PEOPLE'S DEMOCTRATIC REPUBLIC OF ALGERIA

MINISTERY OF HIGHER EDUCATION AND

SCIENTIFIC RECHEARCH

MOHAMED KHIDER UNIVERSITY OF BISKRA

Institute of Sciences and Technologies of Physical and Sport Activities

Departement of Sport Training

COURSE STUDY GUIDE

SUBJECT : ANATOMY

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Level : First Year (1st Semester)
Speciality : Common Trunk

1. General Informations about the Course:

Course Title: Anatomy

Nature Course : Lecture

Target Audience: First year students

Speciality : Sciences and Technologies of Physical and Sport Activities (STAPS)

Educational Unity :Fundamental.

Duration: 14 weeks (42 hours)

Coefficient: 02

Credits: 03

Learning Objectives:

- Understanding the anatomical structure of the human body, especially the main systems (muscular, skeletal, nervous, etc.).
- Comprehending the relationship between anatomical structure and motor performance in various sports activities.
- Identifying the main muscles and bones involved in sports movements.
- Determining the locations, roles, types of joints, and their impact on range of motion.
- Applying anatomical knowledge to injury prevention and enhancement of physical performance.

Required Prior Knowledge:

- General knowledge of the human body (organ names and their basic functions).
- Familiarity with basic concepts in natural sciences (such as cells, tissues, and body systems).
- Basic understanding of scientific terminology used in life sciences (in both Arabic and English, if possible).
- Initial interest in body movement and components of the muscular and skeletal systems.
- Willingness to learn through illustrations and practical models to understand anatomical structures.

Assessment Method: Continuous assessment + Final exam.

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First Course : Introduction to Anatomy

1.Definition of Anatomy

The term **Anatomy** comes from Late 1300's: Anatomia (Latin) and Anatome (Greek) **ana** meaning "up" **tomos** (or temnein) which means "to cut" Together this gives "a cutting up" (Dissection).

Anatomy is considered the "Study or knowledge of the structure (form) and function of the human body".

Also, **Anatomy** is the science concerned with the study of the structure of the human body and its organs, focusing on their shape, location, and interrelationships. It serves as a fundamental basis for understanding organ functions and the changes they undergo due to physical activity or disease.

2.Levels of Organization

The human body exhibits a highly organized structure, arranged in a hierarchical manner from the simplest to the most complex levels. This structural organization ensures the efficient functioning of all biological processes and underpins the study of human anatomy and physiology.

2.1ChemicalLevel

At the most basic level, the human body consists of atoms and molecules. These include essential elements such as carbon, hydrogen, oxygen, and nitrogen, which combine to form biomolecules like proteins, lipids, carbohydrates, and nucleic acids (Marieb & Hoehn, 2019). These substances are the building blocks for cells and carry out vital biochemical reactions.

2.2.CellularLevel

Cells are the fundamental units of life. Each cell is composed of various organelles that perform specific functions necessary for survival and specialization (Tortora & Derrickson, 2017). For example, muscle cells contract to enable movement, while neurons transmit electrical signals.

2.3.TissueLevel

Tissues are groups of similar cells working together to perform a common function. There are four primary types of tissue in the human body: epithelial, connective, muscular, and nervous tissues. Each plays a distinct role in maintaining the body's structure and function (Saladin, 2020).

2.4.OrganLevel

An organ consists of two or more types of tissues working together to carry out specific functions. For instance, the heart is composed of muscle tissue (myocardium), connective tissue, and epithelial tissue, and it functions to pump blood throughout the body (Marieb & Hoehn, 2019).

2.5.OrganSystemLevel

Organ systems are composed of multiple organs that cooperate to perform complex tasks. The digestive system, for instance, includes the mouth, stomach, intestines, liver, and pancreas, all of which work together to digest food and absorb nutrients (Tortora & Derrickson, 2017).

2.6.OrganismLevel

At the highest level of organization, the human organism is formed. It is the result of the coordinated function of all organ systems to maintain homeostasis and support life.

Understanding these levels of anatomical organization provides the foundation for studying health, disease, physical training, and rehabilitation. It also serves as a critical framework for educators, medical professionals, and researchers in the biomedical and sports sciences.

