gas Transport – carbon monoxide

- Co forms as a result of incomplete combustion of fuels.
- It combines with hemoglobin more readily than $O_2$and forms a stable compound.
- Co is toxic because the hemoglobin with which it combines is no longer available for O_2 transport.

<u>Clinical Terms</u>

- Anoxia: absence or a deficiency of O_2 within tissues.
- Asphyxia: deficiency of O_2 and excess of Co_2 in the blood and tissues.
- Atelectasis: collapse of a lung or some portion of it.
- Bronchitis: inflammation of the bronchial lining.
- Cheyne – strokes – respiration: irregular breathing pattern of a series of shallow breaths that increases in depth and rate, followed by breaths that decrease in depth and rate.
- Dyspnea: difficulty in breathing.
- Hyperoxia: excess oxygenation of the blood.
- Hyperpnea: increase in the depth and rate of breathing

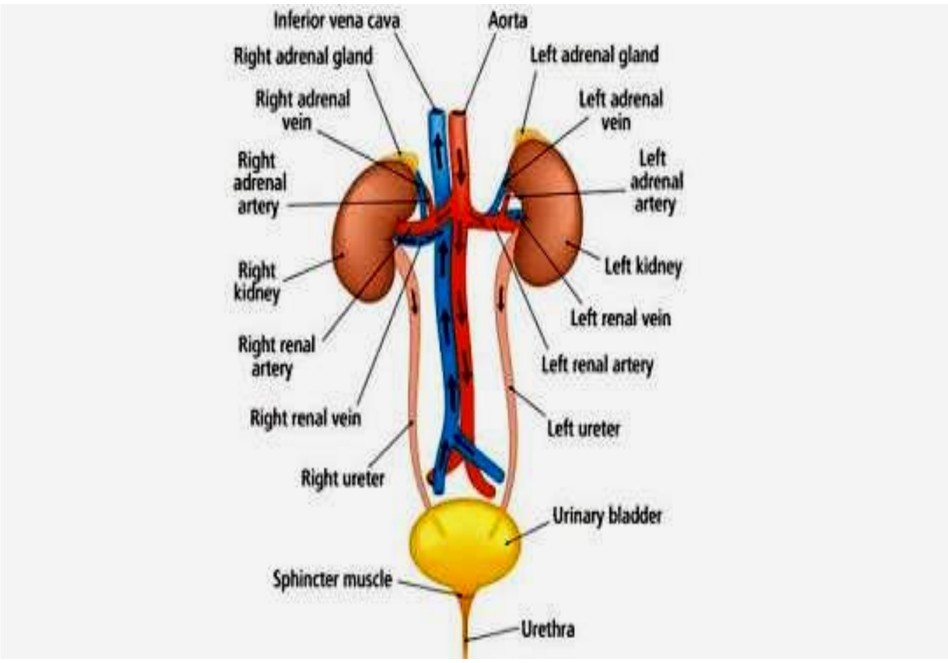
Excretory system

Animals accumulate ammonia, urea, uric acid, carbon dioxide, waterand ions like Na+, K+, Cl–, phosphate, sulphate, etc., either by metabolic activities or by other means like excess ingestion. These substances have to be removed totally or partially. In this chapter, you will learn the mechanisms of elimination of these substances with special emphasis on common nitrogenous wastes. Ammonia, urea and uric acid are the major forms of nitrogenous wastes excreted by the animals. Ammonia is the most toxic form and requires large amount of water for its elimination, whereas uric acid, being the least toxic, can be removed with a minimum loss of water. The process of excreting ammonia is *Ammonotelism*. Many bony fishes, aquatic amphibians and aquatic insects are ***ammonotelic*** in nature. Ammonia, as it is readily soluble, is generally excreted by diffusion across body surfaces or through gill surfaces (in fish) as ammonium ions. Kidneys do not play any significant role in its removal. Terrestrial adaptation necessitated the production of lesser toxic nitrogenous wastes like urea and uric acid for conservation of water. Mammals, many terrestrial amphibians and marine fishes mainly excrete urea and are called ***ureotelic*** animals. Ammonia produced by metabolism is converted into urea in the liver of these animals and released into the blood which is filtered and excreted out by the kidneys. Some amount of urea may be retained in the kidney matrix of some of these animals to maintain a desired osmolarity. Reptiles, birds, land snails and insects excrete nitrogenous wastes as uric acid in the form of pellet or paste with a minimum loss of water and are called ***uricotelic*** animals.

A survey of animal kingdom presents a variety of excretory structures. In most of the invertebrates, these structures are simple tubular forms whereas vertebrates have complex tubular organs called kidneys. Some of these structures are mentioned here. Protonephridia or flame cells are the excretory structures in Platyhelminthes (Flatworms, e.g., Planaria), rotifers, some annelids and the cephalochordate – Amphioxus. Protonephridia are primarily concerned with ionic and fluid volume regulation, i.e., osmoregulation. Nephridia are the tubular excretory structures of earthworms and other annelids. Nephridia help to remove nitrogenous wastes and maintain a fluid and ionic balance. Malpighian tubules are the excretory structures of most of the insects including cockroaches. Malpighian tubules help in the removal of nitrogenous wastes and osmoregulation. Antennal glands or green glands perform the excretory function in crustaceans like prawns

HUMAN EXCRETORY (URINARY) SYSTEM

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



.Kidneys are reddish brown, and bean shaped structures situated between the levels of last thoracic and third lumbar vertebra close to the dorsal inner wall of the abdominal cavity. Each kidney of an adult human measures 10-12 cm in length, 5-7 cm in width, 2-3 cm in thickness with an average weight of 120-170 g. Towards the center of the inner concave surface of the kidney is a notch called hilum through which ureter, blood vessels and nerves enter. Inner to the hilum is a broad funnel shaped space called the renal pelvis with projections called calyces. The outer layer of kidney is a tough capsule. Inside the kidney, there are two zones, an outer *cortex* and an inner *medulla*. The medulla is divided into a few conical masses (medullary pyramids) projecting into the calyces (sing.: calyx). The cortex extends in between the medullary pyramids as renal columns called Columns of Bertini. Each kidney has nearly one million complex tubular structures called nephrons, which are the functional units. Each nephron has two parts – the glomerulus and the renal tubule. Glomerulus is a tuft of capillaries formed by the afferent arteriole – a fine branch of renal artery. Blood from the glomerulus is carried away by an efferent arteriole. The renal tubule begins with a double walled cup-like structure called Bowman's capsule, which encloses the glomerulus. Glomerulus along with Bowman's capsule, is called the Malpighian body or renal corpuscle (Figure 19.4). The tubule continues further to form a highly coiled network – proximal convoluted tubule

URINE FORMATION

Urine formation involves three main processes namely, glomerular filtration, reabsorption and secretion, that takes place in different parts of the nephron. The first step in urine formation is the filtration of blood, which is carried out by the glomerulus and is called **glomerular filtration**. On an average,1100-1200 ml of blood is filtered by the kidneys per minute which constitute roughly 1/5th of the blood pumped out by each ventricle of the heart in a minute. The glomerular capillary blood pressure causes filtration of blood through 3 layers, i.e., the endothelium of glomerular blood vessels, the epithelium of Bowman's capsule and a basement membrane between these two layers. The epithelial cells of Bowman's capsule called podocytes are arranged in an intricate manner so as to leave some minute spaces called filtration slits or slit pores. Blood is filtered so finely through these membranes, that almost all the constituents of the plasma except the proteins pass onto the lumen of the Bowman's capsule. Therefore, it is considered as a process of ultra-filtration.

The amount of the filtrate formed by the kidneys per minute is called glomerular filtration rate (GFR). GFR in a healthy individual is approximately 125 ml/minute, i.e., 180 liters per day!

The kidneys have built-in mechanisms for the regulation of glomerular filtration rate. One such efficient mechanism is carried out by juxtaglomerular apparatus (JGA). JGA is a special sensitive region formed by cellular modifications in the distal convoluted tubule and the afferent arteriole at the location of their contact. A fall in GFR can activate the JG cells to release renin which can stimulate the glomerular blood flow and thereby the GFR back to normal. A comparison of the volume of the filtrate formed per day (180 liters per day) with that of the urine released (1.5 liters), suggest that nearly 99 per cent of the filtrate has to be reabsorbed by the renal tubules. This process is called Reabsorption. The tubular epithelial cells in different segments of nephron perform this either by active or passive mechanisms. For example, substances like glucose, amino acids, Na+, etc., in the filtrate are reabsorbed actively whereas the nitrogenous wastes are absorbed by passive transport. Reabsorption of water also occurs passively in the initial segments of the nephron . During urine formation, the tubular cells secrete substances like H+, K+ and ammonia into the filtrate. Tubular secretion is also an important step in urine formation as it helps in the maintenance of ionic and acid base balance of body fluids.

ROLE OF OTHER ORGANS IN EXCRETION

Other than the kidneys, lungs, liver and skin also help in the elimination of excretory wastes. Our lungs remove large amounts of CO2 (approximately 200mL/minute) and also significant quantities of water every day. Liver, the largest gland in our body, secretes bile-containing substances like bilirubin, biliverdin, cholesterol, degraded steroid hormones, vitamins and drugs. Most of these substances ultimately pass out a long with digestive wastes. The sweat and sebaceous glands in the skin can eliminate certain substances through their secretions. Sweat produced by the sweat glands is a watery fluid containing NaCl, small amounts of urea, lactic acid, etc. Though the primary function of sweat is to facilitate a cooling effect on the body surface, it also helps in the removal of some of the wastes mentioned above. Sebaceous glands eliminate certain substances like sterols, hydrocarbons and waxes through sebum. This secretion provides a protective oily covering for the skin. Do you know that small amounts of nitrogenous wastes could be eliminated through saliva too?

DISORDERS OF THE EXCRETORY SYSTEM

Malfunctioning of kidneys can lead to accumulation of urea in blood, a condition called uremia, which is highly harmful and may lead to kidney failure. In such patients, urea can be removed by a process called hemodialysis. Blood drained from a convenient artery is pumped into a dialyzing unit after adding an anticoagulant like heparin. The unit contains a coiled cellophane tube surrounded by a fluid (dialyzing fluid) having the same composition as that of plasma except the nitrogenous wastes. The porous cellophane membranes of the tube allow the passage of molecules based on concentration gradient. As nitrogenous wastes are absent in the dialyzing fluid, these substances freely move out, thereby clearing the blood. The cleared blood is pumped back to the body through a vein after adding anti-heparin to it. This method is a boon for thousands of uremic patients all over the world.

Kidney transplantation is the ultimate method in the correction of acute renal failures (kidney failure). A functioning kidney is used in transplantation from a donor, preferably a close relative, to minimize its chances of rejection by the immune system of the host. Modern clinical procedures have increased the success rate of such a complicated technique.

Renal calculi: Stone or insoluble mass of crystallized salts (oxalates, etc.) formed within the kidney.

