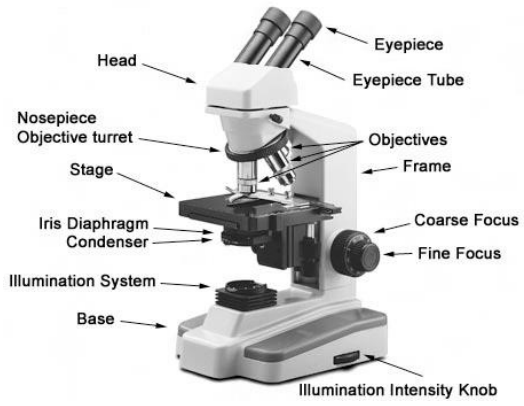
Zoology (1)

Freshman Physics & Chemistry
2022-2023

LECTURE (1)

MICROSCOPY



Applications of laboratory microscopes

- The goal of any laboratory microscope is **to produce clear, high-quality images**.
- whether an optical microscope, which uses light to generate the image.
- a scanning or transmission electron microscope (using electrons).
- or a scanning probe microscope (using a probe).

How do I choose a laboratory microscope?

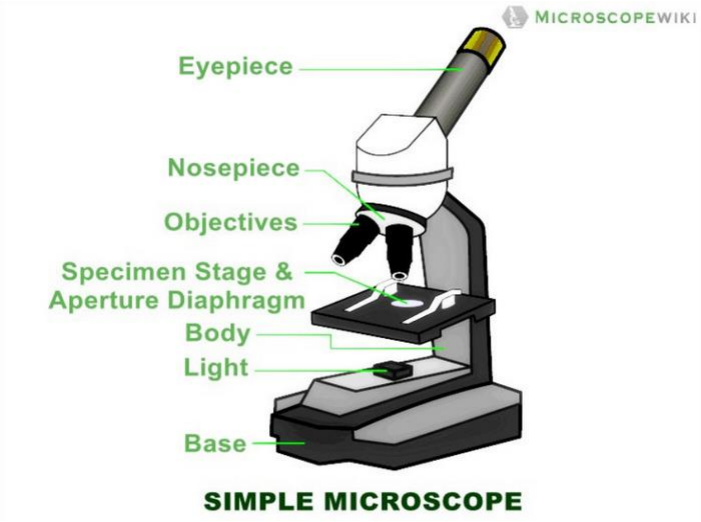
- The basic components of an optical microscope consist of optics, a stage to support the specimen, and a source of light.
- however, these features can be very simple to highly complex, depending on your needs and budget.
- A state-of-the-art design can feature multiple illuminators, polarizers, DIC and phase contrast options, fluorescence attachments, automatic exposure control, and zoom capabilities.

Different Kinds of Microscopes & Their Uses

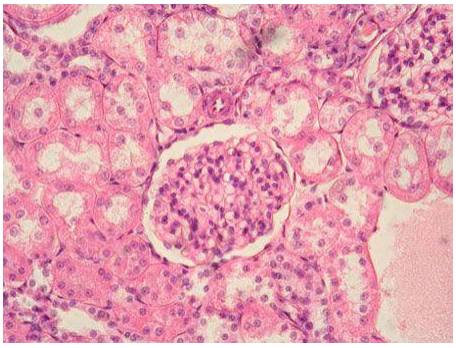
Simple Microscope

- The simple microscope is generally considered to be the first microscope.
- It was created in the 17th century by Antony van Leeuwenhoek
- combined a convex lens with a holder for specimens.
- Magnifying between 200 and 300 times, it was essentially a magnifying glass.
- Today, simple microscopes are not used often because the introduction of a second lens led to the more powerful compound microscope.

Simple Microscope



Simple Microscope

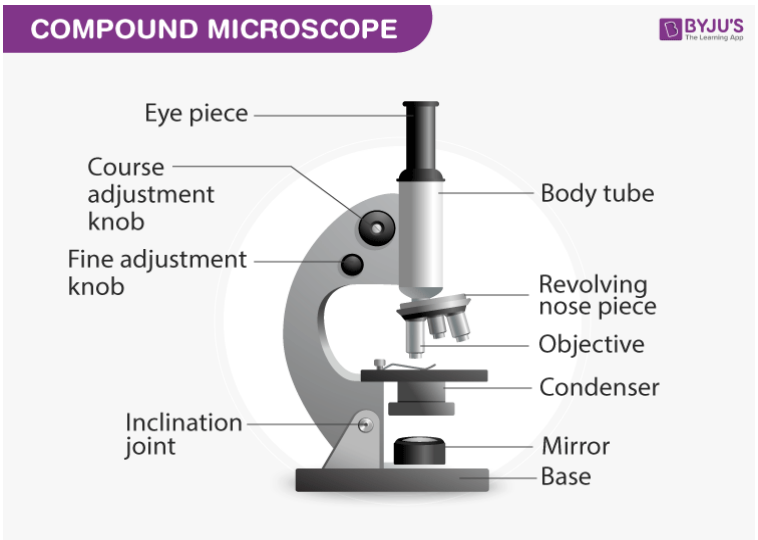


Different Kinds of Microscopes & Their Uses

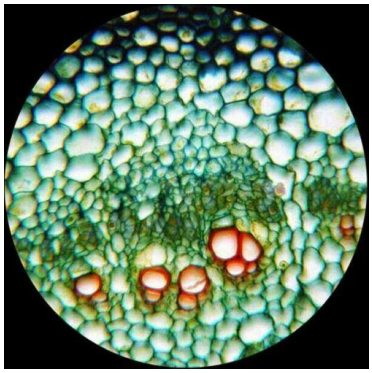
Compound Microscope

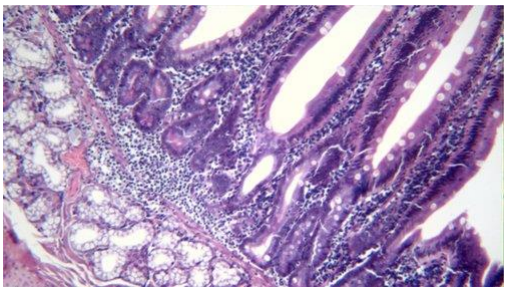
- With two lenses
- offers better magnification than a simple microscope
- the second lens magnifies the image of the first.
- Compound microscopes are bright field microscopes, meaning that the specimen is lit from underneath, and they can be binocular or monocular.
- These devices provide a magnification of 1,000 times.
- they are used everywhere from research labs to high school biology classrooms.

Compound Microscope



Compound Microscope



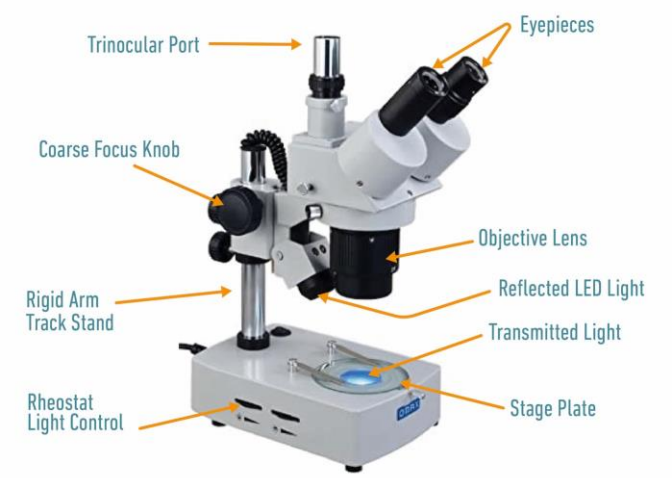


Different Kinds of Microscopes & Their Uses

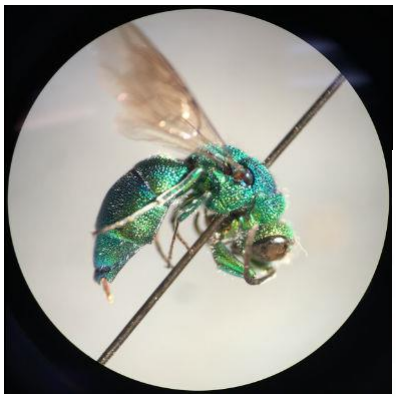
Stereo Microscope

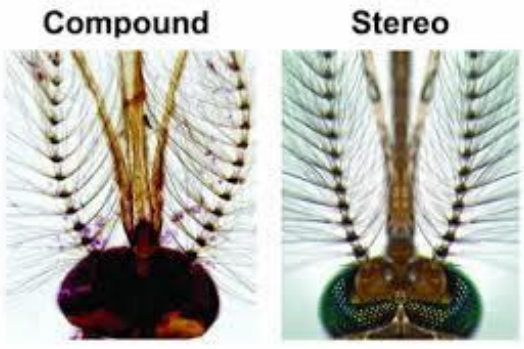
- called a dissecting microscope.
- provides magnification of up to 300 times.
- These binocular microscopes are used to look at opaque objects that are too large to be viewed with a compound microscope. since they do not require a slide preparation.
- magnification is relatively low, they are still useful.
- They provide a close-up, 3-D view of objects' surface textures,
- allow the operator to manipulate the object during viewing.
- used in biological and medical science applications as well as in the electronics industry, such as by those who make circuit boards or watches.

Stereo Microscope



Stereo Microscope



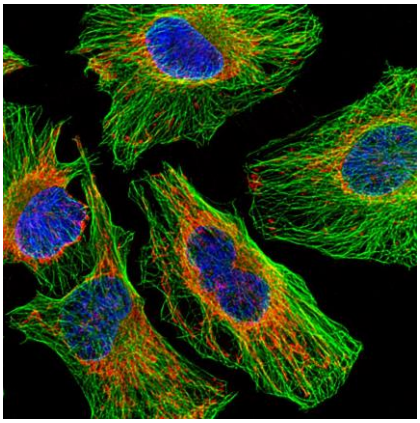


Different Kinds of Microscopes & Their Uses

Confocal Microscope

- uses a laser light to scan samples that have been dyed.
- These samples are prepared on slides and inserted; then, with the aid of a dichromatic mirror, the device produces a magnified image on a computer screen.
- Operators can create 3-D images, as well, by assembling multiple scans.
- offer a high degree of magnification, but their resolution is much better.
- They are commonly used in cell biology and medical applications.

Confocal Microscope

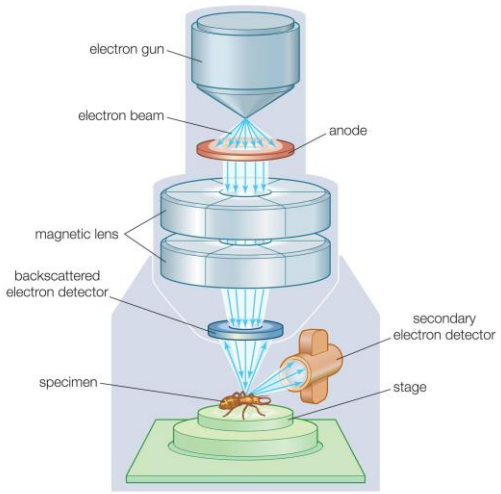


Different Kinds of Microscopes & Their Uses

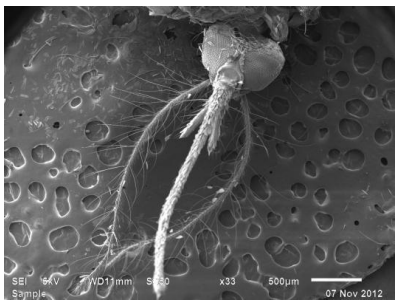
Scanning Electron Microscope (SEM)

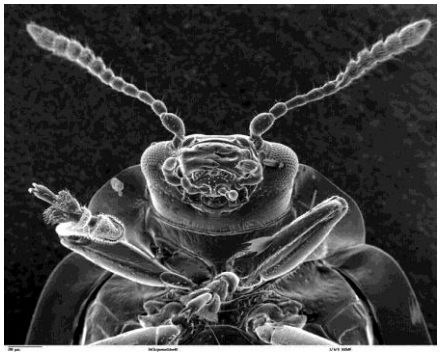
- uses electrons rather than light for image formation.
- Samples are scanned in vacuum or near-vacuum conditions
- they must be specially prepared by first undergoing dehydration and then being coated with a thin layer of a conducive material, such as gold.
- After the item is prepared and placed in the chamber, the SEM produces a 3-D, black-and-white image on a computer screen.
- Offering ample control over the amount of magnification.
- SEMs are used by researchers in the physical, medical and biological sciences to examine a range of specimens from insects to bones.

Scanning Electron Microscope (SEM)



Scanning Electron Microscope (SEM)



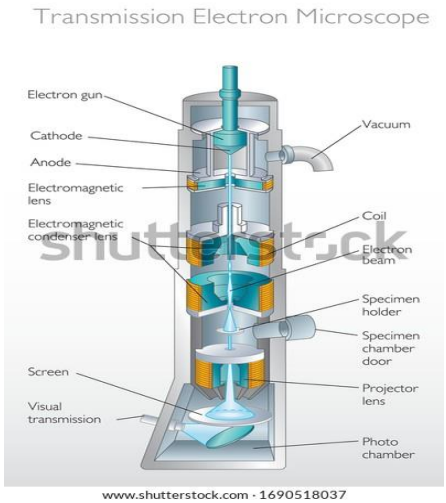


Different Kinds of Microscopes & Their Uses

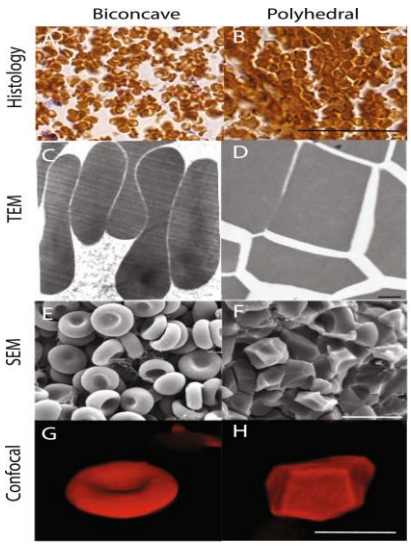
Transmission Electron Microscope (TEM)

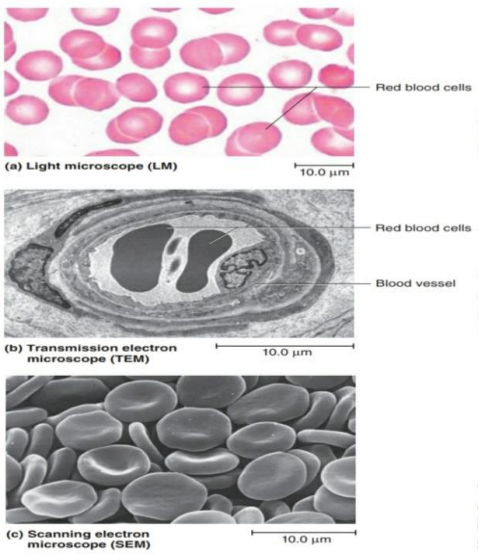
- uses electrons in creating a magnified image.
- samples are scanned in a vacuum so they must be specially prepared.
- Unlike the SEM, however, the TEM uses a slide preparation to obtain a 2-D view of specimens
- it's more suited for viewing objects with some degree of transparency.
- A TEM offers a high degree of both magnification and resolution, making it useful in the physical and biological sciences, metallurgy, nanotechnology and forensic analysis.

Transmission Electron Microscope (TEM)



Transmission Electron Microscope (TEM)





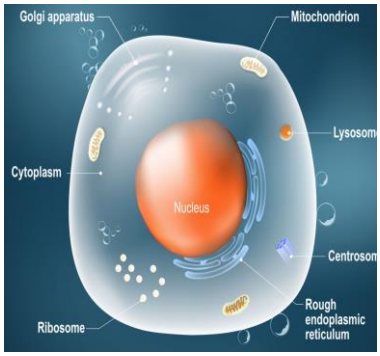
How to use microscope

LECTURE (2)

Cell structure

The Cell

- The cell is the lowest level of structure capable of performing all the activities of life.
- The first cells were observed and named by Robert Hooke in 1665 from slice of cork.

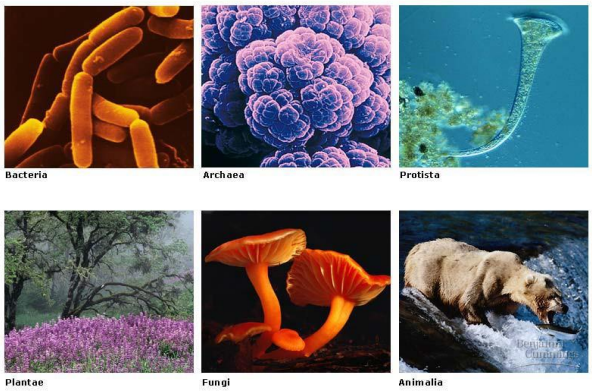


The Cell Theory

- Proposed by Matthais Schleiden and Theodor Schwann in 1839:
- All living things are made up of cells.
- Cells are the smallest working unit of all living things.
- All cells come from preexisting cells through cells division.

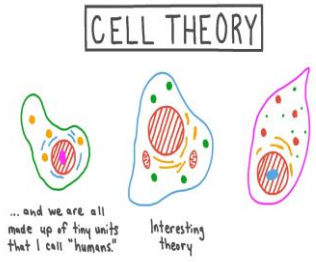
The Cell Theory

- Some organisms consist of a single cells = unicellular organism, others are multicellular aggregates of specialized cells.



The Cell Theory

- Whether multicellular or unicellular, all organisms must accomplish the same functions:
- uptake and processing of nutrients excretion of wastes
- response to environmental stimuli and reproduction among others.



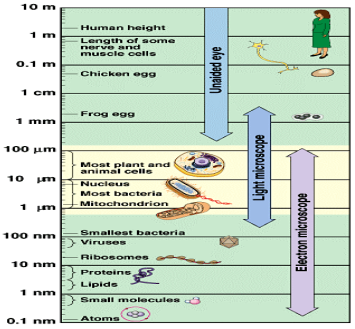
How We Study Cells?

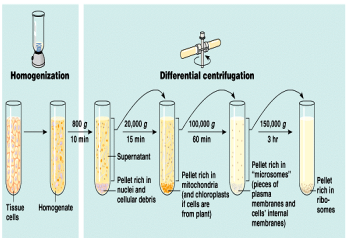
1-Microscope

- Most cells are between 1-100 µm in diameter which can be visualized by light microscope.

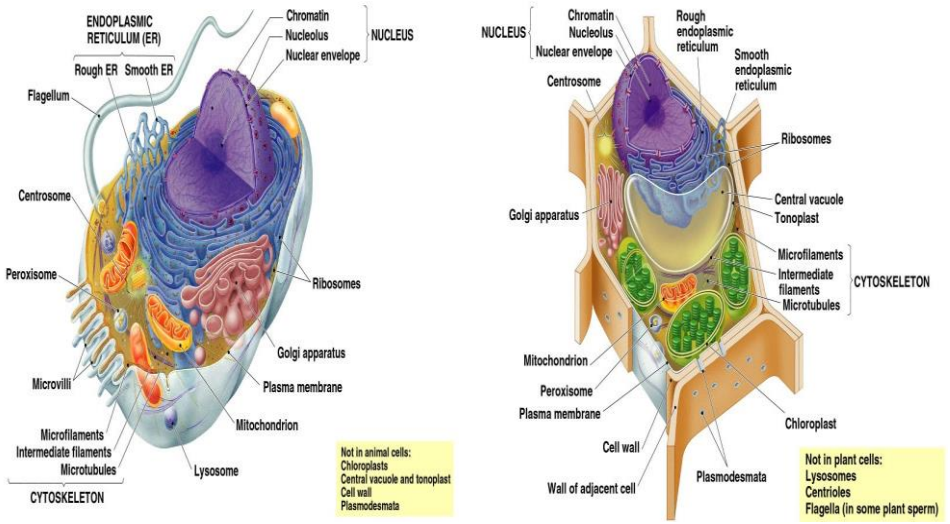
2-Cell Fractionation

- to separate the organelles of cells for functional study
- the disrupted cells are centrifuged at different
- speed and duration to fractionate components of different sizes





Animal and plant cell



Features	Animal Cell	Plant Cell
Cell wall	Absent	Present (formed of cellulose)
Shape	Round (irregular shape)	Rectangular (fixed shape)
Vacuole	One or more small vacuoles (much smaller than plant cells).	One, large central vacuole taking up to 90% of cell volume.
Centrioles	Present in all animal cells	Only present in lower plant forms (e.g. chlamydomonas)
Chloroplast	Absent	Plant cells have chloroplasts to make their own food.
Plasma Membrane	Only cell membrane	Cell wall and a cell membrane
Flagella	Present in some cells (e.g. mammalian sperm cells)	Present in some cells (e.g. sperm of bryophytes and pteridophytes, cycads and Ginkgo)
Lysosomes	Lysosomes occur in cytoplasm.	Lysosomes usually not evident.
Nucleus	Present	Present
Cilia	Present	Most plant cells do not contain cilia.

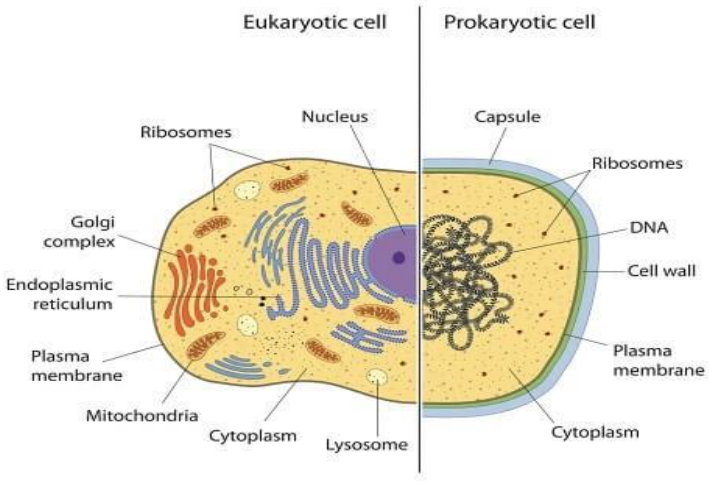
Basic features of cells

- All cells are bounded by a plasma membrane.
- The semifluid substance within the membrane is the cytosol, containing the organelles.
- All cells contain chromosomes which carry genes in the form of DNA.
- All cells also have ribosomes, tiny organelles that make proteins using the instructions contained in genes.

Basic features of cells

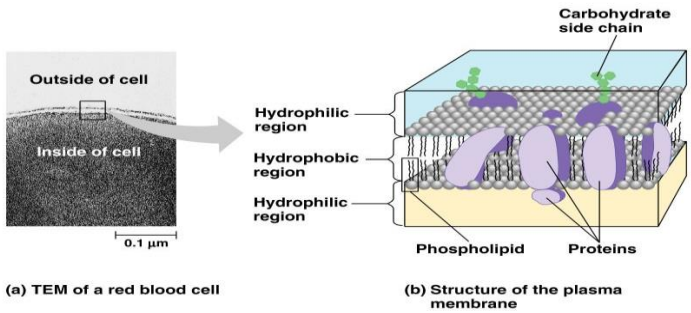
- A major difference between prokaryotic and eukaryotic cells is the location of chromosomes.
- eukaryotic cell, chromosomes are contained in a membrane-enclosed organelle, the nucleus.
- prokaryotic cell, the DNA is concentrated in the nucleoid without a membrane separating it from the rest of the cell.

Basic features of cells



The Plasma Membrane

- double layer of phospholipids
- various proteins are attached to it
- carbohydrate side chains are found only on the outer surface of plasma membrane

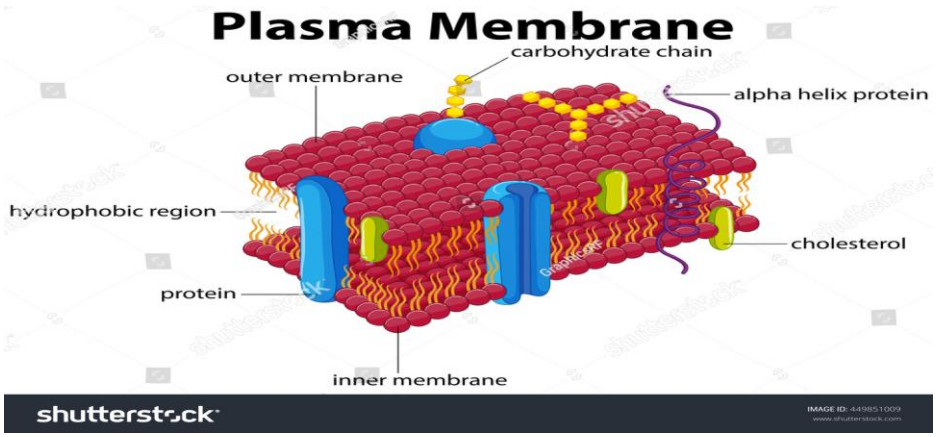


(a) TEM of a red blood cell

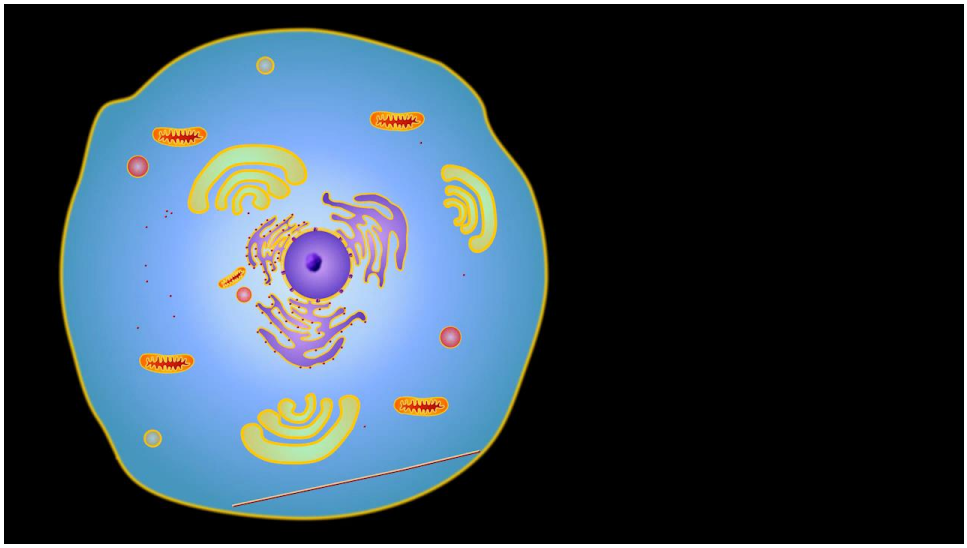
(b) Structure of the plasma membrane

function of plasma membrane

selective barrier that allows passage of oxygen, nutrients, and wastes for the whole volume of the cell.



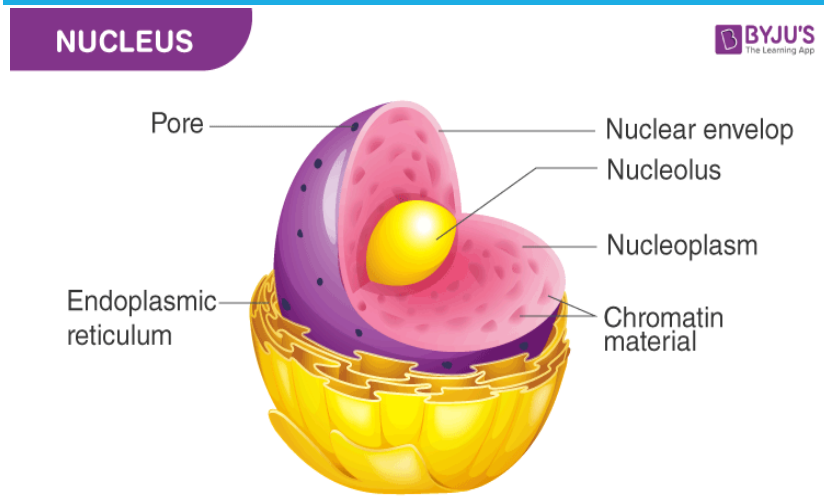
Plasma membrane



The Nucleus and Its Envelope

- The nucleus contains most of the genes in a eukaryotic cell.
- Some genes are in mitochondria and chloroplast
- The nucleus averages about 5 microns in diameter.
- The nucleus is enclosed by a nuclear envelope which is a double membrane of 20 -40 nm apart.
- Where the double membranes are fused, a nuclear pore complex allows large macromolecules and particles to pass through.
- The nuclear side of the envelope is lined by the nuclear lamina, a network of intermediate filaments that maintain the shape of the nucleus.

The Nucleus and Its Envelope



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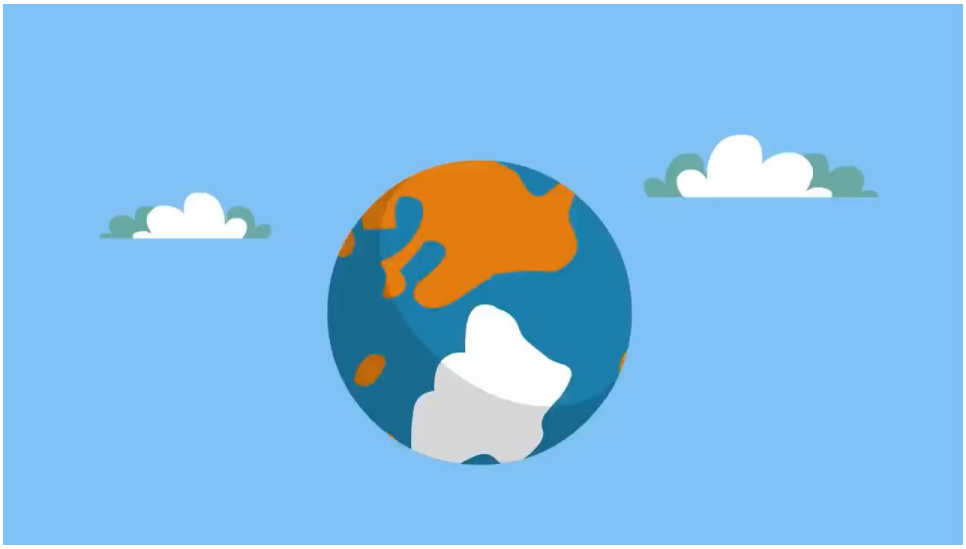
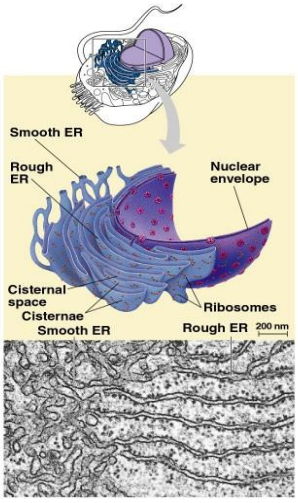


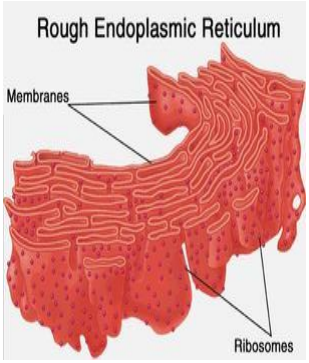
Endoplasmic reticulum (ER)

- ER consists of a network of membranous tubules and sacs called cisternae. (cisterna = a reservoir for a liquid)
- the network are interconnected
- The ER membrane is continuous with the nuclear envelope and the cisternal space of the ER is continuous with the space between the two membranes of the nuclear envelope.



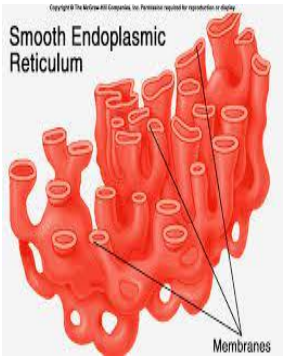
Types of Endoplasmic reticulum (ER)

- Rough ER is named for its rough appearance.
- which is due to the ribosomes attached to its outer (cytoplasmic) surface.
- Rough ER lies immediately adjacent to the cell nucleus, and its membrane is continuous with the outer membrane of the nuclear envelope.
- The ribosomes on rough ER specialize in the synthesis of proteins that possess a signal sequence that directs them specifically to the ER for processing.

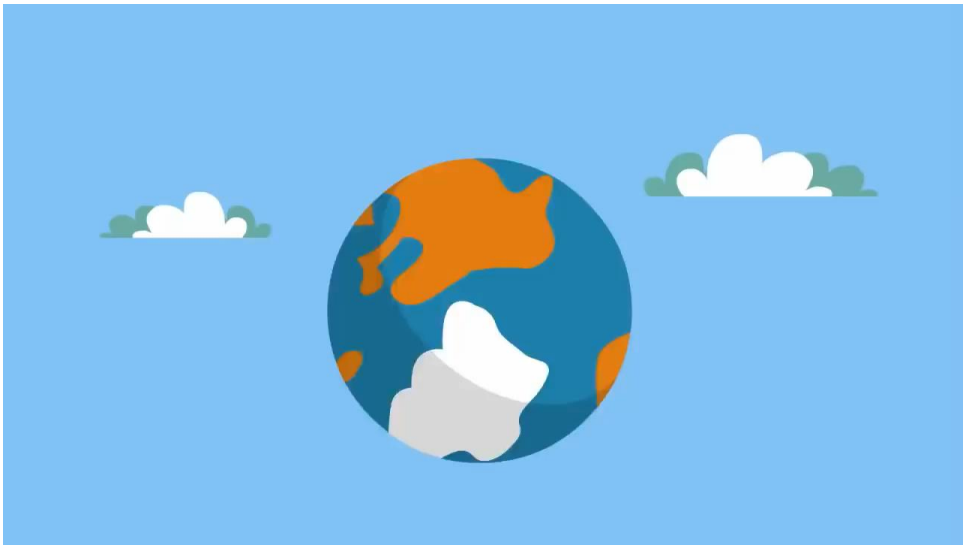


Types of Endoplasmic reticulum (ER)

- Smooth endoplasmic reticulum (SER), meshwork of fine disklike tubular membrane vesicles.
- part of a continuous membrane organelle within the cytoplasm of eukaryotic cells, that is involved in the synthesis and storage of lipids, including cholesterol and phospholipids, which are used in the production of new cellular membrane.
- The smooth endoplasmic reticulum (SER) is distinguished from the rough endoplasmic reticulum (RER).



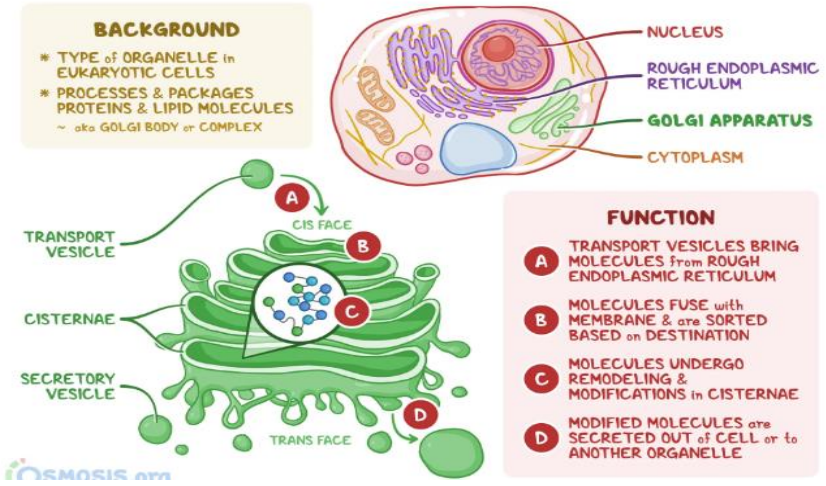
Endoplasmic reticulum (ER)



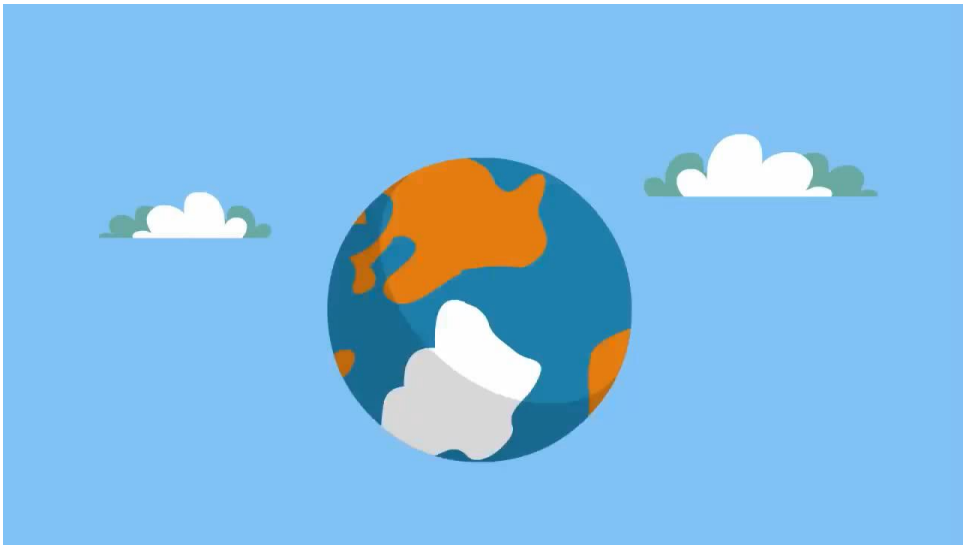
The Golgi apparatus

- Golgi apparatus, also called Golgi complex or Golgi body.
- membrane-bound organelle of eukaryotic cells that is made up of a series of flattened, stacked pouches called cisternae.
- The Golgi apparatus is responsible for transporting, modifying, and packaging proteins and lipids into vesicles for delivery to targeted destinations.
- It is located in the cytoplasm next to the endoplasmic reticulum and near the cell nucleus.