Microscopic Anatomy **Gross Anatomy**

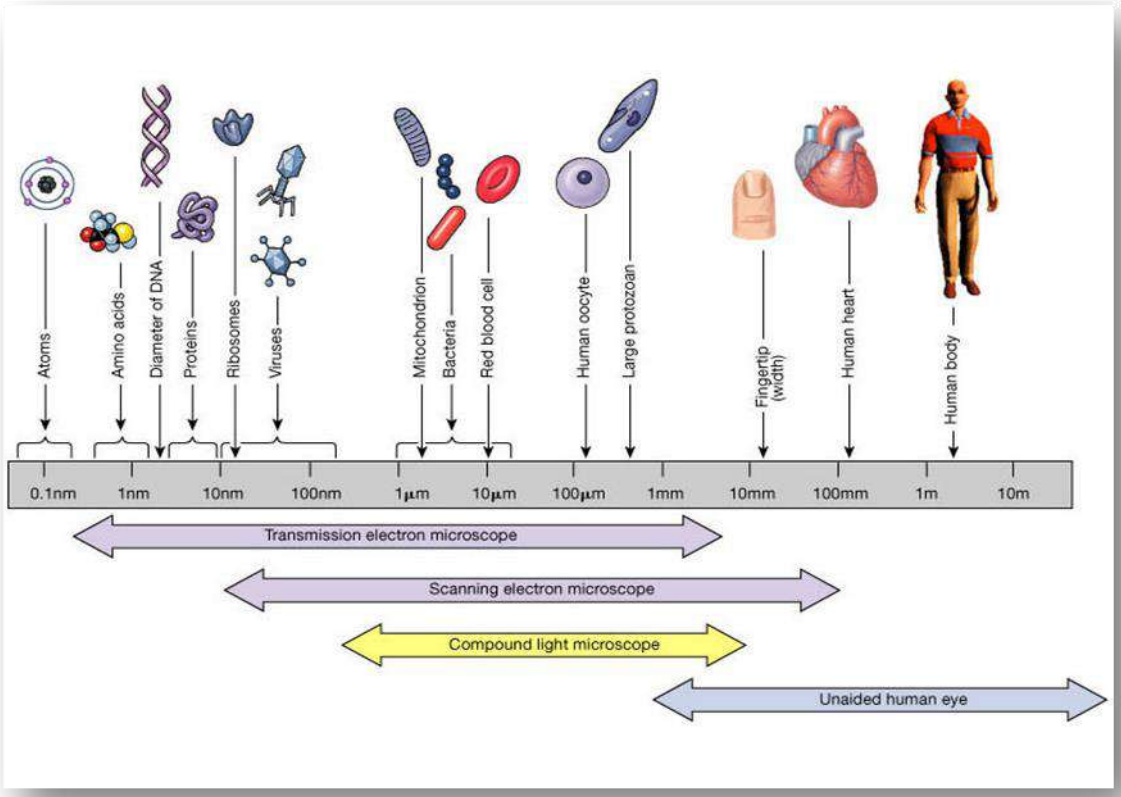


Figure 1. The structural hierarchy of the human body

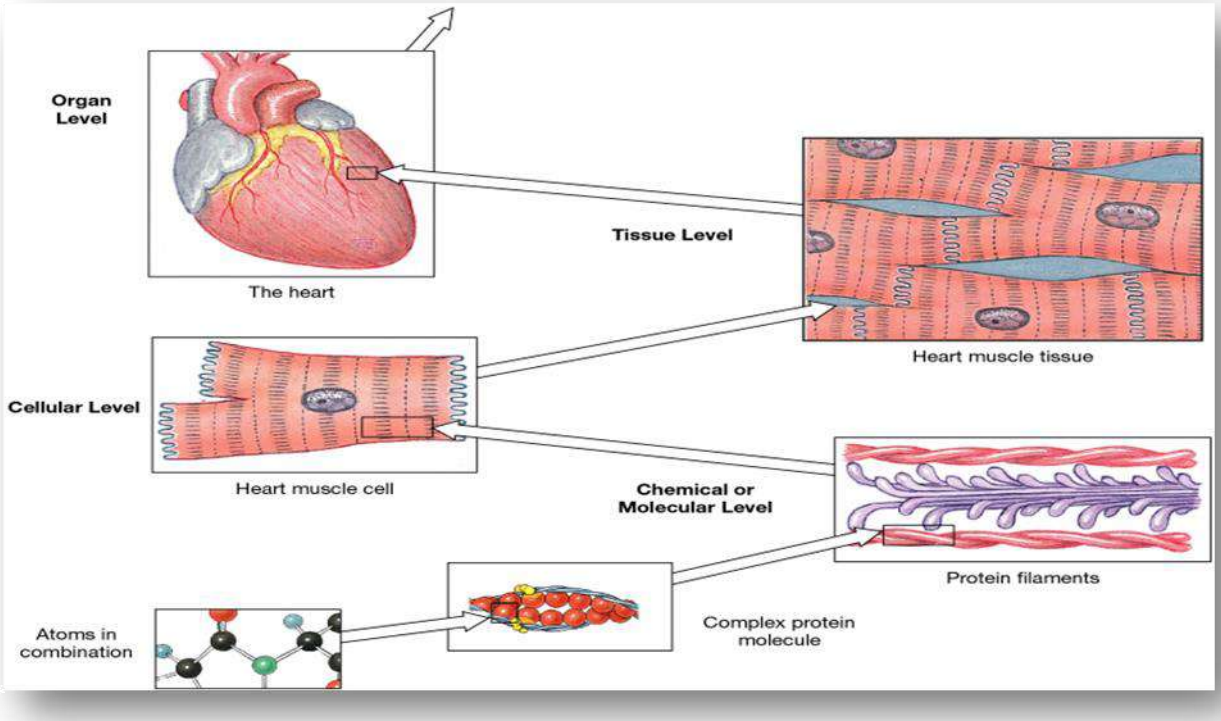


Figure 2. Levels Organization of the human body

Organ System		Major Functions
	**Integumentary system**	Protection from environmental hazards; temperature control
	**Skeletal system**	Support, protection of soft tissues; mineral storage; blood formation
	**Muscular system**	Locomotion, support, heat production
	**Nervous system**	Directing immediate responses to stimuli, usually by coordinating the activities of other organ systems
	**Endocrine system**	Directing long-term changes in the activities of other organ systems
	**Cardiovascular system**	Internal transport of cells and dissolved materials, including nutrients, wastes, and gases

Organ System		Major Functions
	**Lymphatic system**	Defense against infection and disease
	**Respiratory system**	Delivery of air to sites where gas exchange can occur between the air and circulating blood
	**Digestive system**	Processing of food and absorption of organic nutrients, minerals, vitamins, and water
	**Urinary system**	Elimination of excess water, salts, and waste products; control of pH
	**Reproductive system**	Production of sex cells and hormones

Figure 3. Organs of the Human Body

3. Branches of Human Anatomy

Human anatomy is a foundational discipline in medical and biological sciences, concerned with the study of the structure and organization of the human body. It is divided into several major branches, each with specific focus and methodologies that aid in understanding the complexity of the human form and its functions.

.31. Gross Anatomy (Macroscopic Anatomy)

Gross anatomy deals with the study of body structures visible to the naked eye. It can be approached through regional anatomy, which examines all structures in a specific area of the body (e.g., the head or chest), and systemic anatomy, which focuses on specific organ systems (e.g., the muscular or nervous systems). Dissection is a traditional method used in teaching gross anatomy.

Example: Studying the organs of the abdominal cavity through cadaveric dissection.

.32. Microscopic Anatomy (Histology and Cytology)

Microscopic anatomy involves the examination of tissues (histology) and cells (cytology) under a microscope. This branch provides detailed insight into

the functional aspects of tissues and how structural abnormalities can lead to disease.

Example: Analyzing liver tissue to understand hepatic function and pathology.

.33. Developmental Anatomy (Embryology)

This branch focuses on the development of the human body from conception through adulthood, particularly the prenatal stages. Embryology, a subfield of developmental anatomy, examines the formation and development of embryos and fetuses.

Example: Studying how the heart develops in the first eight weeks of gestation.

.34. Functional Anatomy

Functional anatomy integrates structure with function, exploring how anatomical structures perform their physiological roles. This branch is essential in fields such as kinesiology, physical therapy, and biomechanics.

Example: Understanding how the structure of a synovial joint facilitates movement.

.35. Clinical Anatomy

Clinical anatomy emphasizes the application of anatomical knowledge in clinical settings. It aids healthcare professionals in diagnosis, surgical planning, and medical imaging interpretation.

Example: Locating the sciatic nerve to perform a safe intramuscular injection.

.36. Comparative Anatomy

This branch compares human anatomy with that of other animals to understand evolutionary relationships and functional adaptations.

Example: Comparing the vertebral columns of humans and primates.

The classification of human anatomy into various branches enhances the understanding of human structure and its relevance in health sciences. Each branch offers a unique perspective that, when integrated, provides a comprehensive picture of how the body is built and how it operates.

4.Anatomical Regional Terms

Understanding anatomical regional terms is essential in the fields of medicine, physical therapy, and sports science, as they provide a standardized language for describing the locations and relationships of structures in the human body. These terms facilitate accurate communication among healthcare professionals and researchers**.**

.41. Overview of Regional Anatomy

Regional anatomy, a subfield of gross anatomy, divides the body into specific regions for study or clinical reference. Each region includes all the structures—bones, muscles, vessels, nerves, and organs—within a particular area. This approach contrasts with systemic anatomy, which examines the body system by system.

Example: A clinician examining the "thoracic region" will assess all components located in the chest area, including ribs, lungs, and heart.

4.2. Major Body Regions and Their Terms

The human body is commonly divided into two major parts:

- Axial region: Includes the head, neck, and trunk.
- Appendicular region: Consists of the upper and lower limbs. Within these parts, more specific regional terms are used:
- Cephalic (Head): Includes the cranial (skull) and facial (face) areas.
- Cervical (Neck): The region connecting the head to the torso.
- Thoracic (Chest): Includes pectoral (chest), sternal (breastbone), and mammary (breast) areas.
- Abdominal (Abdomen): Houses digestive organs; further divided into quadrants or regions (e.g., epigastric, hypogastric).
- Pelvic (Pelvis): Contains reproductive organs, bladder, and rectum.
- Upper Limb Regions: Brachial (arm), antebrachial (forearm), carpal (wrist), palmar (palm), and digital (fingers).
- Lower Limb Regions: Femoral (thigh), crural (leg), tarsal (ankle), plantar (sole), and digital (toes).
- Dorsal (Back): Includes scapular (shoulder blade), vertebral (spinal column), and lumbar (lower back) regions.

Example: A physiotherapist referring to the “lumbar region” targets the lower back area during treatment.

Using precise regional terms is essential in clinical assessments, surgical planning, and medical education. It reduces ambiguity when documenting findings or describing injuries. Example: A note stating “pain in the right lower quadrant of the abdominal region” provides a clear diagnostic location for appendicitis evaluation.