Glomerulonephritis: Inflammation of glomeruli of kidney.

EXERCISES

1. Define Glomerular Filtration Rate (GFR)
2. Explain the autoregulatory mechanism of GFR.
3. Indicate whether the following statements are true or false :

(a) Micturition is carried out by a reflex.

(b) ADH helps in water elimination, making the urine hypotonic.

(c) Protein-free fluid is filtered from blood plasma into the Bowman's capsule.

(d) Henle's loop plays an important role in concentrating the urine.

(e) Glucose is actively reabsorbed in the proximal convoluted tubule.

4. Give a brief account of the counter current mechanism.
5. Describe the role of liver, lungs and skin in excretion.
6. Name the following:

(a) A chordate animal having flame cells as excretory structures

(b) Cortical portions projecting between the medullar pyramids in the human kidney

(c) A loop of capillary running parallel to the Henle's loop.

7. Fill in the gaps:

(a) Ascending limb of Henle's loop is _______ to water whereas the descending
limb is _______ to it.

(b) Reabsorption of water from distal parts of the tubules is facilitated by hormone
_______.

(c) Dialysis fluid contain all the constituents as in plasma except
_______.

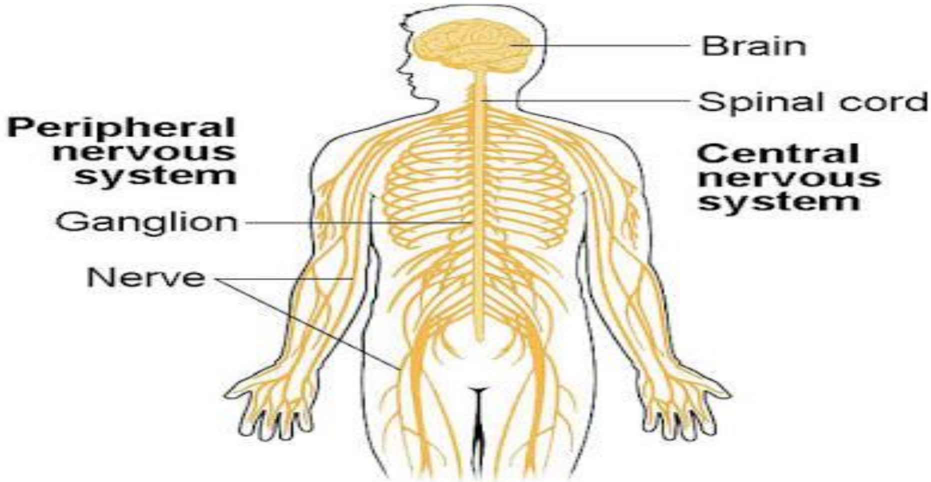
(d) A healthy adult human excretes (on an average) _______ gm of urea/day.

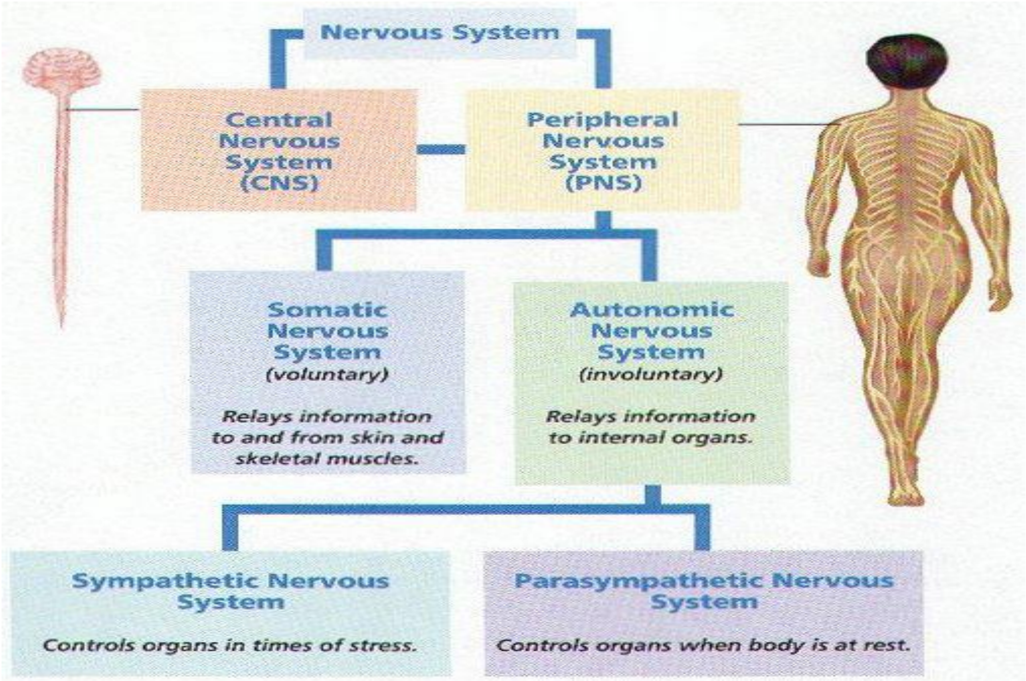
The nervous system

Functions of the Nervous System

1. Gathers information from both inside and outside the body - Sensory Function
2. Transmits information to the processing areas of the brain and spine
3. Processes the information in the brain and spine – Integration Function

4. Sends information to the muscles, glands, and organs so they can respond appropriately – Motor
Function
It controls and coordinates all essential functions of the body including all other body systems allowing the body to maintain homeostasis or its delicate balance.
The Nervous System is divided into **Two Main Divisions**: **Central Nervous System (CNS)** and the **Peripheral Nervous System (PNS)**



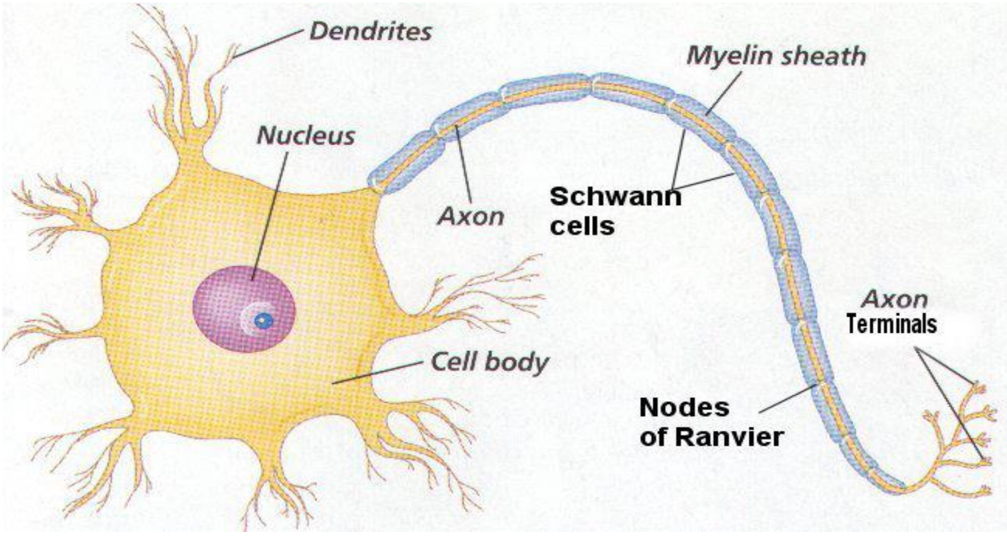


Basic Cells of the Nervous System

Neuron

- Basic functional cell of nervous system
- Transmits impulses (up to 250 mph)

Parts of a Neuron



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

• **Cell Body** with nucleus – nucleus & most of cytoplasm

• **Axon** – fiber which carries impulses away from cell body

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

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

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

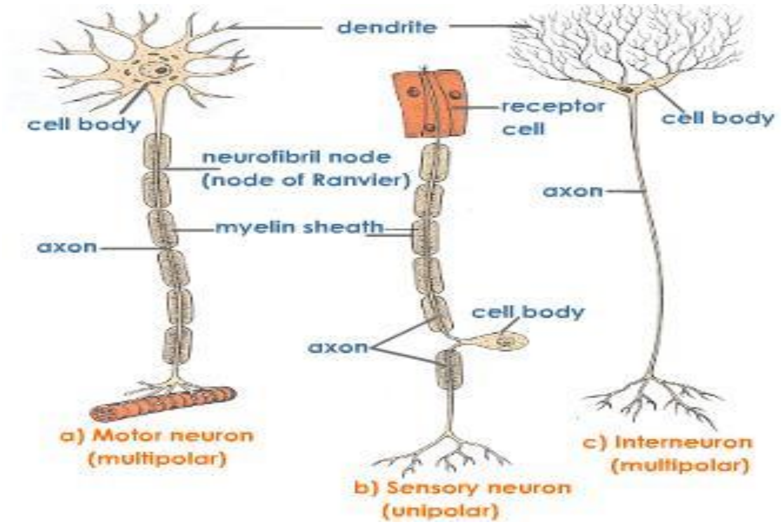
• Impulses travel **from dendrite to cell body to axon**

Three types of Neurons

O **Sensory neurons** – bring messages to CNS

O **Motor neurons -** carry messages from CNS

O **Interneurons** – between sensory & motor neurons in the CNS



Impulses

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

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

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

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

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

Synapse

O **Synapse -** small gap or space between the axon of one neuron and the dendrite of another **– the neurons do not actually tough at the synapse**