The Golgi apparatus

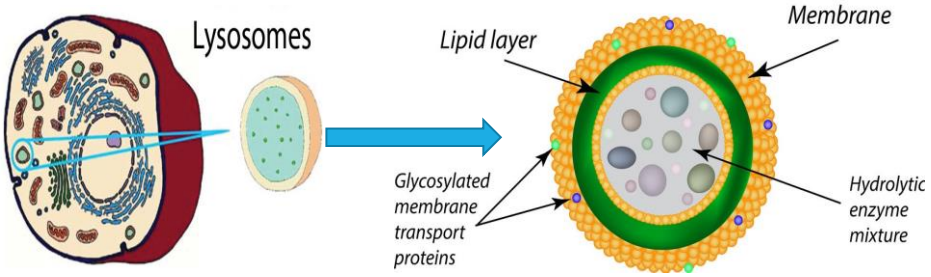


The Golgi apparatus

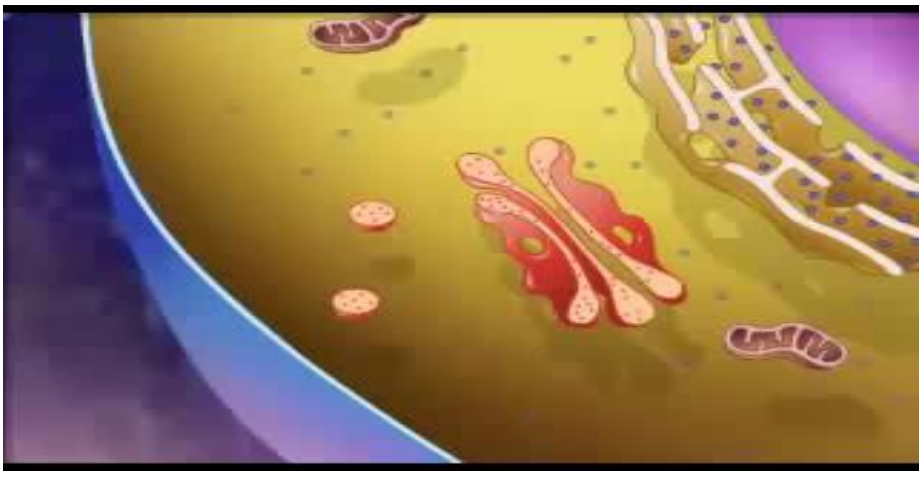


Lysosomes: principal sites of intracellular digestion

- contain hydrolytic enzymes (required acidic pH) to digest proteins, polysaccharides, fats and nucleic acids.
- if those hydrolases leak out of the lysosmes, they are not likely to do damage unless the cells become acidic

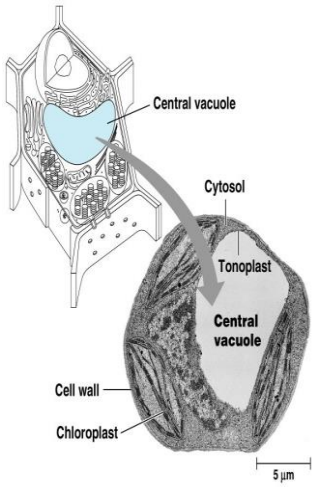


Lysosomes: principal sites of intracellular digestion



Vacuoles

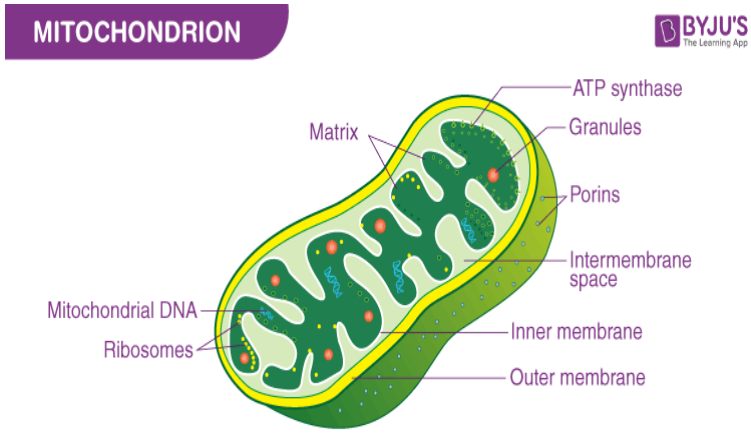
- membrane-bound sacs
- diverse functions in cell maintenance
- food vacuoles formed by phagocytosis and digested by lysosomes
- contractile vacuoles (in protists) pump excess water out of the cells.
- central vacuole (a versatile compartment in plants) stores protein and metabolic by-products, reservoir of inorganic ions, pigments



Mitochondria

- is energy transformer of cells
- mitochondria = cellular respiration
- mitochondrion, membrane-bound organelle found in the cytoplasm of almost all eukaryotic cells.
- the primary function of which is to generate large quantities of energy in the form of adenosine triphosphate (ATP).
- Mitochondria are typically round to oval in shape and range in size from 0.5 to 10 µm. In addition to producing energy, mitochondria store calcium for cell signaling activities, generate heat, and mediate cell growth and death.

Mitochondria

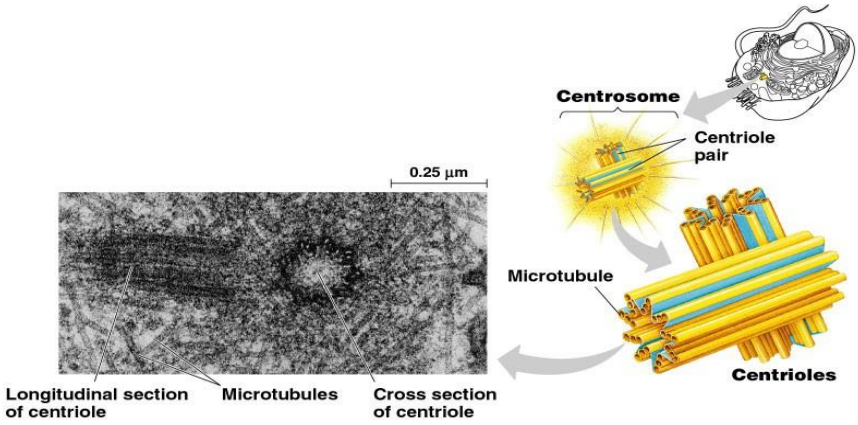


Mitochondria

Excerpt from a biomedical animation project.

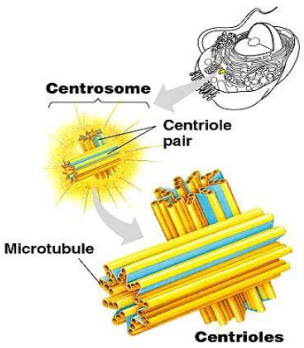
Centrosomes and Centrioles

Centrosomes (microtubule-organizing center) = a region near the nucleus from which microtubules sprouts.



Centrioles

- each centrosomes contain a pair of centrioles
- found in animal cells
- composed of 9 sets of triplet microtubules arranged in a ring
- centrioles replicate before cell division may help organize microtubule assembly
- but centrioles are not essential for this function: centrosomes of most plants lack centrioles



Centrioles

The Cytoskeleton

Network of fibers extending throughout the cytoplasm

function:

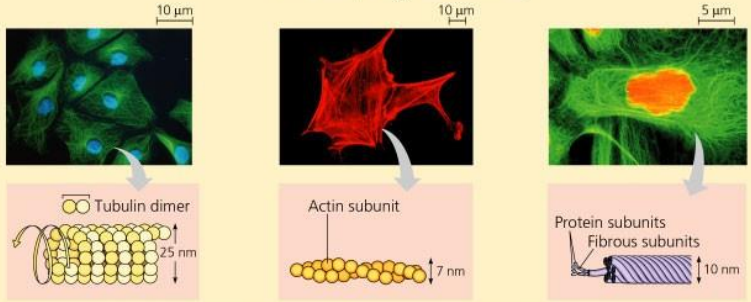
- provide mechanical strength to the cell establish cell shape
- locomotion (several types of cell motility) intracellular transport of organelles

3 main types of fiber:

- microtubules: determine the positions of membrane- enclosed organelles and intracellular transport
- microfilament: determine the shape of the cell and necessary for the whole cell locomotion
- intermediate filament: provide mechanical strength and resistance to shear stress

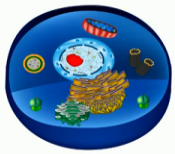
Table 7.2 The Structure and Function of the Cytoskeleton

Property	Microtubules	Microfilaments (Actin Filaments)	Intermediate Filaments
Structure	Hollow tubes; wall consists of 13 columns of tubulin molecules	Two intertwined strands of actin	Fibrous proteins supercoiled into thicker cables
Diameter	25 nm with 15-nm lumen	7 nm	8–12 nm
Protein subunits	Tubulin, consisting of α-tubulin and β-tubulin	Actin	One of several different proteins of the keratin family, depending on cell type
Main functions	Maintenance of cell shape (compression-resisting "girders") Cell motility (as in cilia or flagella) Chromosome movements in cell division Organelle movements	Maintenance of cell shape (tension-bearing elements) Changes in cell shape Muscle contraction Cytoplasmic streaming Cell motility (as in pseudopodia) Cell division (cleavage furrow formation)	Maintenance of cell shape (tension-bearing elements) Anchorage of nucleus and certain other organelles Formation of nuclear lamina



SOURCE: Adapted from W. M. Becker, L. J. Kleinsmith, and J. Hardin, *The World of the Cell*, 4th ed. (San Francisco, CA: Benjamin Cummings, 2000), p. 753.

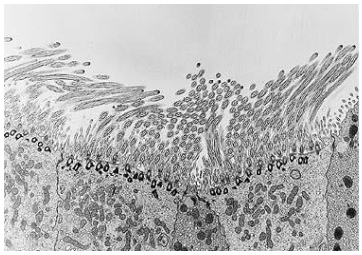
The Cytoskeleton

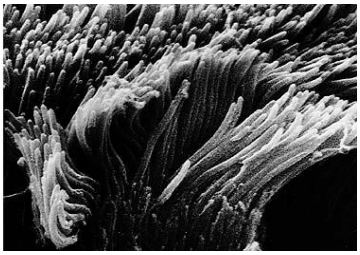


Cilia and Flagella

- both cilia and flagella are constructed from microtubules
- both provide either locomotion for the cell or move fluid pass the cell
- found in prokaryotes and eukaryotes
- cilia and flagella differ in their beating pattern

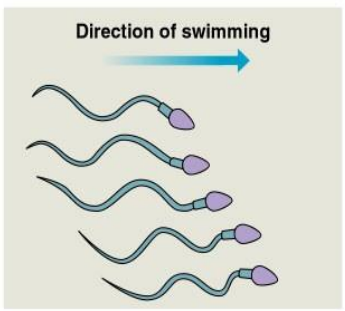
- cilia sweep mucus carrying trapped debris from the lungs.

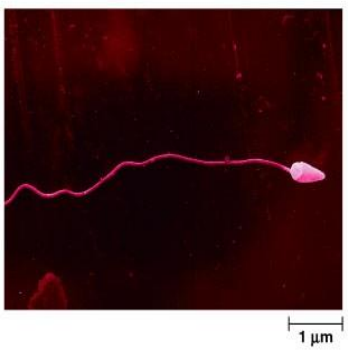




Cilia and Flagella

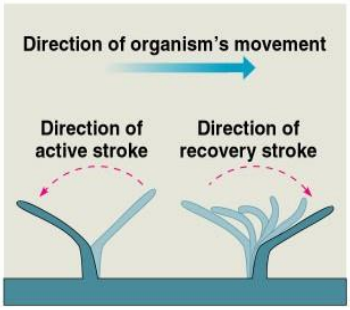
- A flagellum has an undulating motion that generates force in the same direction as the flagellum's axis.

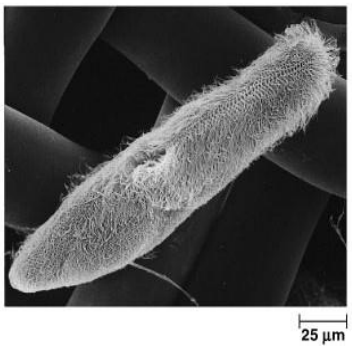




Cilia and Flagella

- Cilia works like oars. The alternating power and recovery strokes generating force in a direction perpendicular to the cilium's axis.





(b) Motion of cilia

Cilia and Flagella

LECTURE (3)

Cell division

Cell Division

When do cells divide?

- Cells divide for many reasons.
- cells divide to replace old, dead, or damaged cells.
- Cells also divide so living things can grow.
- When organisms grow, it isn't because cells are getting larger. Organisms grow because cells are dividing to produce more and more cells. In human bodies, nearly two trillion cells divide every day.

Cell Division

How Many Cells Are in Your Body?

- You and I began as a single cell, or what you would call an egg.
- By the time you are an adult, you will have trillions of cells.
- That number depends on the size of the person, but biologists put that number around 37 trillion cells. Yes, that is trillion with a "T."

Cell size

- One of most important factors affecting size of the
- cell is size of cell membrane
- Cell must remain relatively small to survive (why?)
- Cell membrane has to be big enough to take in nutrients and eliminate wastes
- As cells get bigger, the volume increases faster than the surface area
- Small cells have a larger surface area to volume ratio than larger cells to help with nutrient intake and waste elimination
- When a cell reaches its max size, the nucleus starts cell division: called MITOSIS or MEIOSIS

Mitosis

- General Information
- Occurs in somatic (body) cells ONLY!!
- Nickname: called “normal” cell division
- Produces somatic cells only

Background Info:

- Starts with somatic cell in DIPLOID (2n) state
- Cell contains homologous chromosomes- chromosomes that control the same traits but not necessarily in the same way
- 1 set from mom and 1 set from dad
- Ends in diploid (2n) state as SOMATIC cells
- Goes through one set of divisions
- Start with 1 cell and end with 2 cells

Mitosis

Accounts for three essential life processes

Growth

- Result of cell producing new cells
- Develop specialized shapes/functions in a process called

Differentiation

- Rate of cell division controlled by GH (Growth Hormone) which is produced in the pituitary gland
- Ex. Nerve cell, intestinal cell, etc.

Repair

- Cell regenerates at the site of injury
- Ex. Skin (replaced every 28 days), blood vessels, bone

Mitosis

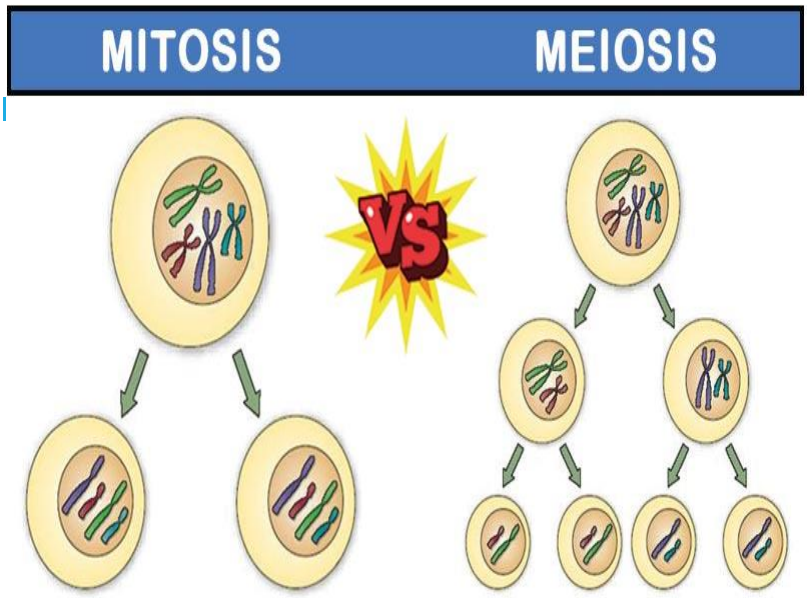
- **Reproduction**
  - Asexual
    - Offspring produced by only one parent
    - Produce offspring that are **genetically identical**
    - **MITOSIS**
    - Ex. Bacteria, fungi, certain plants and animals
  - Sexual
    - Offspring produced by two parents
    - Produce offspring that are a **genetic combination** of the two parents
    - **MEIOSIS**
    - Ex. Most animals (humans), plants
- Some organisms can combine processes
  - Ex. Sea star can regrow a lost arm (repair) and lost arm can form a new sea star (reproduction)

Meiosis

- **General Information**
  - Only happens in gametes (sex cells)
    - Sperm cells in males
    - Egg cells in females
  - Nickname: called "reduction" division (produces gametes)…WHY?
    - ✓ Because No. of chromosomes is reduced in this process
    - ✓ This is important so that the No. of chromosomes doesn't double with each generation

Meiosis

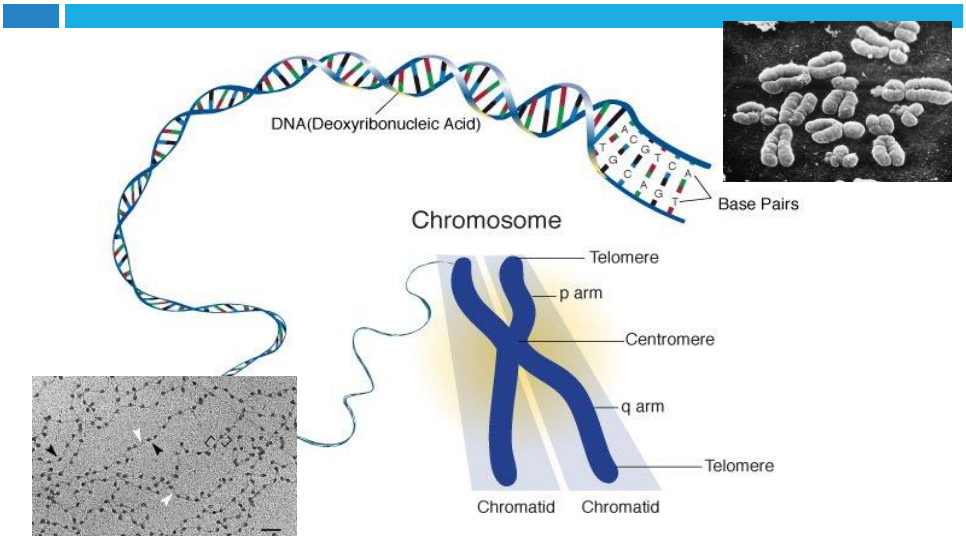
- Background Information
  - Starts with germ cell in diploid (2n) state
  - Ends in haploid (n) state as gametes
    - How many sets of chromosomes? ONE
    - Are there sets of homologous chromosomes? NO
  - Goes through two sets of divisions (Meiosis I and Meiosis II)
  - Start with one cell and end with 4 cells



Chromosomes

- Made of DNA
- Carry genetic information
- Chromatin
  - Thin, fibrous form of DNA (looks like a tangled thread)
  - Form of DNA when cell is resting (not dividing)
  - Shortens, thickens to form chromosomes before cell division

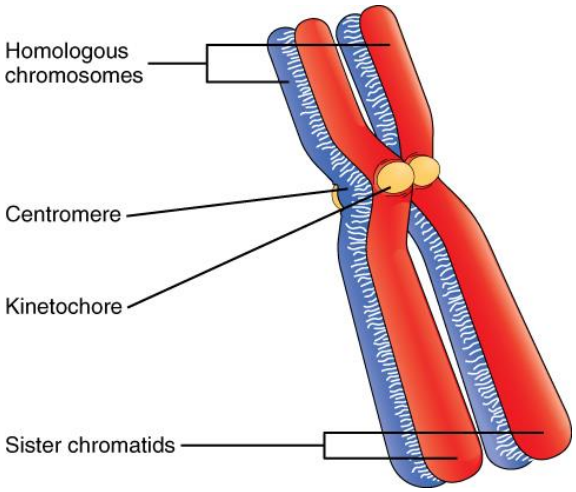
Chromosomes



Chromosomes

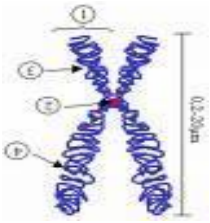
- To prepare for cell division, chromosomes duplicate (replicate)
  - Each replicated chromosome has two **sister chromatids** that are **identical** and are joined by a **centromere**
  - After cell division, each cell receives a full set of chromosomes (one chromatid from each pair)
- Chromosomes come in pairs (like shoes!!)
- Humans have 46 chromosomes or 23 pairs (one of each from both mom and dad)

Chromosomes



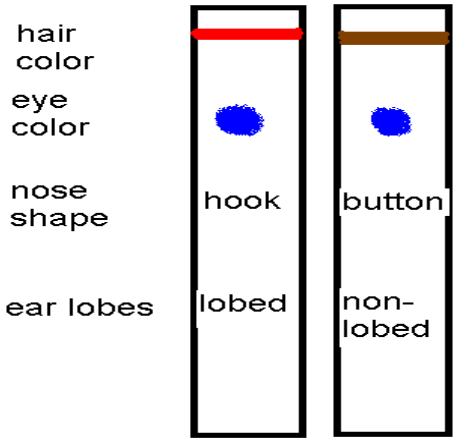
Chromosomes

- Homologous chromosomes
  - Paired chromosomes that control the same traits, but not necessarily the same way
  - Ex. Both have eye color, but one codes for blue eyes and the other for brown eyes



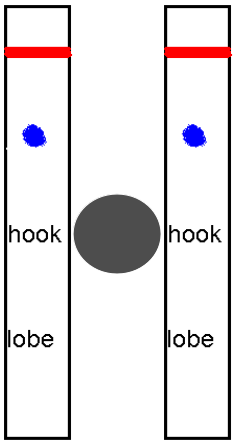
Chromosomes

- Homologous chromosomes



Chromosomes

- Sister Chromatid
- Exact copies of a chromosome from 1 parent.
- Identical in every way; formed during early stages of mitosis and meiosis
- Separate during new cell formation
- Held together with a centromere

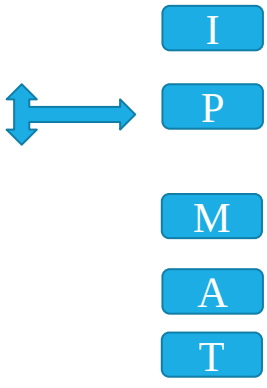


Helpful prefixes

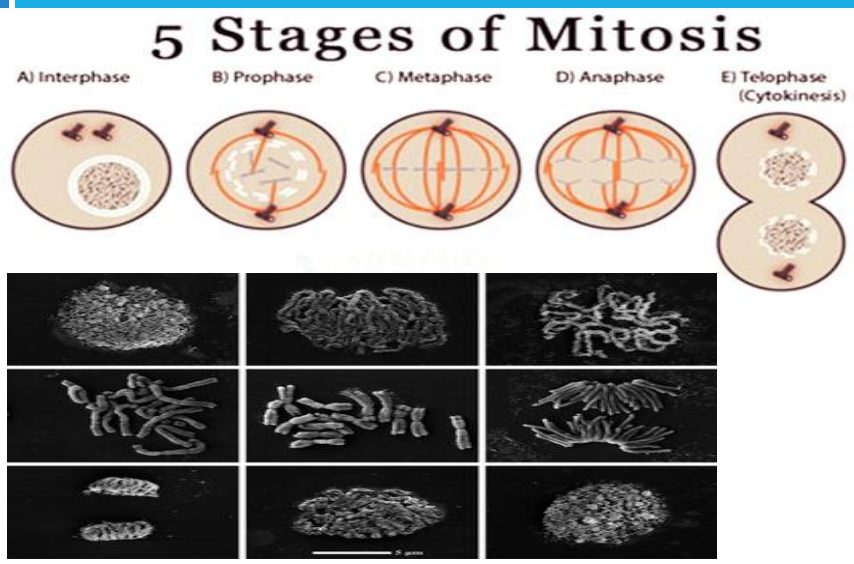
- Haplo- half or single
- Homo- same
- Hetero- different
- Pro- first
- Telo-last or away from (terminal or end)
- Meta- middle
- Locus- location

Mitosis

- Phases (IPMAT)
  1. Interphase
  2. Early Prophase
  3. Late Prophase
  4. Metaphase
  5. Anaphase
  6. Telophase



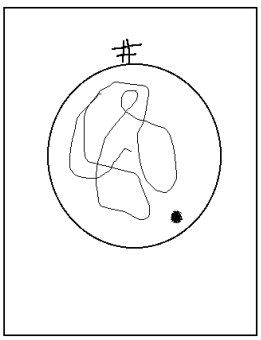
Mitosis

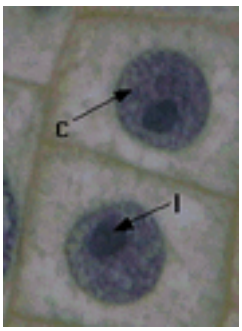


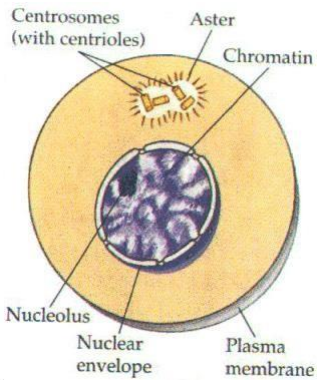
Mitosis

Interphase

- "Resting" stage (not dividing)
- All other cellular processes happening



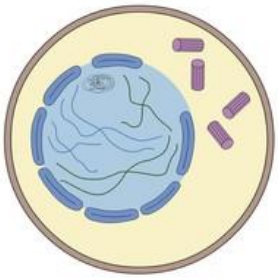




Mitosis

Early Prophase

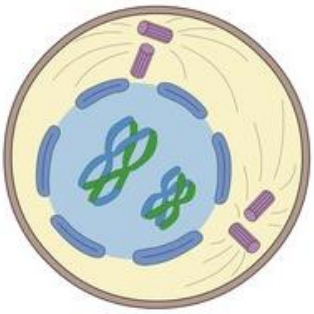
- Nuclear membrane begins to disappear
- Nucleolus disappears
- Chromatin duplicates
- Chromatin shortens and thickens into chromosomes
- Centrioles duplicate and migrate



Mitosis

Late Prophase

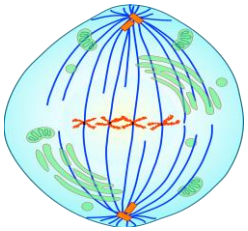
- Aster rays appear
- Spindle fibers appear



Mitosis

Metaphase

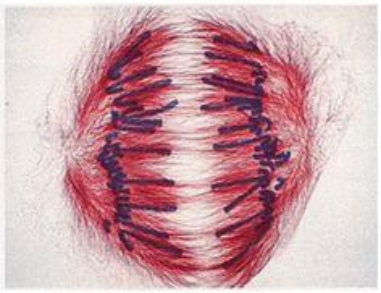
- Chromosomes line up on cell equator
- Homologous chromosomes are present but do not pair (match up)



Mitosis

Anaphase

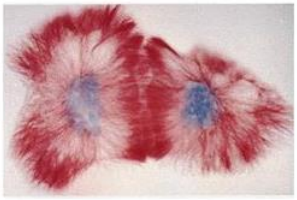
- Sister chromatids begin to migrate to poles



Mitosis

Telophase

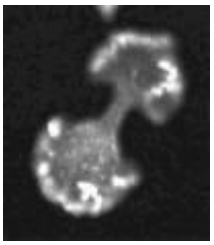
- Chromosomes lengthen/thin to chromatin
- Aster rays disappear
- Spindle fibers disappear
- Nuclear membrane reforms
- Nucleolus reforms
- Centrioles reform
- Partition forms two new cells
- Plant cells: cell plate/cell wall created
- Animal cells: cell membrane pinches off

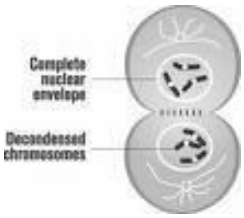


Mitosis

Cytokinesis

- Cell cytoplasm divides to make 2 daughter cells
- Each with two complete sets of chromosomes

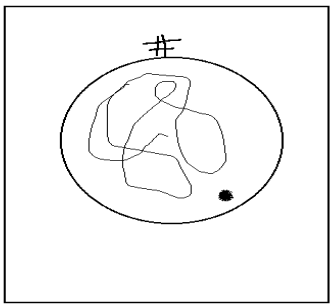


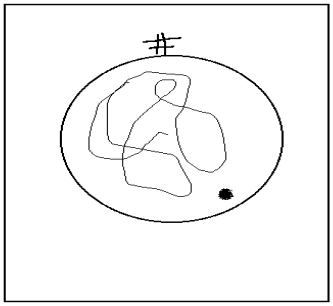


Mitosis

Interphase (again)

- Cell is at rest with two identical cells





Mitosis

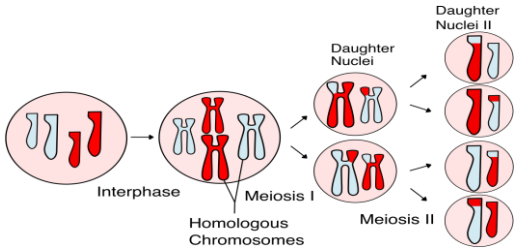
LECTURE (4)

Cell division

Meiosis

What is meiosis?

- a type of cell division that results in four daughter cells each with half the number of chromosomes of the parent cell, as in the production of gametes and plant spores.
- "the sporophytes of green algae form spores only by meiosis"



Meiosis

Reducing chromosome number

What is meiosis?

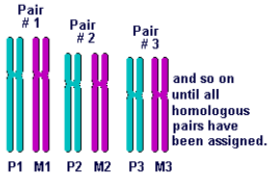
- Asexual reproduction does not undergo meiosis (WHY?)
- Sexual reproduction
- DNA from 2 parents combined
- Creates variability within a population
- Requires specialized cell in which the number of chromosomes is reduced

Meiosis

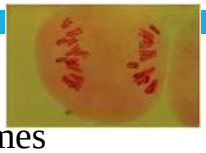
Diploid cell

What is meiosis?

- Contains two complete sets of chromosomes (homologous chromosomes)
- Represented 2n
- Ex. Somatic (body cells)



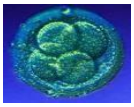
Meiosis



Haploid

- Contains only one complete set of chromosomes
- Represented n
- Ex. Gametes (sperm and egg cells)
- Meiosis also called "gametogenesis" or "reduction division"
- Oogenesis in females
- Spermatogenesis in males

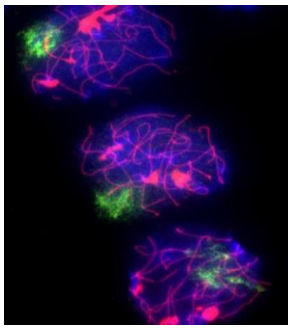
- Combining of two is called fertilization (creates a zygote)

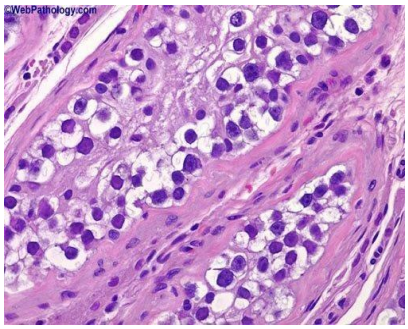


Meiosis

Germ cell

- Specialized diploid cell that is the start of meiosis
- Created in the testes and ovaries





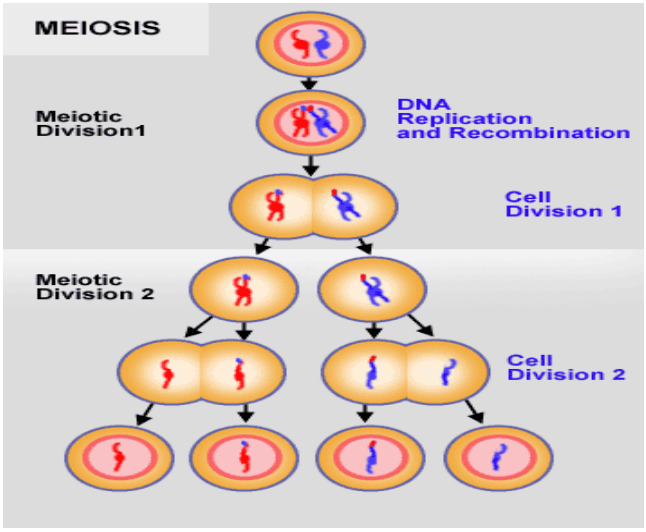
Mitosis vs. Meiosis

	Mitosis	Meiosis
Nickname	"Normal cell division"	"Reduction division"
Starting cell	2n	2n
Starting cell type	Somatic	Germ
No. of division	1	2
Names of stages	IPMATI	IPMATI I IPMATI II
End products	2n (diploid)	n (haploid)
End product cell types	Somatic	Gametes
End product # of cells	2	4

Phases of meiosis

- **2 stages**
  - Meiosis I
    - Prophase I
    - Metaphase I
    - Anaphase I
    - Telophase I
  - **Interphase (very short)**
  - Meiosis II
    - Prophase II
    - Metaphase II
    - Anaphase II
    - Telophase II
  - Interphase
- Same stages as mitosis except they happen twice

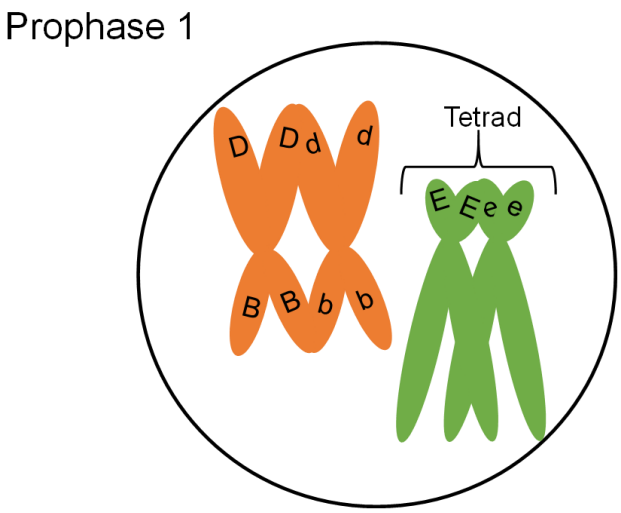
Phases of meiosis



Meiosis I-Prophase I

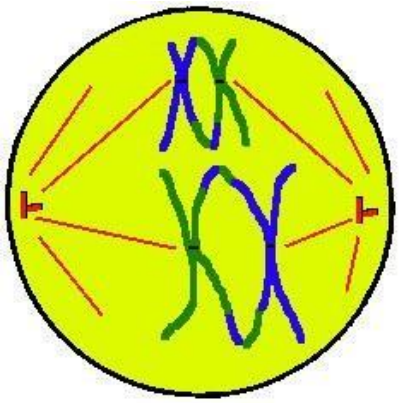
- Chromosomes condense and **duplicate**
- Spindle fibers and aster rays form from centrioles
- Nuclear envelope breaks down
- Homologous pairs attach to each other and form a **tetrad**
- **Crossing over** occurs- recombination of DNA from one sister chromatid to the other (causes variation in the process)

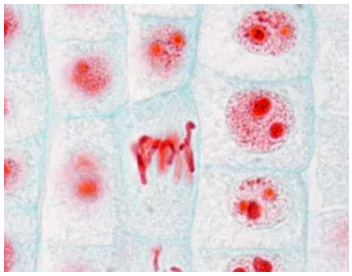
Meiosis I-Prophase I



Meiosis I-Metaphase I

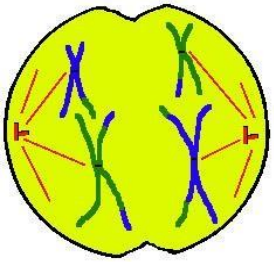
- Pairs (tetrads) line up on cell equator





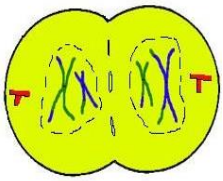
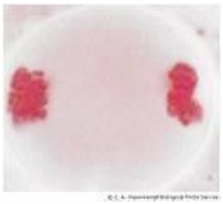
Meiosis I-Anaphase I

- Spindle fibers separate homologous chromosome pairs (tetrads) to opposite poles (creates HAPLOID CELLS)
- Maternal and paternal chromosomes mix



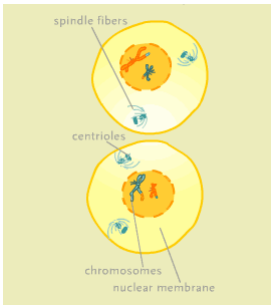
Meiosis I-Telophase I

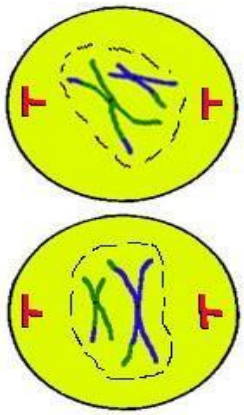
- Spindle fibers and aster rays disappear
- Nuclear envelope reforms
- Cytokinesis occurs
- Results in two HAPLOID cells (each chromosome still has two sister chromatids but NO HOMOLOGOUS CHROMOSOMES are present)

Meiosis II-Prophase II

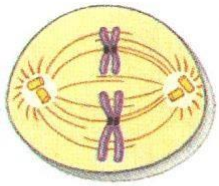
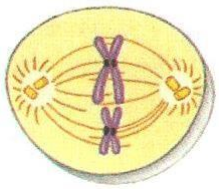
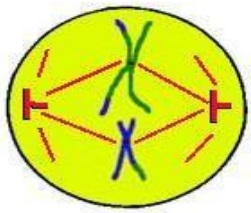
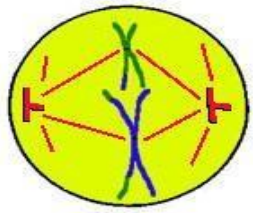
- Chromosomes condense (NO DUPLICATION!!)
- Aster rays, spindle fibers form from centrioles
- Nuclear envelope disappears



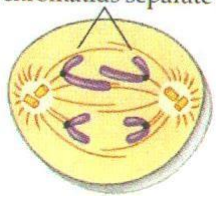
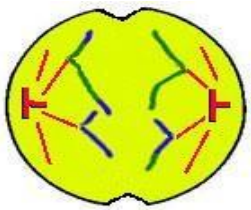
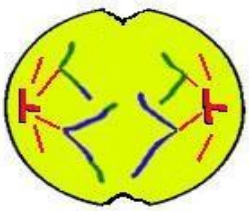
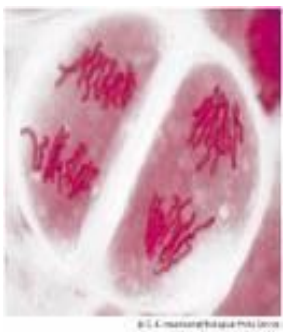
Meiosis II-Metaphase II

- Chromosomes line up at equator

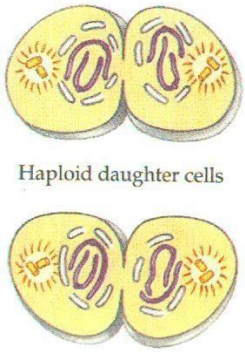

Meiosis II-Anaphase II

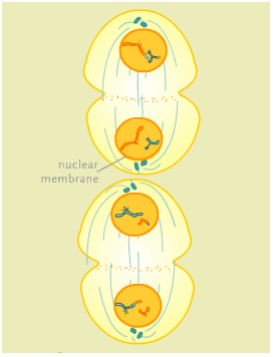
- Sister chromatids pull apart

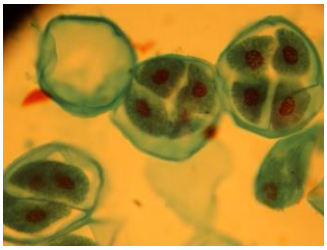





Meiosis II-Telophase II

- Cytokinesis produces four haploid cells
- Aster rays, spindle fibers disappear
- Nuclear envelope reforms







New chromosome combinations

Variation

- Difference between members of a population
- Results from recombination of DNA that occurs during meiosis and fertilization
- Meiosis results in the random separation of chromosomes to make a variety of gametes
- Variation can be important in helping a population survive some kind of change (environmental or disease)

New chromosome combinations

Variation

- Offspring produced through sexual reproduction may look like parents, but are they identical?
- Meiosis makes sure that they will not be identical

Meiosis

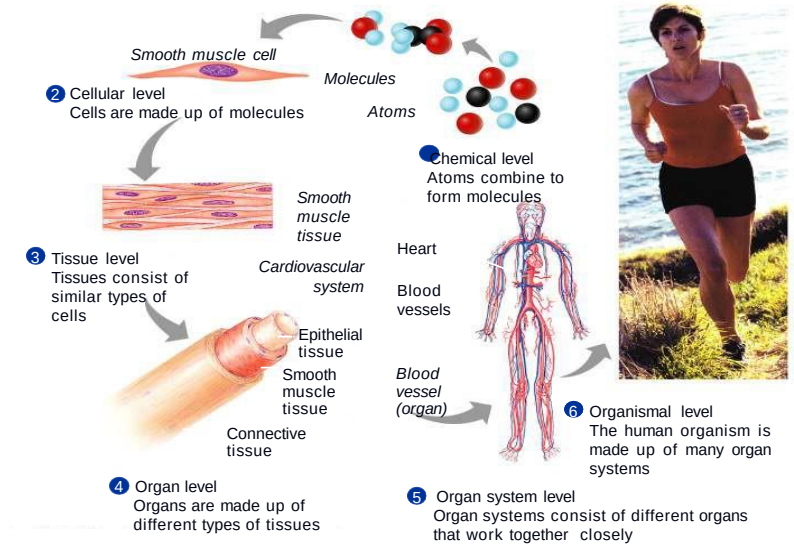
LECTURE (5)

Body tissues

Levels of structural organization

- Chemical – atoms combined to form molecules
- Cellular – cells are made of molecules
- Tissue – consists of similar types of cells
- Organ – made up of different types of tissues
- Organ system – consists of different organs that work closely together
- Organismal – made up of the organ systems

Levels of structural organization



Histology

- The human body is composed of ~200 different types of cells
- The human body is composed of 4 basic kinds of tissues
  - Epithelial Tissue
  - Connective Tissue
  - Muscle Tissue
  - Nervous Tissue
- Tissues: groups of cells which are similar in structure and which perform common or related functions.