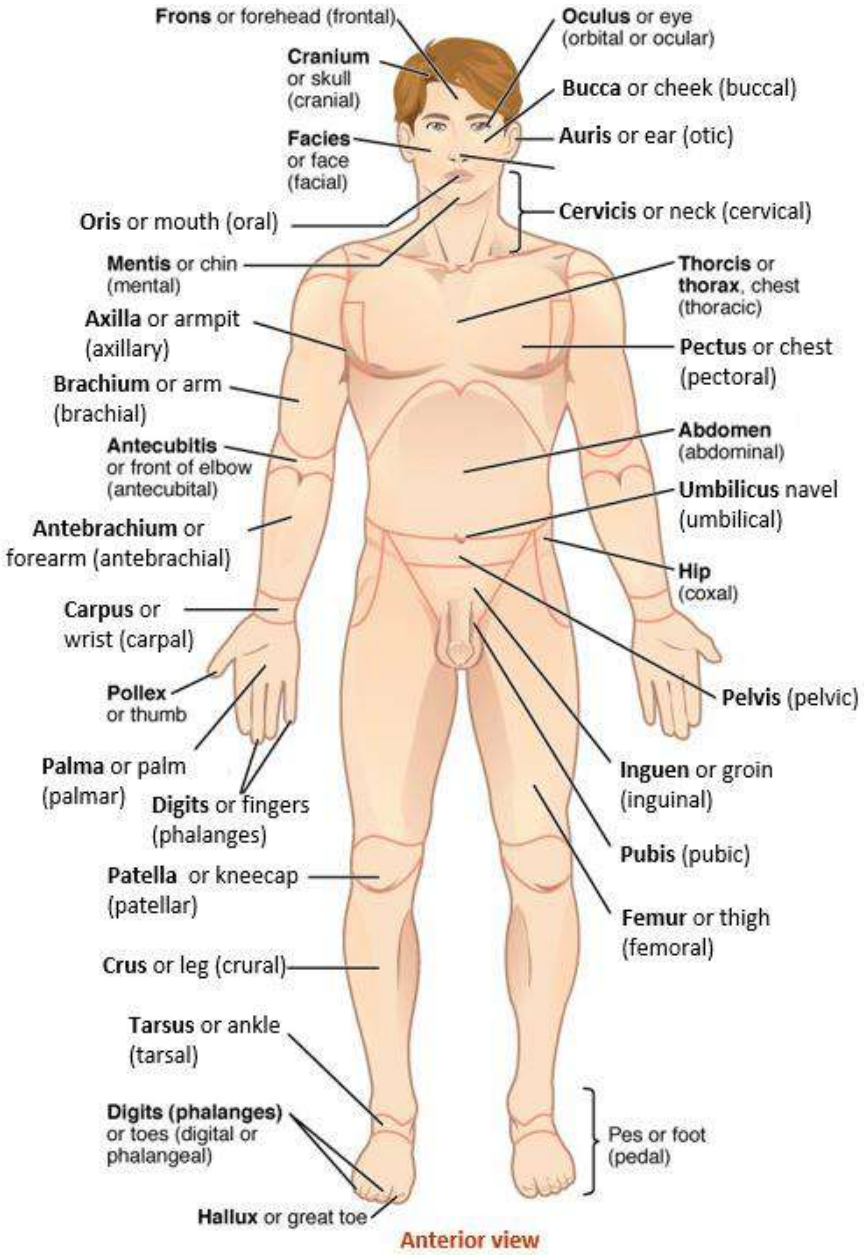


Figure3. Anterior View Terms.

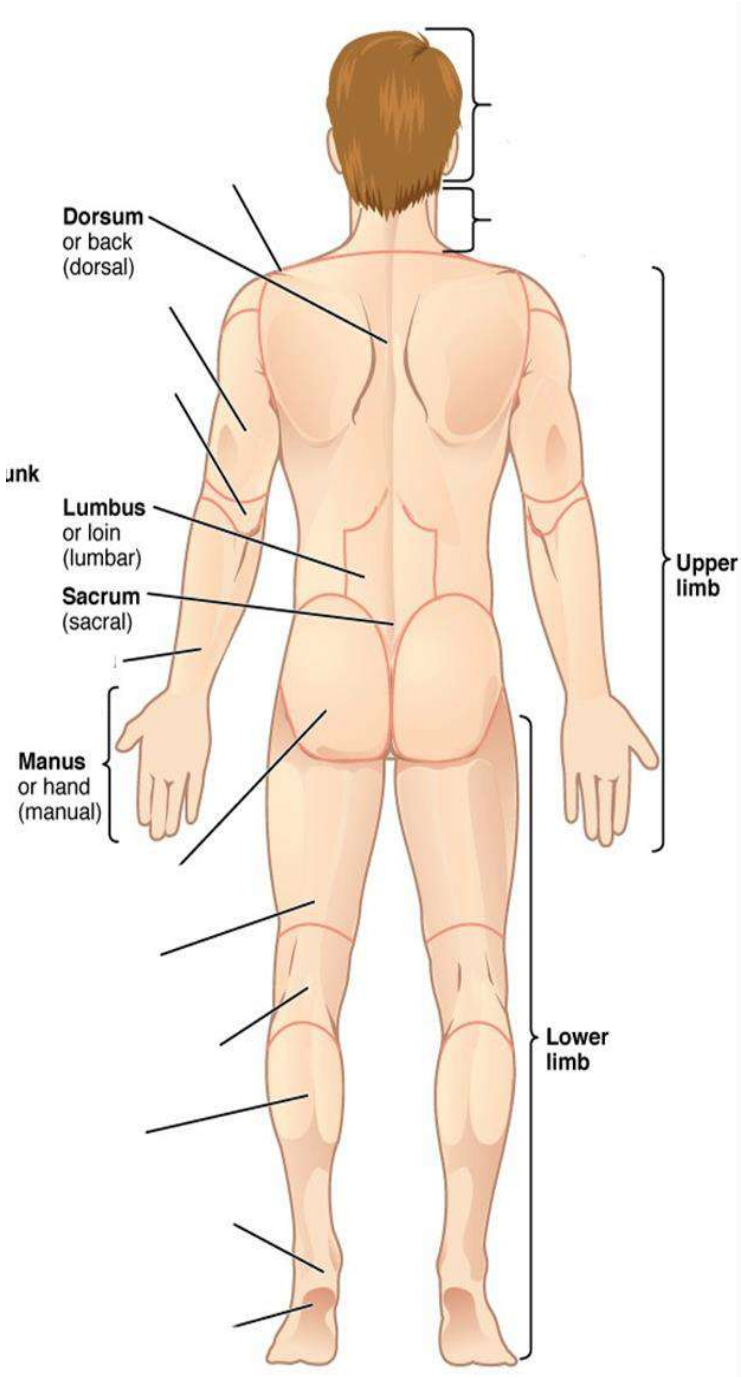


Figure4. Posterior View Terms

5. Abdominopelvic Quadrants and Regions

The abdominopelvic cavity is a major body compartment that houses several vital organs, including components of the digestive, urinary, and reproductive systems. To enhance precision in clinical practice and anatomical study, this cavity is subdivided into quadrants and regions, which aid in diagnosis, physical examination, and medical documentation.

.51. Abdominopelvic Quadrants

The most basic and commonly used method of division splits the abdominopelvic area into four quadrants, using two imaginary perpendicular lines—one horizontal and one vertical—that intersect at the umbilicus (navel):

- Right Upper Quadrant (RUQ): Contains parts of the liver, gallbladder, right kidney, portions of the stomach, and small and large intestines.
- Left Upper Quadrant (LUQ): Contains parts of the stomach, spleen, left lobe of the liver, pancreas, left kidney, and portions of the intestines.
- Right Lower Quadrant (RLQ): Includes the appendix, cecum, portions of the small intestine, right reproductive organs, and right ureter.
- Left Lower Quadrant (LLQ): Contains parts of the small intestine, descending colon, sigmoid colon, left reproductive organs, and left ureter.