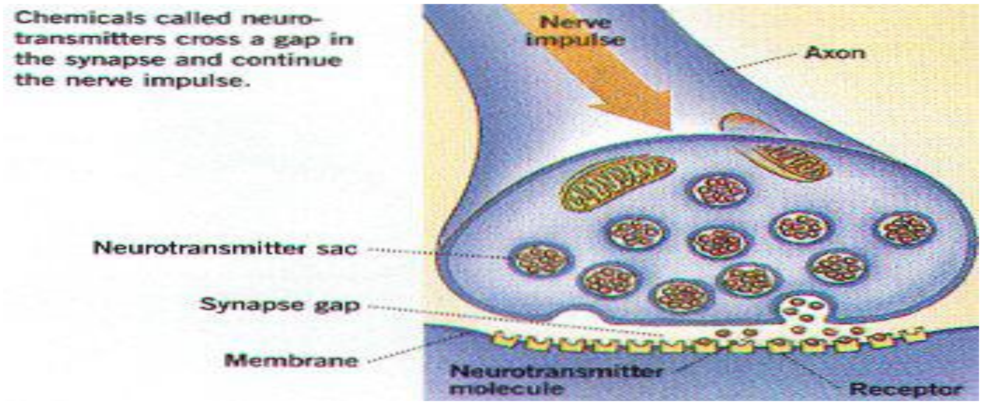
o It is junction between neurons which uses neurotransmitters to start the impulse in the second neuron or an effector (muscle or gland)

o the synapse insures one-way transmission of impulses

Neurotransmitters

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

Reflex Arc



Components of a Reflex Arc

A. **Receptor** - reacts to a stimulus

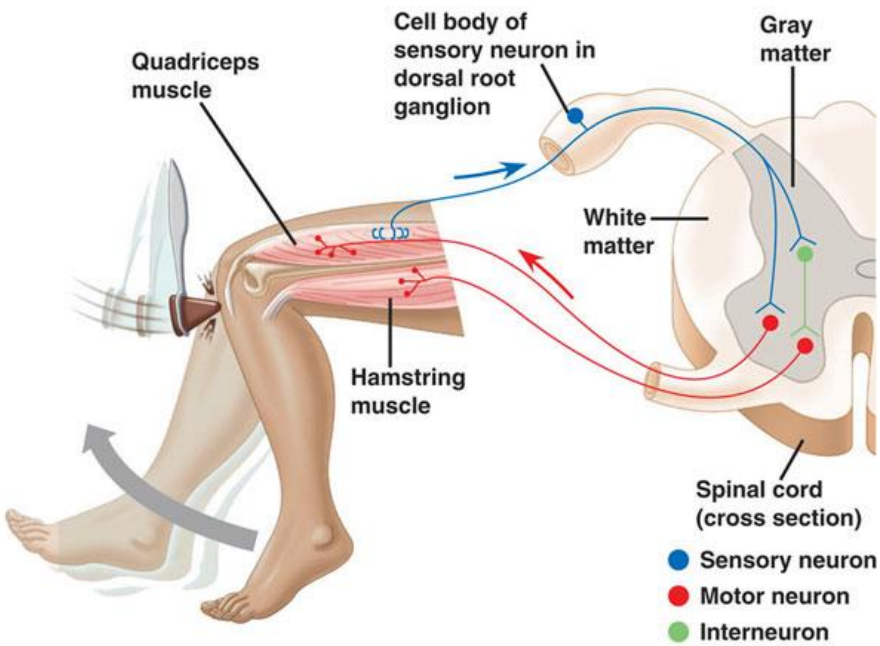
B. **Afferent pathway (sensory neuron)** - conducts impulses to the CNS

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

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

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

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



Central Nervous System

• Brain

*Brain stem – medulla, pons, midbrain

*Diencephalon – thalamus & hypothalamus

*Cerebellem

*Cerebrum

• Spine

* Spinal Cord

Meninges

Meninges are the three coverings around the brain & spine and help cushion, protect, and nourish the brain and spinal cord.

• dura mater is the most outer layer, very tough

• arachnoid mater is the middle layer and adheres to the dura mater and has web like attachments to the innermost layer, the pia mater

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

• cerebrospinal fluid, which buffers, nourishes, and detoxifies the brain and spinal cord, flows through the subarachnoid space, between the arachnoid mater and the pia,

Regions of the Brain

Cerebellum – coordination of movement and aspects of motor learning

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

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

Medulla – vital reflexes as heart beat and respiration

Brainstem – medulla, pons, and midbrain (involuntary responses) and relays information from spine to upper brain

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

Cerebrum

• Is the largest portion of the brain encompassing about two-thirds of the brain mass -

• It consists of two hemispheres divided by a fissure – corpus callosum

• It includes the cerebral cortex, the medullar body, and basal ganglia

• **cerebral cortex** is the layer of the brain often referred to as gray matter because it has cell bodies and synapses but no myelin

o The cortex (thin layer of tissue) is gray because nerves in this area lack the insulation or white fatty myelin sheath that makes most other parts of the brain appear to be white.

o The cortex covers the outer portion (1.5mm to 5mm) of the cerebrum and cerebellum

o The cortex consists of folded bulges called

gyri that create deep furrows or fissures called **sulci**

o The folds in the brain add to its surface area which increases the amount of gray matter and the quantity of information that can be processed

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

o Commissural fibers – conduct impulses between the hemispheres and form corpus callosum

o Projection fibers – conduct impulse in and out of the cerebral hemispheres

o Association fibers – conduct impulses within the hemispheres

• **Basal ganglia** – masses of gray matter in each hemisphere which are involved in the control of voluntary muscle movement.

Lobes of the Cerebrum

• **Frontal –** motor area involved in movement and in planning & coordinating behavior

• **Parietal –** sensory processing, attention, and language

• **Temporal** – auditory perception, speech, and complex visual perceptions

• **Occipital –** visual center **–** plays a role in processing visual information

Peripheral Nervous System

Cranial nerves

• 12 pair

• Attached to undersurface of brain

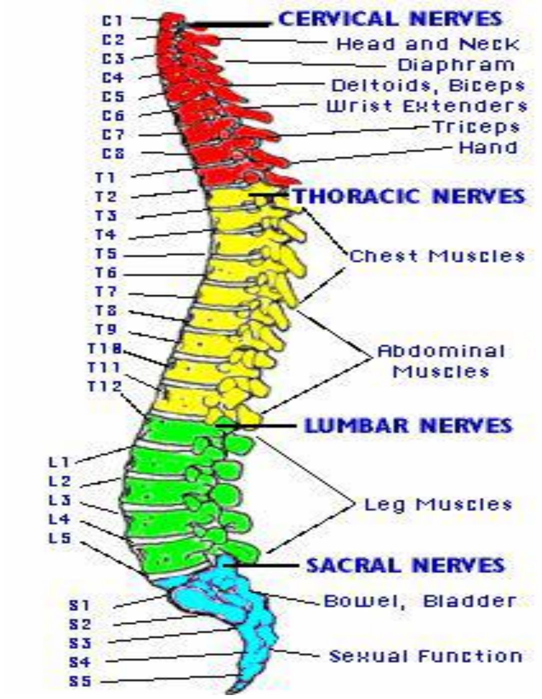
Spinal nerves

• 31 pair

• Attached to spinal cord

Somatic Nervous System (voluntary)

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



• Brings responses back to skeletal muscles for voluntary responses

Autonomic Nervous System (involuntary)

• Regulates bodies involuntary responses

• Relays information to internal organs

• Two divisions

o Sympathetic nervous system – in times of stress

§ Emergency response

§ Fight or flight

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

Major Sense Organ

Sensation and perception

• Vision – Eye

• Hearing – Ear

• Taste – Taste receptors (new)

• Smell – Olfactory system

• Skin – Hot, cold, pressure, pain

Effects of Drugs on the Nervous System

• **Alcohol -** central nervous system **depressant** – cell membranes are highly permeable to alcohol so once in the bloodstream it can diffuse into almost all body tissues. It is absorbed in the stomach so it gets into the blood stream quickly and slows down function of the nervous system

• **Caffeine -** acts as a central nervous system **stimulant -** caffeine suppresses melatonin for up to 10hours and also promotes adrenalin. Melatonin is strongly associated with quality sleep, while adrenalin is the neurotransmitter associated with alertness.

• **Nicotine -** small doses of nicotine have a stimulating action on the central nervous system – it is highly addictive nicotine's effects on the brain cause an increased release of neurotransmitters associated with pleasure. The brain quickly adjusts to repeated nicotine consumption by decreasing the number of neurotransmitters released. The effect of this increased tolerance is that the smoker must continue to use nicotine in order to avoid the feelings of discomfort associated with withdrawal from the drug. Irritability and anxiety often ensue during nicotine withdrawal.

• **Marijuana -** THC, the main active ingredient in marijuana, binds to membranes of nerve cells in the central nervous system that have protein receptors. After binding to nerve cells, THC initiates a chemical reaction that produces the various effects of marijuana use. One of the effects is suppression of memory and learning centers (called the hippocampus) in the brain.

Integumentary system

We will focus on some of them:

BONE TISSUE AND THE SKELETAL SYSTEM

Our skeleton is a structure of living tissue that grows, repairs, and renews itself. The bones within it are dynamic and complex organs that serve a number of important functions, including some necessary to maintain homeostasis.

Bone, or osseous tissue, is a hard, dense connective tissue that forms most of the adult skeleton, the support structure of the body. In the areas of the skeleton where bones move (for example, the ribcage and joints), cartilage, a semi-rigid form of connective tissue, provides flexibility and smooth surfaces for movement. The skeletal system is the body system composed of bones and cartilage and performs the following critical functions for the human body:

- supports the body
- facilitates movement
- protects internal organs
- produces blood cells
- Stores and releases minerals and fat

Support, Movement, and Protection

The most apparent functions of the skeletal system are the gross functions—those visible by observation. Simply by looking at a person, you can see how the bones support, facilitate movement, and protect the human body.

Just as the steel beams of a building provide a scaffold to support its weight, the bones and cartilage of your skeletal system compose the scaffold that supports the rest of your body. Without the skeletal system, you would be a limp mass of organs, muscle, and skin. Bones also facilitate movement by serving as points of attachment for your muscles. While some bones only serve as a support for the muscles, others also transmit the forces produced when your muscles contract. From a mechanical point of view, bones act as levers and joints serve as fulcrums. Unless a muscle spans a joint and contracts, a bone is not going to move. For information on the interaction of the skeletal and muscular systems, that is, the musculoskeletal system, seek additional content.

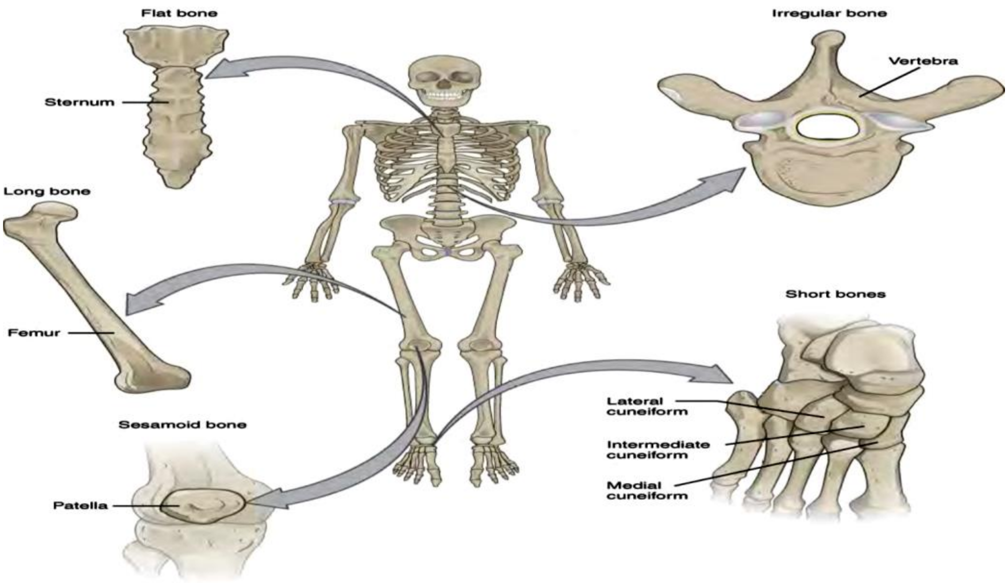
Bones also protect internal organs from injury by covering or surrounding them. For example, your ribs protect your lungs and heart, the bones of your vertebral column (spine) protect your spinal cord, and the bones of your cranium (skull)protect your brain.