Tissue = cells + ECM

- The tissues are formed by cells and molecules of the extracellular matrix (ECM) – an intricate meshwork of proteins and polysaccharides that are secreted by the cell and assembled locally
- The organs are formed by combination of different tissues in variable proportions

Main characteristics of the four basic types of tissues

Tissue	Cells	ECM	Main Functions
Epithelial	Aggregated polyhedral cells	Small amount	Lining of surface or body cavities, glandular secretion
Connective	Several types of fixed and wandering cells	Abundant amount	Support and protection
Muscle	Elongated contractile cells	Moderate amount	Movement
Nervous	Intertwining elongated processes	None	Transmission of nervous impulses

There are also free cells found in body fluids such as blood and lymph

Organs

- Organs can be divided into parenchyma.
- which is composed of the cells responsible for the main functions typical of the organ.
- and stroma, which is the supporting tissue.

Except in the brain and spinal cord, the stroma is made of connective tissue.

Epithelium (epi, upon, + thele, nipple)

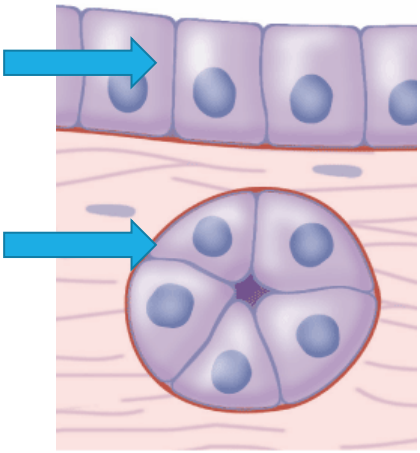
- Composed of closely aggregated polyhedral cells with very little extracellular substance
- Epithelial cells have strong adhesion and form cellular sheets that cover the surface of the body and line its cavities

❖ **Principal functions**

- ✓ Protection of underlying tissues of the body from abrasion and injury
- ✓ Secretion of mucus, hormones, enzymes, and so forth, from various glands
- ✓ Absorption of material from a lumen (e.g., intestinal tract or certain kidney tubules)
- ✓ Detection of sensations via taste buds, retina of the eye, and specialized hair cells in the ear
- ✓ Contractility (eg, myoepithelial cells)

Epithelial tissue is present in 2 forms

- Covering epithelium - as sheets of contiguous cells that cover the body on its external surface and line the body on its internal surface
- Glandular epithelium - glands, which originate from invaginated epithelial cells



Origin of epithelium - from all three embryonic germ layers

- Ectoderm gives rise to the oral and nasal mucosae, cornea, epidermis of the skin, and glands of the skin and the mammary glands.
- Endoderm gives rise to the liver, the pancreas, and the lining of the respiratory and gastrointestinal tract
- Mesoderm gives rise to the uriniferous tubules of the kidney, the lining of the male and female reproductive systems, the endothelial lining of the circulatory system, and the mesothelium of the body cavities

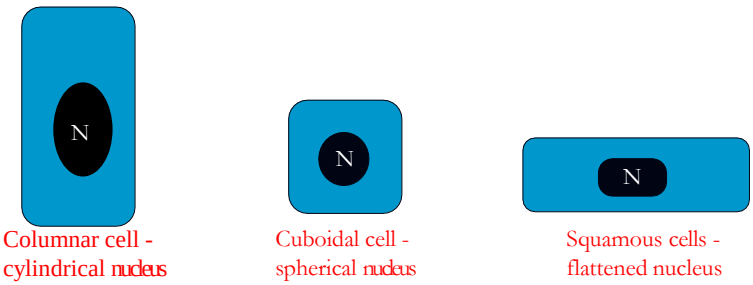
Common characteristic features of epithelial cells

- Epithelial cells have polyhedral form
- Epithelial cells show polarity
- Most epithelia rest on connective tissue – it provides support and nutrition to the epithelium (epithelium is avascular!) as well as binds it to underlying structures
- Epithelial cells have basal lamina at the interface with connective tissue

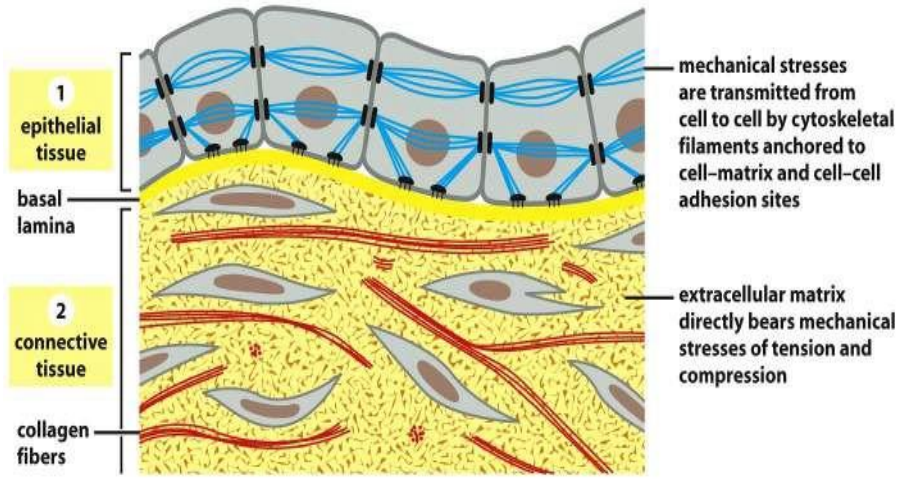
Epithelial cells have polyhedral form

- The polyhedral form (ranging from high columnar to cuboidal to low squamous cells) results from their close juxtaposition in cellular layers or masses
- The nuclear form of epithelial cells often corresponds roughly to the cell shape because the long axis of the nucleus is always parallel to the main axis of the cell
- cuboidal cells have spherical nuclei
- squamous cells have flattened nuclei
- The stained cell nucleus is a clue to the shape and number of cells. Nuclear form is also useful to determine whether the cells are arranged in layers, a primary morphologic criterion for classifying epithelia.

Form of epithelial cells and their nucleus

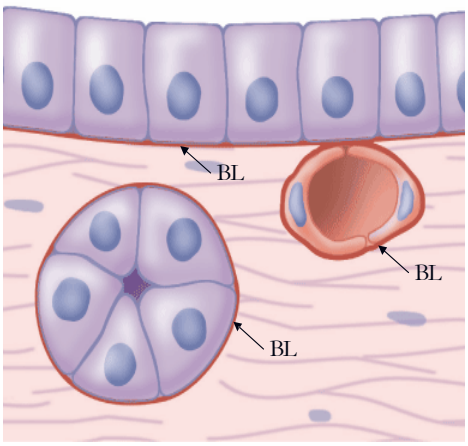


Epithelia rest on connective tissue



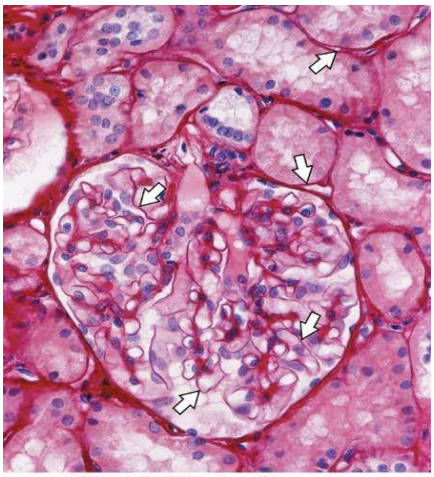
Basal lamina

- Lies at the interface of epithelial cells and connective tissue
- Nutrients for epithelial cells must diffuse across the basal lamina
- Blood capillaries never enter an epithelium across a basal lamina
- Nerves enter an epithelium across a basal lamina



Basement membrane

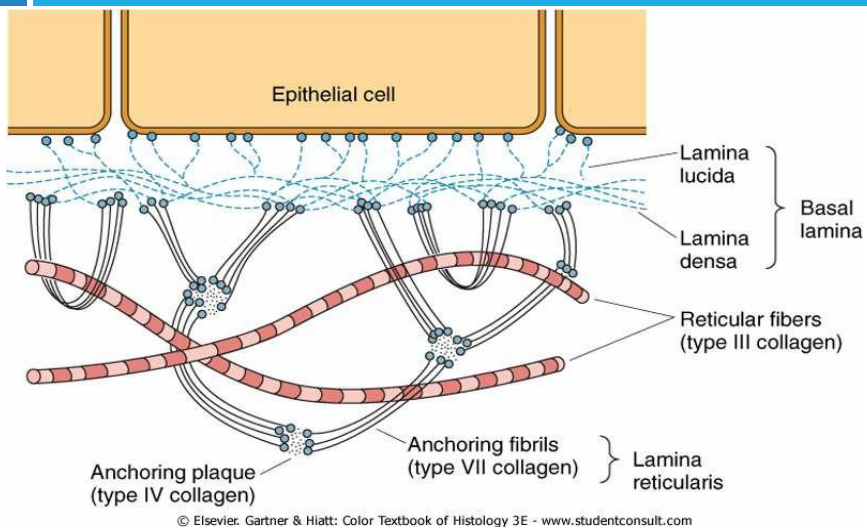
- **Components**
  - Basal lamina – produced by epithelial cells
  - Reticular lamina – produced by CT cells
- Basement membrane is light microscopic basal lamina – EM term



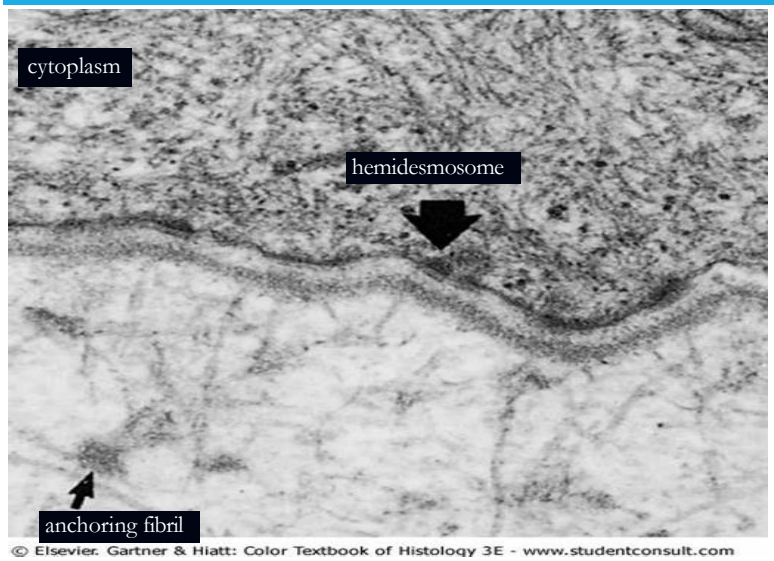
Basement membrane structure

- Lamina lucida - 50-nm-thick electron-lucent region just beneath the epithelium.
  - transmembrane molecules - integrins and dystroglycans
  - extracellular glycoproteins laminin and entactin.
- Lamina densa - 50-nm-thick electron-dense region
  - meshwork of type IV collagen, coated by the proteoglycan perlecan
  - heparan sulfate GAG
- Lamina reticularis
  - type I and type III collagen
  - fibronectin
  - anchoring fibrils (type VII collagen)
  - microfibrils (fibrillin)

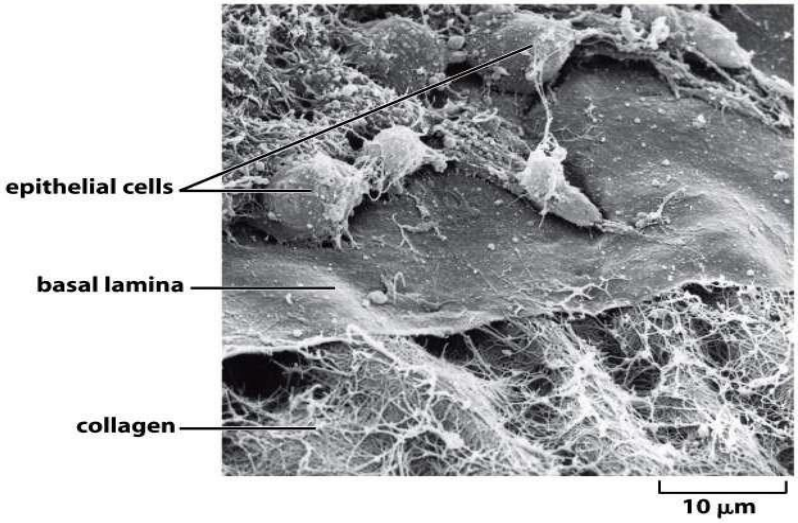
Basement membrane structure



Basement membrane structure



Basement membrane structure

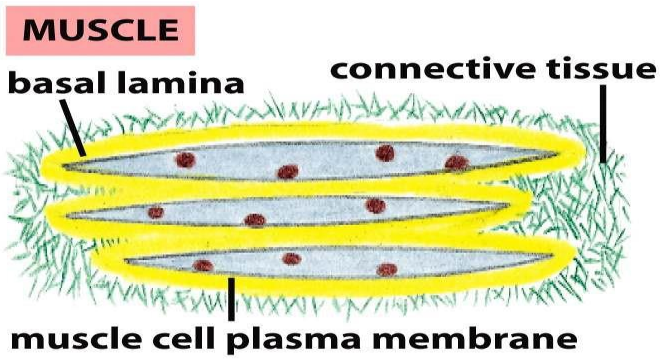


Basal lamina - functions

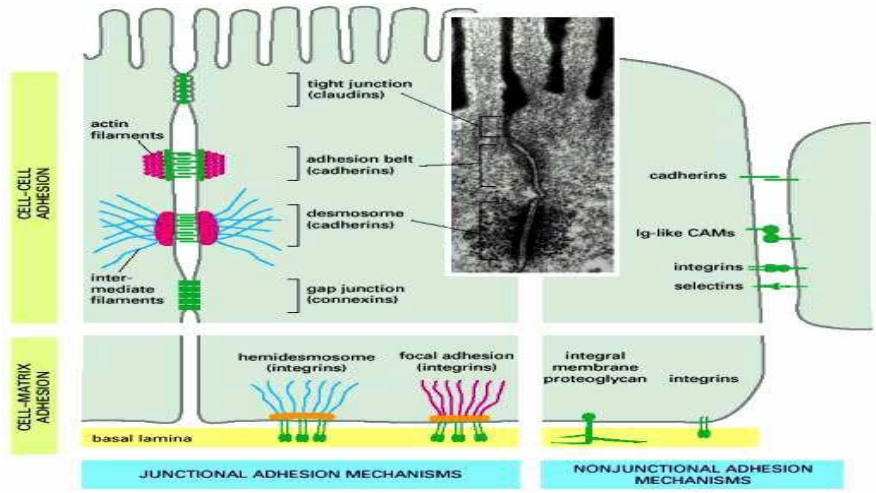
- Molecular filter
- Support for the overlying epithelium
- Regulation of mitotic activity, cell differentiation, and migration
- Modulation of cellular metabolism
- Assisting in the establishment of cell polarity

Basal lamina - functions

- Basal laminae are found not only in epithelial tissues (muscle, adipocytes, Schwann cells).



Epithelial tissue is rich in intercellular junctions

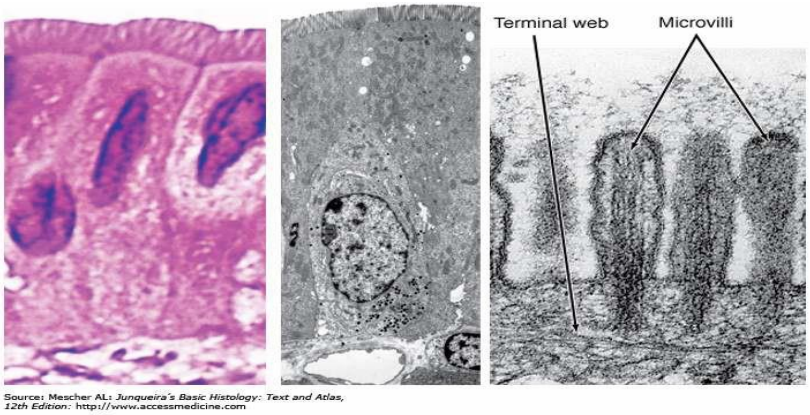


Specializations on the plasmalemma of epithelial cells

- Specializations of the apical cell surface
  - Microvilli & stereocilia - AF
  - Cilia – MT
- Specializations of the basolateral cell surface – see Cell Junctions

Specializations on the plasmalemma of epithelial cells

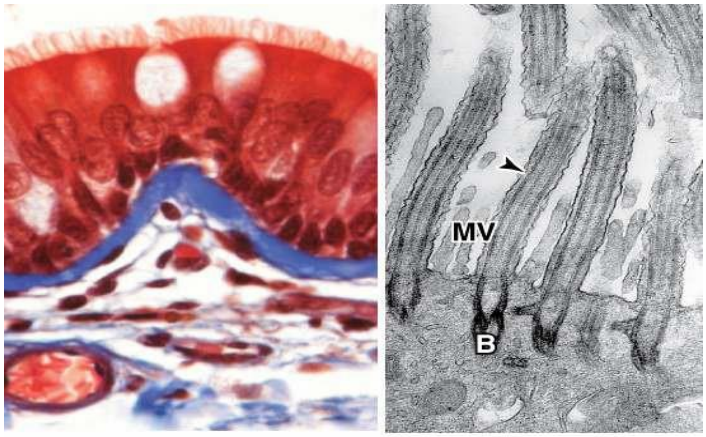
- Microvilli



Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas, 12th Edition:* http://www.accessmedicine.com

Specializations on the plasmalemma of epithelial cells

- Cilia



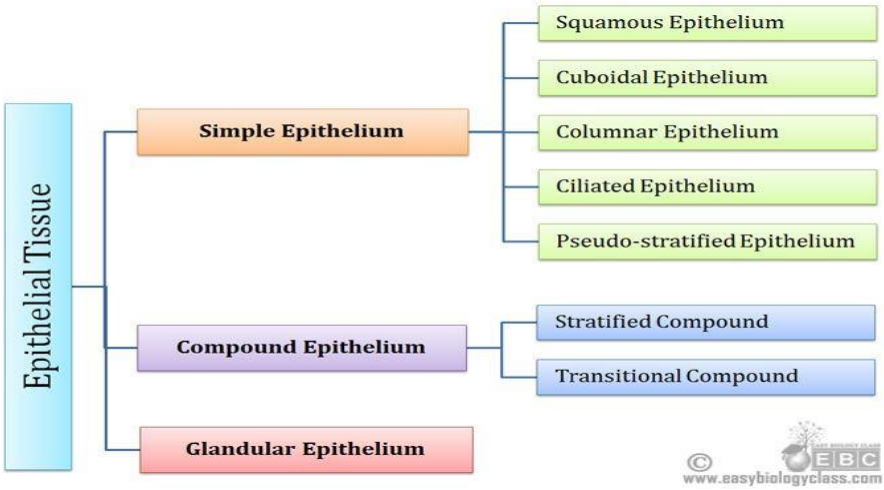
LECTURE (6)

Body tissues

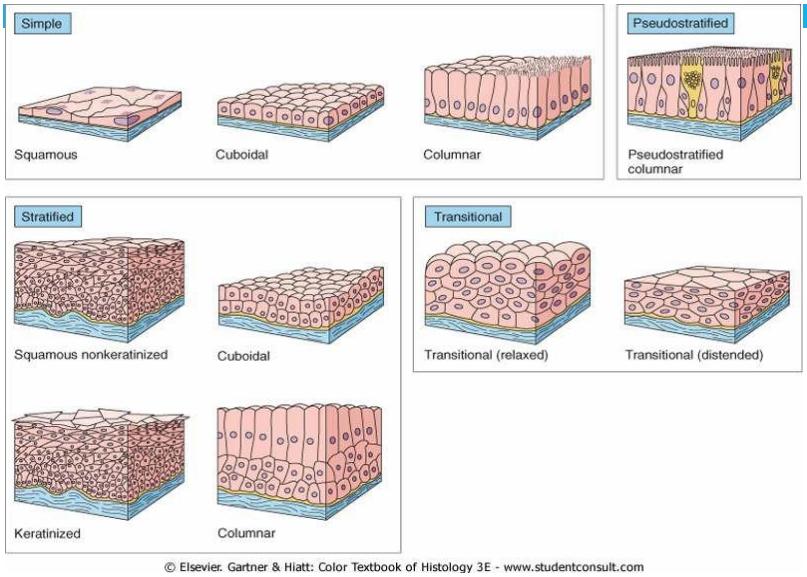
Major types of epithelia

- Covering (lining) - the cells are organized in layers that cover the external surface or line the cavities of the body
- Glandular (secretory) epithelia - specialized to secrete proteins (e.g., in the pancreas), lipids (e.g., adrenal, complexes of carbohydrates and proteins (e.g., salivary glands)

Epithelia tissue classification



Common types of covering epithelia in the human body



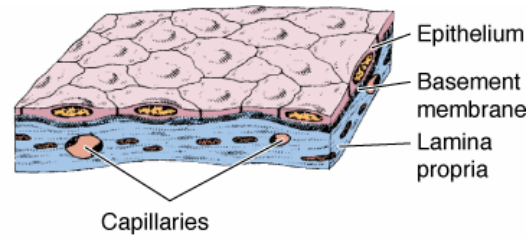
Common types of covering epithelia in the human body

Number of Cell Layers	Cell Form	Examples of Distribution	Main Function
Simple (one layer)	Squamous	Lining of vessels (endothelium). Serous lining of cavities; pericardium, pleura, peritoneum (mesothelium).	Facilitates the movement of the viscera (mesothelium), active transport by pinocytosis (mesothelium and endothelium), secretion of biologically active molecules (mesothelium).
	Cuboidal	Covering the ovary, thyroid.	Covering, secretion.
	Columnar	Lining of intestine, gallbladder.	Protection, lubrication, absorption, secretion.
Pseudostratified (layers of cells with nuclei at different levels; not all cells reach surface but all adhere to basal lamina)		Lining of trachea, bronchi, nasal cavity.	Protection, secretion; cilia-mediated transport of particles trapped in mucus out of the air passages.
Stratified (two or more layers)	Squamous keratinized (dry)	Epidermis.	Protection; prevents water loss.
	Squamous nonkeratinized (moist)	Mouth, esophagus, larynx, vagina, anal canal.	Protection, secretion; prevents water loss.
	Cuboidal	Sweat glands, developing ovarian follicles.	Protection, secretion.
	Transitional	Bladder, ureters, renal calyces.	Protection, distensibility.
	Columnar	Conjunctiva.	Protection.

Common types of covering epithelia in the human body

Simple squamous epithelium

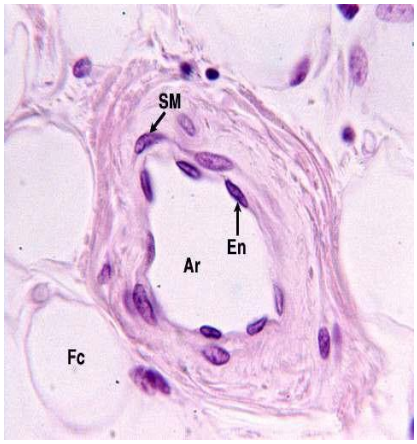
- Simple = 1 layer
- Squamous = thin cells
- Lining of vessels and cavities – often exhibit transcytosis

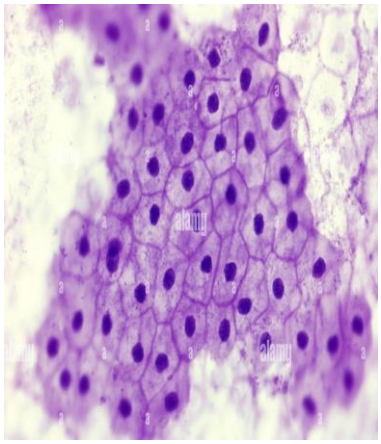


Source: Mescher AL: *Junqueira's Basic Histology: Text and Atlas, 12th Edition:* http://www.accessmedicine.com

Common types of covering epithelia in the human body

Simple squamous epithelium

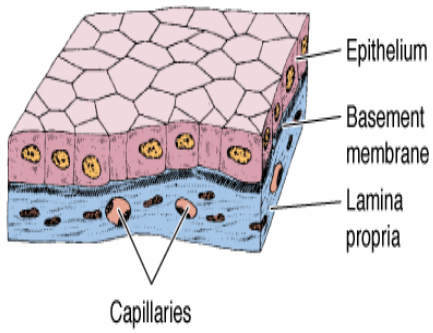




Common types of covering epithelia in the human body

Simple cuboidal epithelium

- Simple = 1 layer
- Cuboidal = cells roughly as thick as they are wide
- Greater thickness often includes cytoplasm rich in mitochondria providing energy for active transport of substances across the epithelium



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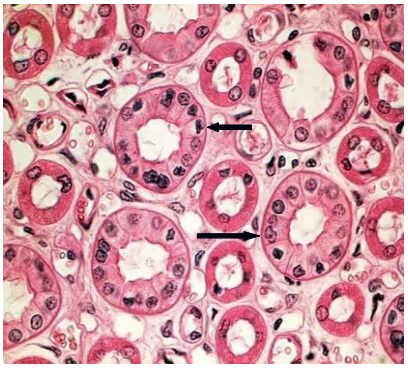
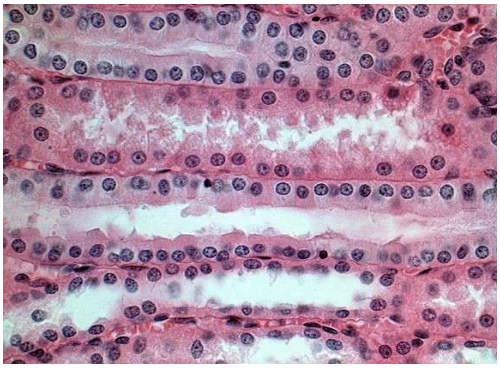
Common types of covering epithelia in the human body

Simple cuboidal epithelium

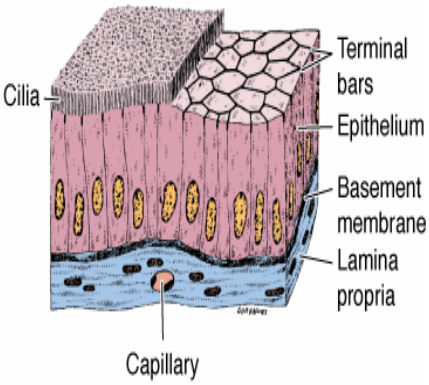




Common types of covering epithelia in the human body

Simple columnar epithelium

- Simple = 1 layer
- Columnar = cells are taller than they are wide
- Specialized for absorption, with microvilli
- Tight and adherent junctional complexes at the apical surface



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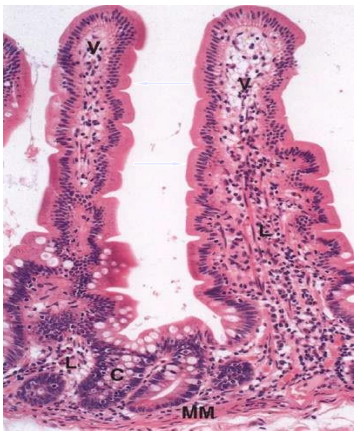
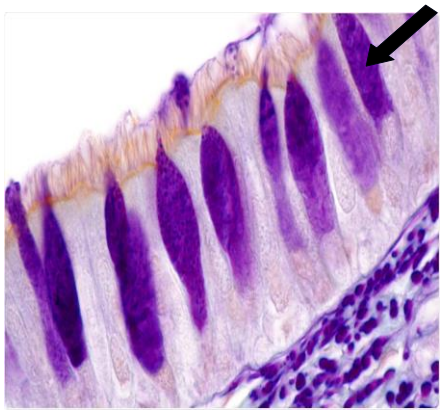
Common types of covering epithelia in the human body

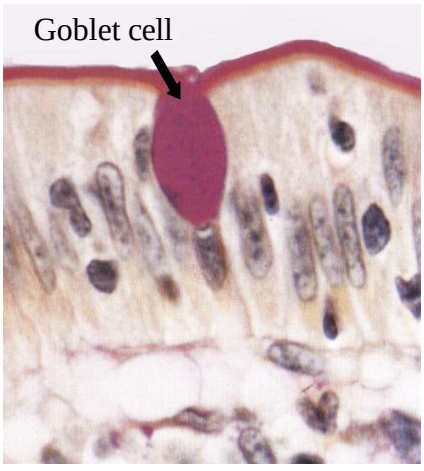
Simple columnar epithelium



Common types of covering epithelia in the human body

Simple columnar epithelium

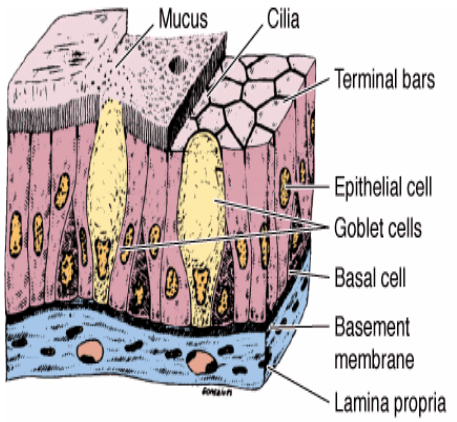




Common types of covering epithelia in the human body

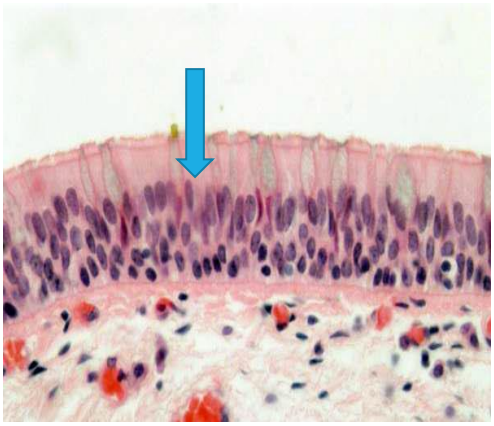
Pseudostratified columnar epithelium

- Only appears stratified; all cells are in contact with the basal lamina
- Cells are of different heights, their nuclei are located at different levels
- Can be ciliated (e.g. upper respiratory tract) or non-ciliated (e.g. male urethra



Common types of covering epithelia in the human body

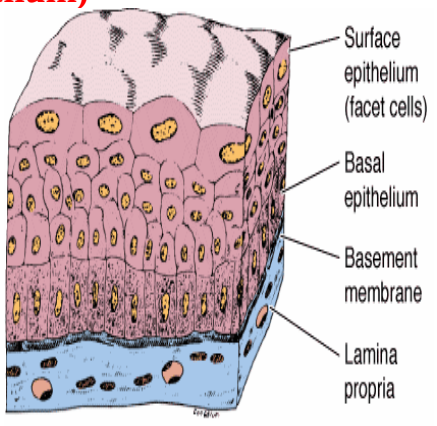
Pseudostratified columnar epithelium



Common types of covering epithelia in the human body

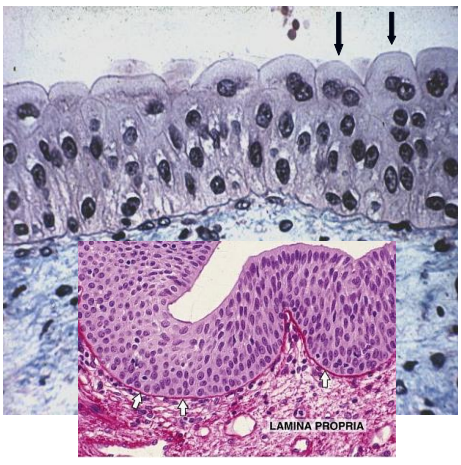
Transitional epithelium (urothelium)

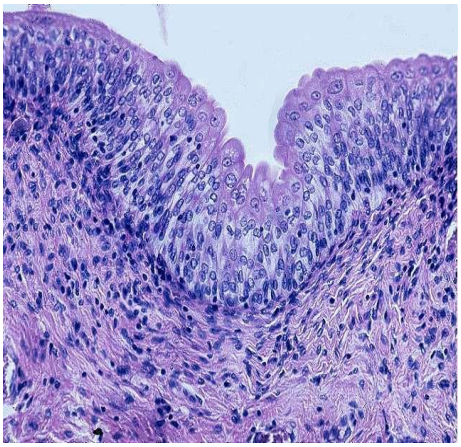
- Lines only the urinary bladder, the ureter, and the upper part of the urethra
- Composed of many layers of cells
- Superficial layer of domelike cells that are neither squamous nor columnar (protective against cytotoxic effects of urine



Common types of covering epithelia in the human body

Transitional epithelium (urothelium)

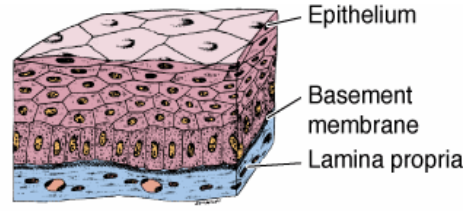




Common types of covering epithelia in the human body

Stratified squamous epithelium

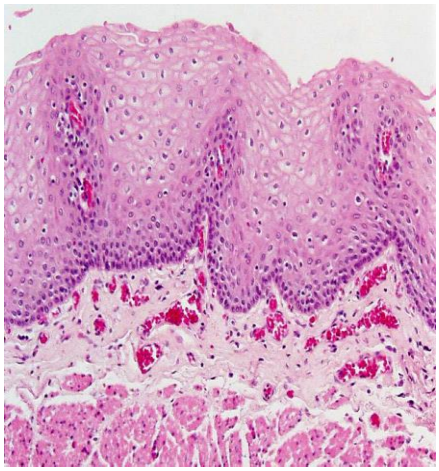
- Nonkeratinized - several layers of cells; the surface-most layer possesses nuclei
- Keratinized - the layers of cells composing the free surface are dead, non-nucleated, and filled with keratin



Common types of covering epithelia in the human body

Stratified squamous nonkeratinized epithelium

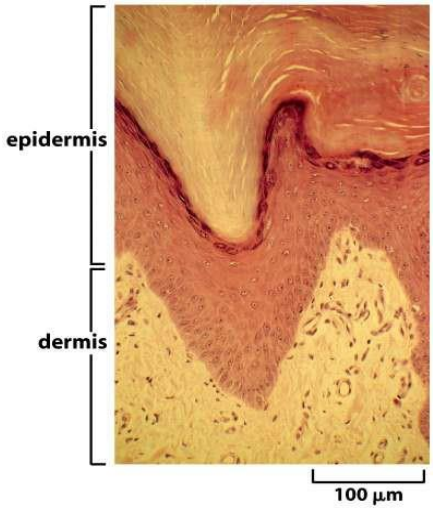
- Lines wet cavities (e.g. mouth, esophagus, and vagina).
- In such areas where water loss is not a problem, the flattened cells of the epithelial surface layer are living cells containing much less keratin and retaining their nuclei



Common types of covering epithelia in the human body

Stratified squamous keratinized epithelium forms epidermis of the skin

- Composed of keratinocytes (synthesize keratin intermediate filament proteins, which give the epidermis its toughness)
- Interlocking columns of hexagonal or irregular cells



LECTURE (7)

Body tissues

Connective Tissue

- Most abundant & widely distributed tissue

Connective Tissue Functions:

- Connects, binds and supports structures,
- Tendons, ligaments, etc.
- Protects & cushions organs and tissues,
- Insulates (fat) and
- Transports substances (blood).

Connective Tissue

- Connective tissue can further be broken down into three categories:
  - **Loose connective tissue.**
  - **Dense connective tissue.**
  - **Specialized connective tissue.**

Connective Tissue

- Loose connective tissue works to hold organs in place and is made up of extracellular matrix and collagenous, elastic and reticular fibers.
- Dense connective tissue is what makes up tendons and ligaments and consist of a higher density of collagen fibers.
- Specialized connective tissues are adipose tissue, cartilage, bone, blood, and lymph.