Clinical Application: Pain in the RLQ is often associated with appendicitis, while LUQ pain may indicate gastric ulcers or splenic injuries.

.52. Abdominopelvic Regions

For more detailed anatomical and diagnostic purposes, the abdominopelvic area can be divided into nine regions using two vertical lines (midclavicular lines) and two horizontal lines (subcostal and intertubercular planes):

Top Row (Superior):

- Right Hypochondriac Region – Includes parts of the liver and gallbladder.
- Epigastric Region – Contains the stomach, part of the liver, and pancreas.
- Left Hypochondriac Region – Houses the spleen and parts of the stomach.

Middle Row:

- Right Lumbar Region – Includes parts of the large intestine and right kidney.

- Umbilical Region – Contains the transverse colon, small intestine, and parts of both kidneys.

- Left Lumbar Region – Houses portions of the colon and left kidney.

Bottom Row (Inferior):

- Right Iliac (Inguinal) Region – Includes the appendix and cecum.

- Hypogastric (Pubic) Region – Contains the bladder, reproductive organs, and portions of the small intestine.

- Left Iliac (Inguinal) Region – Includes the sigmoid colon and parts of the small intestine.

This regional division is particularly useful in surgical procedures and internal medicine, where organ-specific pathology is localized and described accurately (Drake et al., 2019).