Mineral Storage, Energy Storage, and Hematopoiesis

On a metabolic level, bone tissue performs several critical functions. For one, the bone matrix acts as a reservoir for a number of minerals important to the functioning of the body, especially calcium, and potassium. These minerals, incorporated into bone tissue, can be released back into the bloodstream to maintain levels needed to support physiological processes. Calcium ions, for example, are essential for muscle contractions and controlling the flow of other ions involved in the transmission of nerve impulses. Bone also serves as a site for fat storage and blood cell production. The softer connective tissue that fills the interior of most bone is referred to as bone marrow. There are two types of bone marrow: yellow marrow and red marrow. Yellow marrow contains adipose tissue; the triglycerides stored in the adipocytes of the tissue can serve as a source of energy. Red marrow is where hematopoiesis—the production of blood cells—takes place. Red blood cells, white blood cells, and platelets are all produced in the red marrow.

Bone Classification

The 206 bones that compose the adult skeleton are divided into five categories based on their shapes. Their shapes and their functions are related such that each categorical shape of bone has a distinct function.



Bones are classified according to their shape.

Long Bones

A long bone is one that is cylindrical in shape, being longer than it is wide. the shape of a bone, not its size. Long bones are found in the arms (humerus, ulna, radius) and legs (femur, tibia, fibula), as well as in the fingers (metacarpals, phalanges) and toes (metatarsals, phalanges). Long bones function as levers; they move when muscles contract.

Short Bones

A short bone is one that is cube-like in shape, being approximately equal in length, width, and thickness. The only short bones in the human skeleton are in the carpals of the wrists and the tarsals of the ankles. Short bones provide stability and support as well as some limited motion.

Flat Bones

The term “flat bone” is somewhat of a misnomer because, although a flat bone is typically thin, it is also often curved. Examples include the cranial (skull) bones, the scapulae (shoulder blades), the sternum (breastbone), and the ribs. Flat bones serve as points of attachment for muscles and often protect internal organs.

Irregular Bones

An irregular bone is one that does not have any easily characterized shape and therefore does not fit any other Classification. These bones tend to have more complex shapes, like the vertebrae that support the spinal cord and protect it from compressive forces. Many facial bones, particularly the ones containing sinuses, are classified as irregular bones.

Sesamoid Bones

A sesamoid bone is a small, round bone that, as the name suggests, is shaped like a sesame seed. These bones form in tendons (the sheaths of tissue that connect bones to muscles) where a great deal of pressure is generated in a joint. The sesamoid bones protect tendons by helping them overcome compressive forces. Sesamoid bones vary in number and Placement from person to person but are typically found in tendons associated with the feet, hands, and knees. The patellae (singular = patella) are the only sesamoid bones found in common with every person. Reviews bone classifications with their associated features, functions, and examples

Bone Structure

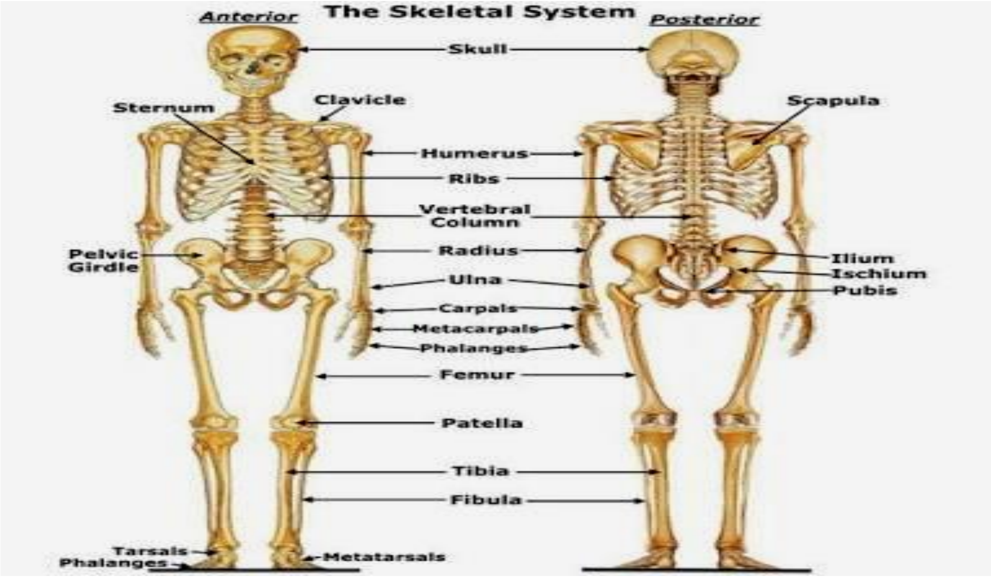
Bone tissue (osseous tissue) differs greatly from other tissues in the body. Bone is hard and many of its functions depend onthat characteristic hardness. Later discussions in this chapter will show that bone is also dynamic in that its shape adjusts to accommodate stresses. This section will examine the gross anatomy of bone first and then move on to its histology.

Gross Anatomy of Bone

The structure of a long bone allows for the best visualization of all of the parts of a bone. 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. 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 18–21 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. In this region, the epiphyses are covered with particular cartilage, a thin layer of cartilage that reduces friction and acts as a shock absorber.

SKELETAL SYSTEM

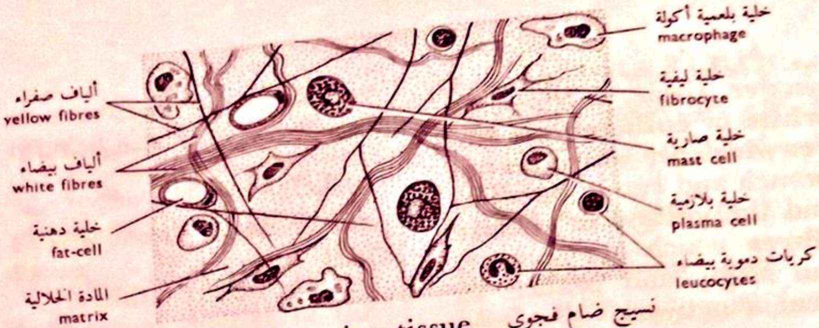
Our skeleton consists of all our bones, teeth, cartilage, and joints. Some bones protect our internal organs. Some bones provide a framework for the body (just as the spokes of an umbrella provide a framework). Some bones contain red marrow that produces blood cells and yellow marrow that also stores fat. the bones that enclose the brain and support the face and teeth



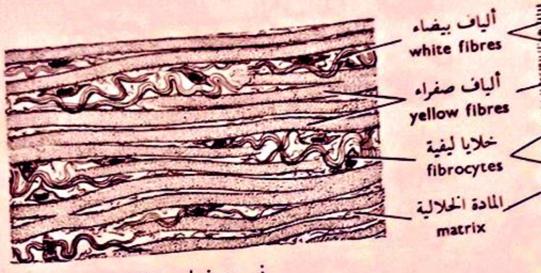
Cartilage

Cartilage is softer than bones and is somewhat flexible, like rubber. The Cartilage connects the ribs to the sternum, allowing the ribs to move as we breathe. Cartilage supports our nose and outer ears. Joints contain some cartilage. Much of an infant's skeleton consists of cartilage, which is gradually replaced by bone. The backbone is made of vertebrae.

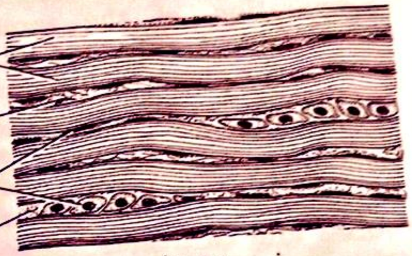
PRACTICAL PART



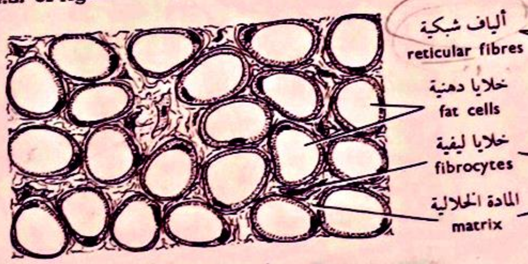
نسيج ضام فجوى
Areolar connective tissue
(From subcutaneous layer (من الطبقة تحت الجلد



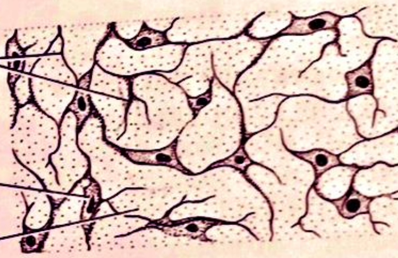
نسيج ضام مرن
Elastic connective tissue
(L.S. of ligamentum nuchae (ق . ط . من الرباط القفوى



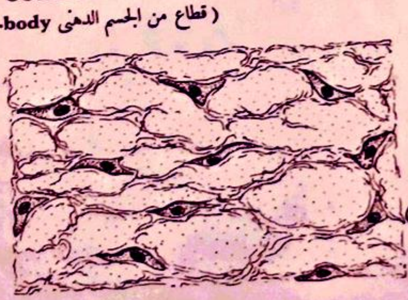
نسيج ضام ليفى
Fibrous connective tissue
(L.S. of tendon (قطاع طولى من وتر