Connective Tissue

Loose connective tissue

- In vertebrates, the most common type of connective tissue is loose connective tissue.
- It holds organs in place and attaches epithelial tissue to other underlying tissues.
- named so because of the "weave" and type of its constituent fibers.
- These fibers form an irregular network with spaces between the fibers.
- The spaces are filled with ground substance.
- **The three main types of loose connective fibers include collagenous, elastic, and reticular fibers.**

Connective Tissue

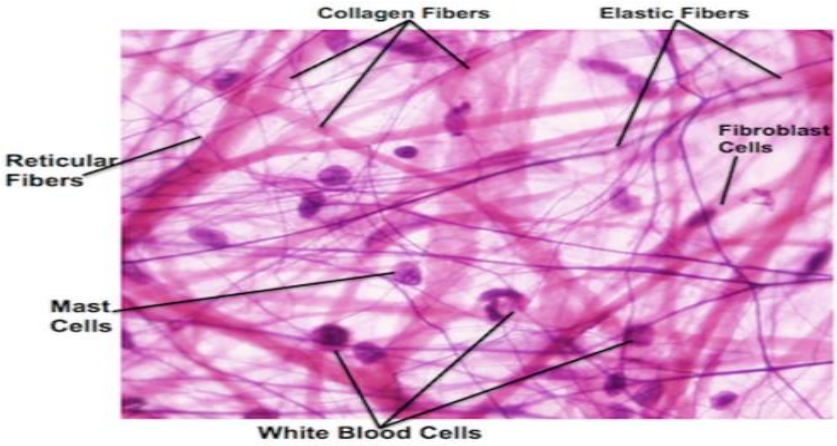
Loose connective tissue

- **Collagenous fibers** are made of collagen and consist of bundles of fibrils that are coils of collagen molecules. These fibers help to strengthen connective tissue.
- **Elastic fibers** are made of the protein elastin and are stretchable. They help to give connective tissue elasticity.
- **Reticular fibers** join connective tissues to other tissues.

Loose connective tissues provide support, flexibility, and strength required to support internal organs and structures such as blood vessels, lymph vessels, and nerves.

Connective Tissue

Loose connective tissue



Connective Tissue

Dense Connective Tissue

- Fibrous connective tissue, which can be found in tendons and ligaments.
- These structures help attach muscles to bones and link bones together at joints.
- composed of large amounts of closely packed collagenous fibers.

In comparison to loose connective tissue, dense tissue has a higher proportion of collagenous fibers to ground substance. It is thicker and stronger than loose connective tissue and forms a protective capsule layer around organs such as the liver and kidneys.

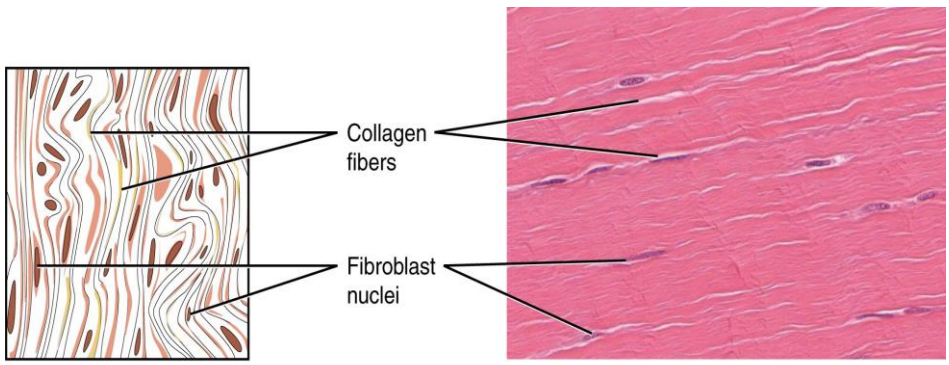
Connective Tissue

Dense Connective Tissue

- **Dense regular**: Tendons and ligaments are examples of dense regular connective tissue.
- **Dense irregular**: Much of the dermis layer of the skin is composed of dense irregular connective tissue. The membrane capsule surrounding several organs is also dense irregular tissue.
- **Elastic**: These tissues enable stretching in structures such as arteries, vocal cords, the trachea, and bronchial tubes in the lungs.

Connective Tissue

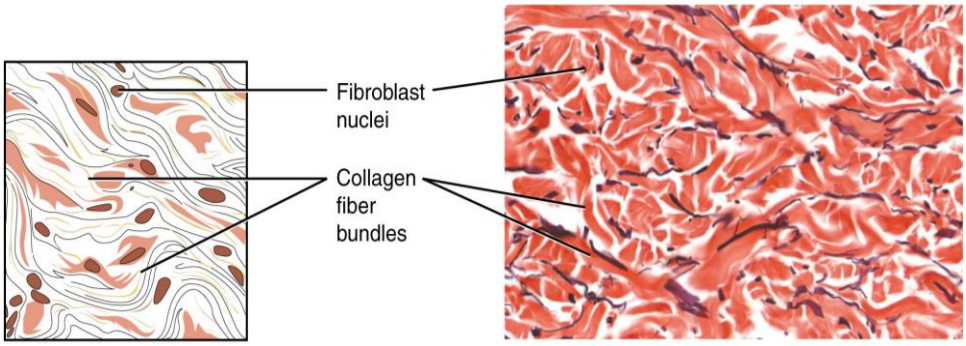
Dense Connective Tissue



(a) Regular dense

Connective Tissue

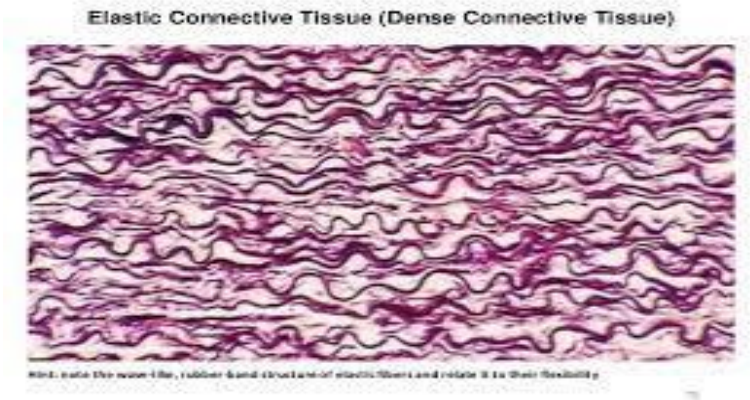
Dense Connective Tissue



(b) Irregular dense

Connective Tissue

Dense Connective Tissue



Connective Tissue

Specialized Connective Tissues

- Specialized connective tissues include a number of different tissues with specialized cells and unique ground substances.
- Some of these tissues are solid and strong, while others are fluid and flexible.
- Examples include **adipose**, **cartilage**, **bone**, **blood**, and **lymph**.

Connective Tissue

Specialized Connective Tissues: Adipose Tissue

- form of loose connective tissue that stores fat.
- Adipose lines organs and body cavities to protect organs and insulate the body against heat loss.
- Adipose tissue also produces endocrine hormones that influence activities such as blood clotting, insulin sensitivity, and fat storage.

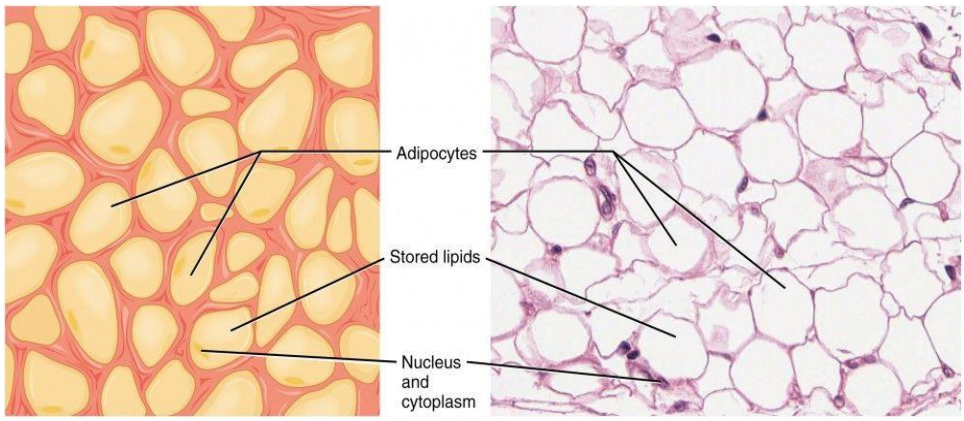
Connective Tissue

Specialized Connective Tissues: Adipose Tissue

- The primary cells of adipose are adipocytes.
- These cells store fat in the form of triglycerides.
- Adipocytes appear round and swollen when fat is being stored and shrink as fat is used.
- Most adipose tissue is described as white adipose which functions in the storage of energy.
- Both brown and beige adipose burn fat and produce heat..

Connective Tissue

Specialized Connective Tissues: Adipose Tissue



Connective Tissue

Specialized Connective Tissues: Cartilage

- Cartilage is a form of fibrous connective tissue that is composed of closely packed collagenous fibers in a rubbery gelatinous substance called chondrin.
- The skeletons of sharks and human embryos are composed of cartilage.
- Cartilage also provides flexible support for certain structures in adult humans including the nose, trachea, and ears.

Connective Tissue

Specialized Connective Tissues: Cartilage

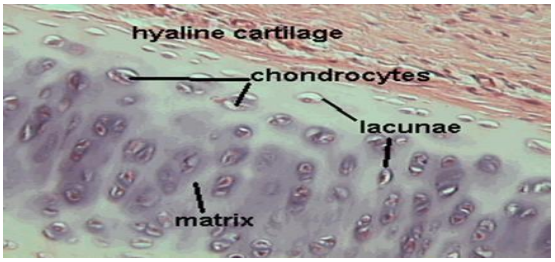
There are three different types of cartilage, each with different characteristics.

- **Hyaline cartilage** is the most common type and is found in areas such as the trachea, ribs, and nose. Hyaline cartilage is flexible, elastic, and surrounded by a dense membrane called perichondrium.
- **Fibrocartilage** is the strongest type of cartilage and composed of hyaline and dense collagen fibers. It is inflexible, tough, and located in areas such as between vertebrae, in some joints, and in heart valves. Fibrocartilage does not have perichondrium.
- **Elastic cartilage** contains elastic fibers and is the most flexible type of cartilage. It is found in locations such as the ear and larynx (voice box).

Connective Tissue

Specialized Connective Tissues: Cartilage

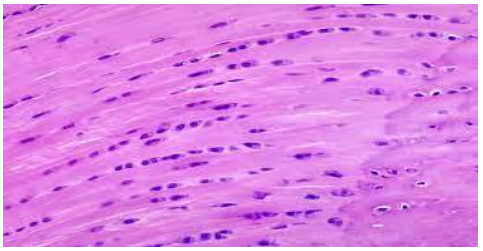
- **Hyaline cartilage** is the most common type and is found in areas such as the trachea, ribs, and nose. Hyaline cartilage is flexible, elastic, and surrounded by a dense membrane called perichondrium.



Connective Tissue

Specialized Connective Tissues: Cartilage

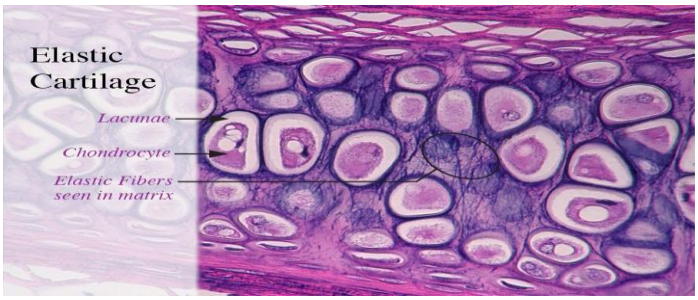
- **Fibrocartilage** is the strongest type of cartilage and composed of hyaline and dense collagen fibers. It is inflexible, tough, and located in areas such as between vertebrae, in some joints, and in heart valves. Fibrocartilage does not have perichondrium.



Connective Tissue

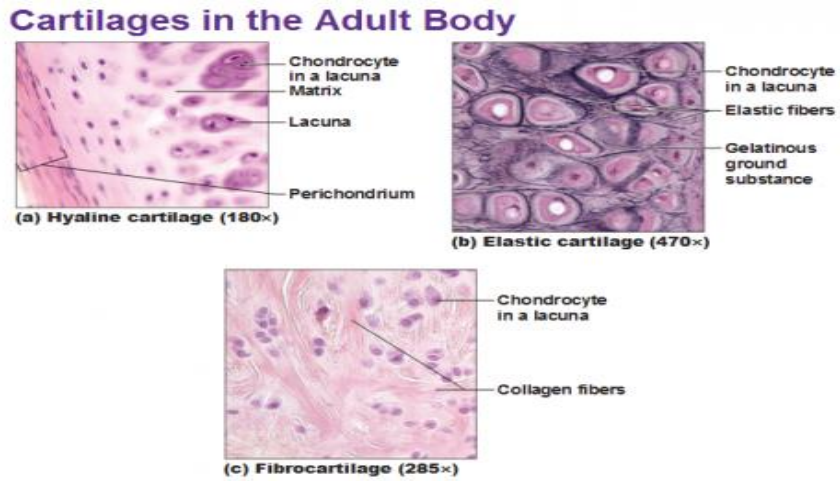
Specialized Connective Tissues: Cartilage

- **Elastic cartilage** contains elastic fibers and is the most flexible type of cartilage. It is found in locations such as the ear and larynx (voice box).



Connective Tissue

Specialized Connective Tissues: Cartilage



Connective Tissue

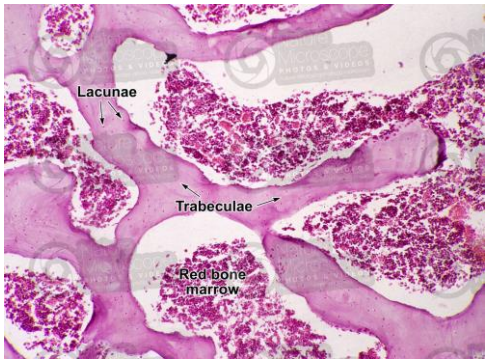
Specialized Connective Tissues: Bone Tissue

- Bone is a type of mineralized connective tissue that contains collagen and calcium phosphate, a mineral crystal.
- Calcium phosphate gives bone its firmness. There are two types of bone tissue: spongy and compact.
- **Spongy bone**
- **Compact bone**

Connective Tissue

Specialized Connective Tissues: Bone Tissue

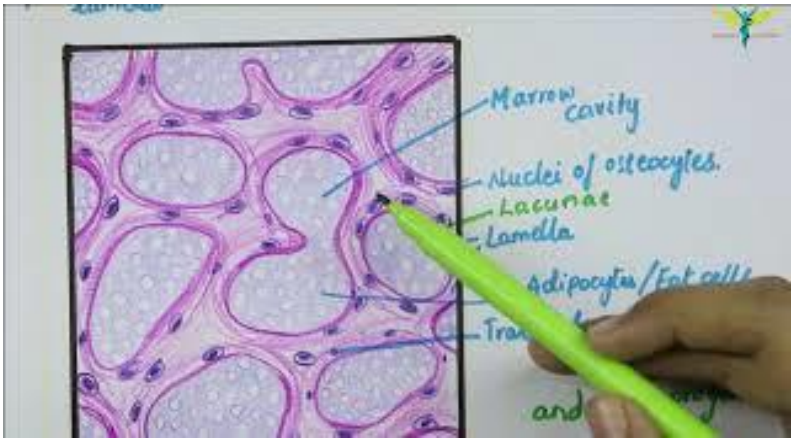
- **Spongy bone**
  - called cancellous bone, gets its name because of its spongy appearance.
  - The large spaces, or vascular cavities, in this type of bone tissue contain blood vessels and bone marrow.
  - Spongy bone is the first bone type formed during bone formation and is surrounded by compact bone.



Connective Tissue

Specialized Connective Tissues: Bone Tissue

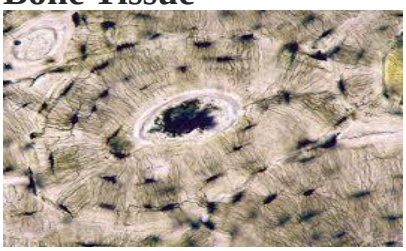
- **Spongy bone**

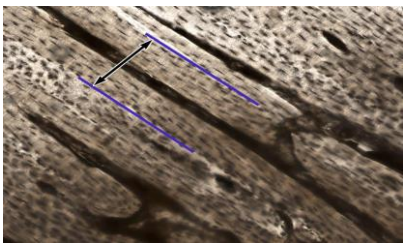


Connective Tissue

Specialized Connective Tissues: Bone Tissue

- **Compact bone**
  - cortical bone, is strong, dense, and forms the hard outer bone surface.
  - Small canals within the tissue allow for the passage of blood vessels and nerves.
  - Mature bone cells, or osteocytes, are found in compact bone.

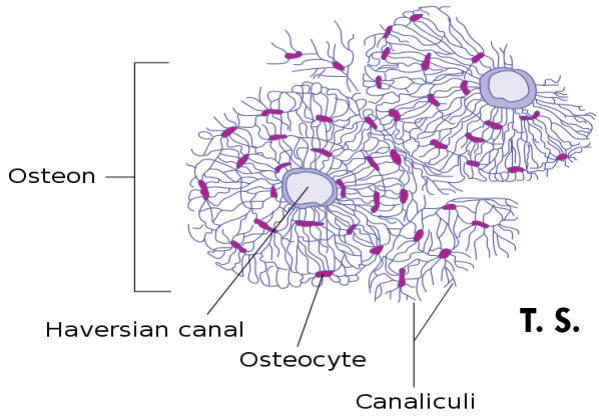




Connective Tissue

Specialized Connective Tissues: Bone Tissue

- Compact bone



Connective Tissue

Specialized Connective Tissues: Bone Tissue

- Compact bone

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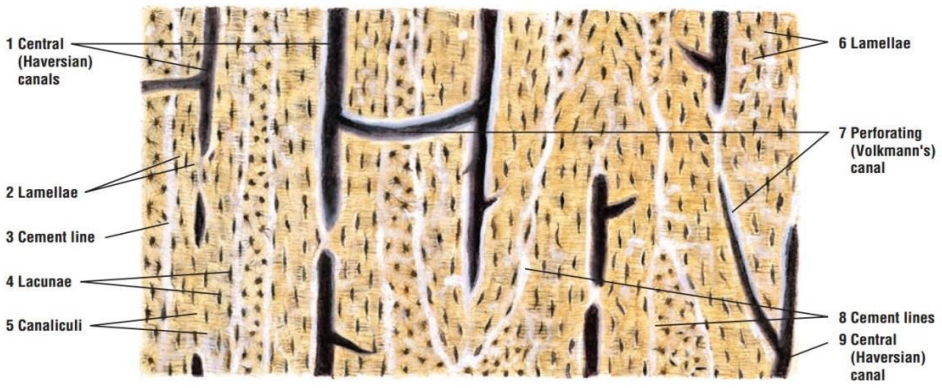


FIGURE 4.18 ■ Dry, compact bone: ground, longitudinal section. Low magnification.

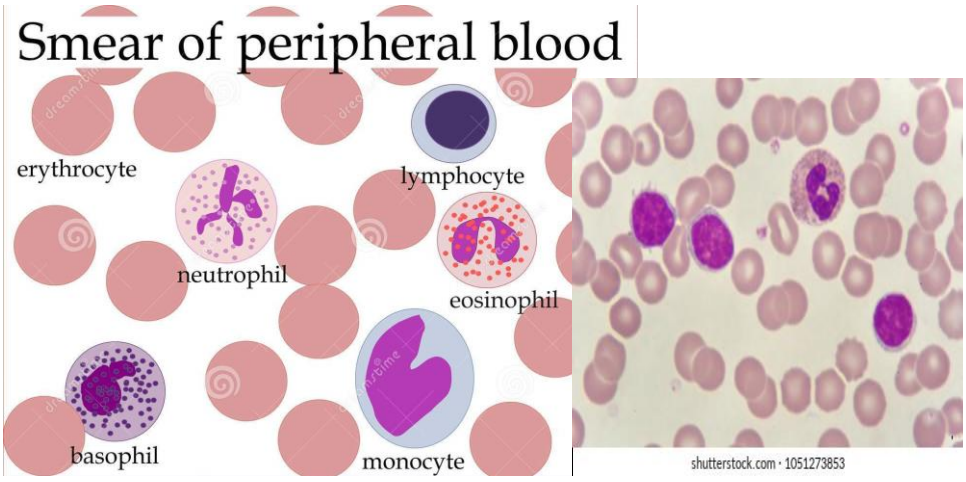
Connective Tissue

Specialized Connective Tissues: Blood and Lymph

- Interestingly enough, blood is considered to be a type of connective tissue.
- Like other connective tissue types, blood is derived from mesoderm, the middle germ layer of developing embryos.
- Blood also serves to connect other organ systems together by supplying them with nutrients and transporting signal molecules between cells.
- Plasma is the extracellular matrix of blood with red blood cells, white blood cells, and platelets suspended in the plasma.

Connective Tissue

Specialized Connective Tissues: Blood and Lymph



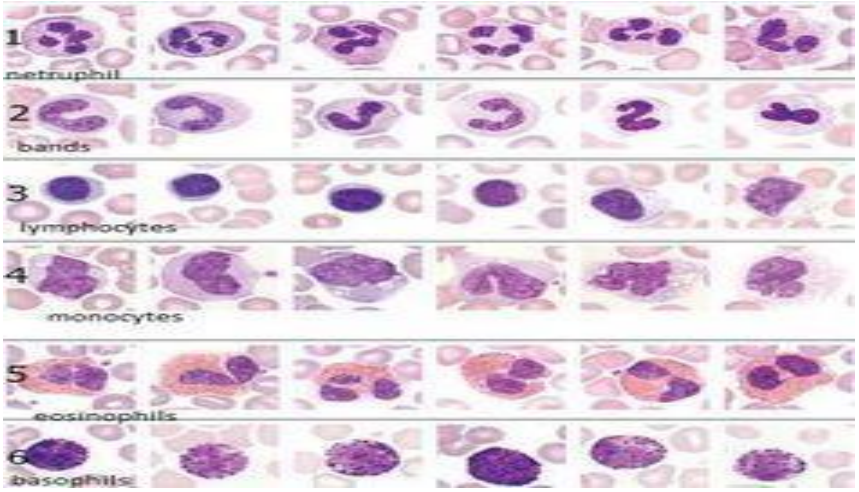
Connective Tissue

Specialized Connective Tissues: Blood and Lymph

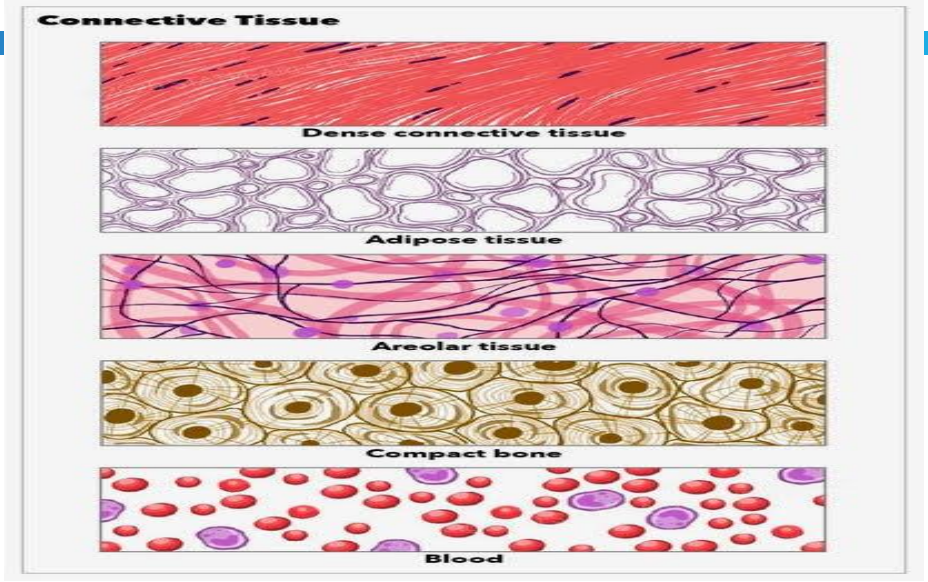
- Lymph is another type of fluid connective tissue.
- This clear fluid originates from blood plasma that exits blood vessels at capillary beds.
- A component of the lymphatic system, lymph contains immune system cells that protect the body against pathogens.
- Lymph is delivered back to blood circulation via lymphatic vessels.

Connective Tissue

Specialized Connective Tissues: Blood and Lymph



Connective Tissue



LECTURE (8)

Body tissues

Muscle Tissue

- Associated with the bones of the skeleton, the heart and in the walls of the hollow organs of the body.

Muscle Tissue Functions:

- Movement
- Locomotion
- Maintains posture
- Produces heat
- Facial expressions
- Pumps blood
- Peristalsis

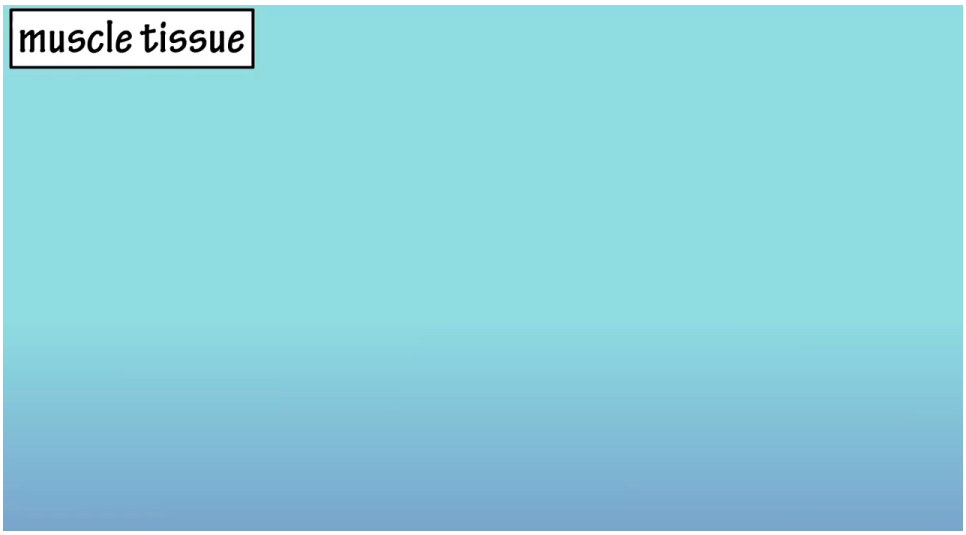
Muscle Tissue

Muscle Tissue Types

- Muscle tissue contains numerous microfilaments composed of the contractile proteins actin and myosin. These proteins are responsible for movement in muscles. The three major types of muscle tissue are:

- **Cardiac Muscle**
- **Skeletal Muscle**
- **Visceral (Smooth) Muscle**

Muscle Tissue Types



Muscle Tissue

Muscle Tissue Types

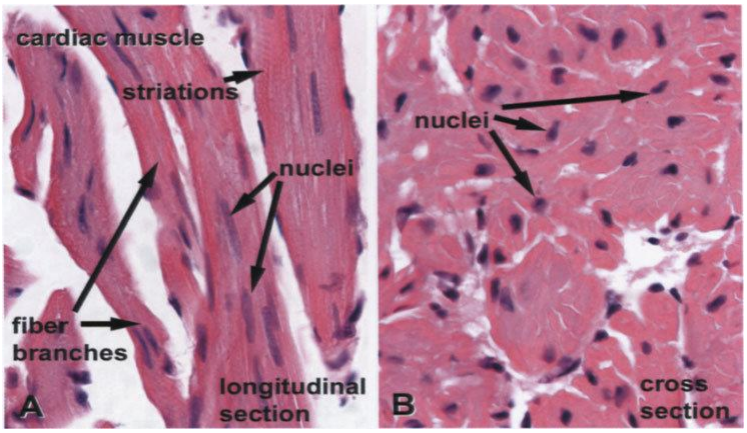
Cardiac Muscle

- Cardiac muscle is so named because it is found in the heart.
- Cells are joined to one another by intercalated discs, which allow the synchronization of the heartbeat.
- Cardiac muscle is branched, striated muscle.
- The heart wall consists of three layers: epicardium, myocardium, and endocardium.
- Myocardium is the middle muscular layer of the heart. Myocardial muscle fibers carry electrical impulses through the heart that power cardiac conduction.

Muscle Tissue

Muscle Tissue Types

Cardiac Muscle



Muscle Tissue

Muscle Tissue Types

Skeletal Muscle

- is attached to the bones by tendons.
- is controlled by the peripheral nervous system and associated with the body's voluntary movements.
- Skeletal muscle is striated muscle.
- Unlike cardiac muscle, the cells are not branched.
- Skeletal muscle cells are covered by connective tissue, which protects and supports muscle fiber bundles.

Muscle Tissue

Muscle Tissue Types

Skeletal Muscle

- is organized into several muscle groups that work in coordination to perform body movements.

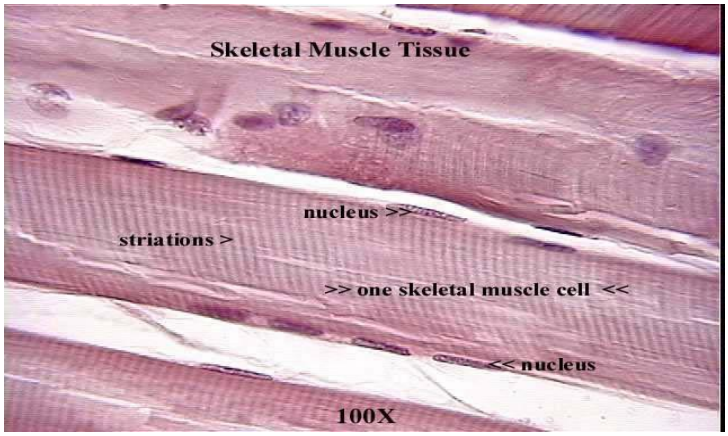
Some of these groupings include:

- head and neck muscles (facial expressions, chewing, and neck movement).
- trunk muscles (moving the chest, back, abdomen, and vertebral column).
- upper extremity muscles (moving the shoulders, arms, hands, and fingers).
- lower extremity muscles (moving the legs, ankles, feet, and toes).

Muscle Tissue

Muscle Tissue Types

Skeletal Muscle



Muscle Tissue

Muscle Tissue Types

Visceral (Smooth) Muscle

- found in various parts of the body including the blood vessels, the bladder, and the digestive tract as well as in many other hollow organs.
- Like cardiac muscle, most visceral muscle is regulated by the autonomic nervous system and is under involuntary control.
- Visceral muscle is also called smooth muscle because it doesn't have cross striations.
- Visceral muscle contracts slower than skeletal muscle, but the contraction can be sustained over a longer period.

Muscle Tissue

Muscle Tissue Types

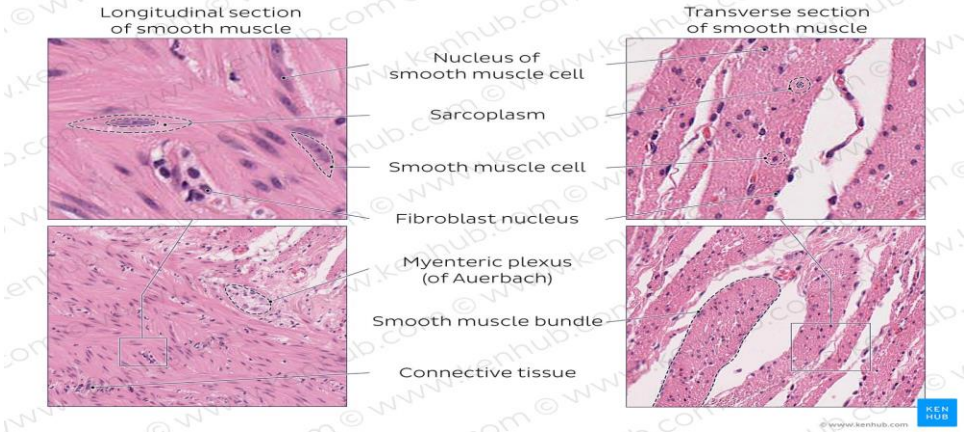
Visceral (Smooth) Muscle

- Organs of the cardiovascular, respiratory, digestive, and reproductive systems are lined with smooth muscle.
- This muscle can be described as rhythmic or tonic. Rhythmic, or phasic, smooth muscle contracts periodically and spends most of the time in a relaxed state.
- Tonic smooth muscle remains contracted for most of the time and only relaxes periodically.

Muscle Tissue

Muscle Tissue Types

Visceral (Smooth) Muscle



Nervous Tissue

- Nervous tissue is the primary tissue that composes the central nervous system and the peripheral nervous system.
- Neurons are the basic unit of nervous tissue.
- They are responsible for sensing stimuli and transmitting signals to and from different parts of an organism.
- In addition to neurons, specialized cells known as glial cells serve to support nerve cells.
- As structure and function are very much intertwined within biology, the structure of a neuron is uniquely suited to its function within nervous tissue.

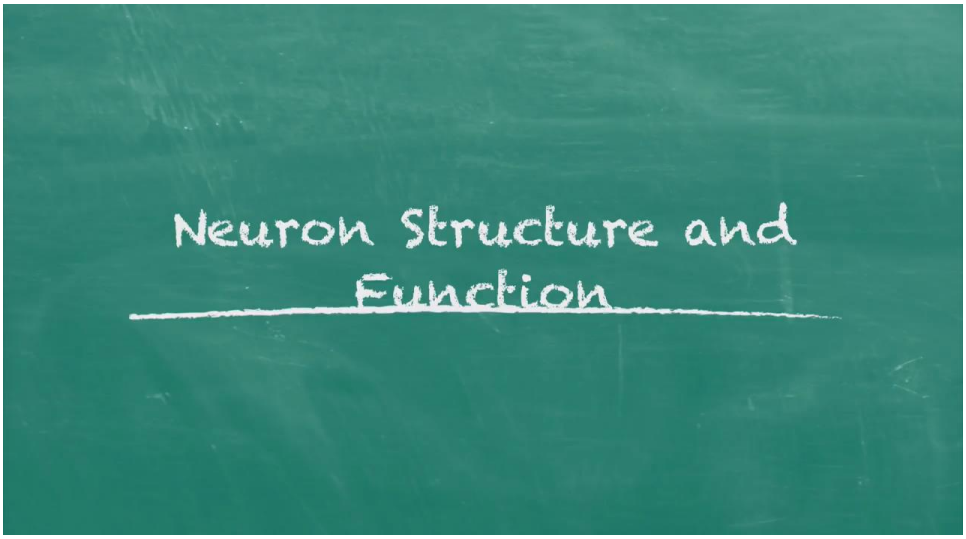
Nervous Tissue

Neurons

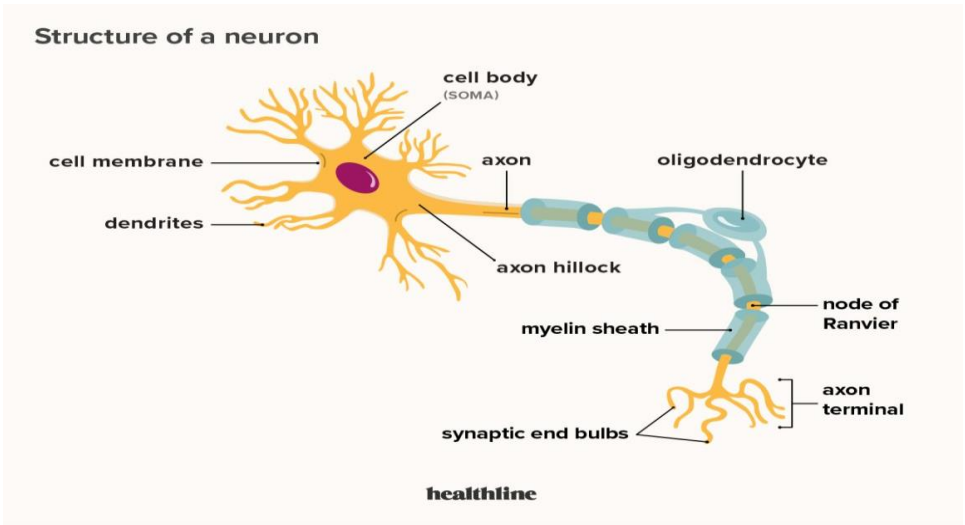
A neuron consists of three major parts:

- **Cell Body**: The central cell body contains the neuron's nucleus, associated cytoplasm, and other organelles.
- **Axons**: This part of the neuron transmits information and extends away from the soma or cell body. It typically carries signals away from the cell body, but occasionally receives impulses from axoaxonic connections.
- **Dendrites**: Dendrites are similar to axons but tend to be multibranched extensions that typically carry signals toward the cell body. They generally receive neurochemical impulses from the axons of other cells.