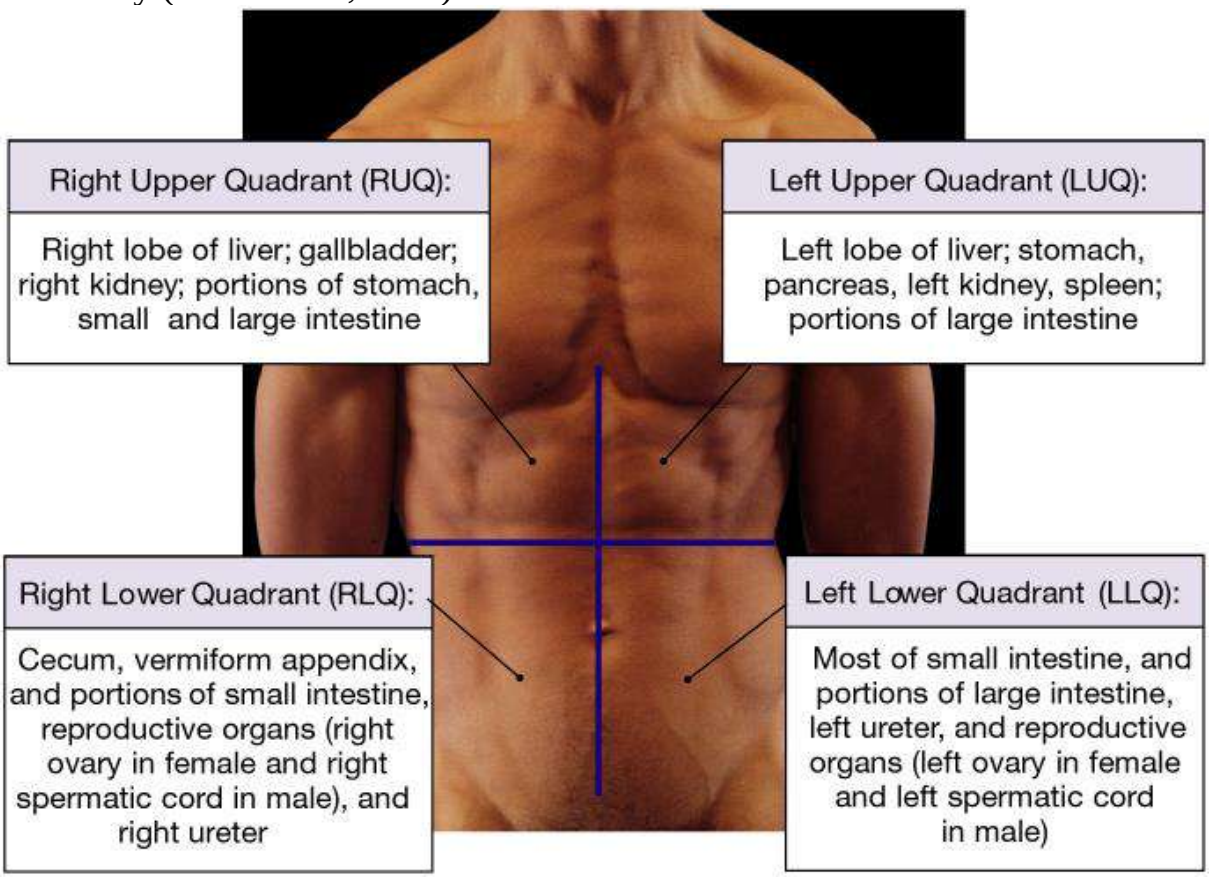


Figure5. Abdominopelvic Quadrants and Regions

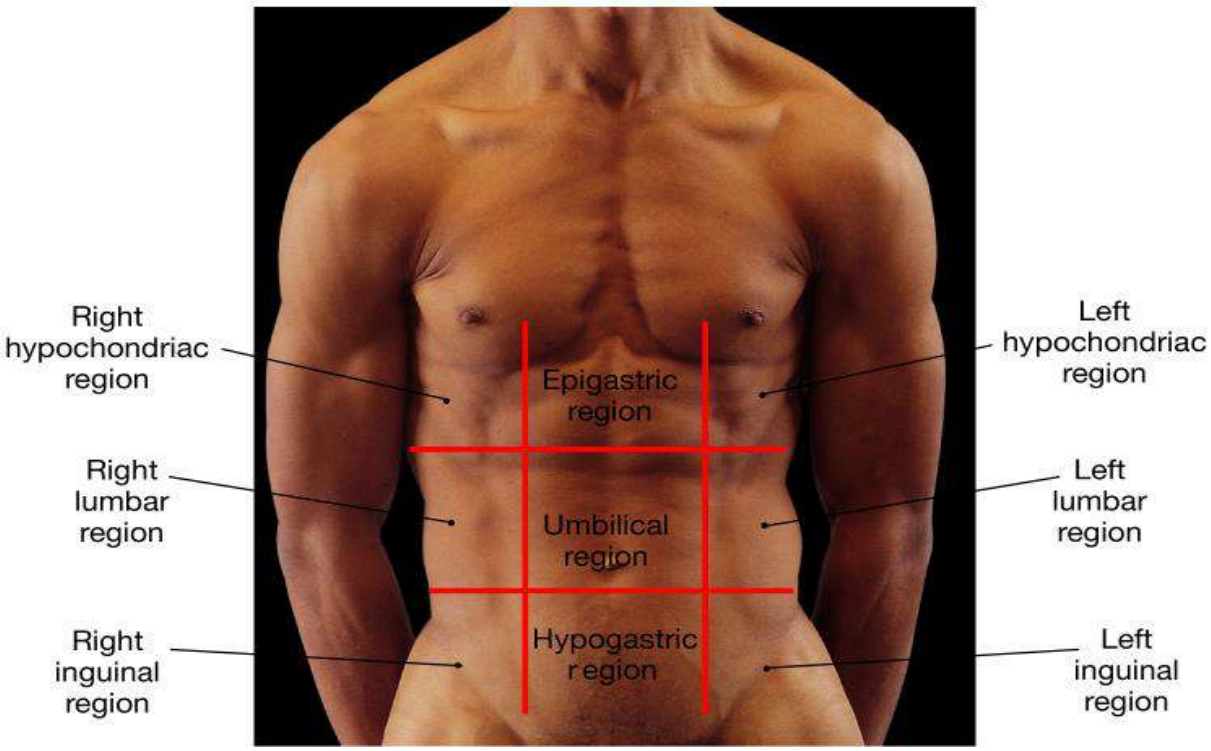


Figure6. Represente Abdominopelvic Quadrants

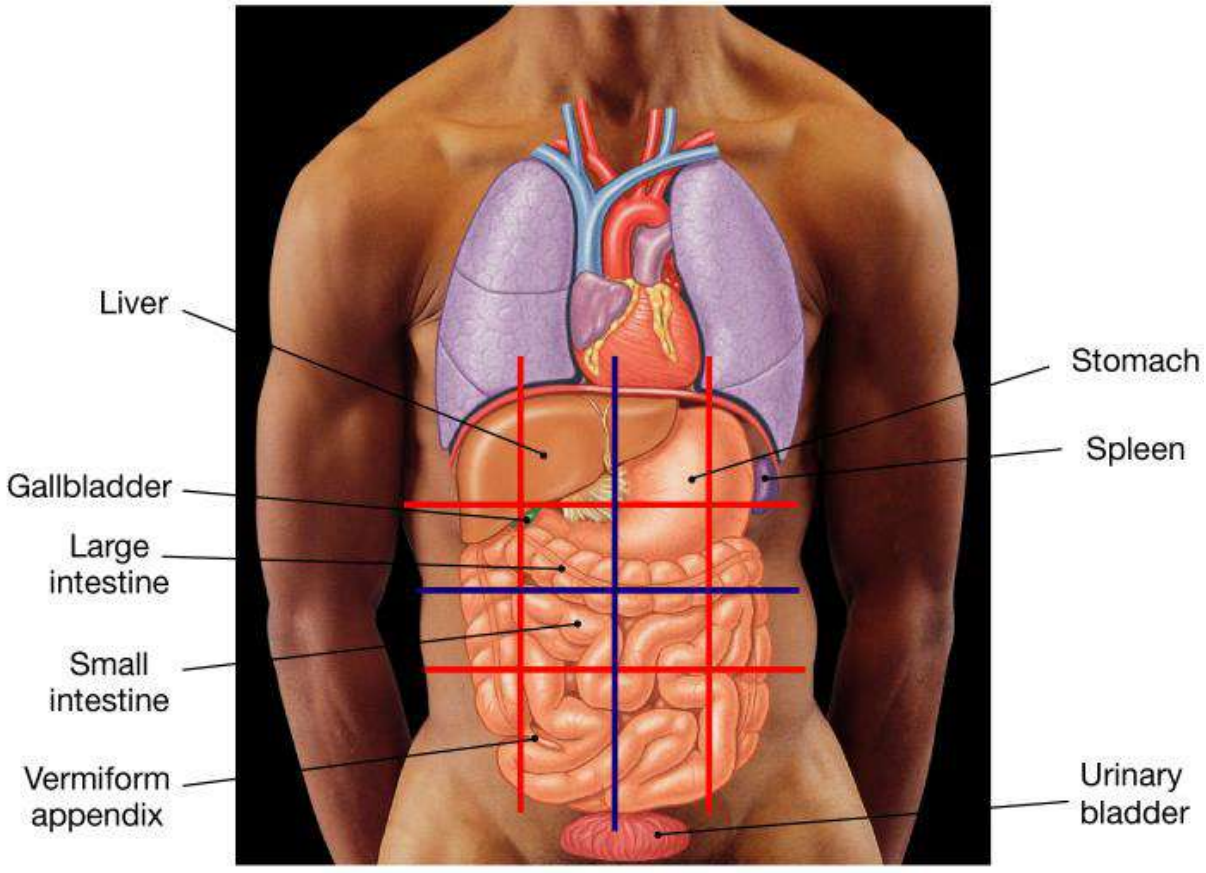


Figure7. Represente Anatomic Regions

6. Sectional Anatomy

6.1. Sagittal Plane

sagittal plane divides the body into left and right portions.

- A midsagittal plane (median plane) divides the body exactly into equal left and right halves.
- A parasagittal plane divides the body into unequal left and right portions.

Clinical Application: MRI scans in the sagittal plane are useful for evaluating spinal alignment and brain structures (Moore et al., 2013).

6.2.Frontal (Coronal) Plane

The frontal plane divides the body into anterior (front) and posterior (back) parts.

It is particularly valuable in studying thoracic organs, such as the heart and lungs. It helps in surgical approaches involving the chest wall or face.

For example, a chest X-ray is typically taken in the coronal plane to visualize lung fields and cardiac silhouette (Drake et al., 2019).

6.3. Transverse (Horizontal or Axial) Plane

This plane divides the body into superior (upper) and inferior (lower) sections. It is widely used in CT scans and MRI imaging, particularly for abdominal and cranial studies.

Enables clinicians to assess cross-sections of organs like the brain, liver, or intestines.

Axial views are critical for identifying tumors, internal bleeding, or anatomical abnormalities in the abdomen and brain (Tortora & Nielsen, 2017).

5.4.Oblique Plane

Although less commonly used, the oblique plane passes through the body at an angle, combining aspects of sagittal, frontal, and transverse cuts. It is particularly helpful in diagnostic imaging when standard planes do not provide adequate visualization**.**