نسيج ضام دهنى
Adipose connective tissue
(S. of Fat-body (قطاع من الجسم الدهنى

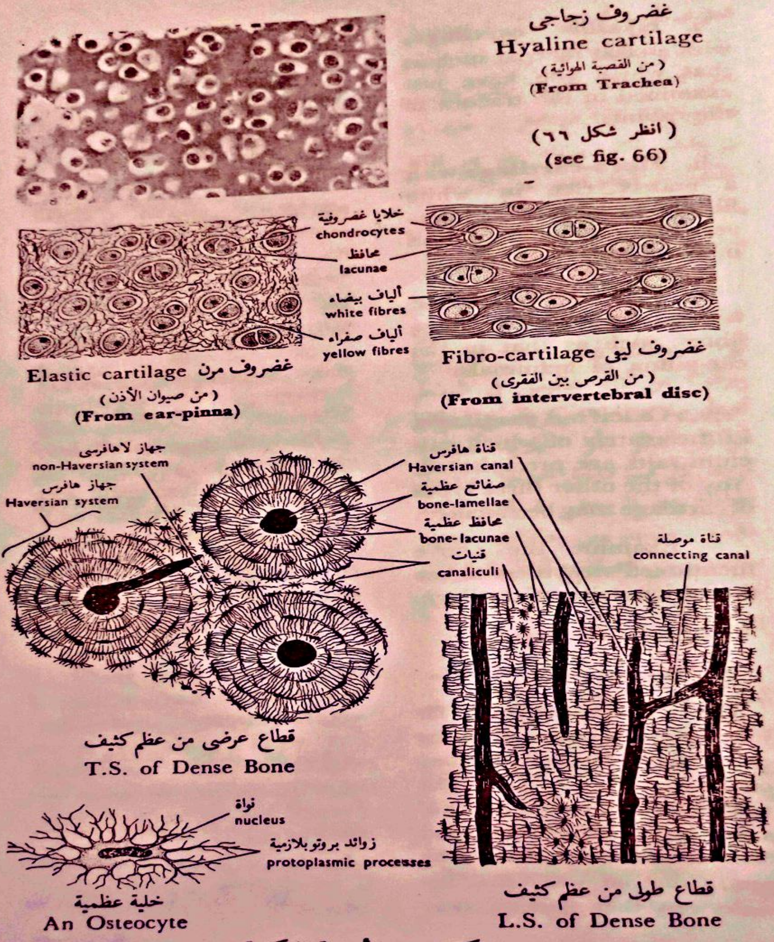


نسيج ضام شبكى
Reticular connective tissue
(S. of lymph gland (قطاع من غدة لمفية

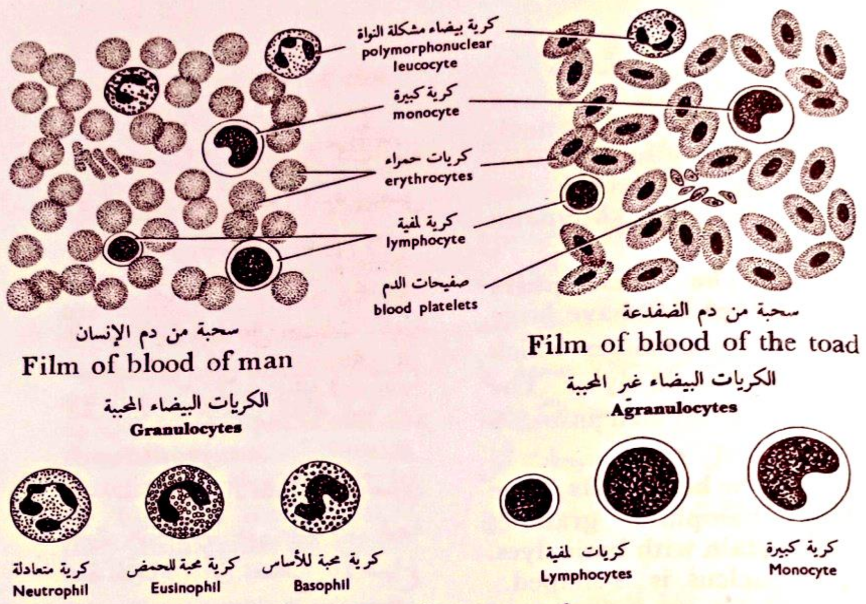


نسيج ضام مخاطى
Mucous connective tissue
(T.S. of umbilical cord (ق . ع . من الحبل السرى