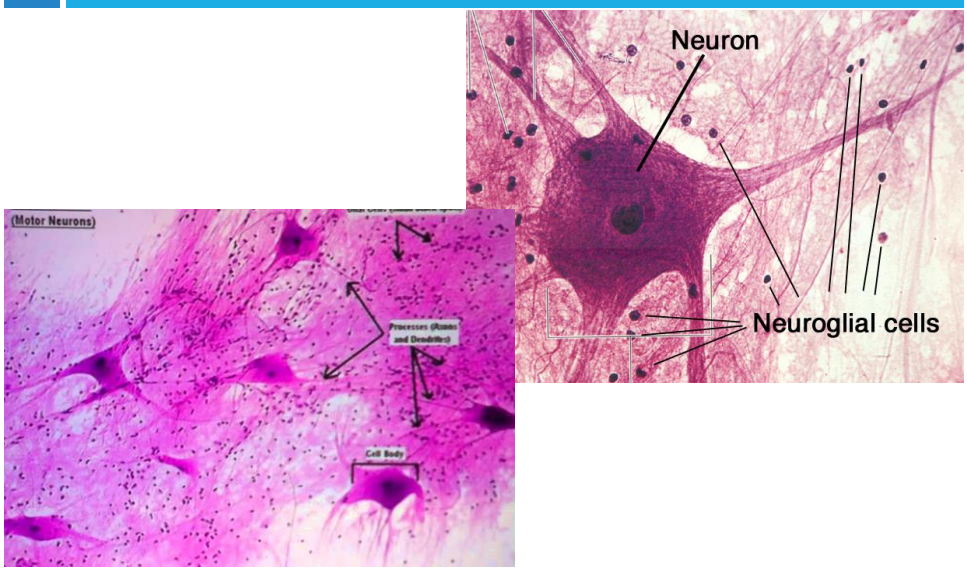
Nervous Tissue



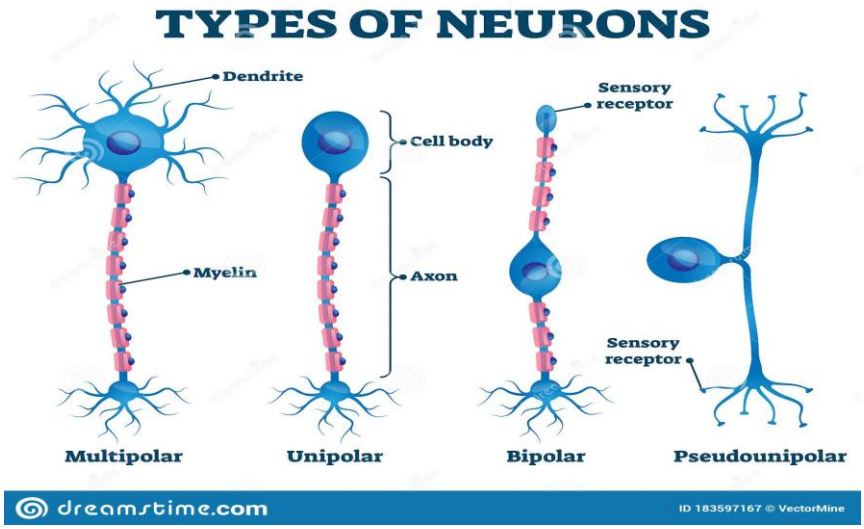
Nervous Tissue



Nervous Tissue



Nervous Tissue



LECTURE (9)

Digestive System

Digestion

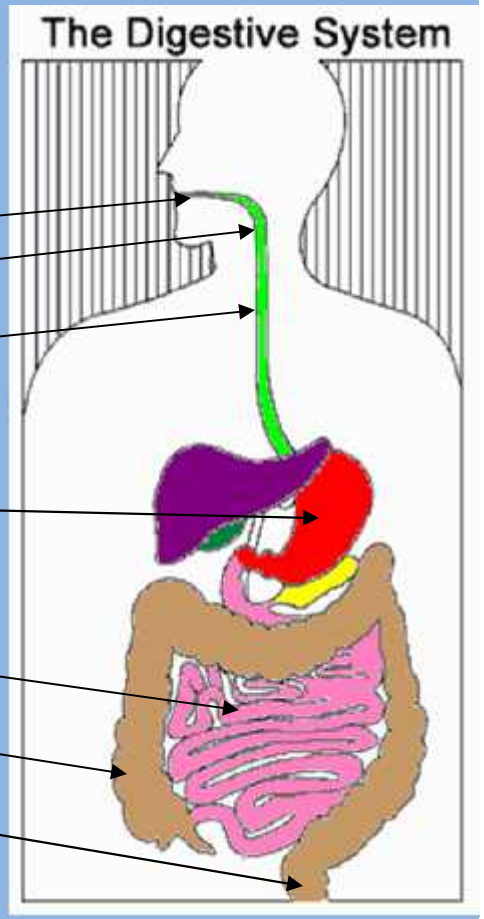
- Phases Include
  1. Ingestion
  2. Movement
  3. Mechanical and Chemical Digestion
  4. Absorption
  5. Elimination

Digestion

- Types
  - Mechanical (physical)
    - Chew
    - Tear
    - Grind
    - Mash
    - Mix
  - Chemical
    - Enzymatic reactions to improve digestion of
      - Carbohydrates
      - Proteins
      - Lipids

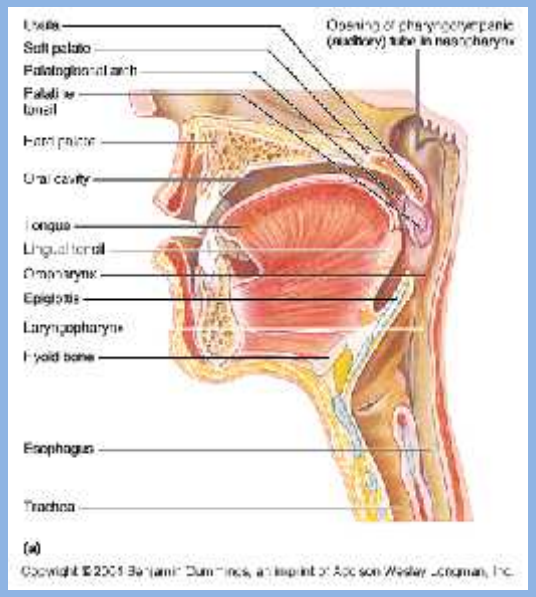
Digestive System Organization

- **Gastrointestinal (GI) tract**
  - **Tube within a tube**
  - **Direct link/path between organs**
  - **Structures**
    - **Mouth**
    - **Pharynx**
    - **Esophagus**
    - **Stomach**
    - **Small intestine**
    - **Large Intestine**
    - **Rectum**

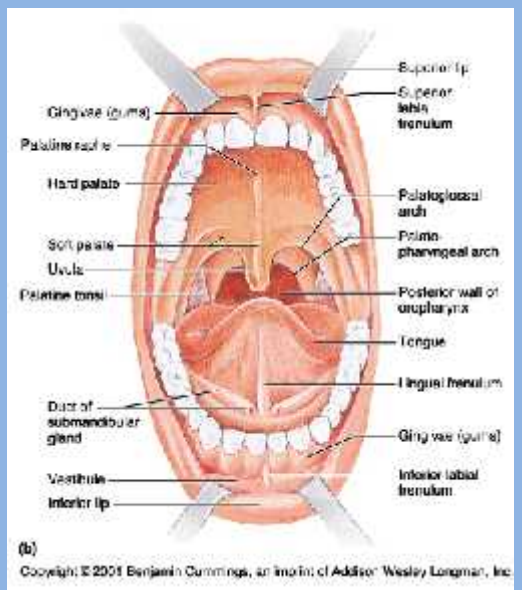


Mouth

- Teeth mechanically break down food into small pieces. Tongue mixes food with saliva (contains amylase, which helps break down starch).



- Epiglottis is a flap-like structure at the back of the throat that closes over the trachea preventing food from entering it. It is located in the Pharynx.



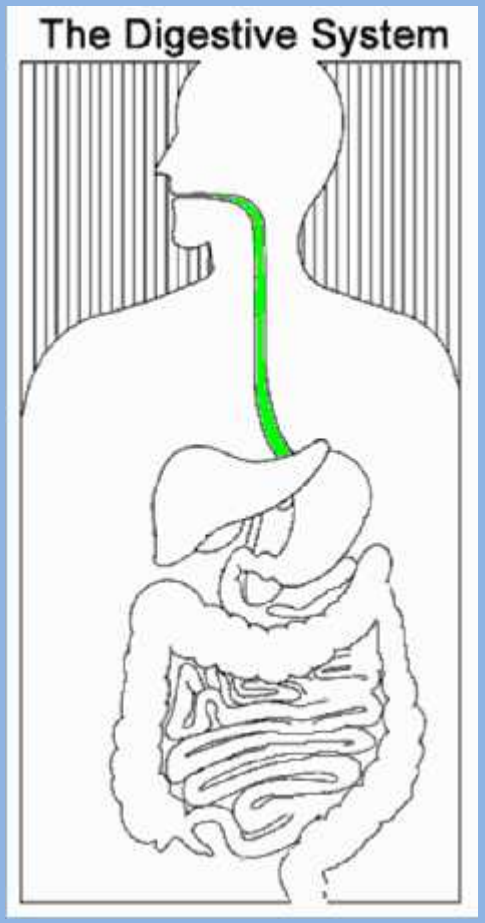
Esophagus

- Approximately 20 cm long.
- Functions include:

1. Secrete mucus
2. Moves food from the throat to the stomach using muscle movement called peristalsis

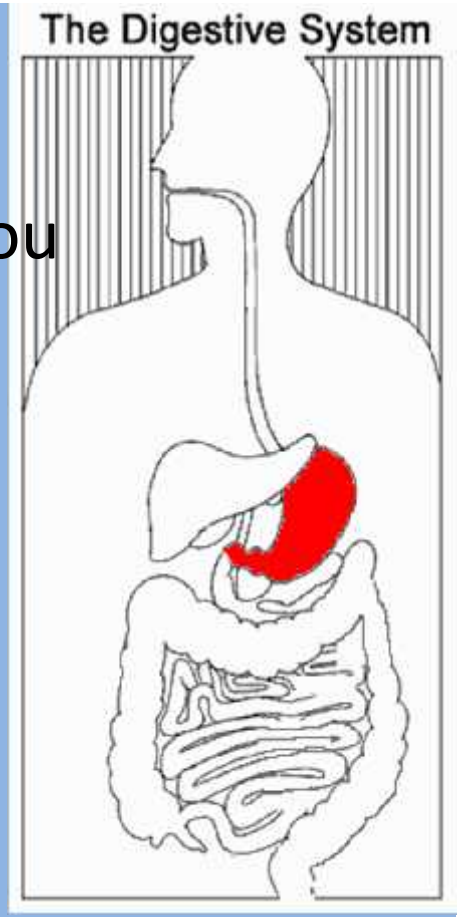
- If acid from the stomach gets in here that's heartburn.

Mouth, Pharynx and Esophagus Video



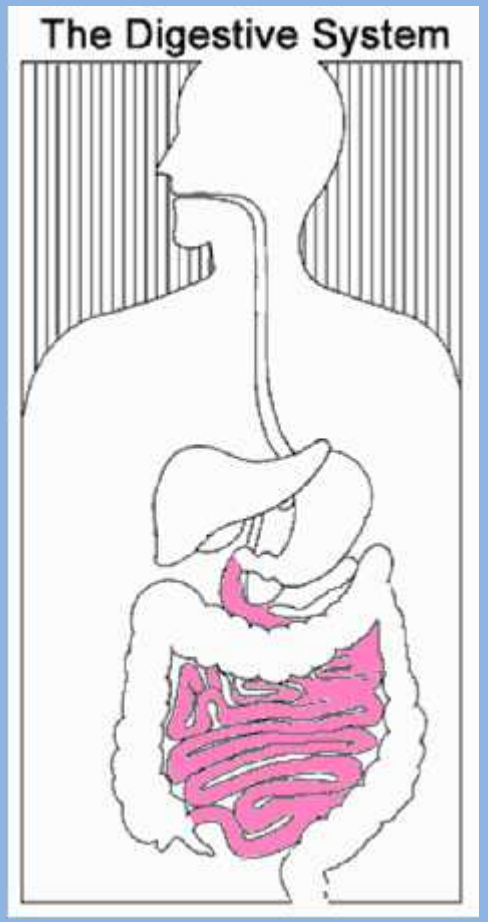
Stomach

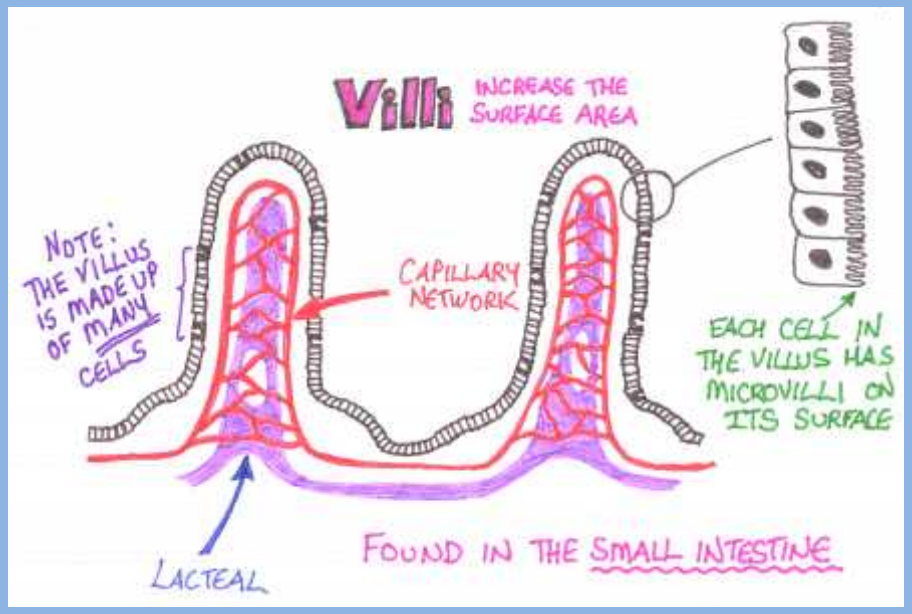
- J-shaped muscular bag that stores the food you eat, breaks it down into tiny pieces.
- Mixes food with Digestive Juices that contain enzymes to break down **Proteins and Lipids**.
- Acid (HCl) in the stomach Kills Bacteria.
- Food found in the stomach is called Chyme.



Small Intestine

- Small intestines are roughly 7 meters long
- Lining of intestine walls has finger-like projections called villi, to increase surface area.
- The villi are covered in microvilli which further increases surface area for absorption.





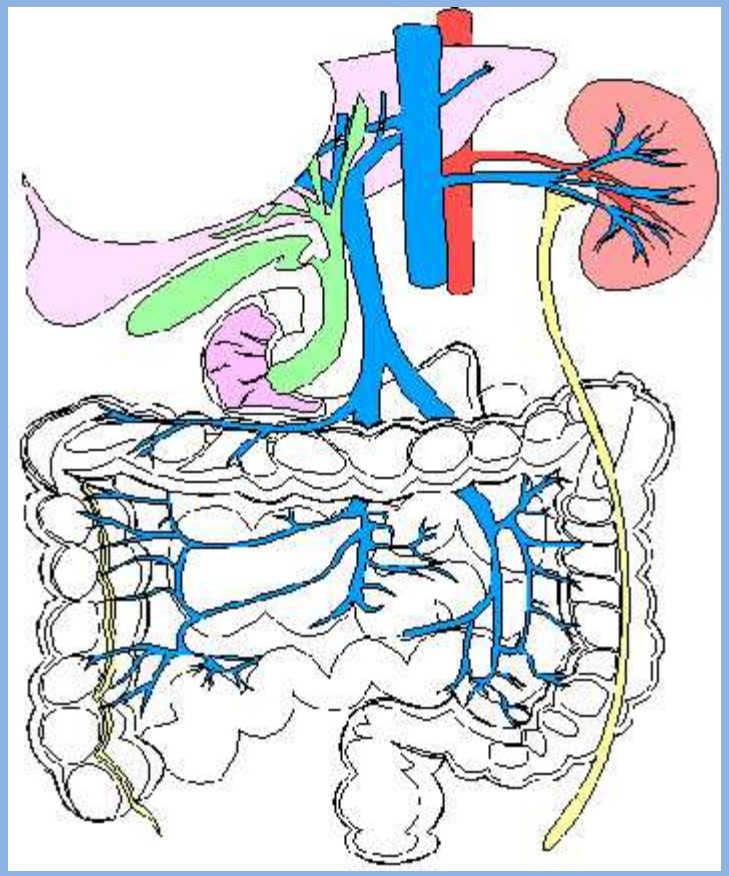
Crash Course Review

Small Intestine

- Nutrients from the food pass into the bloodstream through the small intestine walls.

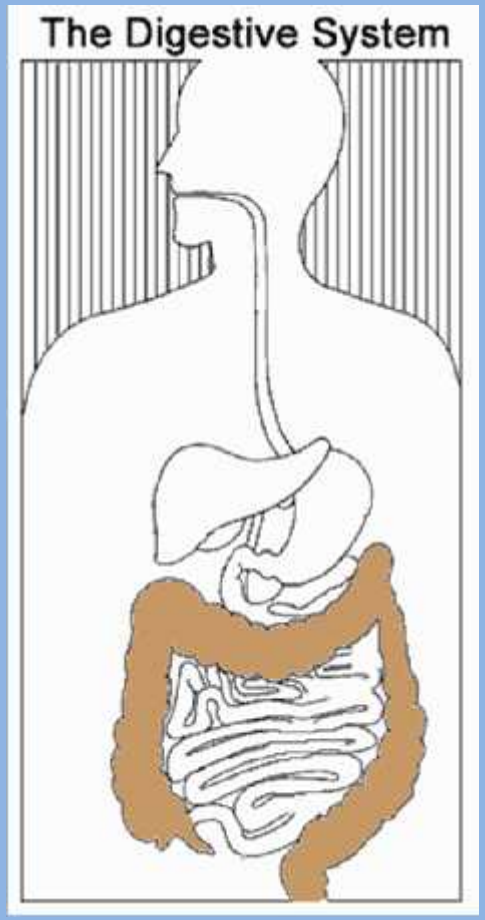
- Absorbs:
  - 80% ingested water
  - Vitamins
  - Minerals
  - Carbohydrates
  - Proteins
  - Lipids

  - Secretes digestive enzymes



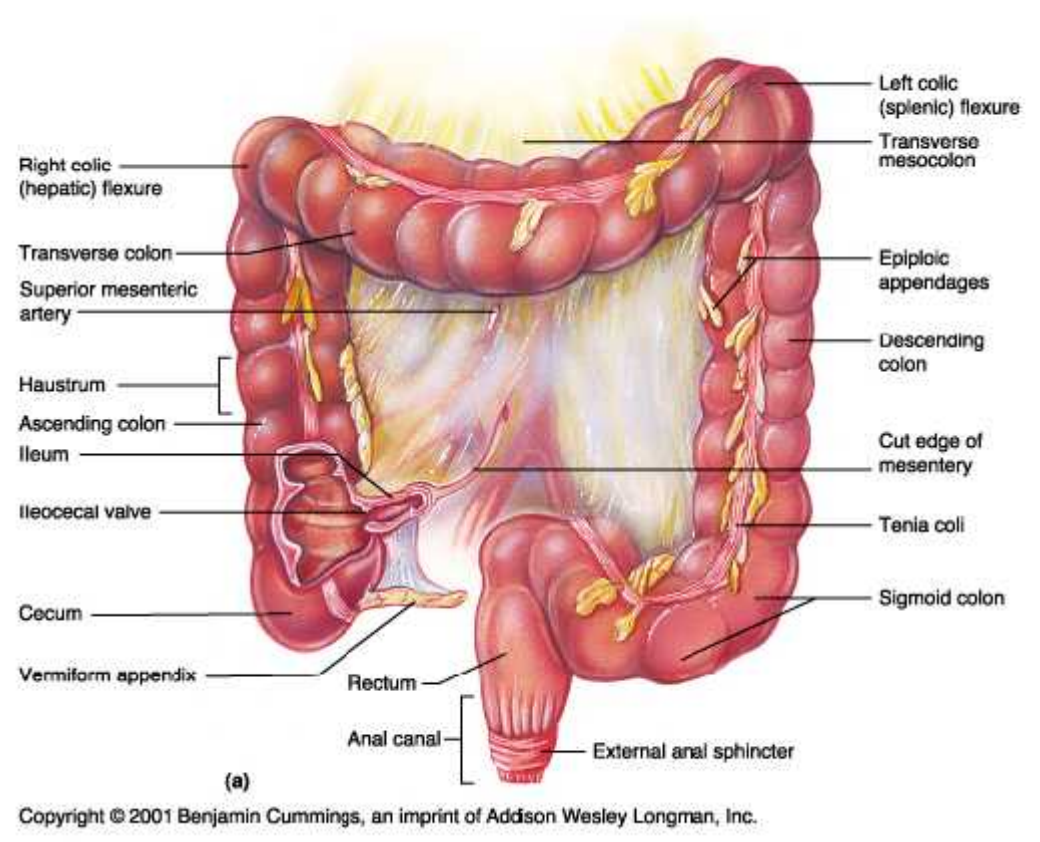
Large Intestine

- About 1.5 meters long
- Accepts what small intestines don't absorb
- Rectum (short term storage which holds feces before it is expelled).



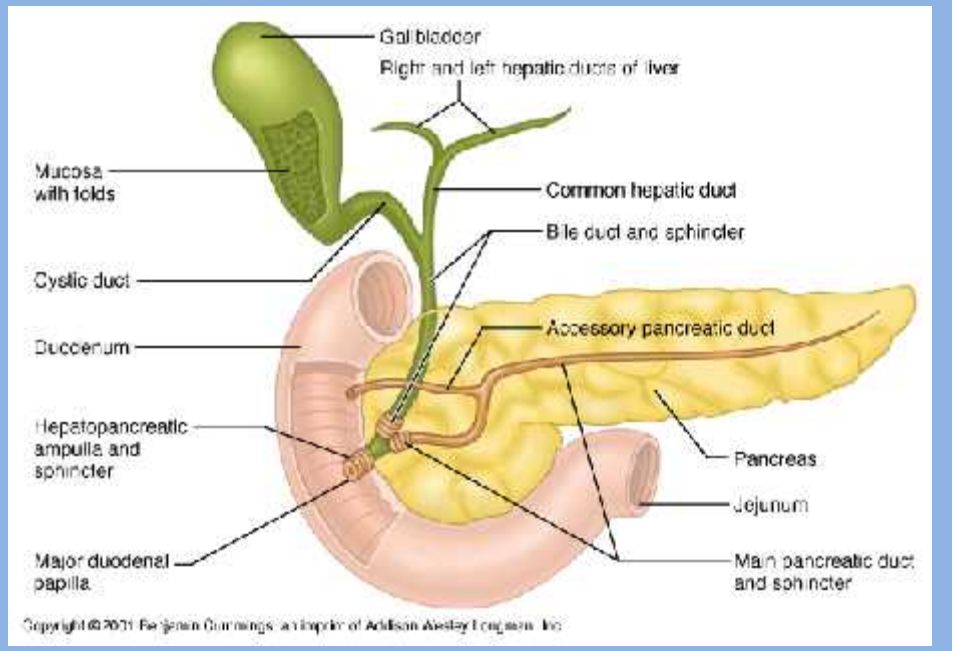
Large Intestine

- Functions
  - Bacterial digestion
    - Ferment carbohydrates
  - Absorbs more water
  - Concentrate wastes



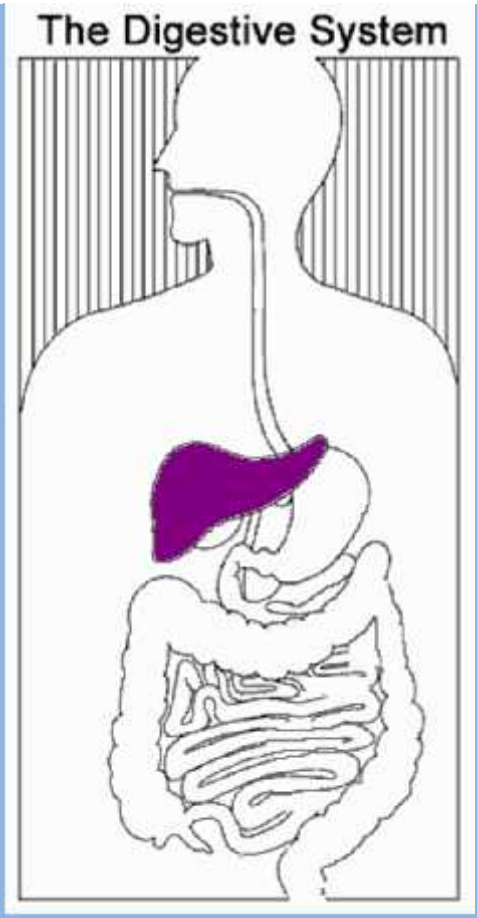
Accessory Organs The Glands

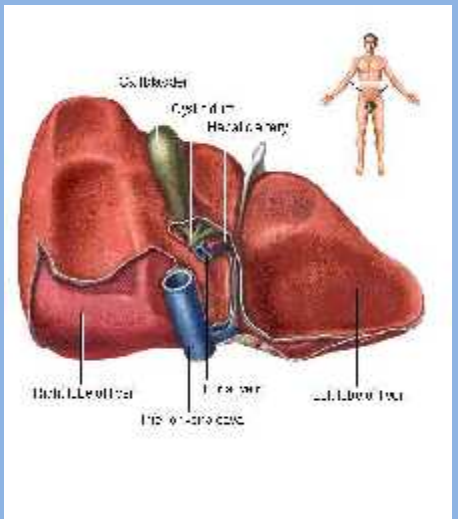
- Not part of the path of food, but play a critical role.
- Include: Liver, gall bladder, and pancreas



Liver

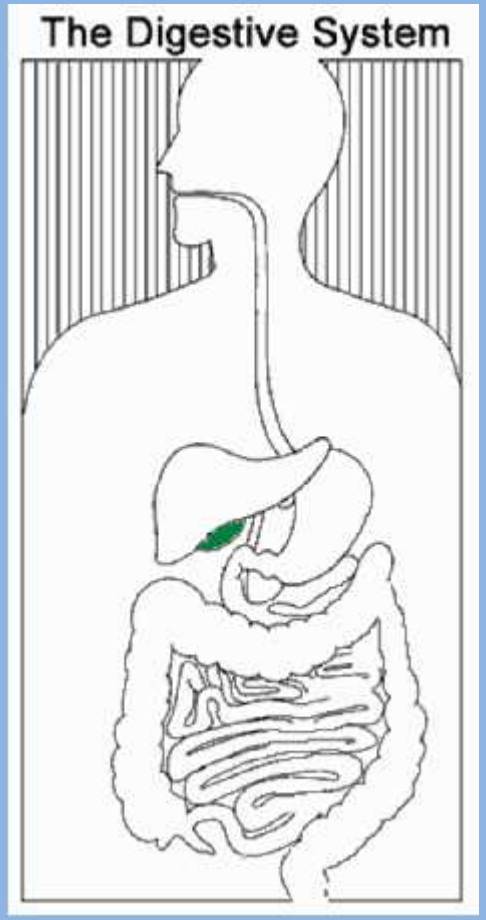
- Directly affects digestion by producing bile
  - Bile helps digest fat
  - filters out toxins and waste including drugs and alcohol and poisons.





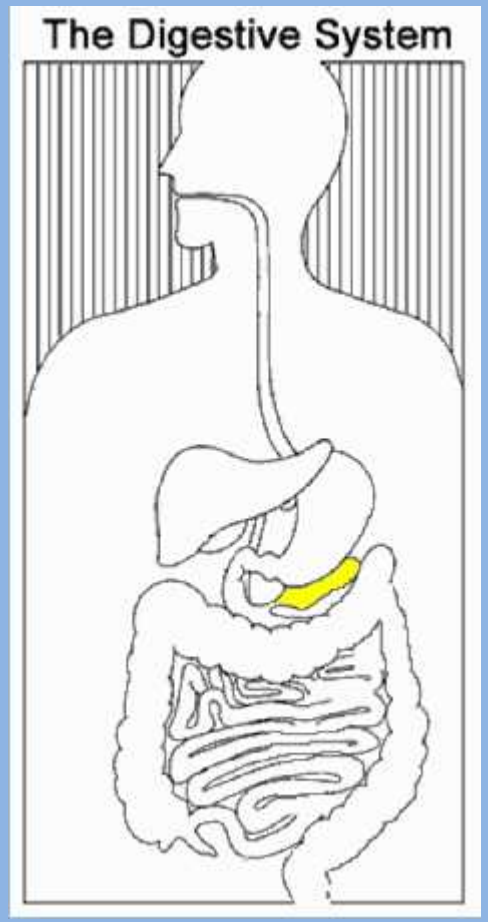
Gall Bladder

- Stores bile from the liver, releases it into the small intestine.
- Fatty diets can cause gallstones



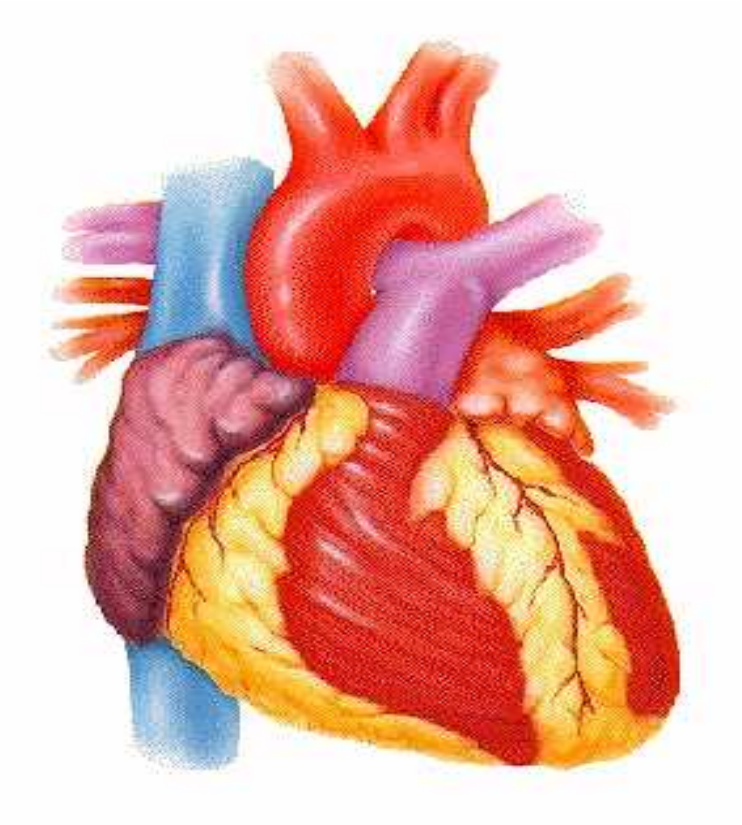
Pancreas

- Produces digestive enzymes to digest fats, carbohydrates and proteins
- Regulates blood sugar by producing insulin



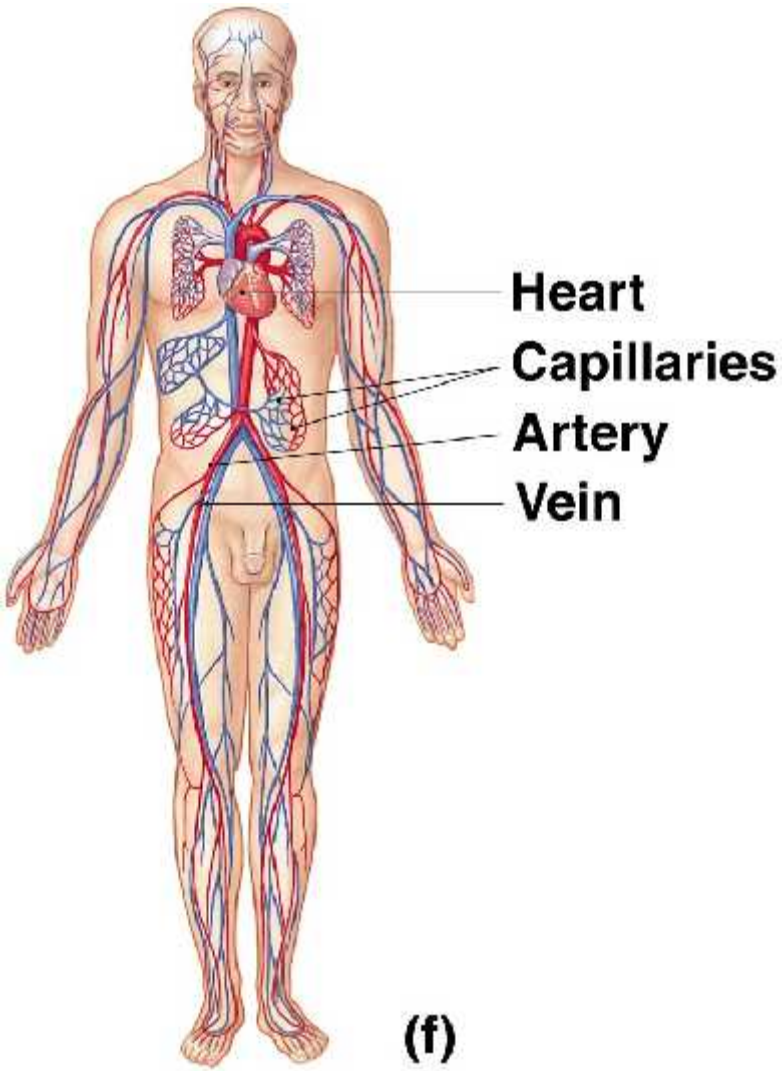
Web Page Reinforcement Video

Introduction to the Human Cardiovascular System



INTRODUCTION

- The cardiovascular system is transport system of body
- It comprises blood, heart and blood vessels.
- The system supplies nutrients to and remove waste products from various tissue of body.
- The conveying media is liquid in form of blood which flows in close tubular system.



FUNCTION OF CARDIOVASCULAR SYSTEM

- Transport nutrients, hormones
- Remove waste products
- Gaseous exchange
- Immunity
- Blood vessels transport blood
  - Carries oxygen and carbon dioxide
  - Also carries nutrients and wastes
- Heart pumps blood through blood vessels

COMPONENTS OF CARDIOVASCULAR SYSTEM

- **BLOOD**
- **HEART**
- **BLOOD VESSELS**

BLOOD

- **The Blood: Blood cells & Plasma**
- **Blood cells**

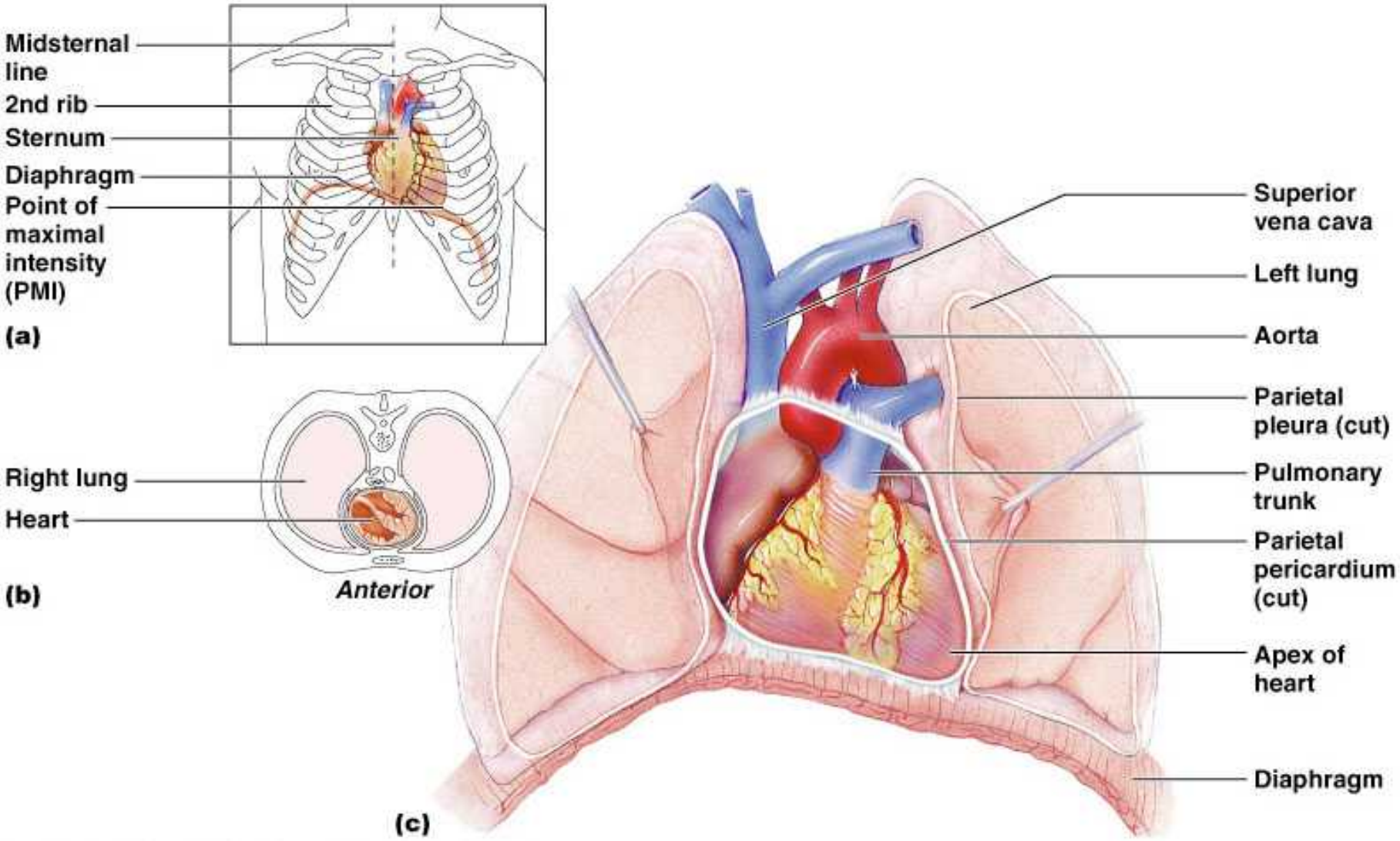
1- Erythrocytes - Red Blood Cells
2- Leucocytes
3- Thrombocytes

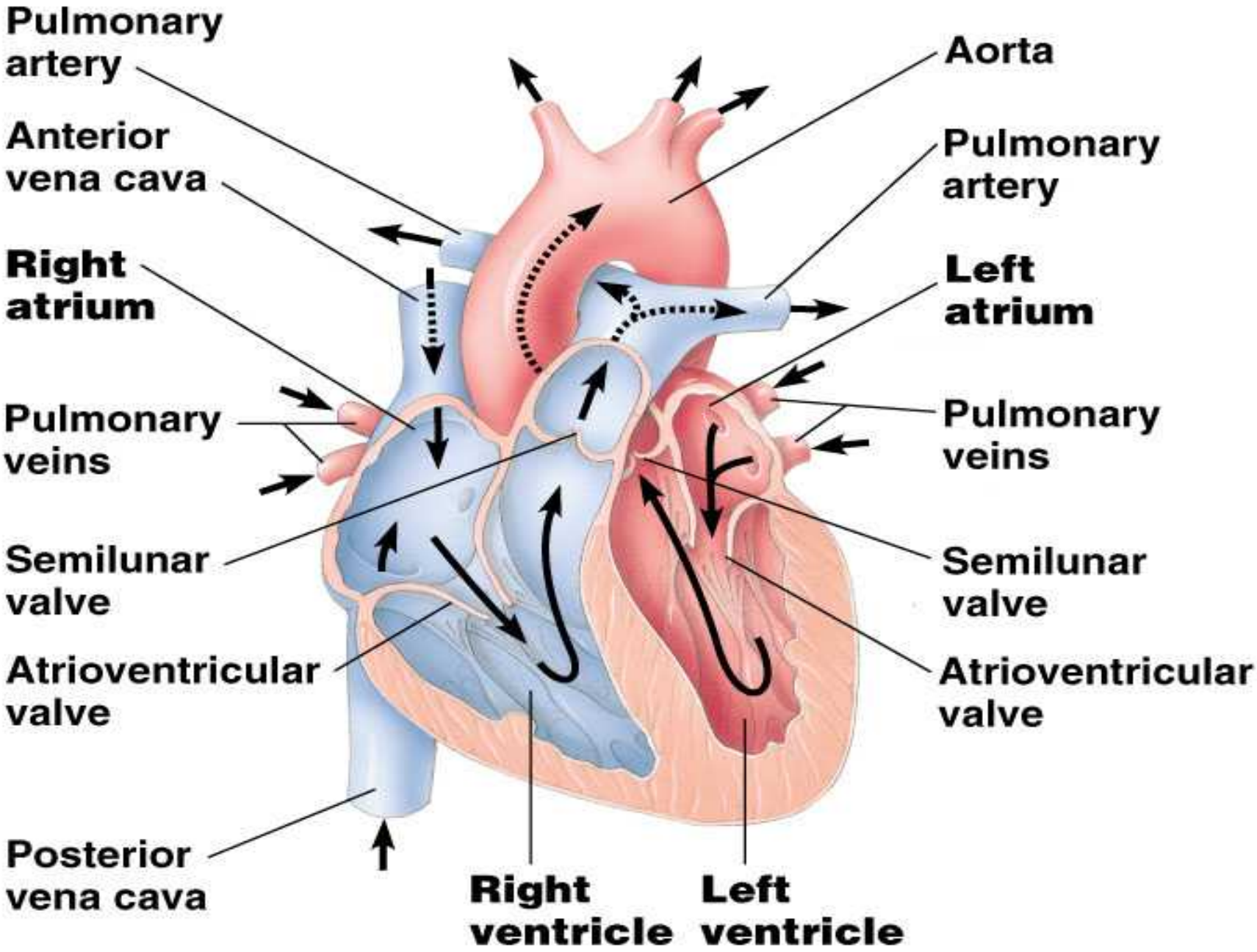
- **Plasma is fluid portion**

HEART

- **Heart is a four chambered, hollow muscular organ approximately the size of your fist**
- **Location:**
  - **Superior surface of diaphragm**
  - **Left of the midline**
  - **Anterior to the vertebral column, posterior to the sternum**