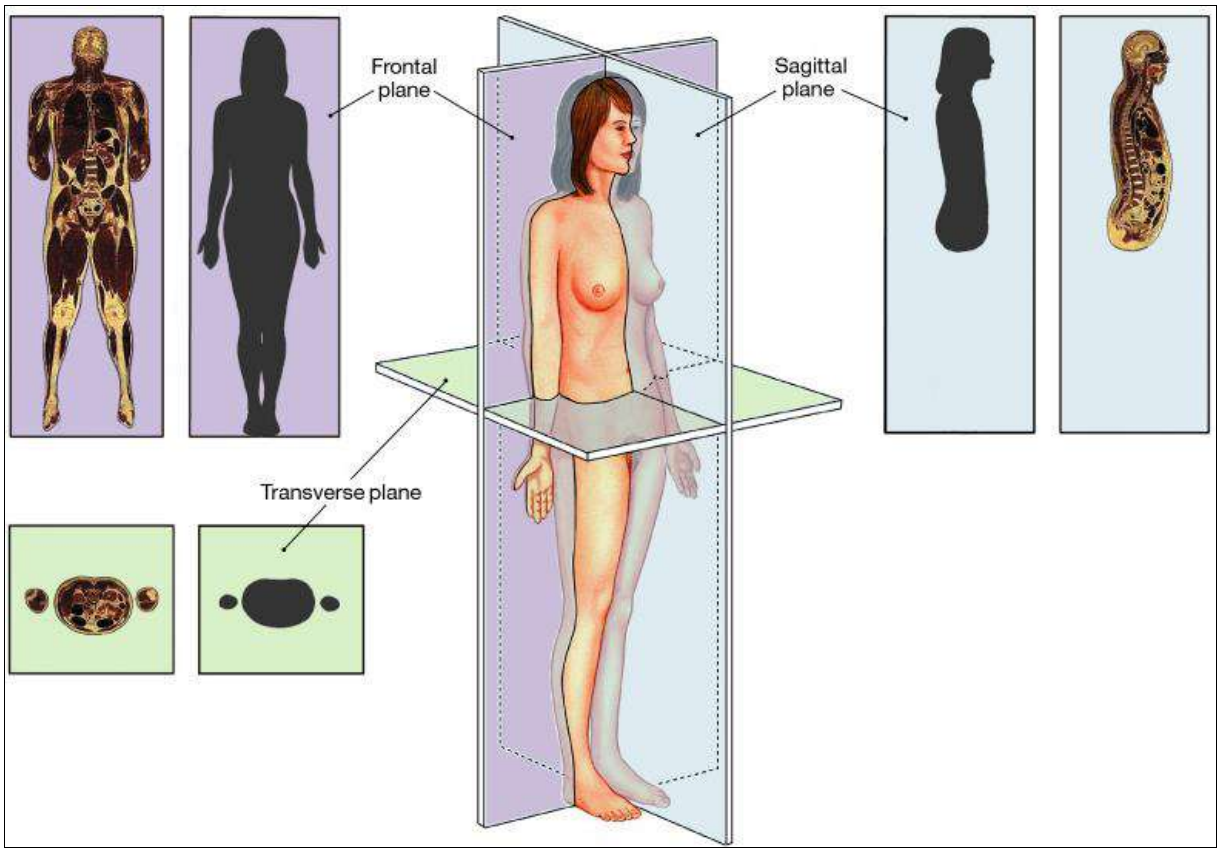


Figure7. Represente Anatomic Planes

Second Course : Cells

1.Definition of Cells

The basic organizational structure of the human body is the cell. There are 50-100 trillion cells in the human body. Differentiation is when cells specialize. As a result of differentiation, cells vary in size and shape due to their unique function.

2.Composite of Cell

Also called a 'typical' cell Major parts include:

- Nucleus.
- Cytoplasm.
- Cell membrane.

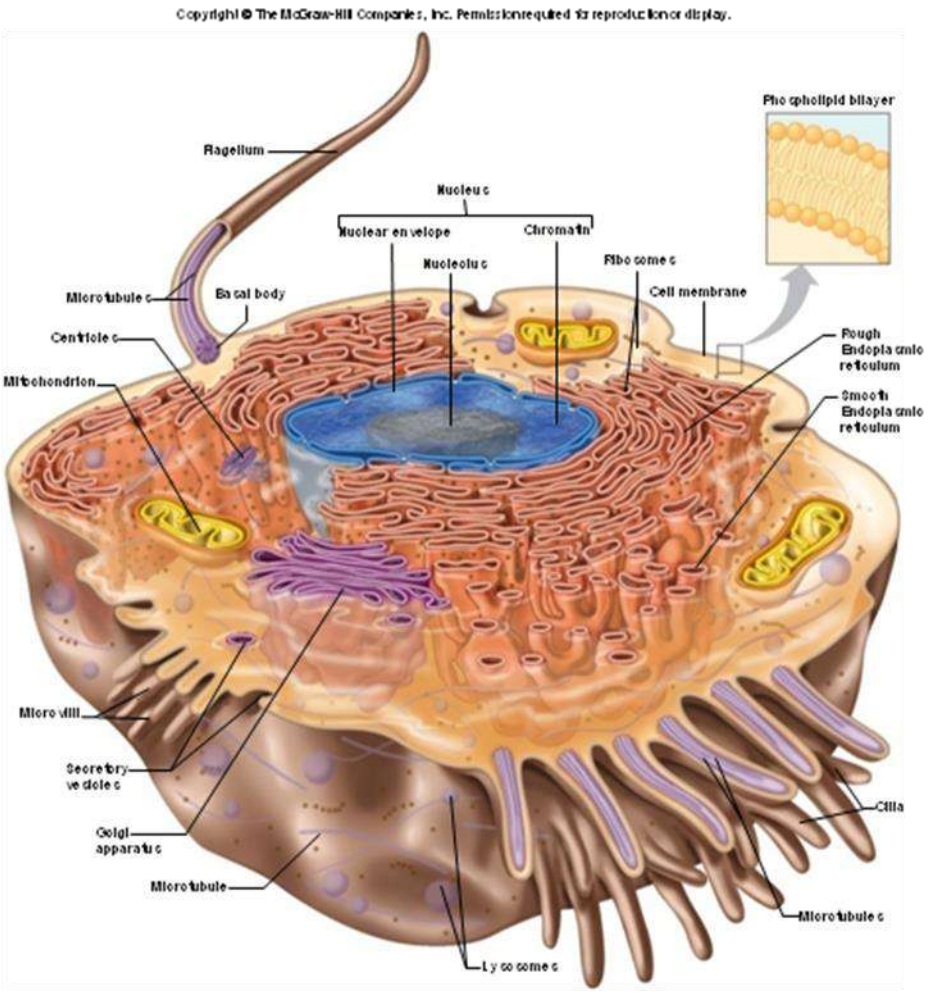


Figure8. Represente Human Cell

2.1.Cell Membrane

Its role is to :

- Outer limit of the cell.
- Controls what moves in and out of the cell.
- Selectively permeable.
- Phospholipid bilayer:

  -Water-soluble “heads” form surfaces (hydrophilic)

  -Water-insoluble “tails” form interior (hydrophobic)

  - Permeable to lipid-soluble substances

Cholesterol stabilizes the membrane:

- Proteins:
- Receptors.
- Pores, channels and carriers.
- Enzymes.
- CAMS.
- Self-markers.