شكل ٣٩ – الأنسجة الضامة الأصيلة
FIG. 39 – CONNECTIVE TISSUES PROPER

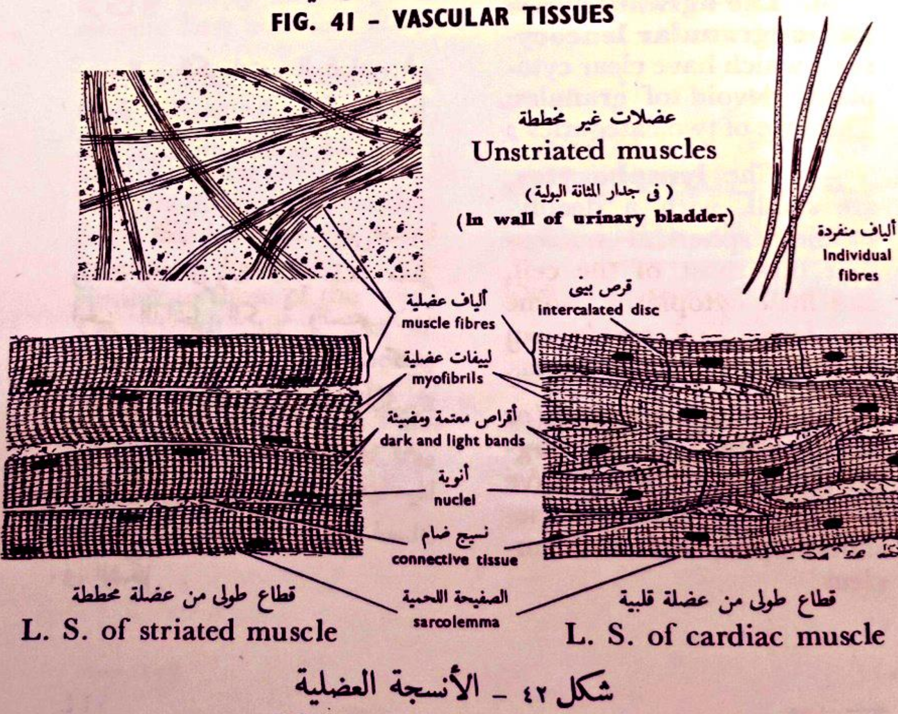


شكل ٤٠ - الأنسجة الهيكلية
FIG. 40 - SKELETAL TISSUES



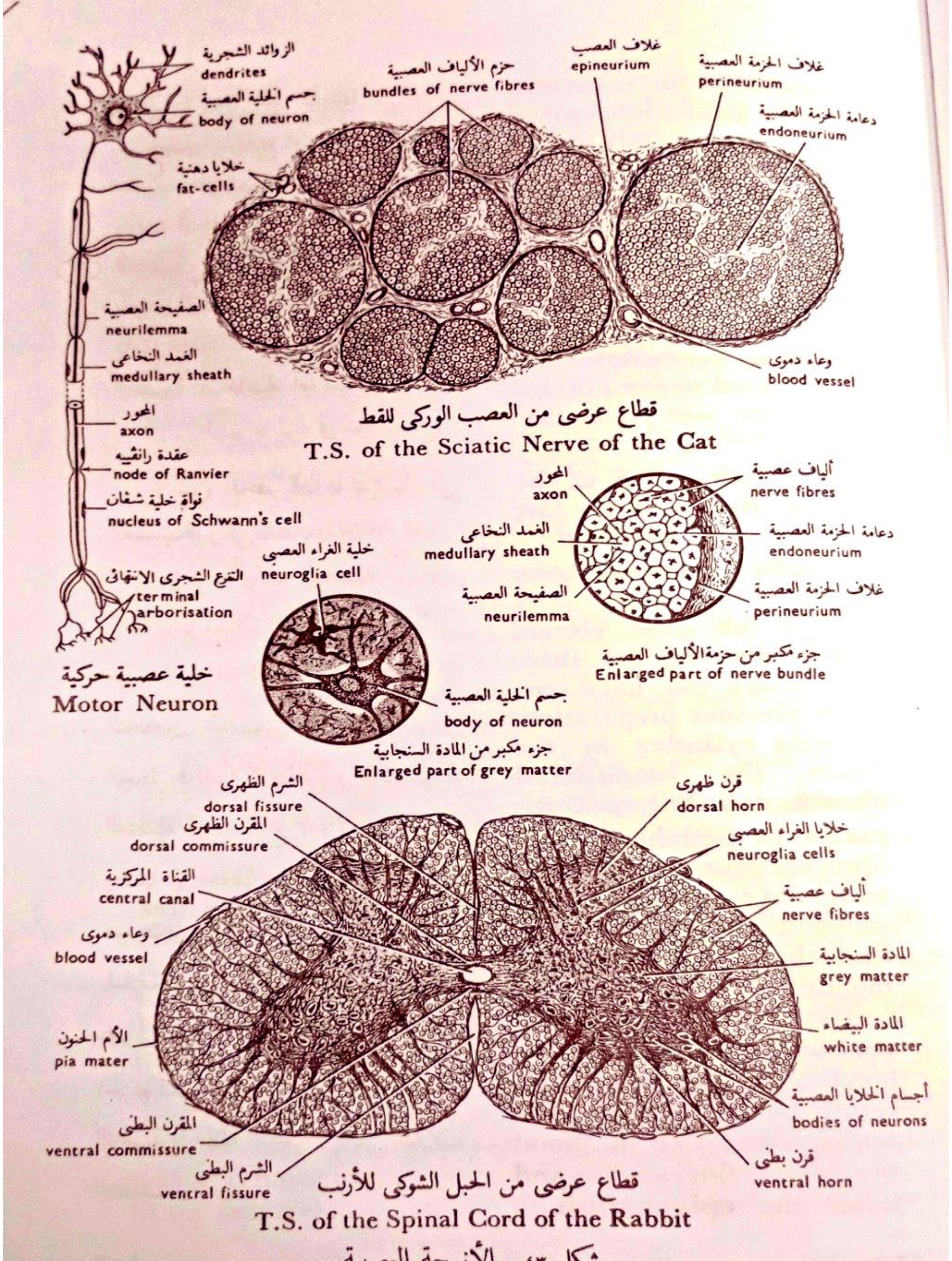
شكل ٤١ - الأنسجة الوعائية

FIG. 41 - VASCULAR TISSUES



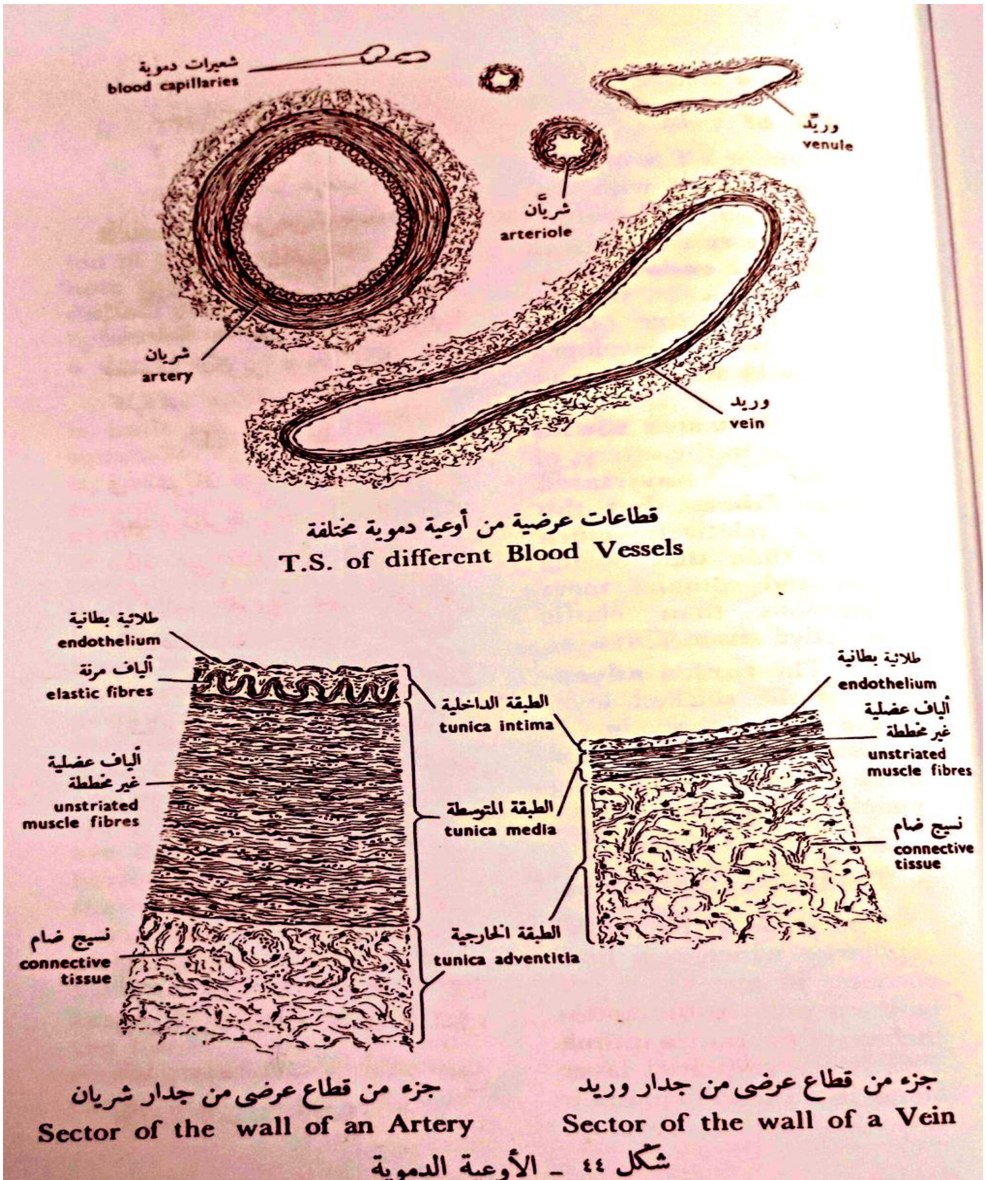
شكل ٤٢ - الأنسجة العضلية

FIG. 42 - MUSCULAR TISSUES



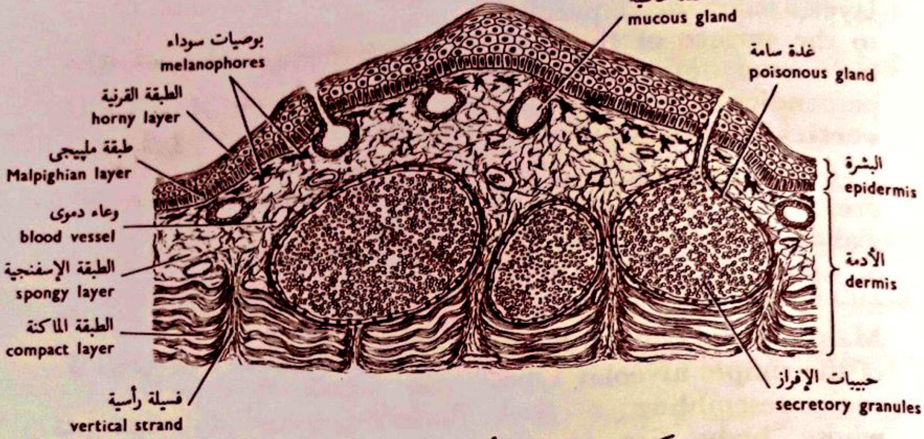
شكل ٤٣ ـ الأنسجة العصبية

FIG. 43 - NERVOUS TISSUES



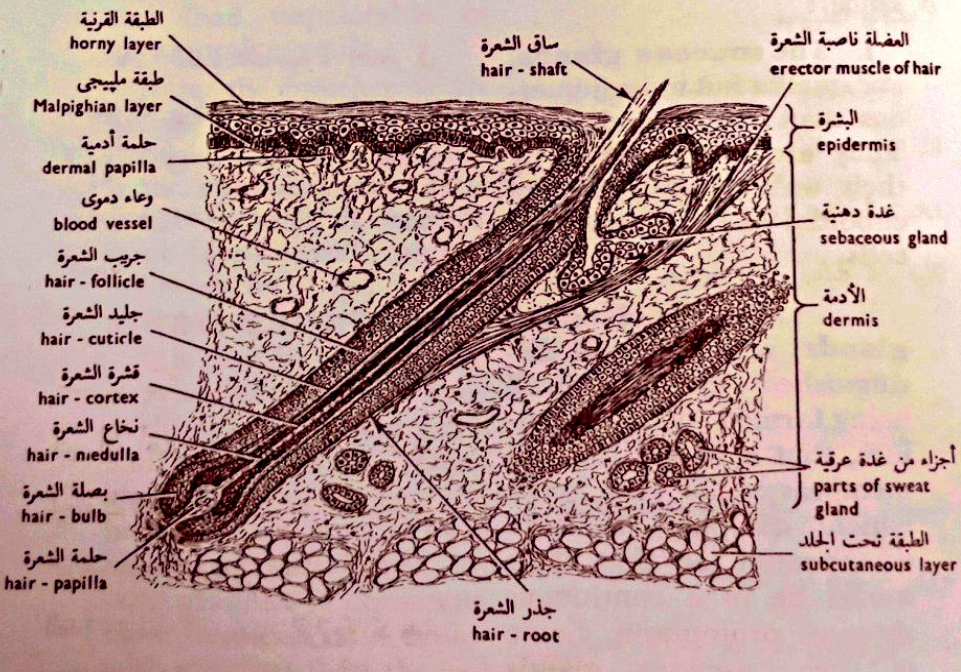
شكل ٤٤ ـ الأوعية الدموية

FIG. 44 - BLOOD VESSELS



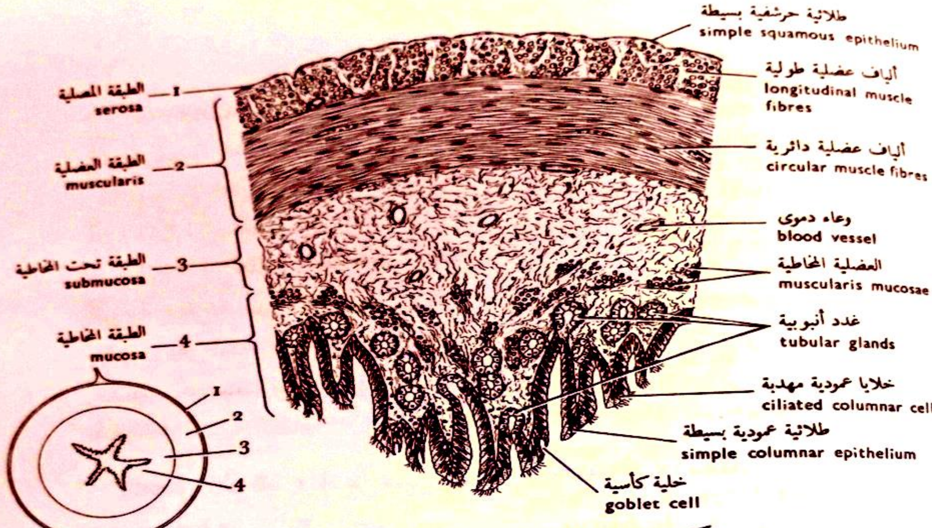
شكل ٤٥ – قطاع رأسى من جلد الضفدعة

FIG. 45 - V.S. OF THE SKIN OF THE TOAD

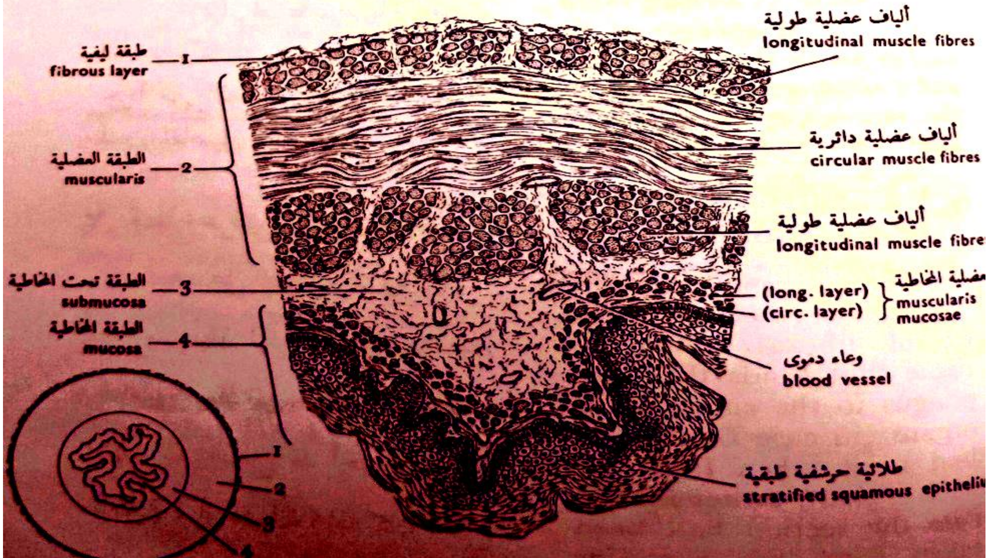


شكل ٤٦ – قطاع رأسى من جلد الخنزير

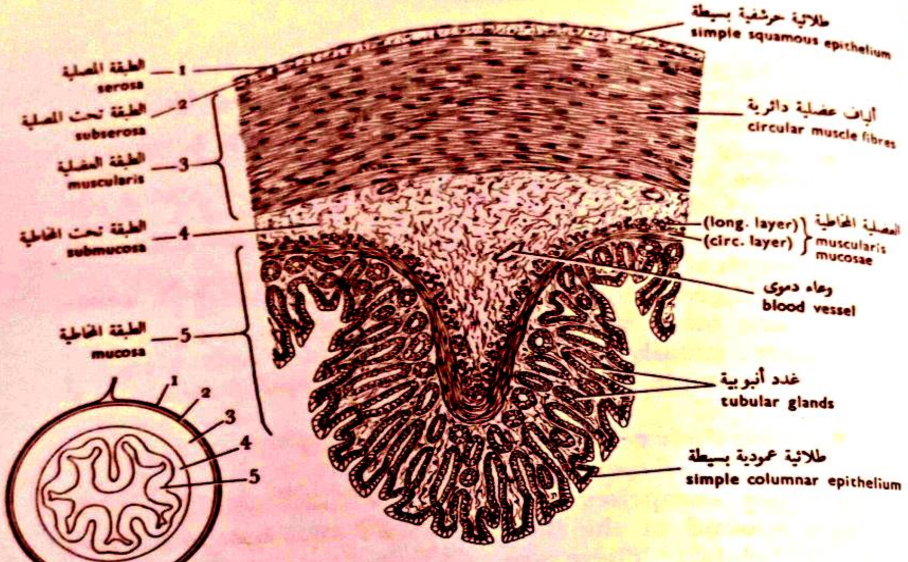