HEART


Midsternal line
2nd rib
Sternum
Diaphragm
Point of maximal intensity (PMI)
(a)
Right lung
Heart
(b)
Anterior
(c)
Superior vena cava
Left lung
Aorta
Parietal pleura (cut)
Pulmonary trunk
Parietal pericardium (cut)
Apex of heart
Diaphragm


Pulmonary artery
Anterior vena cava
Right atrium
Pulmonary veins
Semilunar valve
Atrioventricular valve
Posterior vena cava
Aorta
Pulmonary artery
Left atrium
Pulmonary veins
Semilunar valve
Atrioventricular valve
Right ventricle
Left ventricle

FUNCTIONS OF THE HEART

- **Generating blood pressure**
- **Routing blood**

  Heart separates pulmonary and systemic circulations
- **Ensuring one-way blood flow**

  Heart valves ensure one-way flow
- **Regulating blood supply**

  Changes in contraction rate and force match blood delivery to changing metabolic needs

BLOOD VESSELS

- **Blood Vessels -A closed network of tubes**

- **These includes:**
  - **Arteries**
  - **Capillaries**
  - **Veins**

BLOOD VESSELS

-Arteries(Distributing channel)

- Thick walled tubes
- Elastic Fibers
- Circular Smooth Muscle

–Capillaries (microscopic vessels)

- One cell thick
- Serves the Respiratory System

–Veins (draining channel)

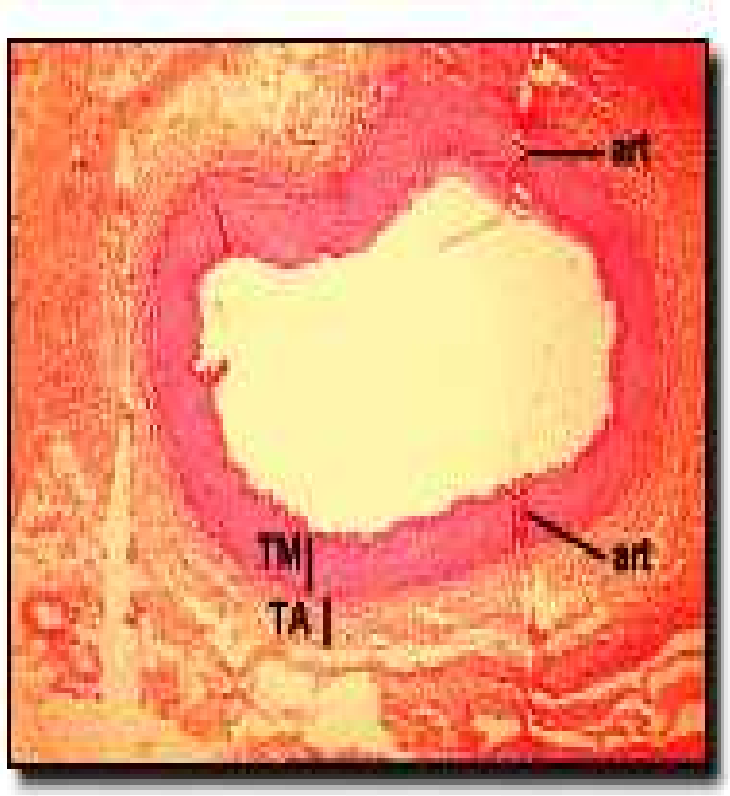
BLOOD VESSELS

- **General structure**

  1.Tunica intima

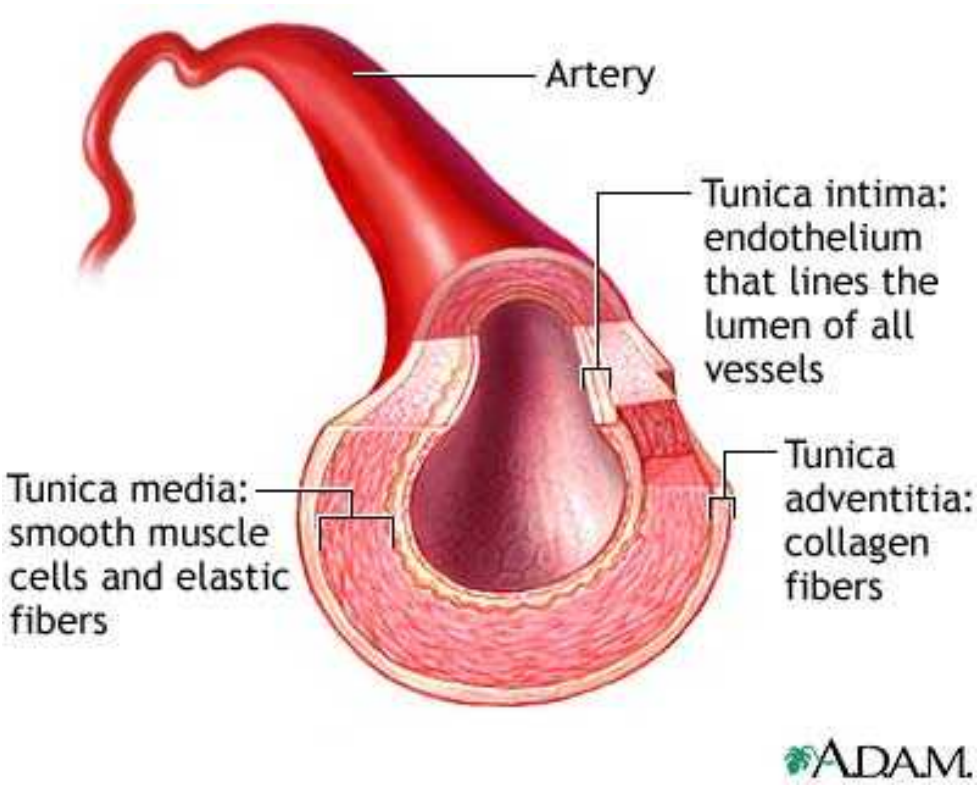
  2.Tunica media

  3.Tunica adventitia



ARTERIES

- Blood vessels that carry blood away from the heart are called arteries.
- They are the thickest blood vessels and they carry blood high in oxygen known as oxygenated blood (oxygen rich blood).



ARTERIES

- **Accompanied by vein and nerves**
- **Lumen is small**
- **No valves**
- **Repeated branching**

CLASSIFICATION OF ARTEIES

- **Elastic- e.g. (Aorta & its Major branches)**
- **Muscular -e.g.(Renal, Testicular, Radial, Tibial etc.)**
- **Arterioles (<0.1 mm)-**

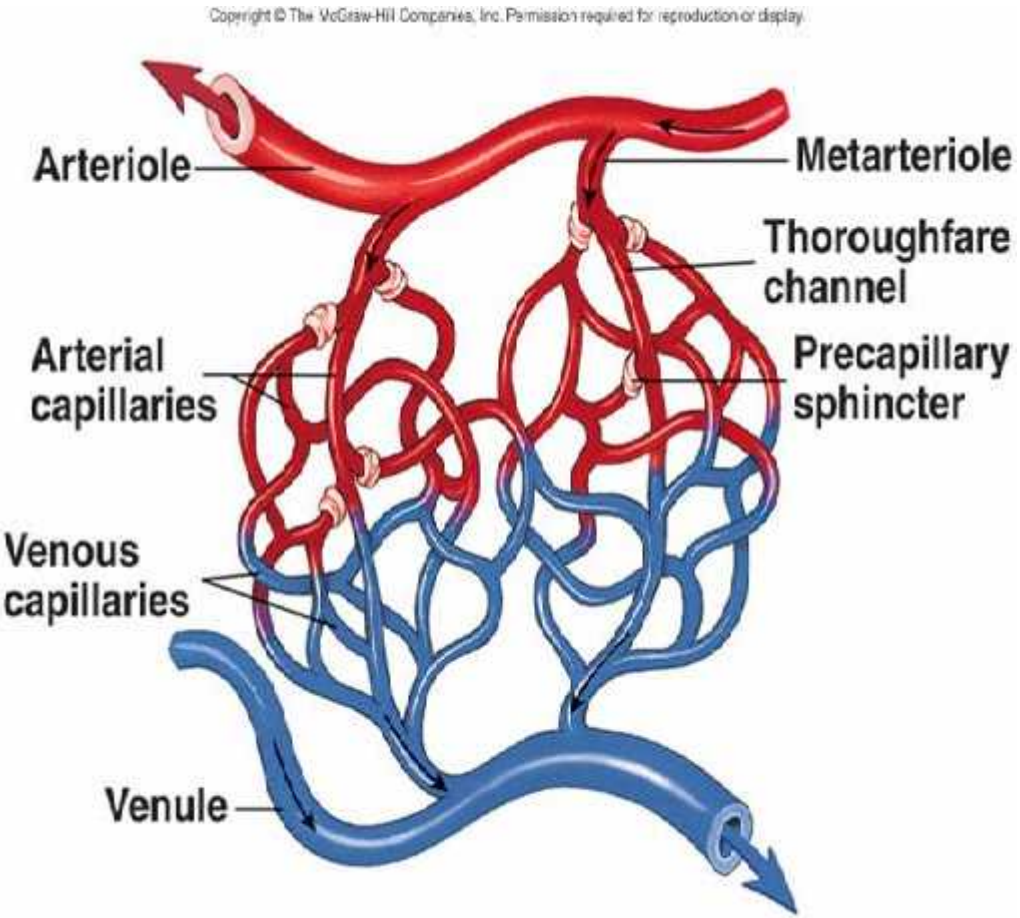
Terminal arterioles

Meta-arterioles

Thoroughfare channel/ preferred

CAPILLARIES (5-8 micron)

- **The smallest blood vessels are capillaries and they connect the arteries and veins.**
- **This is where the exchange of nutrients and gases occurs.**



BODY CONTAINS TWO KINDS OF CAPILLARIES

- **CONTINUOUS-SKIN, LUNG, SMMOTH MUSCLE, CONNECTIVE TISSUES**

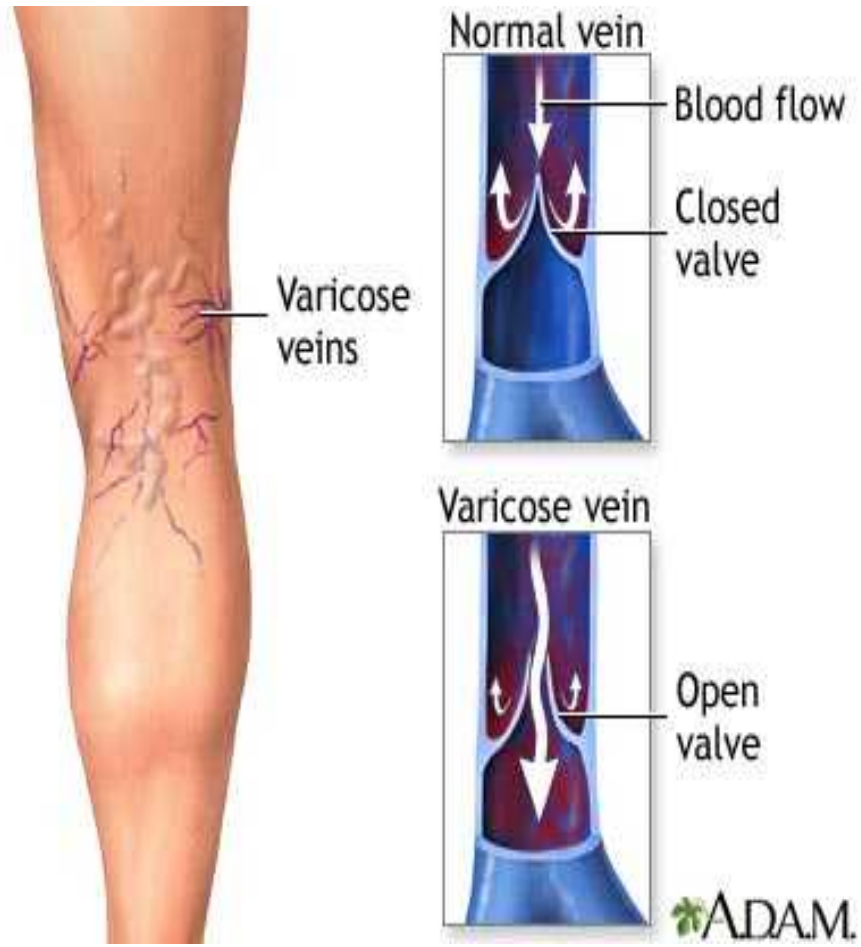
- **FENESTRATED- PANCREAS,ENDOCRINE GLANDS, SMALL INTESTINE,CHOROID PLEXUS,CILLIARY PROCESS etc.**

SINUSOIDS

- **SINUSOIDS- Large irregular vascular space (30-40 micron) eg.Liver, Spleen, Bone marrow, suprarenal, Parathyroid etc.**

VEINS

- **Blood vessels that carry blood back to the heart are called veins.**
- **They have one-way valves which prevent blood from flowing backwards.**
- **They carry blood that is high in carbon dioxide known as deoxygenated blood (oxygen poor blood).**



VEINS

- **Thin Walled**
- **Large irregular lumen**
- **Have valves**
- **Dead space around**
- **Types:**
    - **Large**
    - **Medium**
    - **Small**

VEINS

- **Veins without valves:**
  - **SVC & IVC**
  - **Hepatic, Renal**
  - **Uterine, Ovarian not Testicular**
  - **Facial**
  - **Pulmonary**
  - **Umbilical**
  - **Emissary**
  - **Portal Veins <2mm**

VEINS

- **Veins without Muscular tissue:**
  - **Dural venous sinuses**
  - **Pial Veins**
  - **Retinal**
  - **Veins of erectile tissue of sex organs**
  - **Veins of spongy bones**

VEINS

- **Factors responsible for venous return:**

1. **Muscle contraction**
2. **Negative intrathoracic pressure**
3. **Pulsation of arteries**
4. **Gravity**
5. **Valves**

CIRCULATION

- Coronary circulation – the circulation of blood within the heart.
- Pulmonary circulation – the flow of blood between the heart and lungs.
- Systemic circulation – the flow of blood between the heart and the cells of the body.
- Fetal Circulation

SYSTEMIC AND PULMONARY CIRCULATION

Pulmonary circulation

The flow of blood between the heart and lungs.

Systemic circulation

The flow of blood between the heart and the cells of the body.

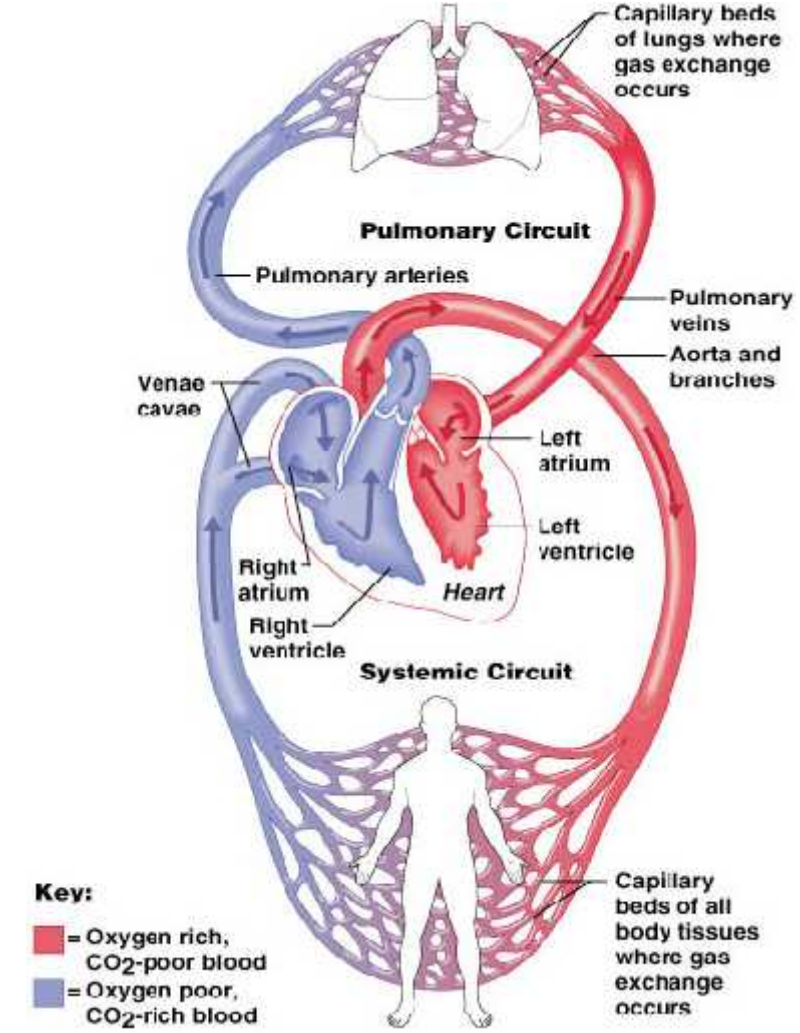


Figure 18.5

CORONARY CIRCULATION: ARTERIAL SUPPLY

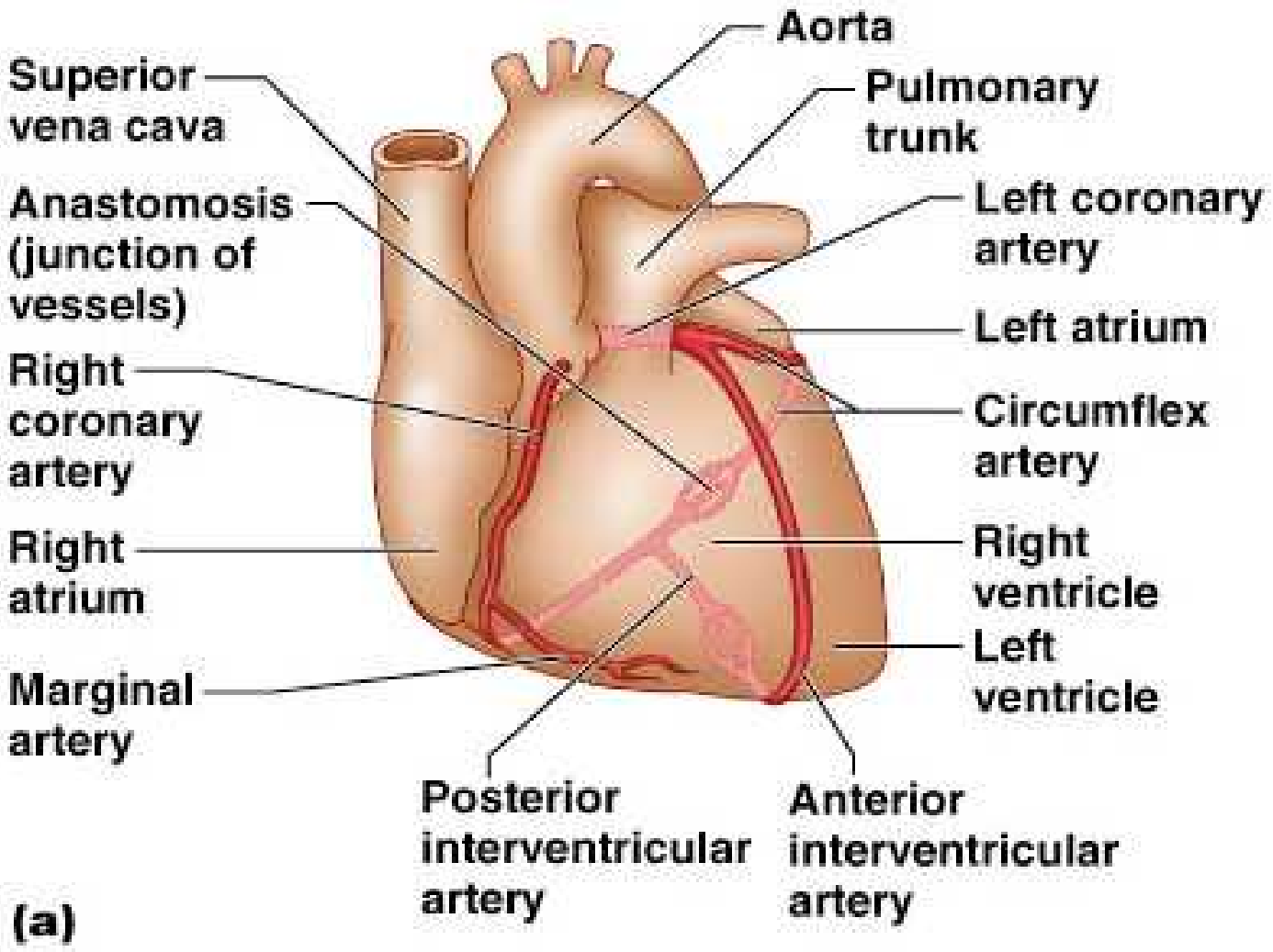
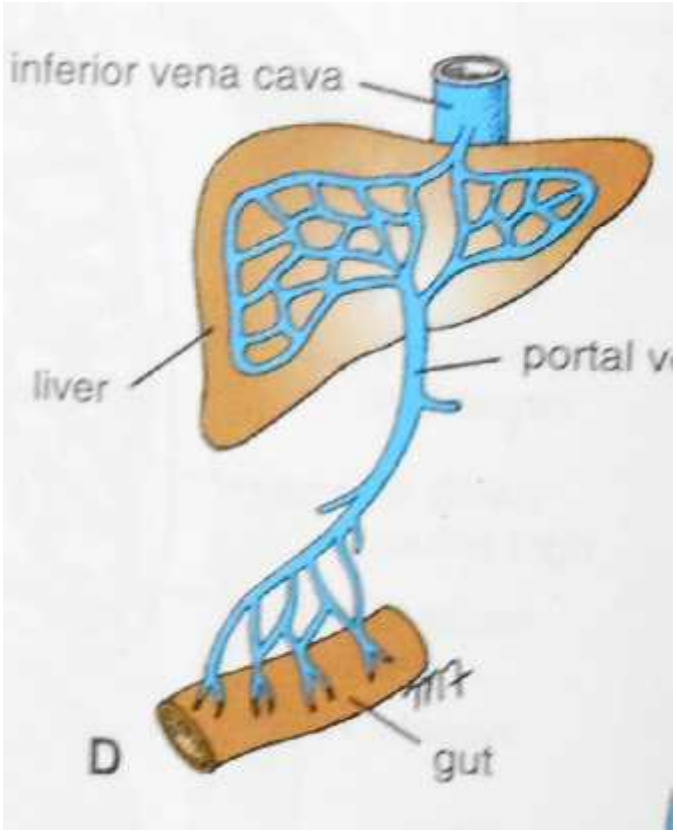


Figure 18.7a

PORTAL CIRCULATION

- **Portal circulation - the flow of blood between tow set of capillaries before draining in systemic veins.**



Nervous System

Function of the Nervous System

- To coordinate the actions of your body
- To ensure effective behaviour
- To maintain the internal environment within safe limits (homeostasis)

Messages are relayed throughout the body via electrochemical messages from the brain or through chemical messengers – hormones (hormones require more time than nervous transmission but are long lasting)

There are more nerve cells in the body than there are visible stars in the Milky Way!

1 cm^3 of brain tissue houses several million neurons with each connecting with several thousand others

Nervous Tissue

The nervous system is divided into a *central nervous system* (*CNS*), consisting of the brain and spinal cord, and a *peripheral nervous system* (*PNS*), consisting of nerves carrying sensory and motor information between the CNS and muscles and glands.

Both systems have two types of cells: *neurons* that transmit impulses and *neuroglial cells* that support neurons.

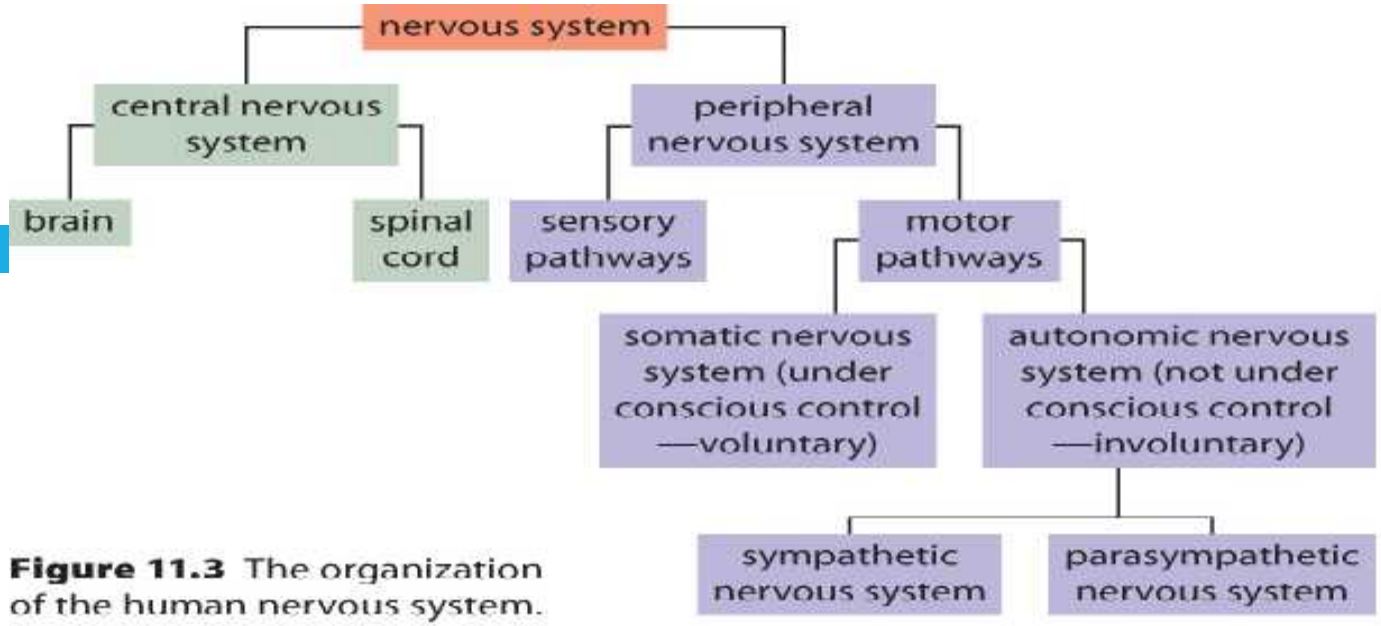
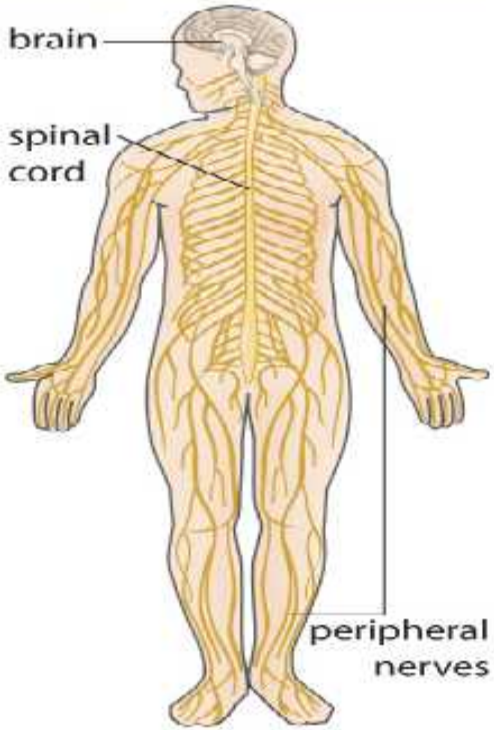
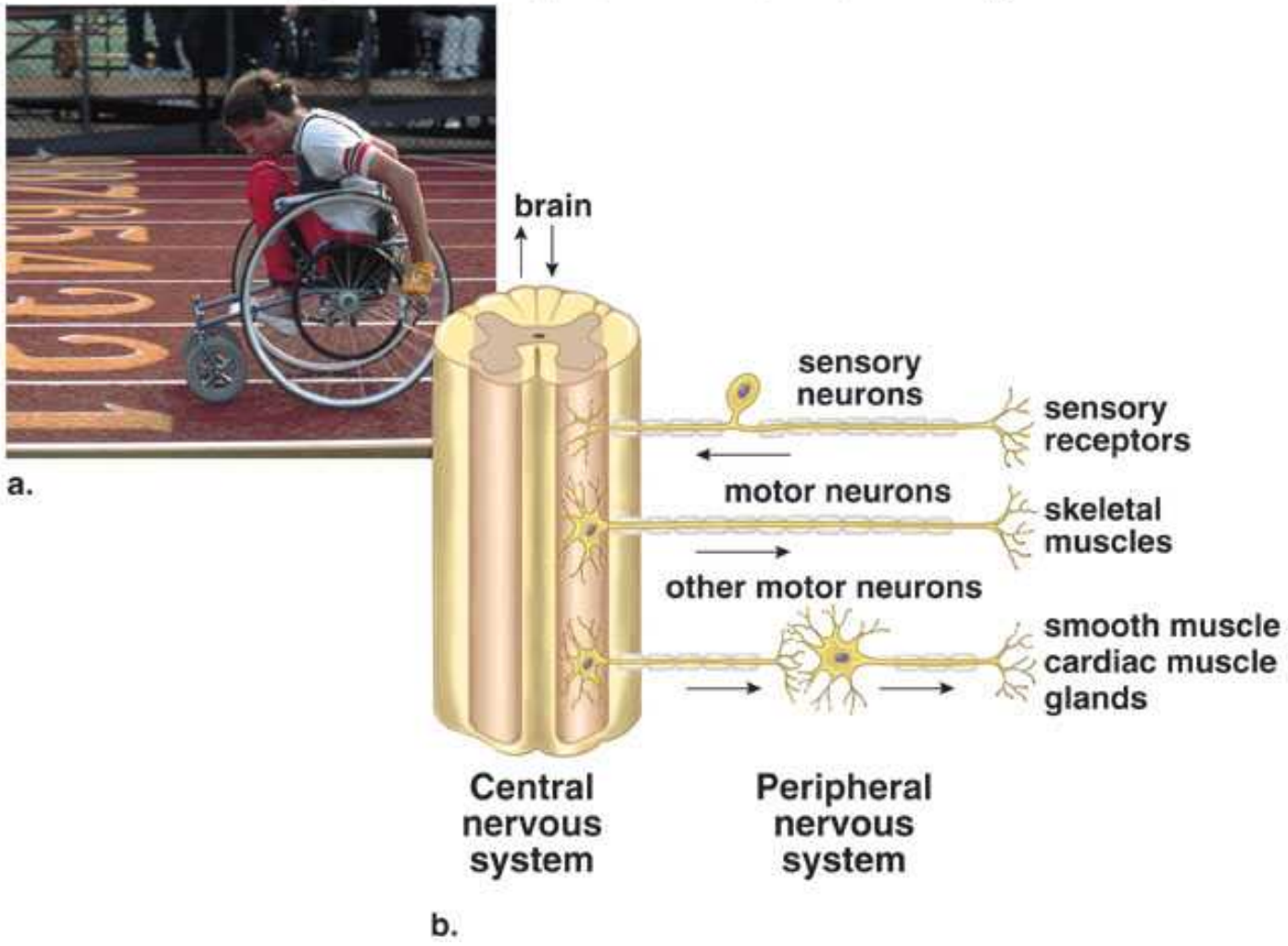


Figure 11.3 The organization of the human nervous system.



Organization of the nervous system



Neuron Structure

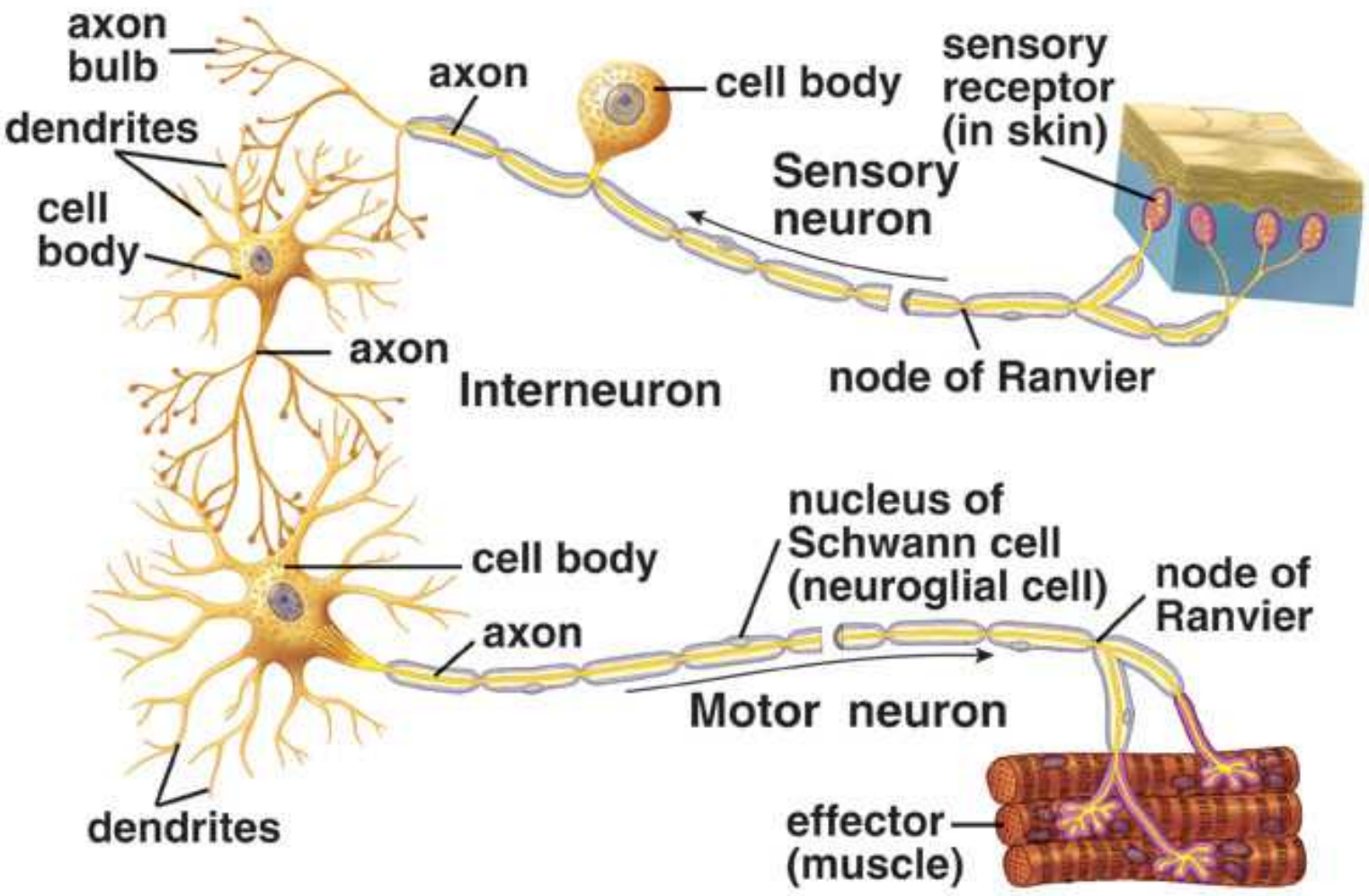
Neurons are composed of *dendrites* that receive signals, a *cell body* with a nucleus, and an *axon* that conducts a nerve impulse away.

Sensory neurons take information from *sensory receptors* to the CNS.

Interneurons occur within the CNS and integrate input (nonmyelinated).

Motor neurons take information from the CNS to muscles or glands.

Types of neurons



dendrites – receive information (either from receptor cells or other nerve cells), conducting towards the cell body (~200 dendrites/cell body)

cell body – location of the nucleus, high metabolic rate (so contains mitochondria)

axon– may be 1m long, very thin, conducts the impulse towards other neurons or effectors, starts at axon hillock, the smaller the neuronal diameter, the faster the neuronal transmission

nodes of Ranvier– the unmyelinated sections of a myelinated neuron, impulses "jump" between the nodes of Ranvier

neurilemma– a thin layer encompassing neurons in the peripheral nervous system, promoting their regeneration

Schwann cell – responsible for the myelin synthesis, type of glial cell (supporting and nourishing cell found in the nervous system)

Axon Bulb – either at a synaptic bulb or end plate to muscle, contains neurotransmitter

Myelin Sheath

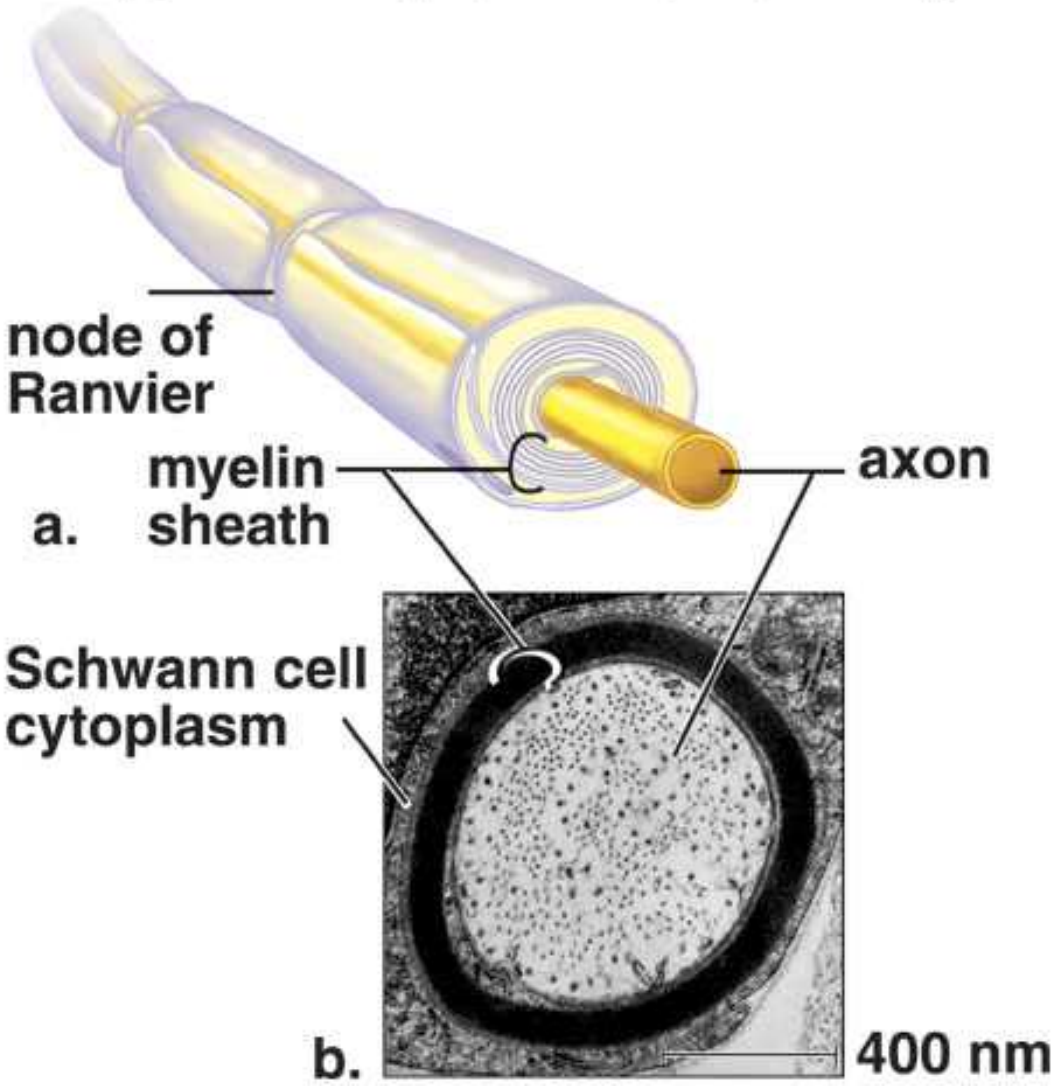
Myelination covers long axons with a protective *myelin sheath* (made by neuroglial cells called *Schwann cells)*.