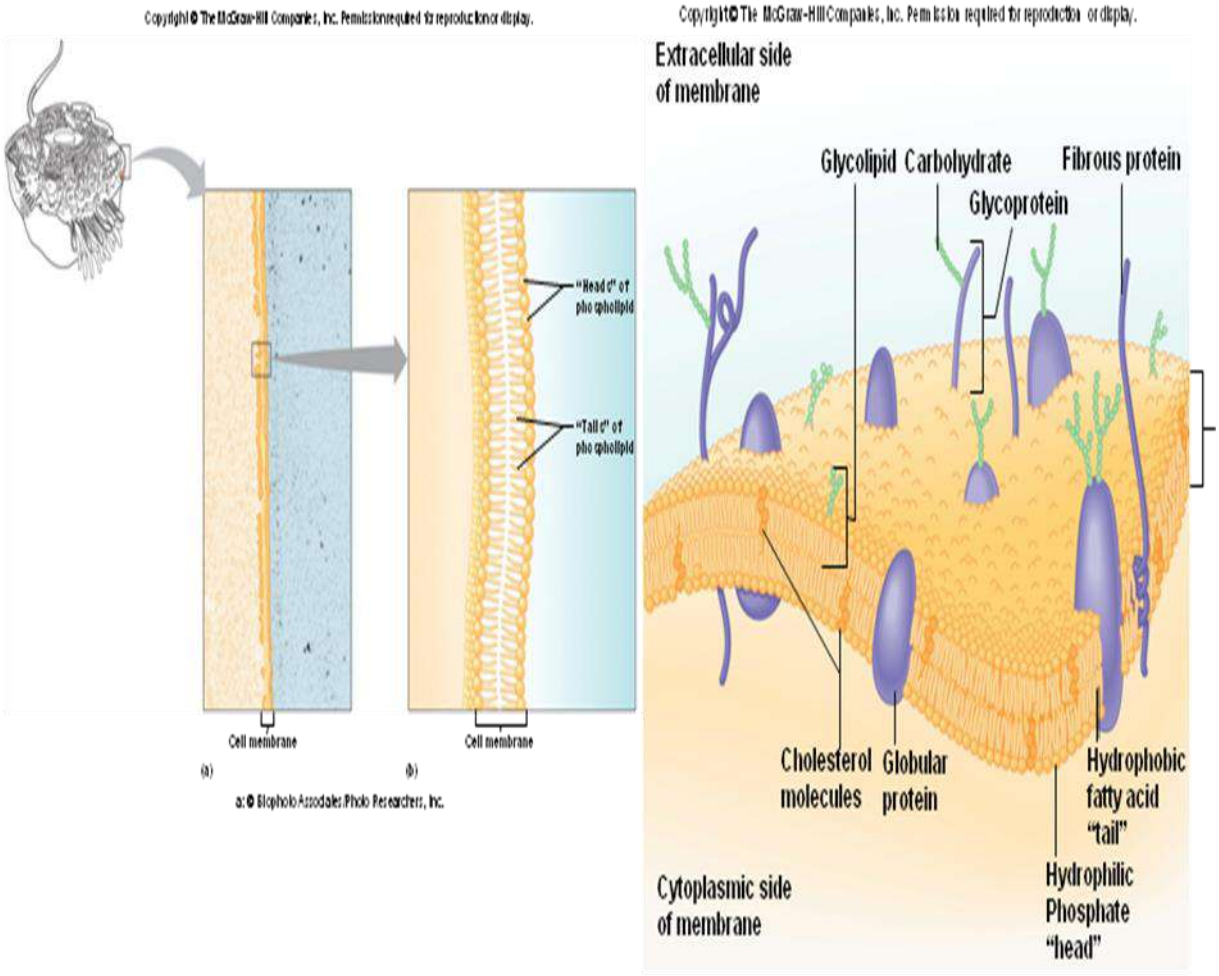


Figure9. Represente Cell Membrane

2.2.Cell Adhesion Molecules (CAMs)

- Guide cells on the move.
- Selectin – allows white blood cells to “anchor”.
- Integrin – guides white blood cells through capillary walls.
- Important for growth ofembryonic tissue.
- Important for growth of nerve cells.

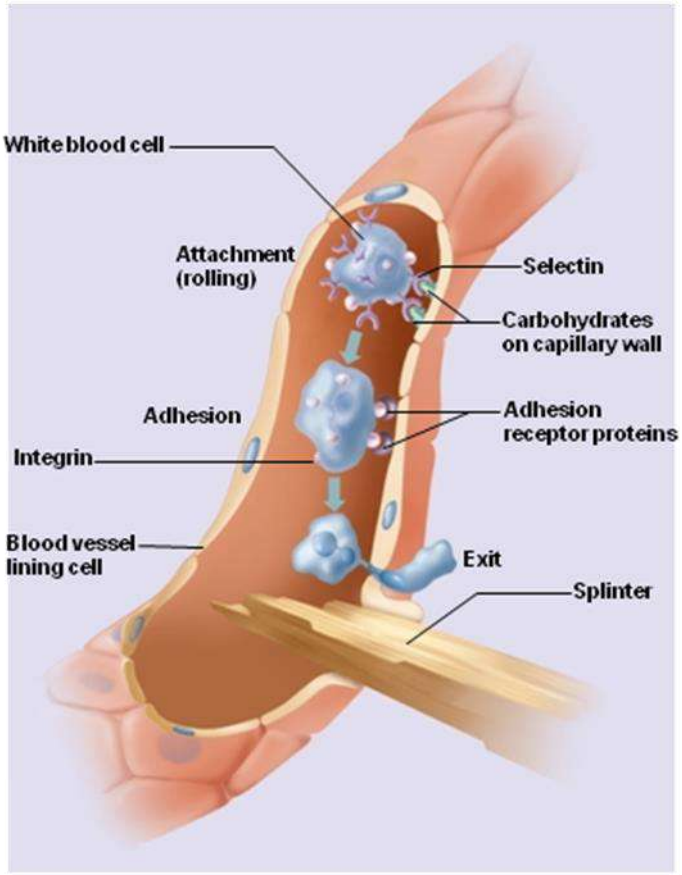


Figure9. Represente Cell Adhesion Molecules (CAMs)

2.3.Cytoplasm

Cytosol = water

Organelles = solids

Cytoplasm is really like a Jello fruit salad where the Jello is the cytosol and the fruits (oranges, grapes, bananas, maybe walnuts, etc.) are the organelles

2.4.Endoplasmic Reticulum (ER)

Connected, membrane-bound sacs, canals, and vesicles.

- Transport system.
- Rough ER.

Studded with ribosomes.

- Smooth ER.
- Lipid synthesis.
- Added to proteins arriving from rough ER
- Break down of drugs

2.5. Ribosomes

- Free floating or connected to ER
- Provide structural support and enzyme activity to amino acids to form protein.

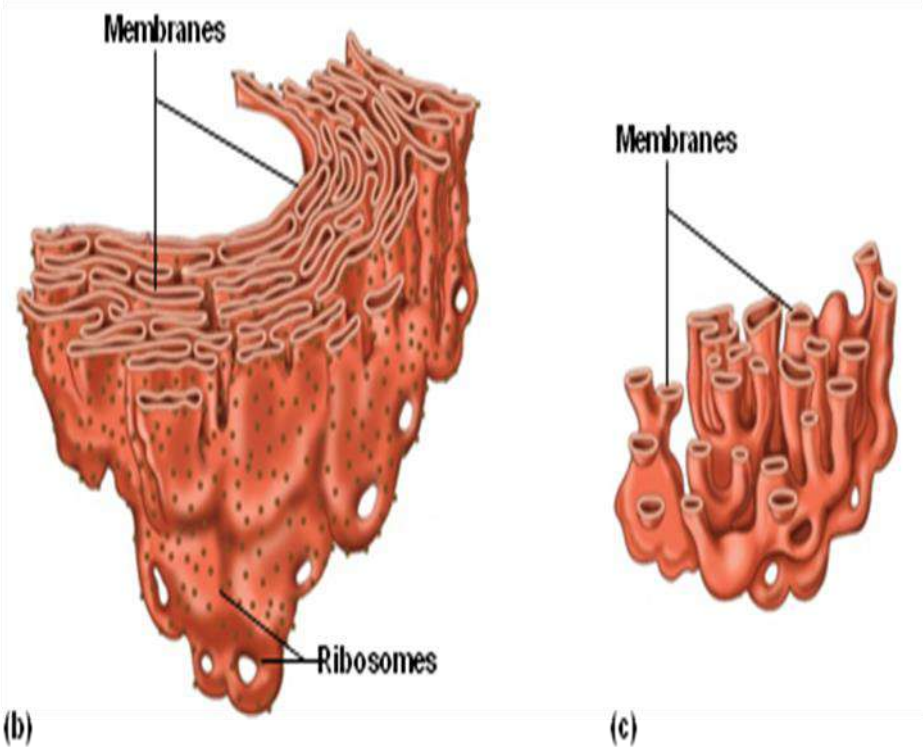


Figure10. Represente Endoplasmic Reticulum (ER)