FIG. 46 - V.S. OF THE SKIN OF THE PIG



شكل ٥٢ – قطاع عرضى من مرىء الضفدعة
FIG. 52 – T.S. OF THE OESOPHAGUS OF THE TOAD

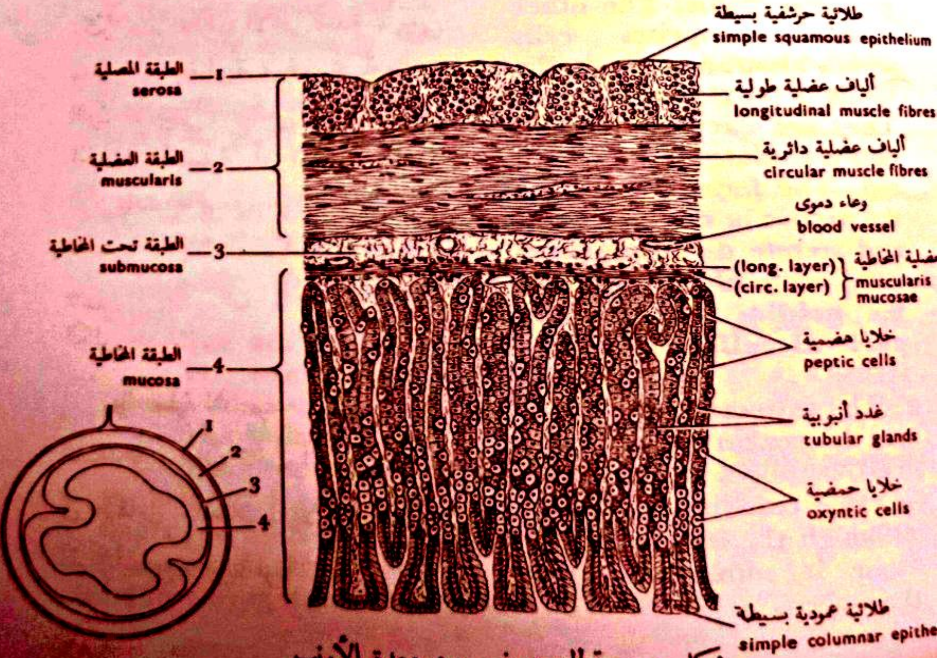


شكل ٥٣ – قطاع عرضى من مرىء الأرنب
FIG. 53 – T.S. OF THE OESOPHAGUS OF THE RABBIT



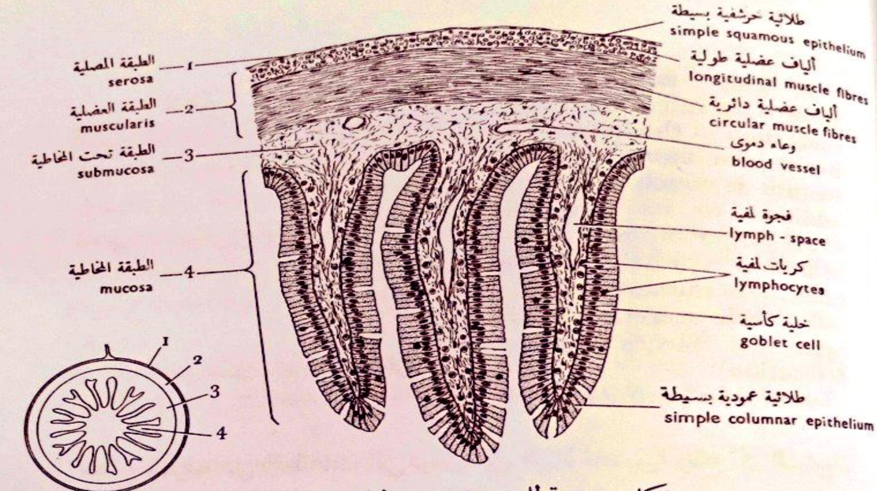
شكل ٥٤ - قطاع عرضى من معدة الضفدعة

FIG. 54 – T.S. OF THE STOMACH OF THE TOAD



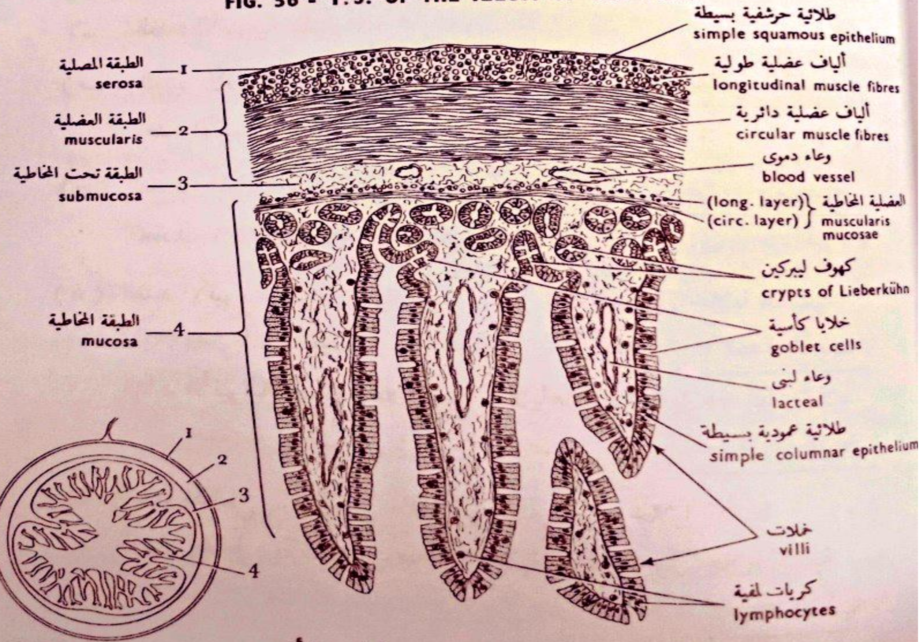
شكل ٥٥ - قطاع عرضى من معدة الأرنب

FIG. 55 – T.S. OF THE STOMACH OF THE RABBIT



شكل ٥٦ – قطاع عرضى من لفائفى الضفدعة

FIG. 56 - T.S. OF THE ILEUM OF THE TOAD



شكل ٥٧ – قطاع عرضى من لفائفى الأرنب

FIG. 57 - T.S. OF THE ILEUM OF THE RABBIT

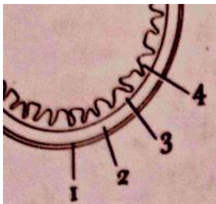
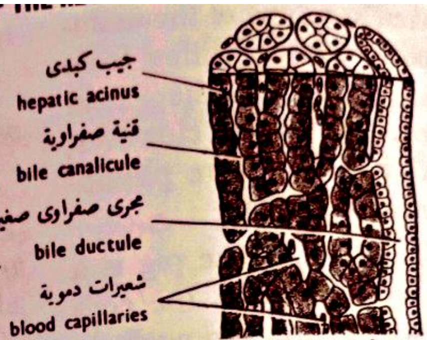
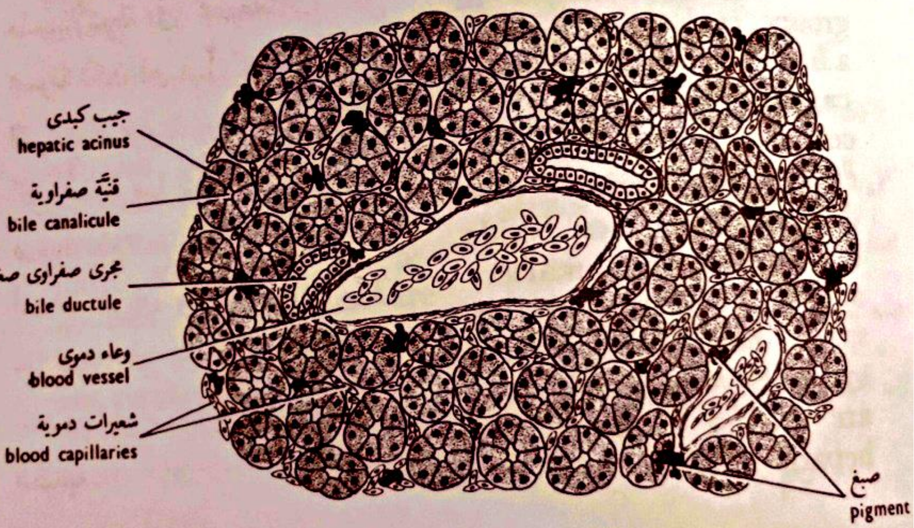