The sheath contains lipid *myelin* which gives nerve fibers their white, glistening appearance.

The sheath is interrupted by gaps called *nodes of Ranvier*.

Multiple sclerosis is a disease of the myelin sheath.

Myelin sheath



FYI

Nerves are generally comprised of many neurons together (like fibre optic cable)

Myelinated neurons in the brain are termed white matter (the myelin makes them look white)

White matter may regenerate after injury, whereas grey matter (unprotected) will not

The Central Nervous System

The *central nervous system* (*CNS*) consists of the *spinal cord* and *brain*.

Both are protected by bone, wrapped in protective membranes called *meninges*, and surrounded and cushioned with *cerebrospinal fluid* that is produced in the ventricles of the brain.

The *ventricles* are interconnecting cavities that produce and serve as a reservoir for cerebrospinal fluid.

The CNS receives and integrates sensory input and formulates motor output.

Gray matter contains cell bodies and short, nonmyelinated fibers; *white matter* contains myelinated axons that run in *tracts*.

The Brain

- consumes more oxygen and glucose than any other part of the body
- meninges – outer layers (protection) – dura mater, arachnoid and pia mater
- cerebrospinal fluid –between the inner, middle meninges & central canal of s.cord, carries nutrients, acts as a shock absorber, relays waste by diffusion & fac. diffusion, flows within ventricles – four "spaces" in the brain

The human brain

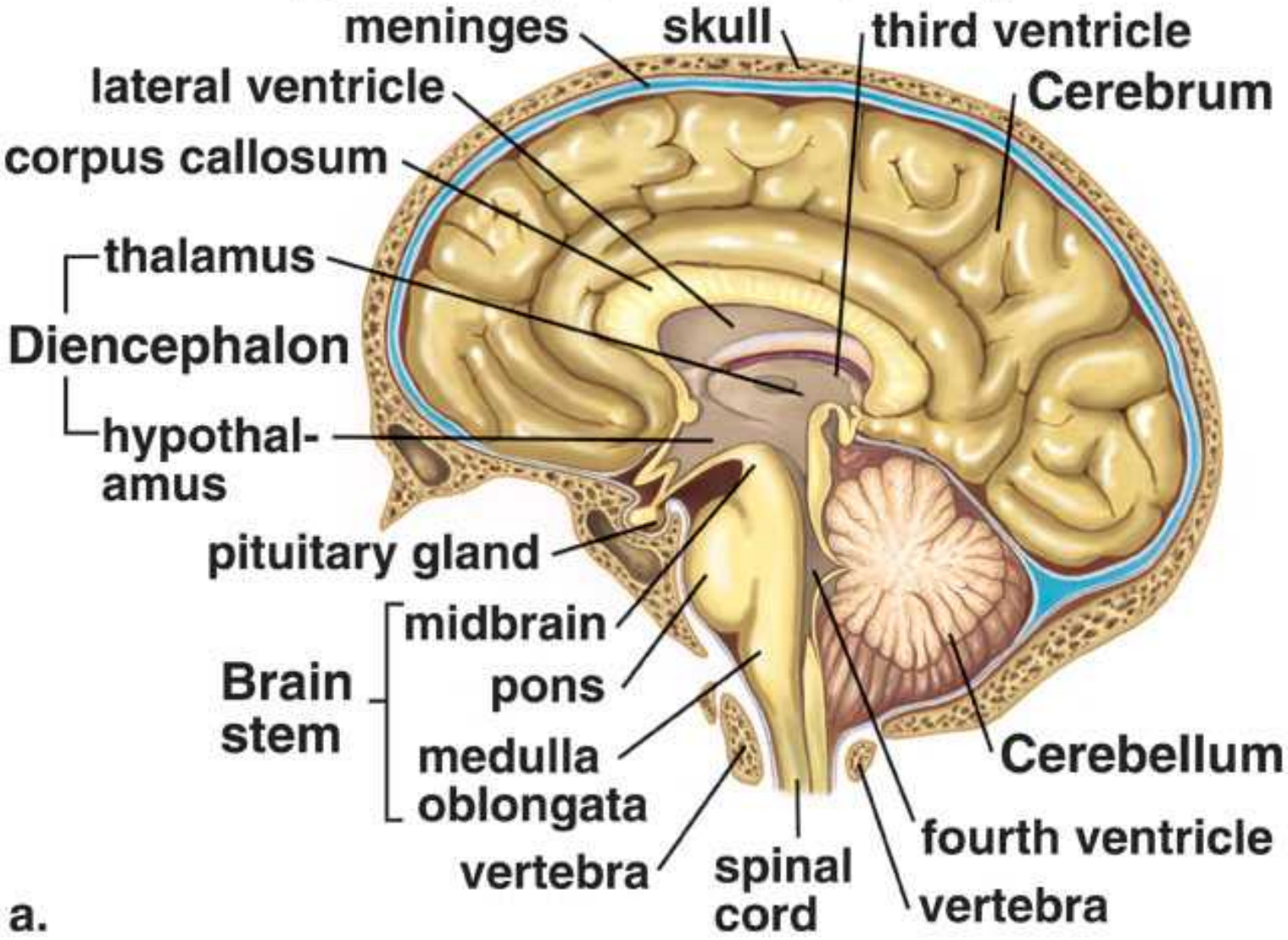
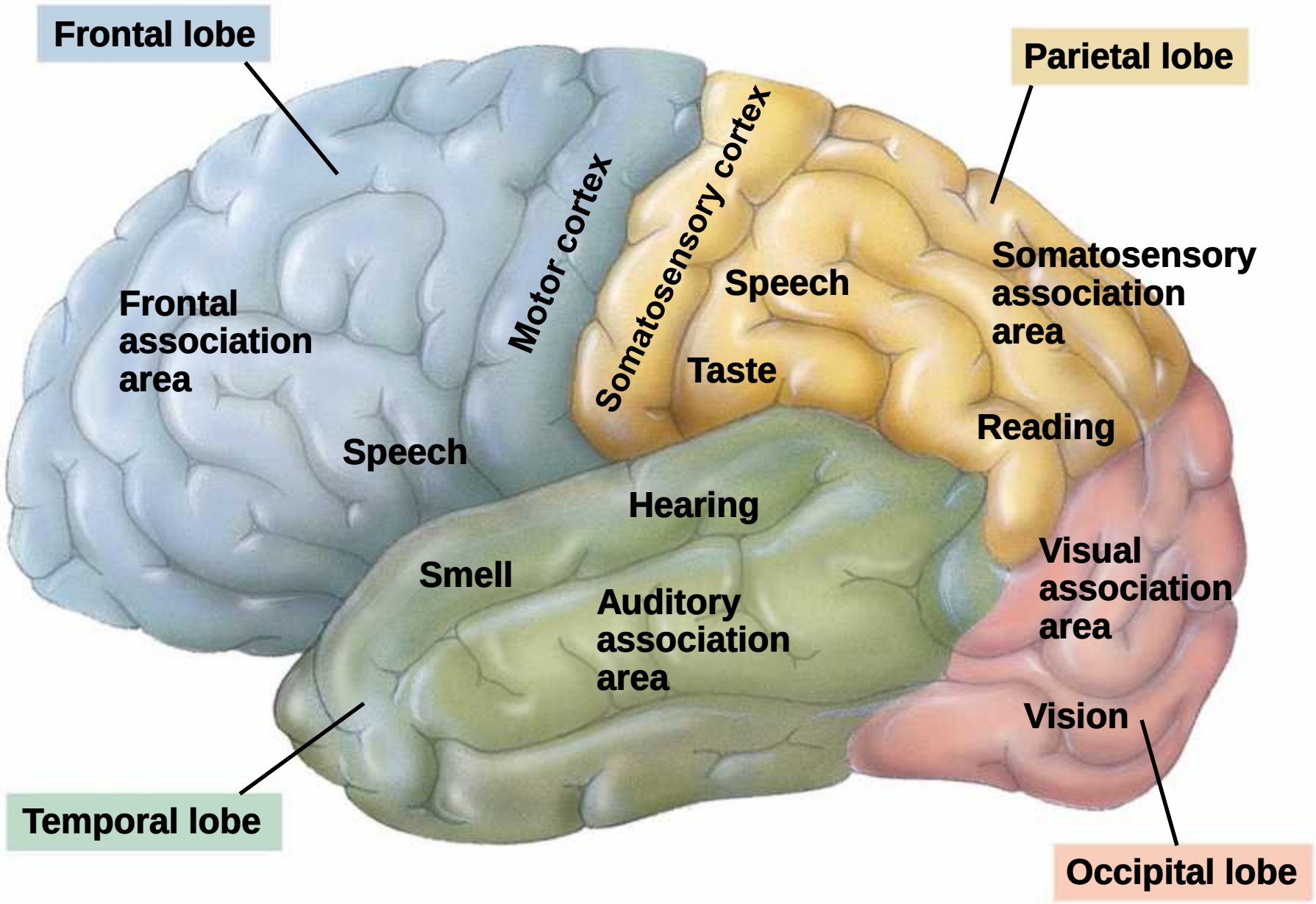
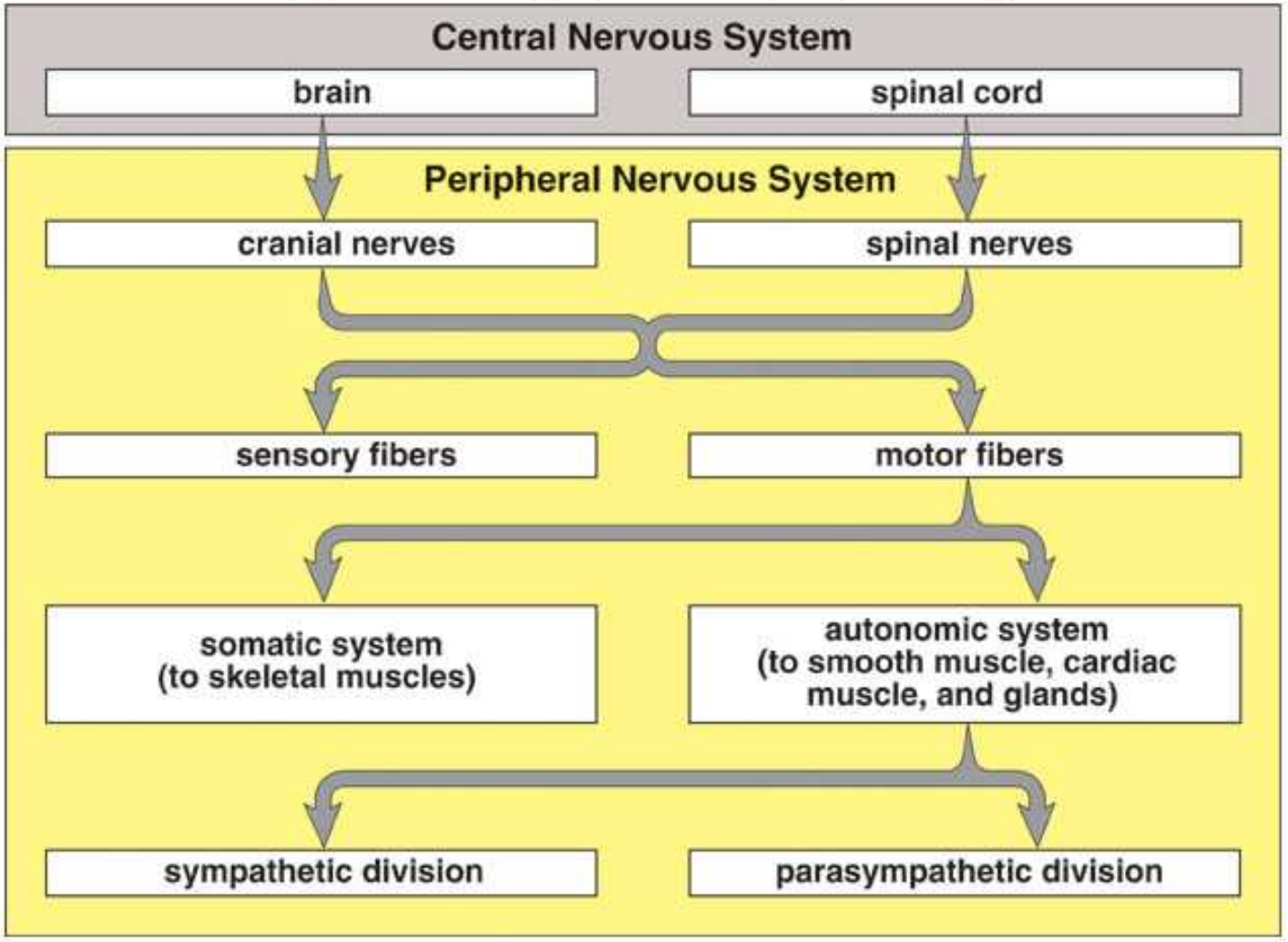


Fig. 49-15



Organization of the nervous system



The Spinal Cord

The *spinal cord* extends from the base of the brain through the vertebral canal.

Structure of the Spinal Cord

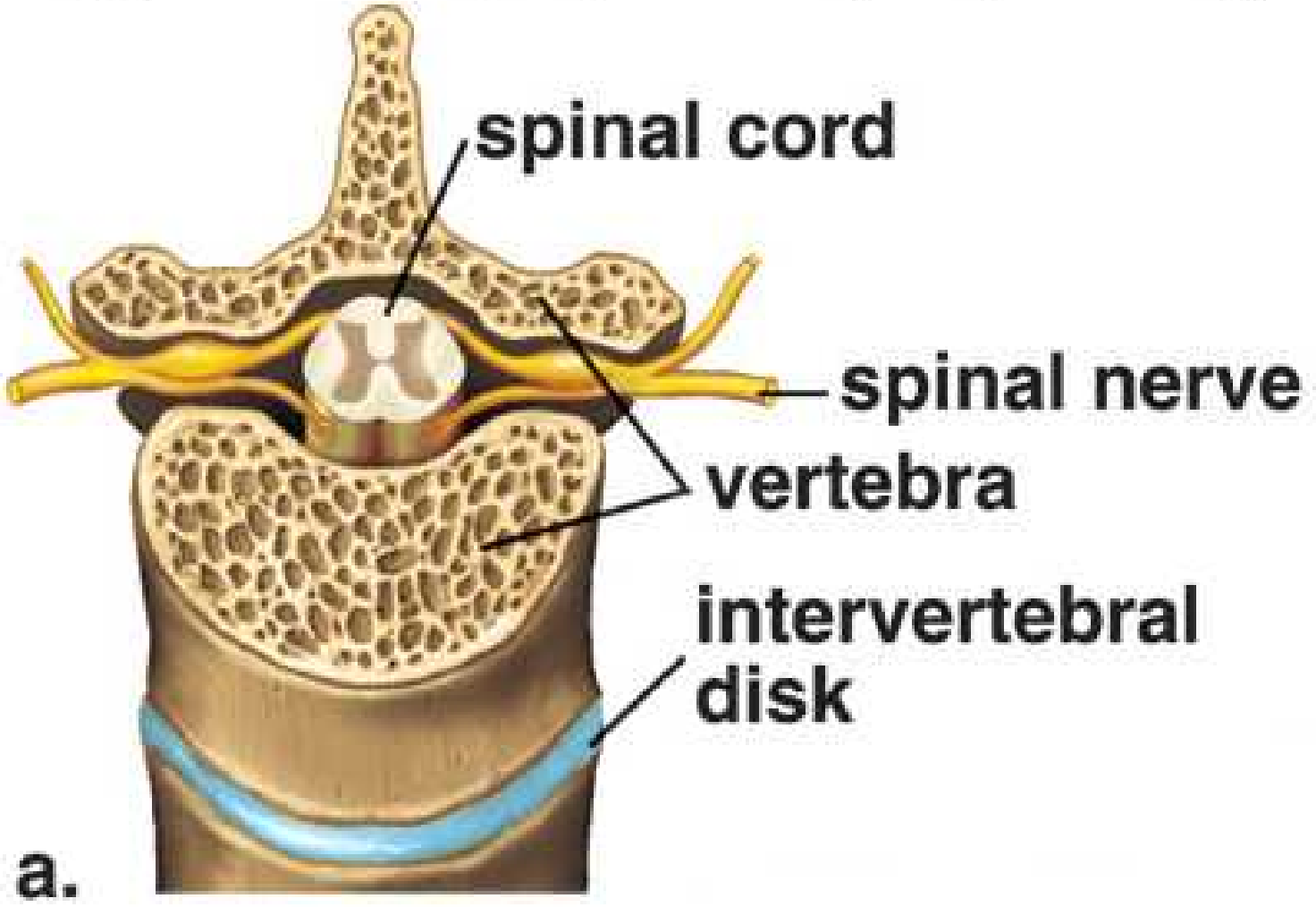
A *central canal* holds cerebrospinal fluid.

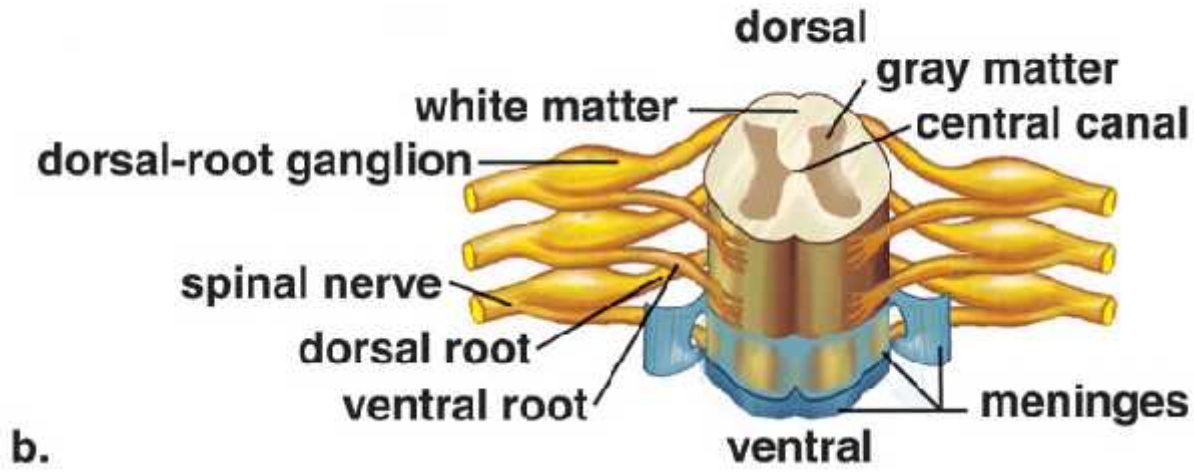
Gray matter of the spinal cord forms an "H" and contains *interneurons* and portions of sensory and motor neurons.

White matter consists of *ascending tracts* taking sensory information to the brain and *descending tracts* carrying motor information from the brain.

- ventral root (towards front of body) carries motor neuron messages to muscles
- dorsal root (towards back) carries sensory neuron messages from the body

Spinal cord





b.

c.

white matter | central canal | gray matter

Functions of the Spinal Cord

The *spinal cord* is the center for many *reflex arcs*.

It also sends *sensory* information to the brain and receives *motor* output from the brain, extending communication from the brain to the peripheral nerves for both control of voluntary skeletal muscles and involuntary internal organs.

Severing the spinal cord produces *paralysis*.

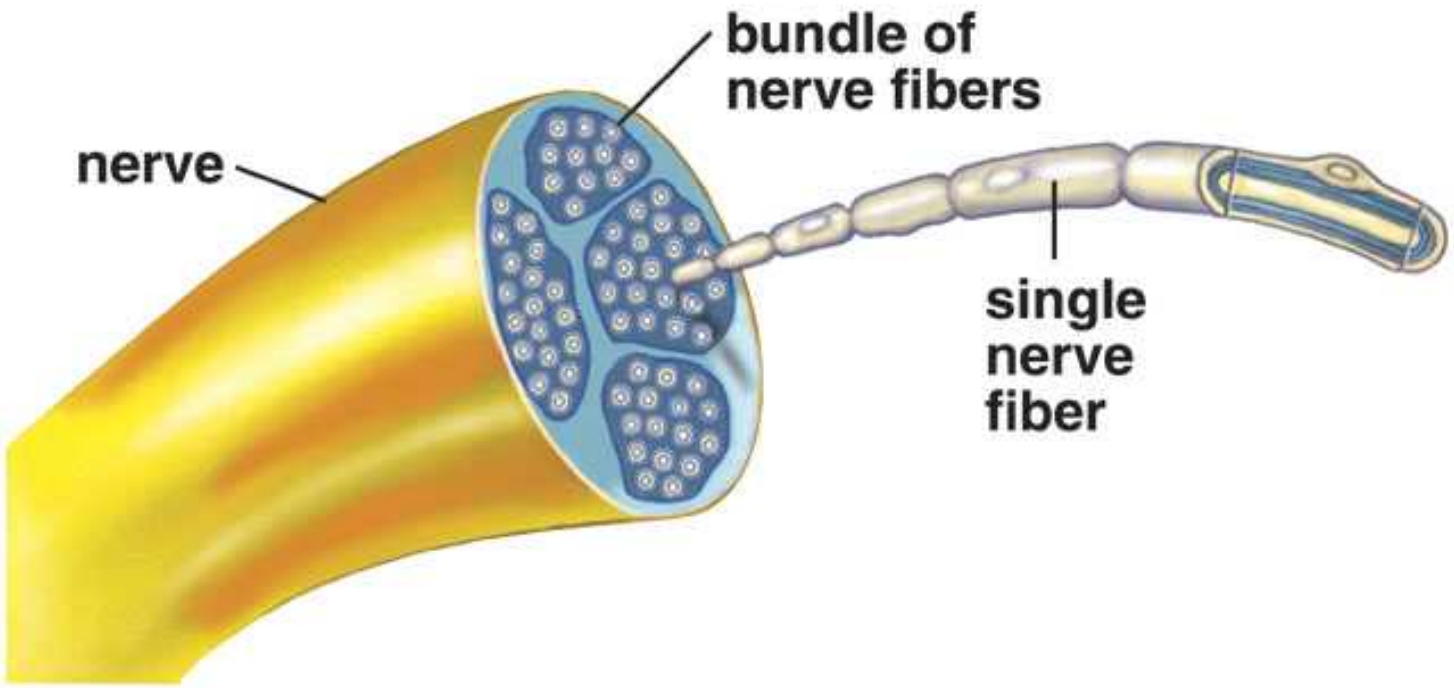
The Peripheral Nervous System

The *peripheral nervous system* (*PNS*) contains *nerves* (bundles of axons) and *ganglia* (cell bodies).

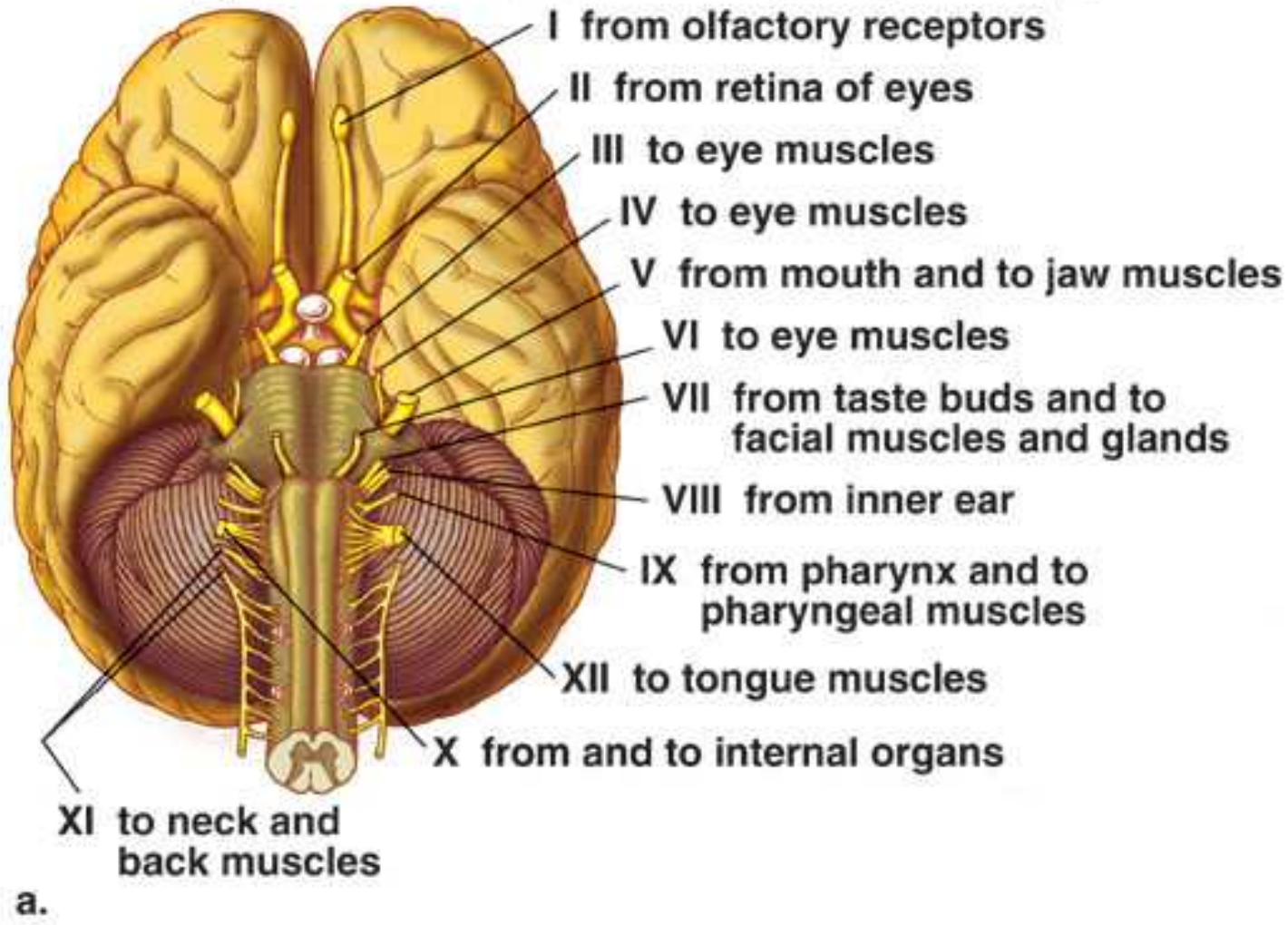
Sensory nerves carry information to the CNS, *motor nerves* carry information away

Humans have 12 pairs of *cranial nerves* and 31 pairs of *spinal nerves*.

Nerve structure



Cranial nerves

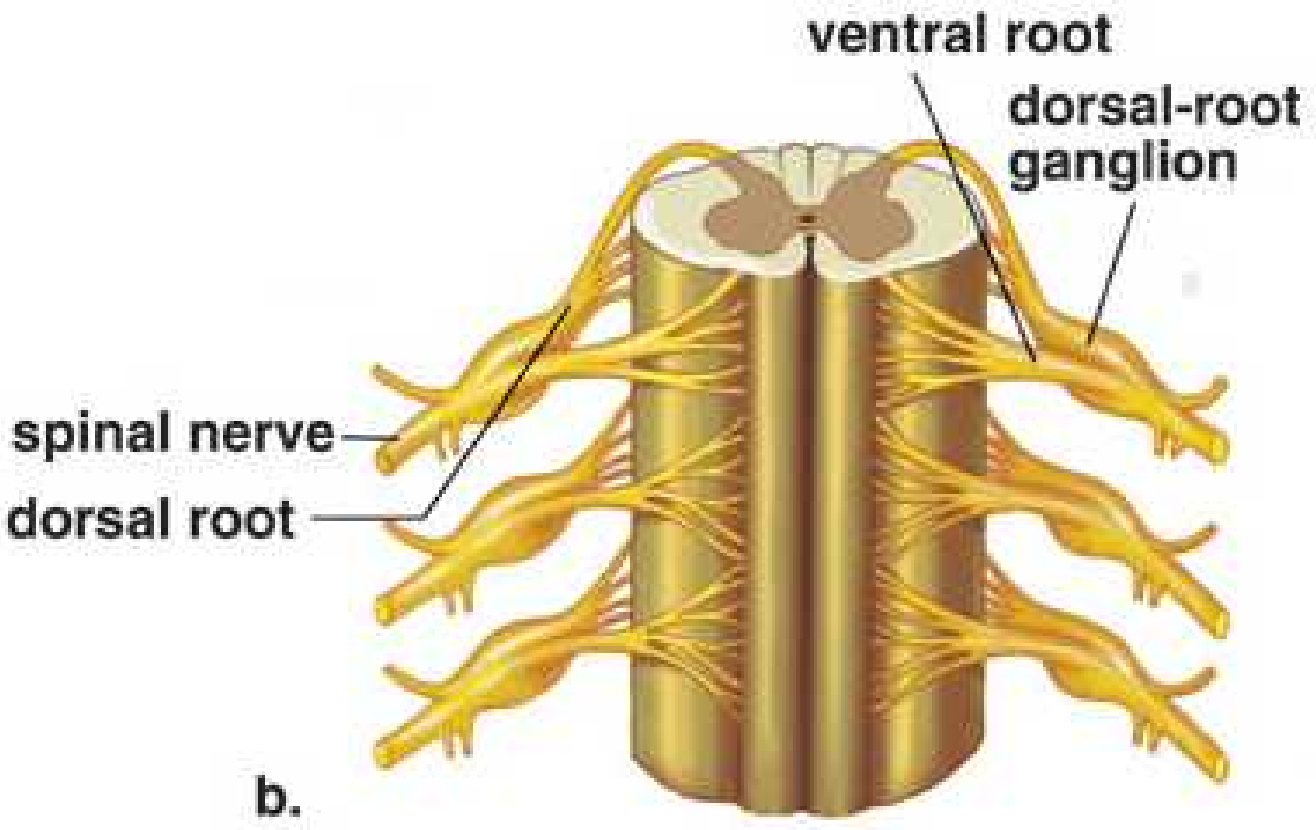


The *dorsal root* of a spinal nerve contains sensory fibers that conduct sensory impulses from sensory receptors toward the spinal cord.

Dorsal root ganglia near the spinal cord contain the cell bodies of sensory neurons.

The *ventral root* of a spinal nerve contains motor fibers that conduct impulses away from the spinal cord to effectors.

Spinal nerves



Somatic System

The *somatic system* serves the skin, skeletal muscles, and tendons.

The brain is always involved in voluntary muscle actions but somatic system reflexes are automatic and may not require involvement of the brain.

- nerves running to skeletal muscle system (under voluntary control)
- motor neurons → voluntary effectors (skeletal muscle)
- control exists in the cerebrum & cerebellum (coordination)

Homeostasis and the Autonomic Nervous System

- All autonomic nerves are motor nerves that regulate the organs of the body without conscious control; involuntary
- Control exists in the medulla
- Effectors are smooth muscle (digestive system), cardiac muscle (heart) and glands (exocrine & endocrine)
- Responsible for maintaining homeostasis during times of rest and during emergencies

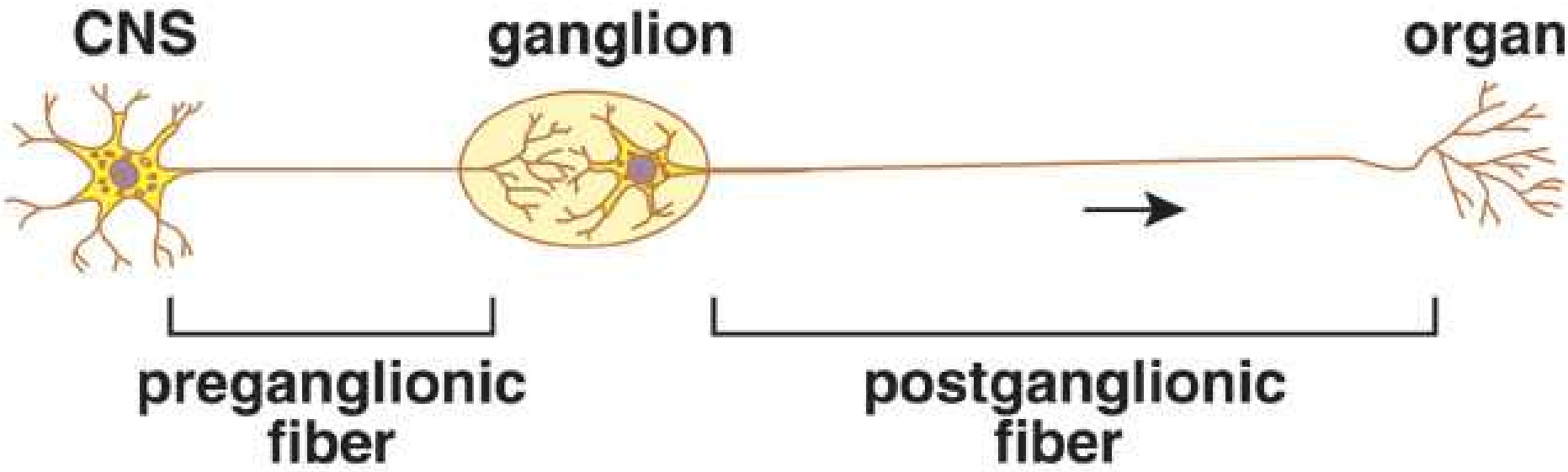
Consists of two parts:

Sympathetic

- prepares the body for stress, including "fight or flight" response
- short preganglionic nerve (Ach), long postganglionic nerve (NEp)
- originate in the thoracic vertebrae (ribs) or lumbar vertebrae (small of back)

Parasympathetic

- restores normal balance; times of relaxation
- long preganglionic nerve (Ach), short postganglionic nerve (ACh)
- originate in the brain (cranial nerves) or the spinal cord


CNS
ganglion
organ
preganglionic fiber
postganglionic fiber

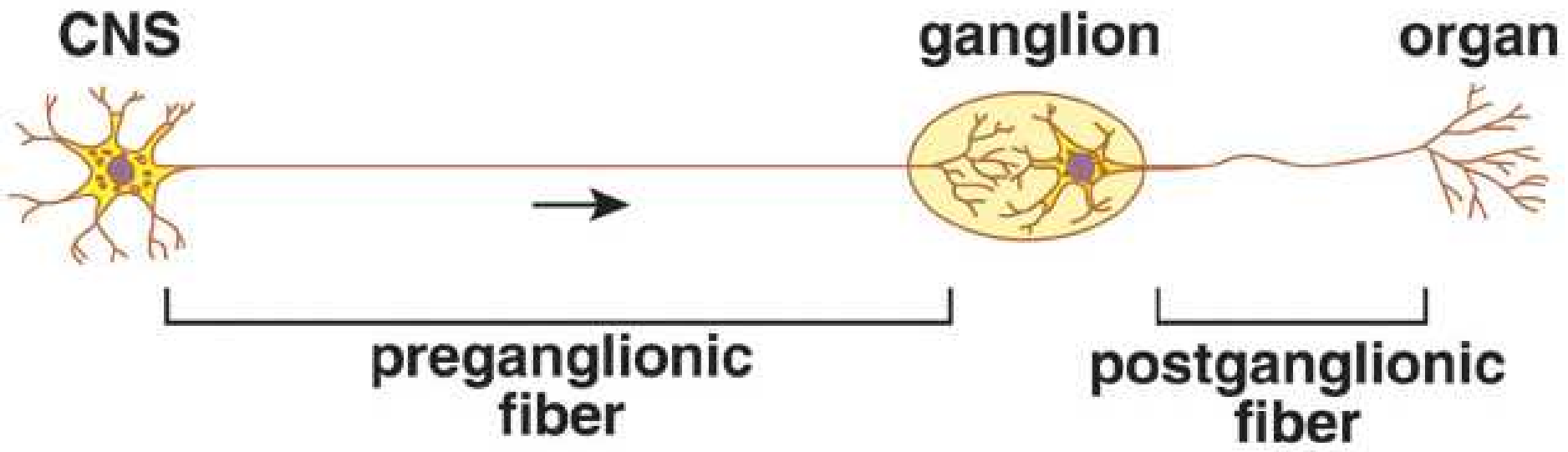
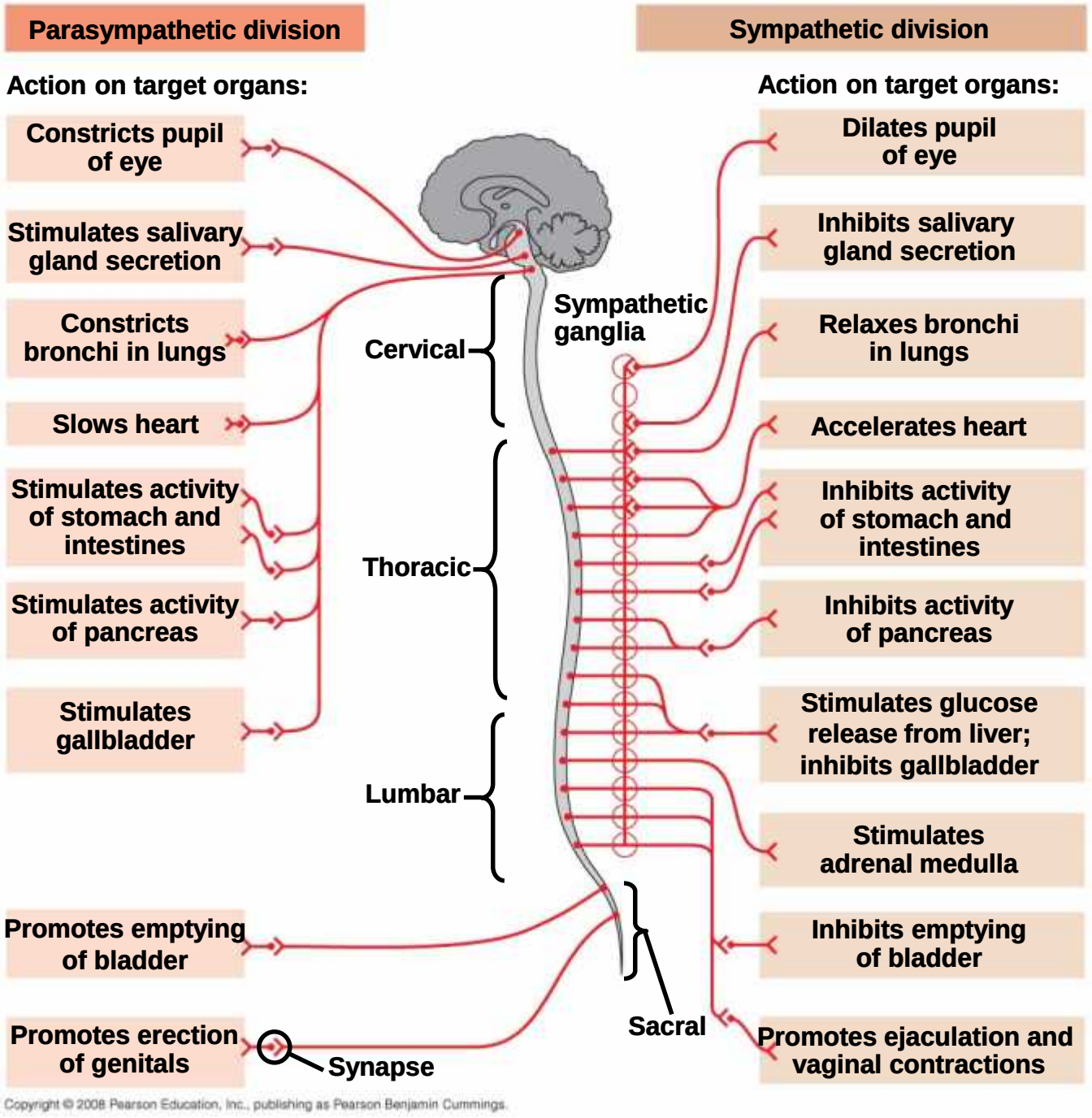
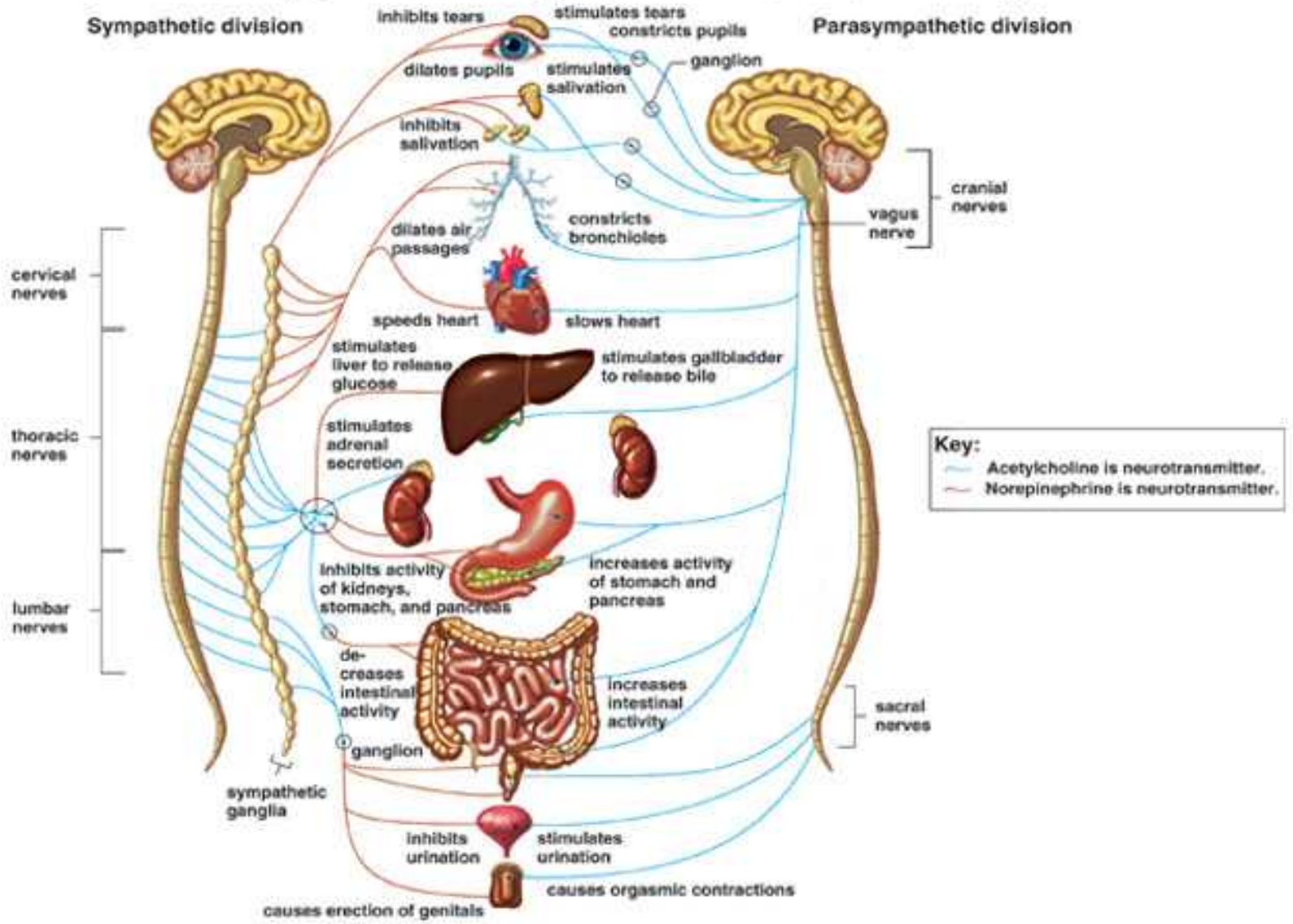

CNS
ganglion
organ
preganglionic fiber
postganglionic fiber

Fig. 49-8



Autonomic nervous system



LECTURE (12)

REPRODUCTIVE SYSTEM

Role of the Reproductive System

The Function of Female reproductive system

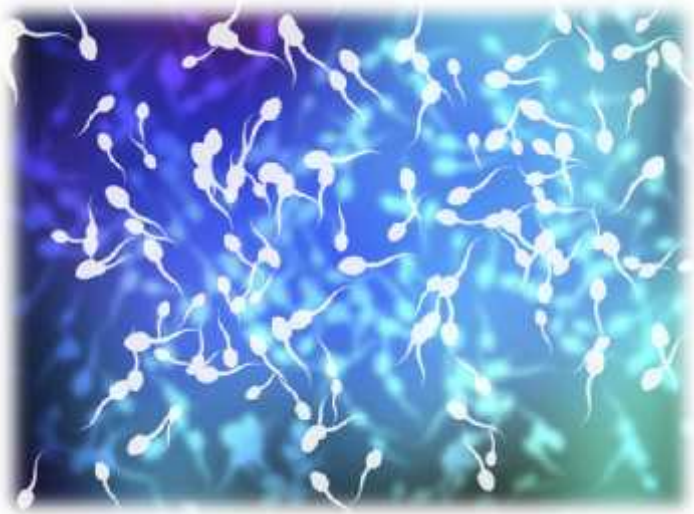
1- To produce egg cells.

2- To protect and nourish the offspring until birth.

:

The Function of male reproductive system

1-It is to produce and deposit sperm.



The Testicles or Testes

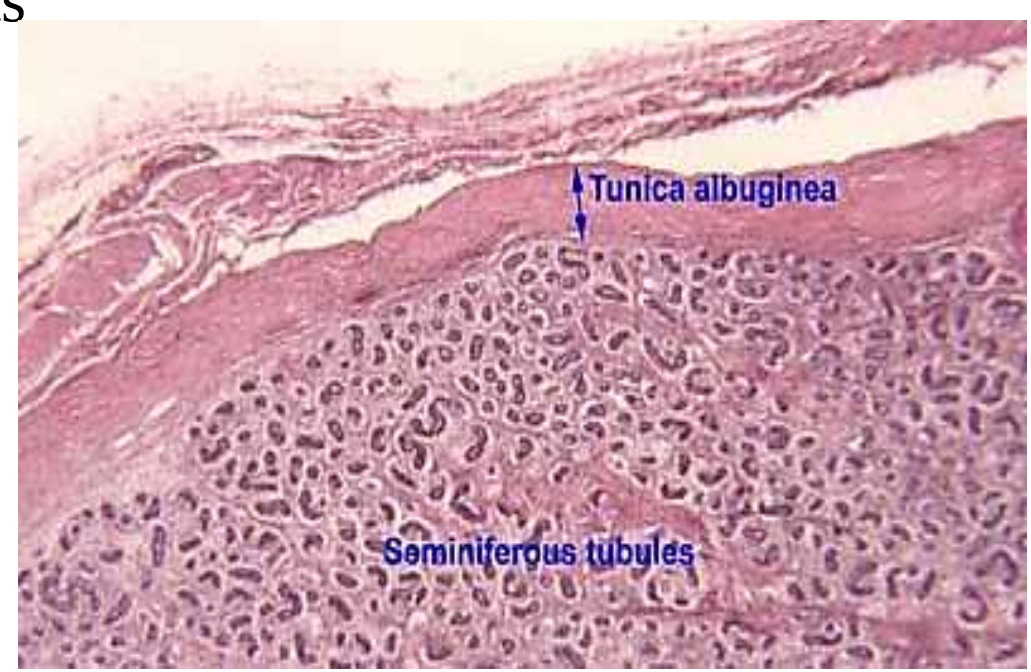
Testes functions:

1- Produce the male gametes or spermatozoa.

2- Produce male sexual hormone (testosterone).

Tunica albuginea a thick capsule surround the testes , from which a conical mass of connective tissue, the **mediastinum testis,** projects into the testis.

Serosa connective tissue that covers the tunica albuginea externally.



The Convoluted Seminiferous Tubules

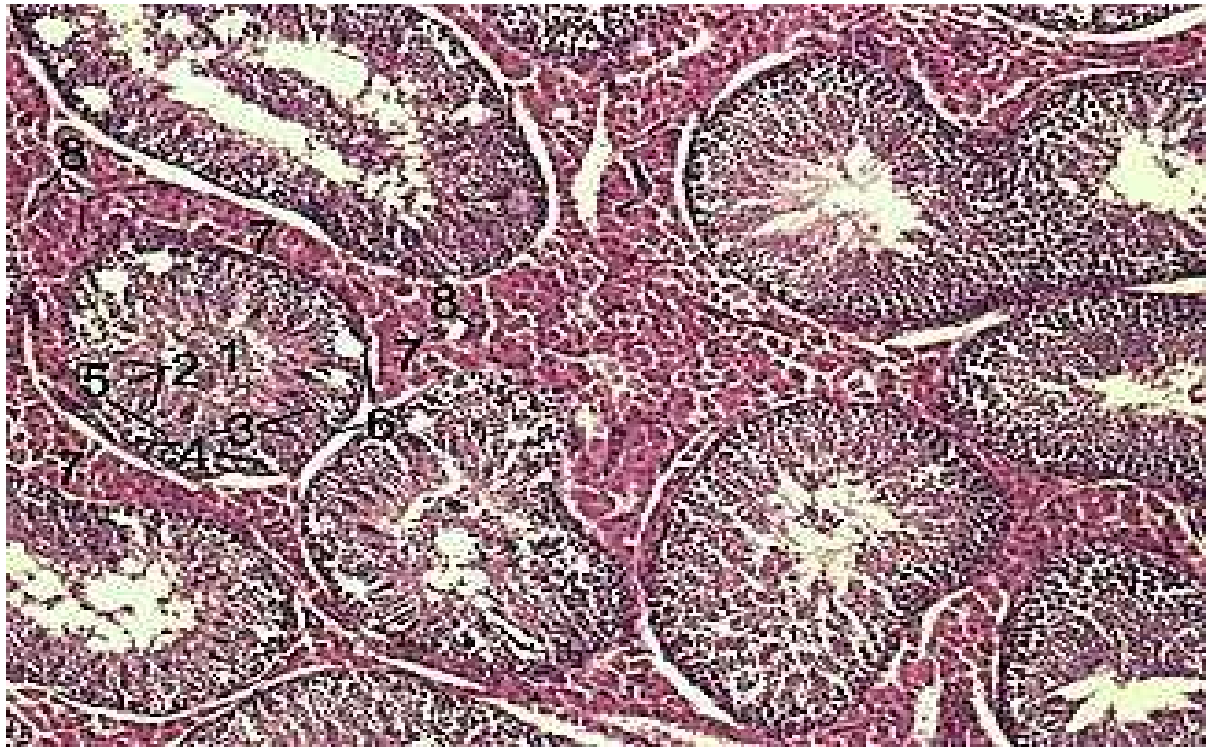
These tubules are surrounded by 3-4 layers of smooth muscle cells

The insides of the tubules are lined with **seminiferous epithelium**,

which consists of two general types of cells:

1- **Spermatogenium**

2- **Sertoli cells**



Spermatogonia

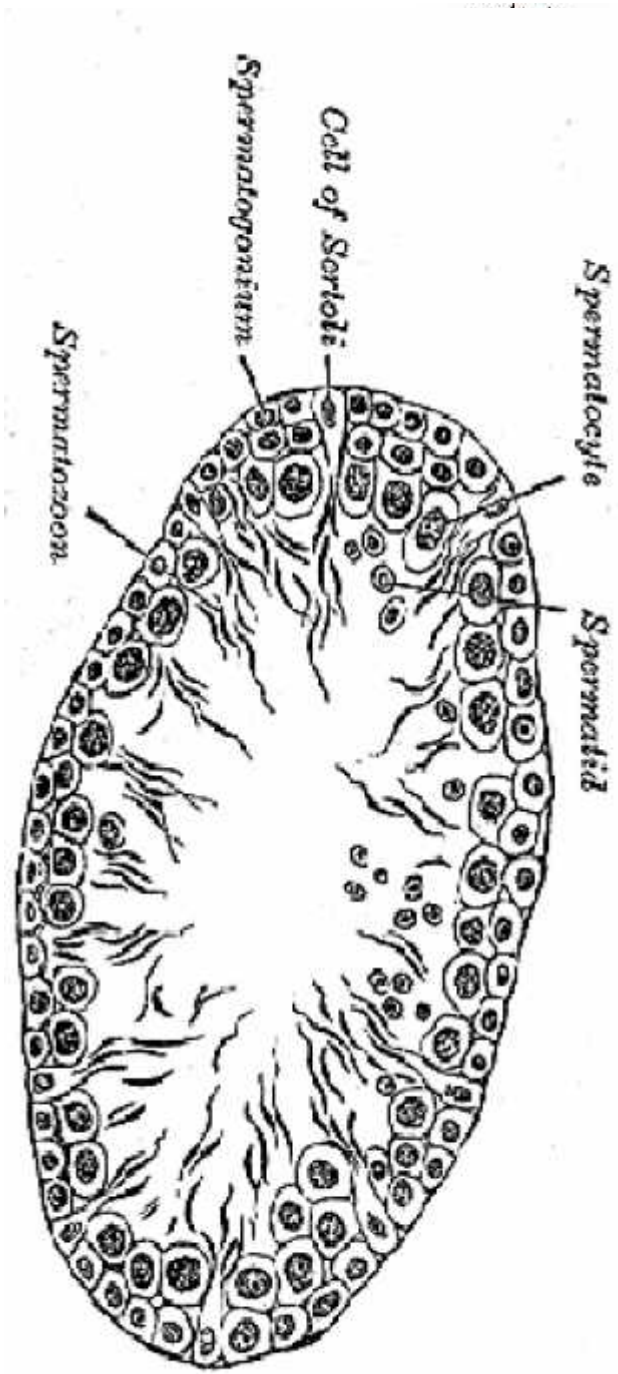
1- Spermatogonium is an undifferentiated male germ cell. undergo spermatogenesis to form mature spermatozoa.

There are three subtypes of spermatogonia in humans:

Type A (dark) cells, with dark nuclei. which do not usually undergo active mitosis.

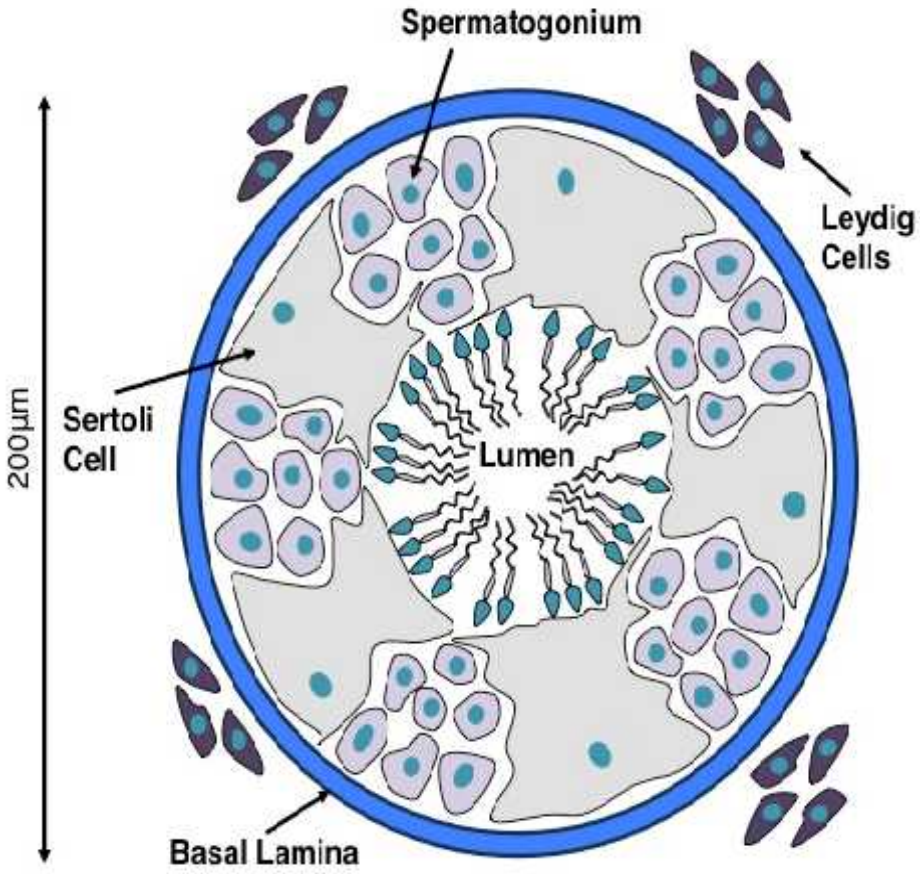
Type A (pale) cells, with pale nuclei, they undergo active mitosis. These cells divide to produce Type B cells.

Type B cells, which divide to give rise to primary spermatocytes.



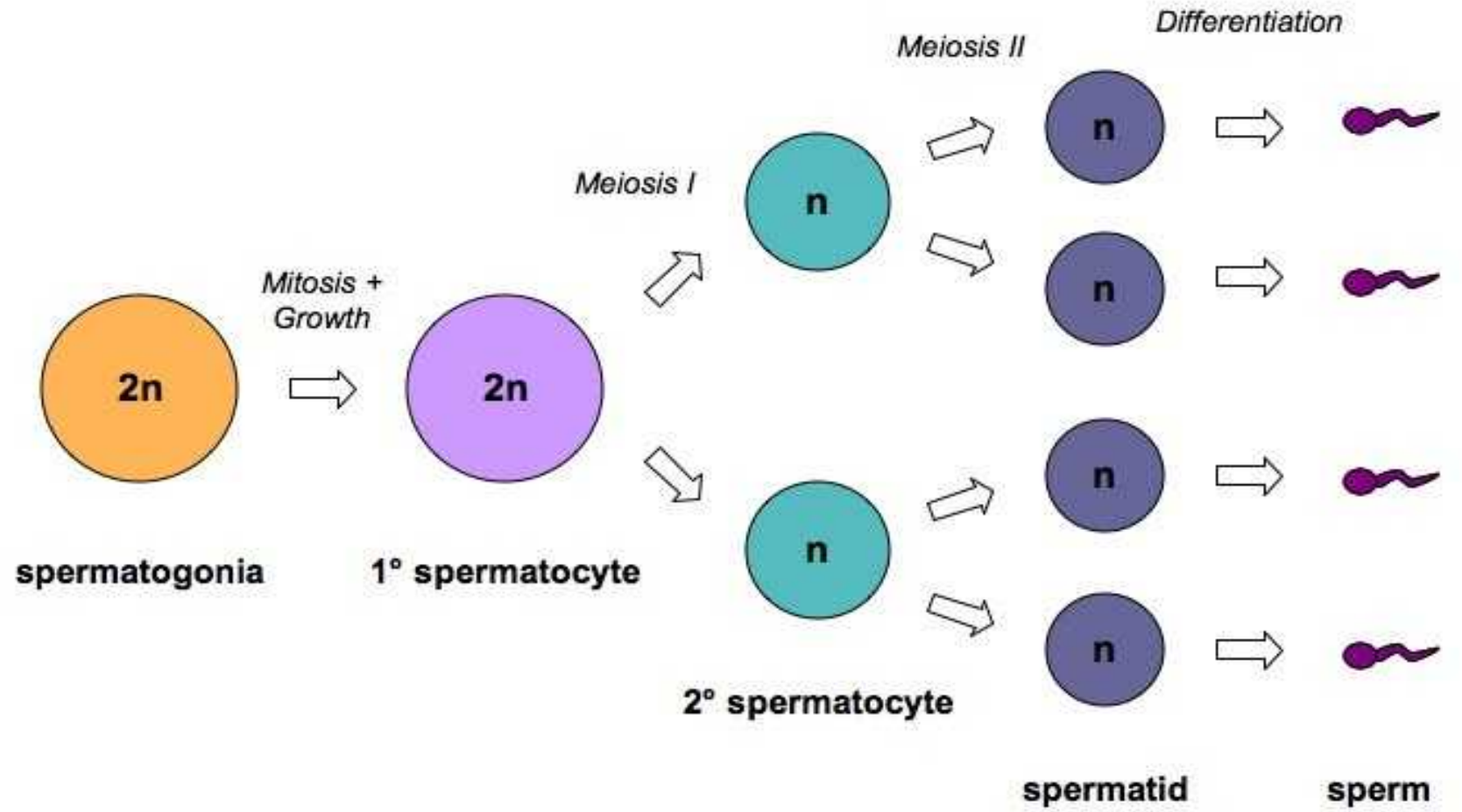
The Sertoli cells

2- **Sertoli cells** are the somatic cells of the testis that are essential for testis formation and spermatogenesis. **Sertoli cells** facilitate the progression of germ cells to spermatozoa via direct contact and by controlling the environment milieu within the seminiferous tubules.



Spermatogenesis

It is the process in which spermatozoa are produced from spermatogonial stem cells by mitosis and meiosis. It occurs in the testis.



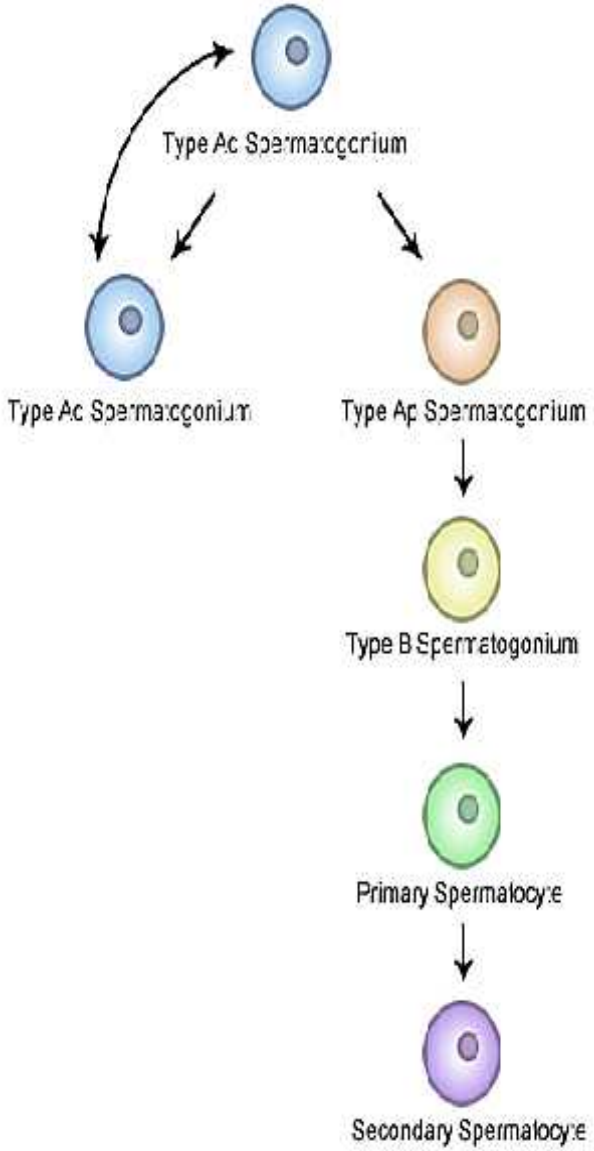
https://anatomytopics.wordpress.com/2009/0

Cells of Spermatogenesis process

1- Spermatogonium: are the first cells of spermatogenesis.

2- Primary spermatocytes: They appear larger than spermatogonia. They immediately enter the prophase of the first meiotic division, which is extremely prolonged.

3- Secondary spermatocytes: smaller than primary spermatocytes. They rapidly enter and complete the second meiotic division.



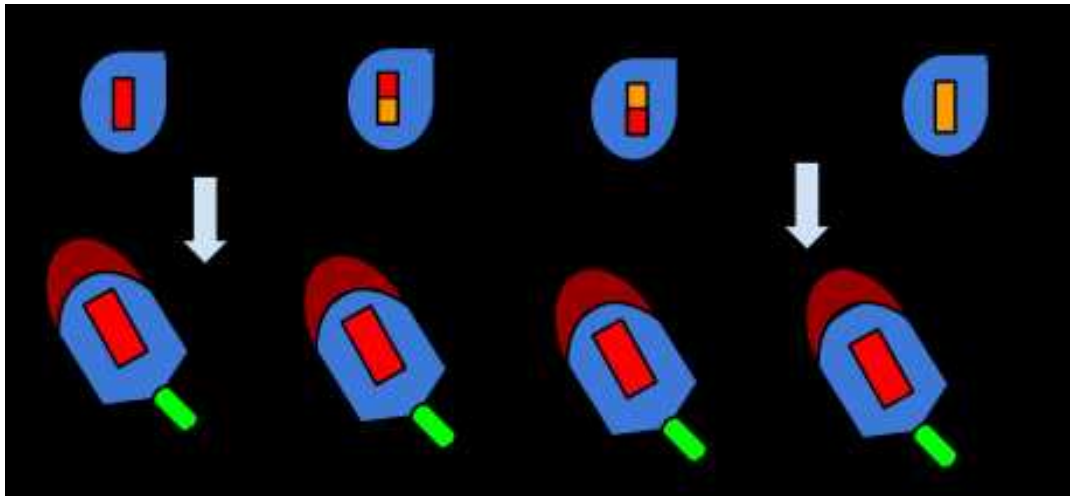
Cells of Spermatogenesis process

4- Spermatids: formed from the division of secondary spermatocytes, They are small with an initially very light (often eccentric) nucleus.

5- Spermatozoa: The mature human spermatozoon is about 60 µm long and actively motile. It is divided into head, neck and tail.

Spermiogenesis process :

is the final stage of spermatogenesis, which sees the maturation of spermatids into mature, motile spermatozoa.



Female Reproductive System

ovaries, oviducts, uterus and vagina

Ovaries functions

1-production and ovulation of oocytes

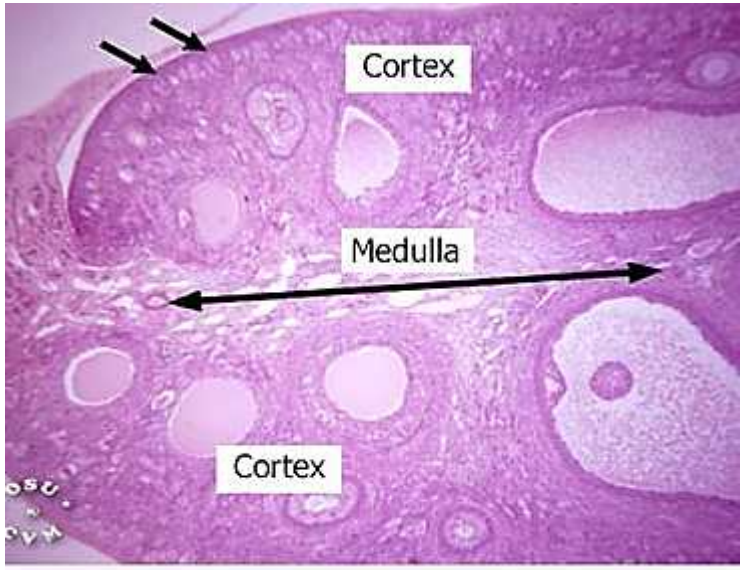
2- the production and secretion of hormones

The Structure of the Ovary

ovary is divided into:

- **Outer cortex** : consists of a very cellular connective tissue stroma where ovarian follicles are embedded.

- **Inner medulla**: it is composed of loose connective tissue, which contains blood vessels and nerves.



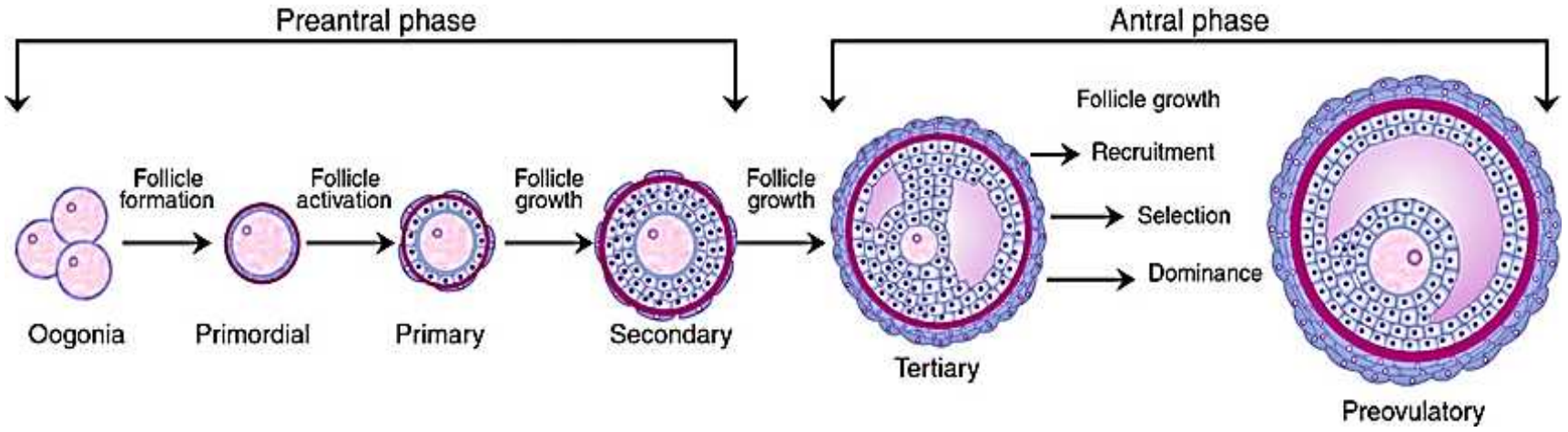
Ovarian Follicles

They are consist of one oocyte and surrounding follicular cells.

Stages of Follicular development.

1- Primordial follicle: are located in the cortex, one layer of flattened follicular cells surround the oocyte.

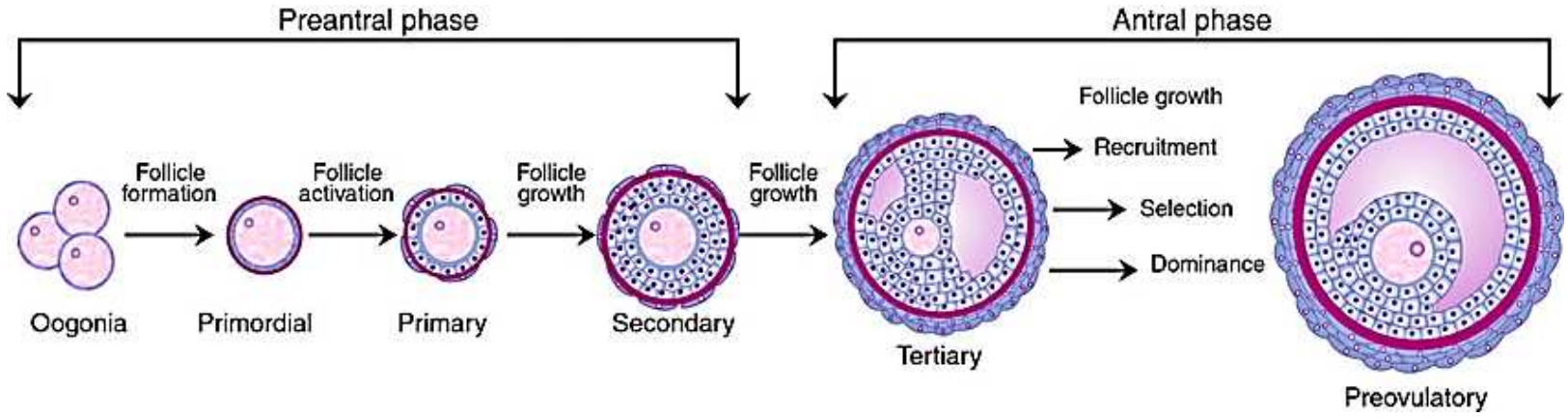
2- Primary follicle: is the first morphological stage that marks the onset of follicular maturation, flattened cell surrounding the oocyte form a cuboidal or columnar epithelium surrounding the oocyte



3- Secondary follicle: Small fluid-filled spaces become visible between granulosa cells as the follicle reaches a diameter of about 400 µm.

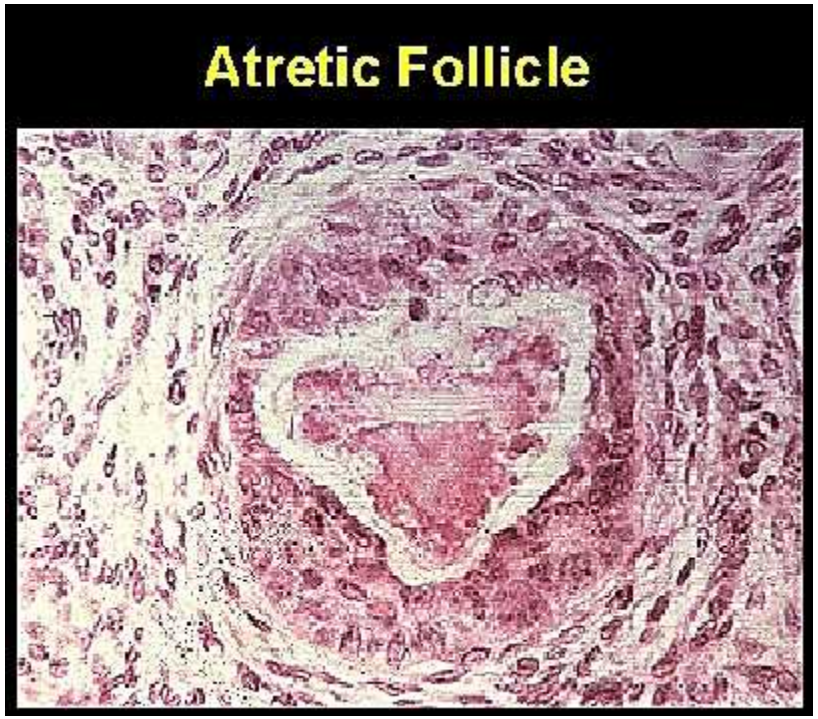
4- The mature or tertiary or Graafian follicle: the follicle increases further in size.

5- The stigma: The Graafian follicle forms a small "bump" on the surface of the ovary



Atresia

Atresia refers to the degeneration of ovarian follicles that do not ovulate during the menstrual cycle.



- about 400 oocytes ovulate and about 99.9 % of the oocytes, that where present at the time of adulthood undergo atresia.

- Atresia may effect oocytes at all stages of their "life" - both prenatally and postnatally.

The Oviduct

The oviduct functions as a conduit for the oocyte, from the ovaries to the uterus. Histologically, the oviduct consists of a mucosa and a muscularis.

The mucosa: is formed by a ciliated and secretory epithelium resting on a very cellular lamina. Some of the secreted substances are thought to nourish the oocyte and the very early embryo.

The muscularis: consists of an inner circular muscle layer and an outer longitudinal layer. muscle action seems to be more important for the transport of sperm and oocyte than the action of the cilia.

The Uterus

The uterus is divided into **body and cervix**. The walls of the uterus are composed of a mucosal layer, the endometrium, and a fibromuscular layer, the myometrium. The peritoneal surface of the uterus is covered by a serosa.

1- Myometrium: The muscle fibres of the uterus form layers with preferred orientations of fibres. The muscular tissue hypertrophies during pregnancy

2- Endometrium

The endometrium consists of a simple columnar epithelium (ciliated cells and secretory cells) and an underlying thick connective tissue stroma.

3- The endometrium can be divided into two zones based on their involvement in the changes during the menstrual cycle:
the basalis and the functionalis.

•**The basalis** is not sloughed off (appealed) during menstruation but functions as a regenerative zone for the functionalis after its rejection.

•**The functionalis** is the luminal part of the endometrium. It is sloughed off during every menstruation and it is the site of cyclic changes in the endometrium.