FIG. 58 - T.S. OF THE



رسم توضيحى لبيان تركيب كبد الضفدعة

Illustration of the structure of the Toad's Liver

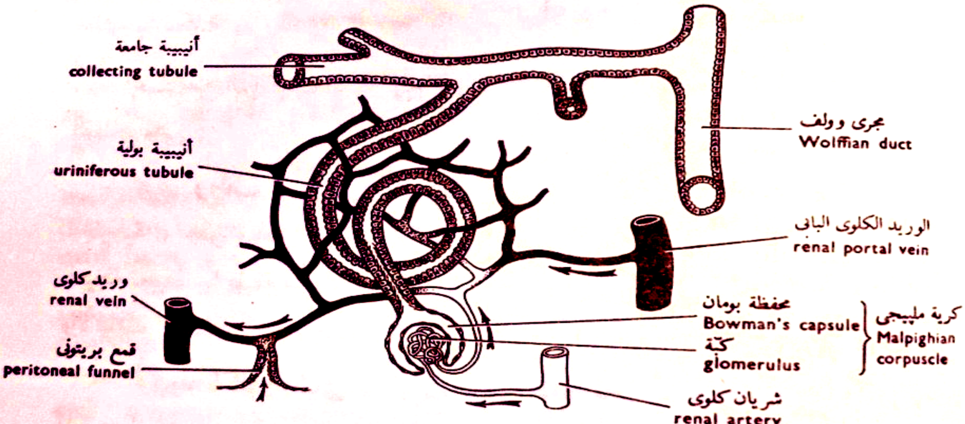


شكل ٥٩ ـ قطاع من كبد الضفدعة

FIG. 59 - S. OF THE LIVER OF OF THE TOAD

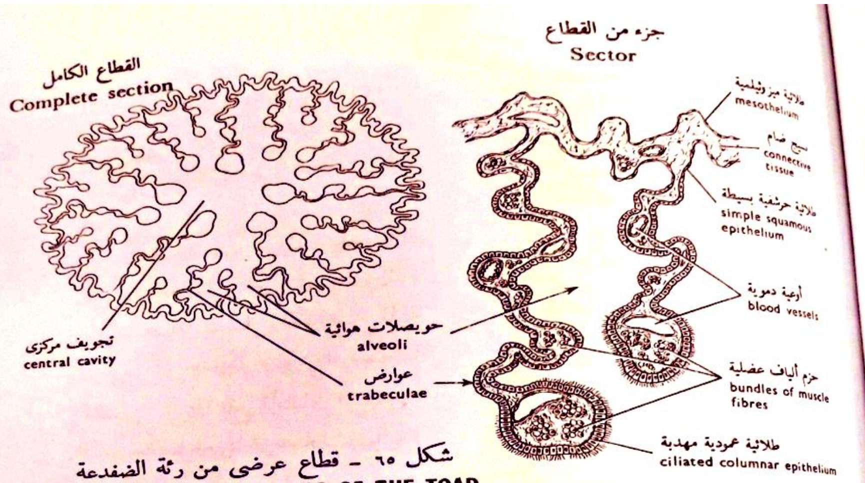
شكل ٦٣ ـ قطاع عرضى من كلية الضفدعة

FIG. 63 - T.S. OF THE KIDNEY OF THE TOAD



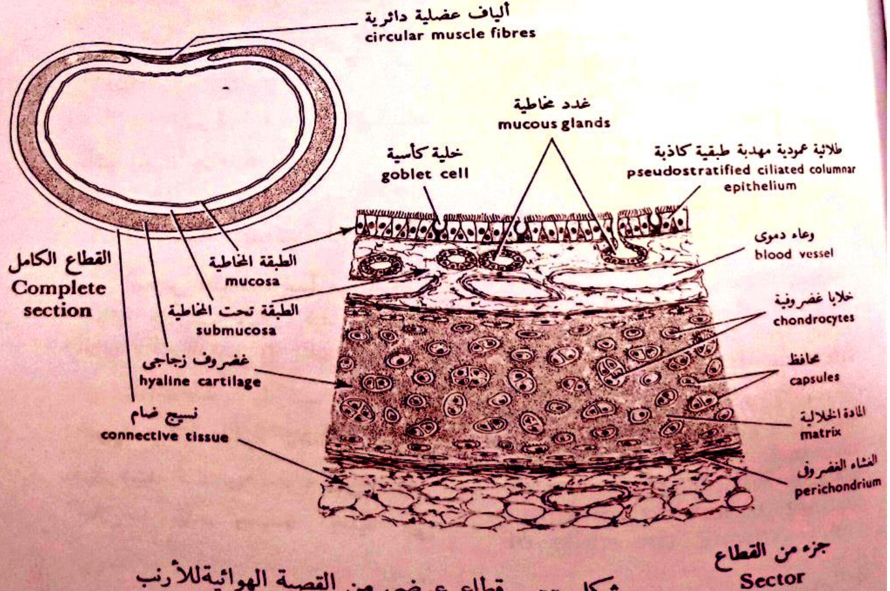
تمثيل تخطيطى يبين الوحدة البولية من كلية الضفدعة

Diagrammatic representation of a Nephric Unit from the Toad's Kidney



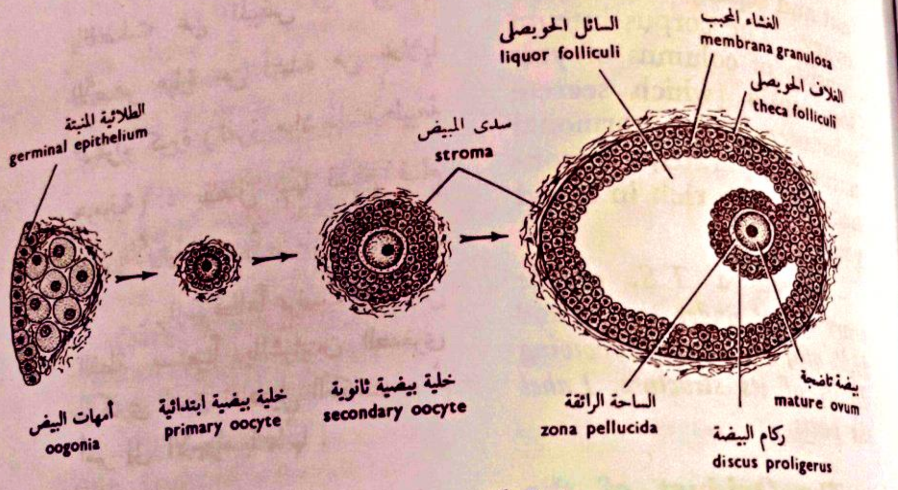
شكل ٦٥ – قطاع عرضى من رئة الضفدعة

FIG. 65 – T.S. OF THE LUNG OF THE TOAD

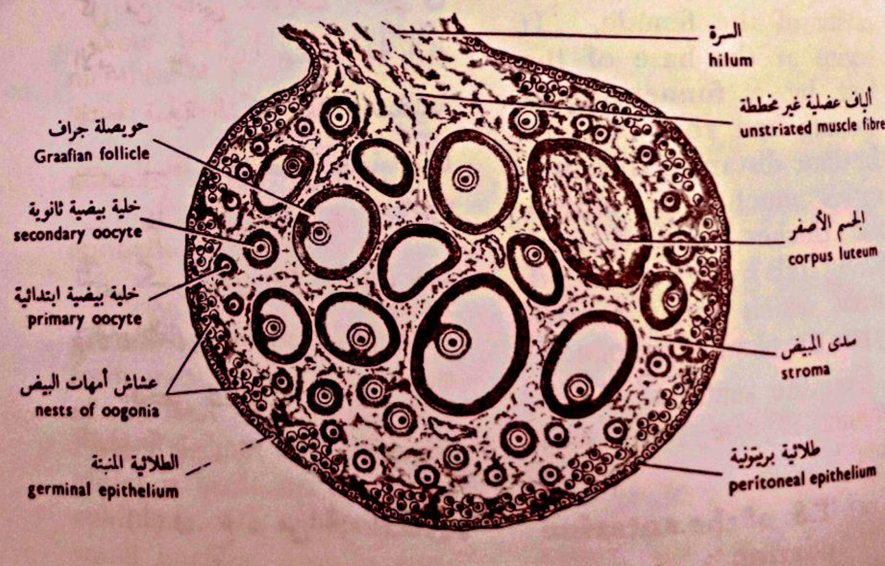


شكل ٦٦ – قطاع عرضى من القصبة الهوائية للأرنب

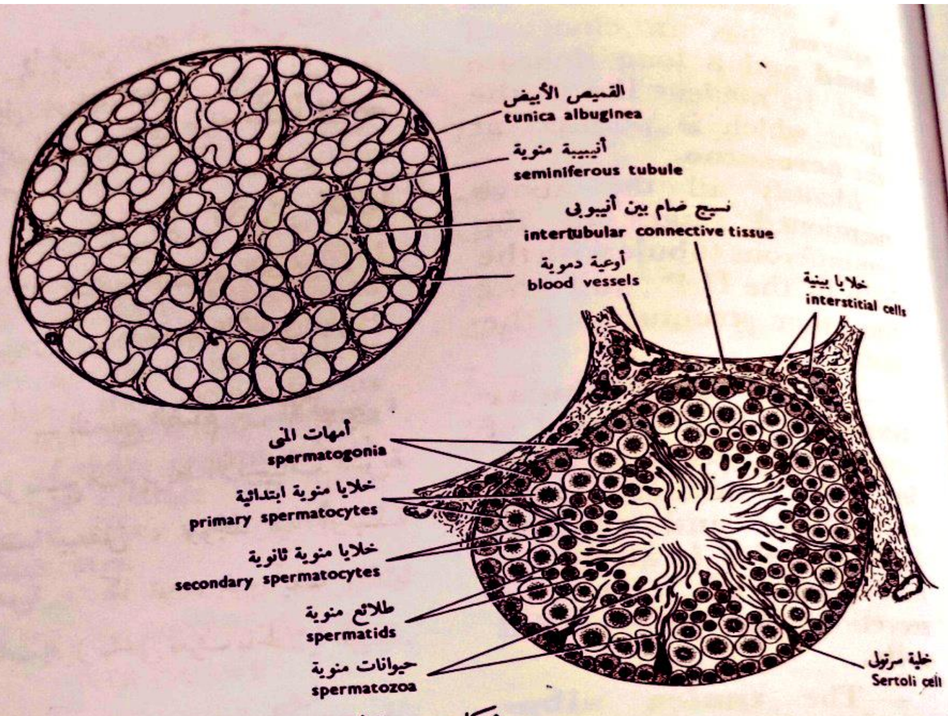
FIG. 66 – T.S. OF THE TRACHEA OF THE RABBIT



مراحل تكوين حويصلة جراف
Developmental stages of a Graafian follicle

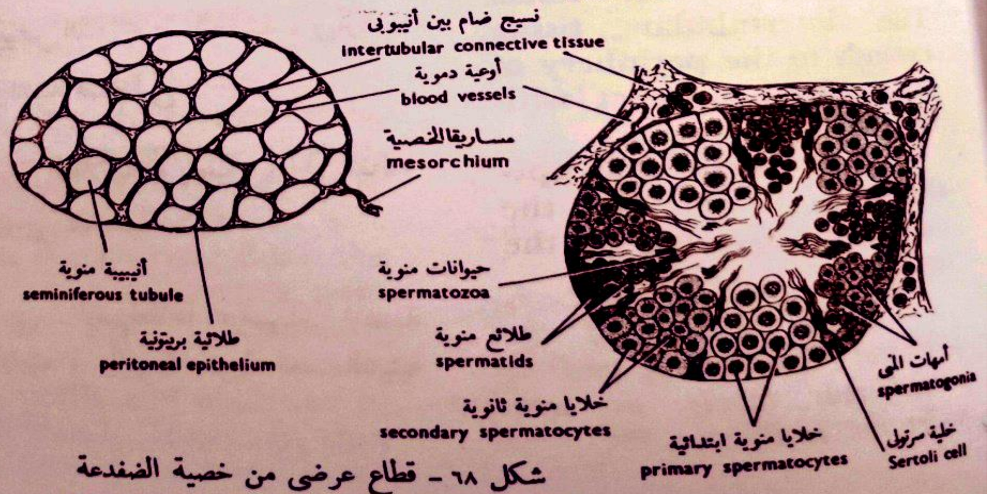


شكل ٧١ – قطاع عرضي من مبيض القطة
FIG. 71 - T. S. OF THE OVARY OF THE CAT



شكل ٦٧ – قطاع عرضى من خصية الفأر
FIG. 67 – T.S. OF THE TESTIS OF THE RAT

الأنيبيبات المنوية
The Seminiferous Tubules



شكل ٦٨ – قطاع عرضى من خصية الضفدعة
FIG. 68 – T.S. OF THE TESTIS OF THE TOAD

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