2.6.Golgi apparatus

- Stack of flattened, membranous sacs
- Modifies, packages and delivers proteins

2.7.Vesicles

- Membranous sacs
- Store substances

2.8.Mitochondria

- Membranous sacs with inner partitions
- Generate energy

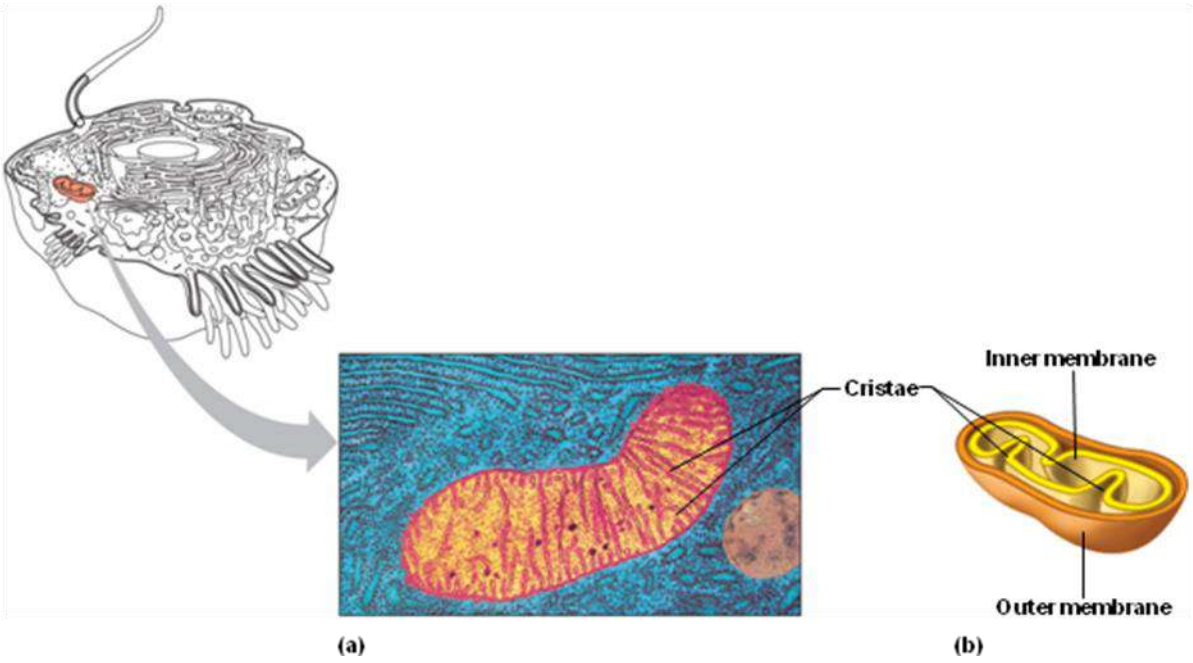


Figure11. Represente Endoplasmic Reticulum (ER)

2.9. Lysosomes

- Enzyme-containing sacs.
- Digest worn out cell parts or unwanted substances.

2.10. Centrosome

- Two rod-like centrioles.
- Used to produce cilia and flagella..
- Distributes chromosomes during cell division.

2.11. Peroxisomes

- Enzyme-containing sacs.
- Break down organic molecules

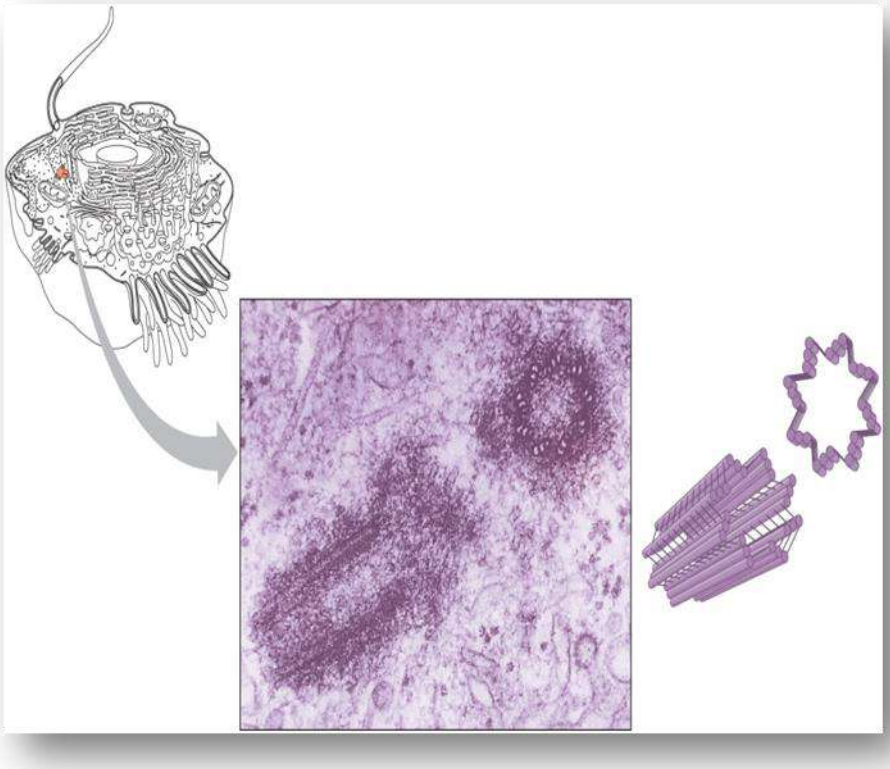


Figure12. Represente Centrosome, Centrosome, Peroxisomes

2.12. Cilia

- Short hair-like projections.
- Propel substances on cell surface.

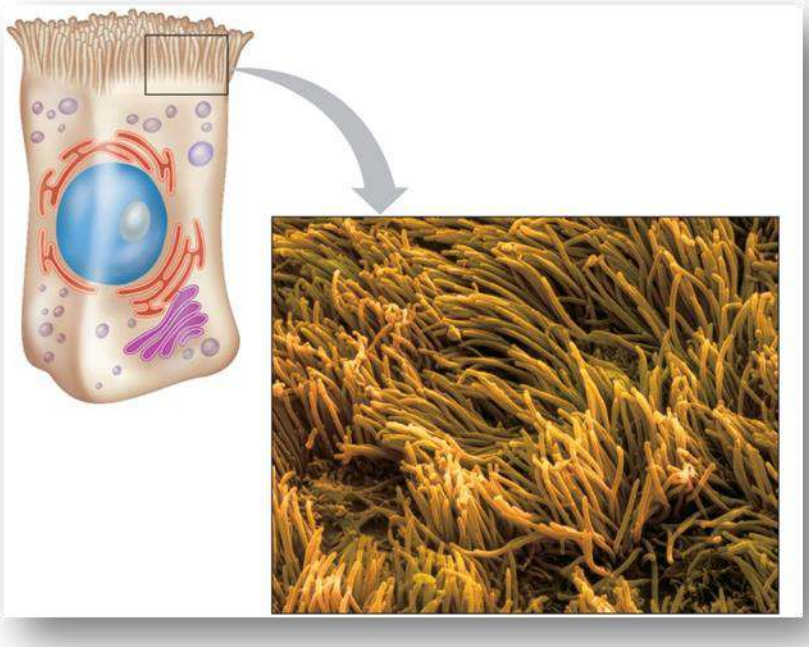


Figure13. Represente Cilia

2.13. Flagellum

- Long tail-like projection.
- Provides motility to sperm.

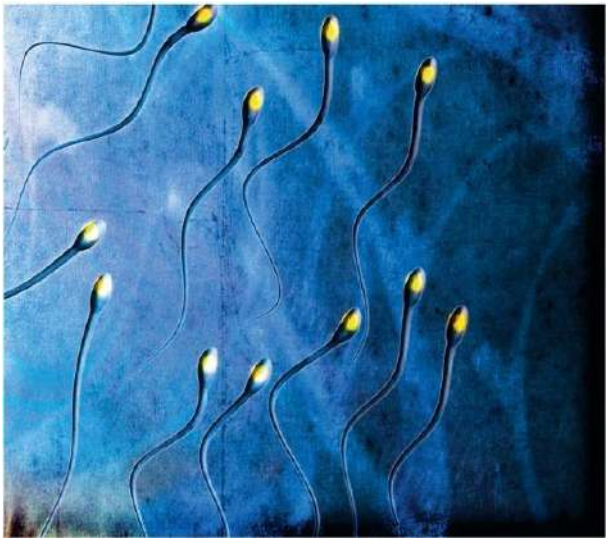


Figure14. Represente Flagellum.

2.14.Microfilaments and microtubules

- Thin rods and tubules
- Support cytoplasm
- Allows for movement of organelles

2.15. Inclusions

- Temporary nutrients and pigments.

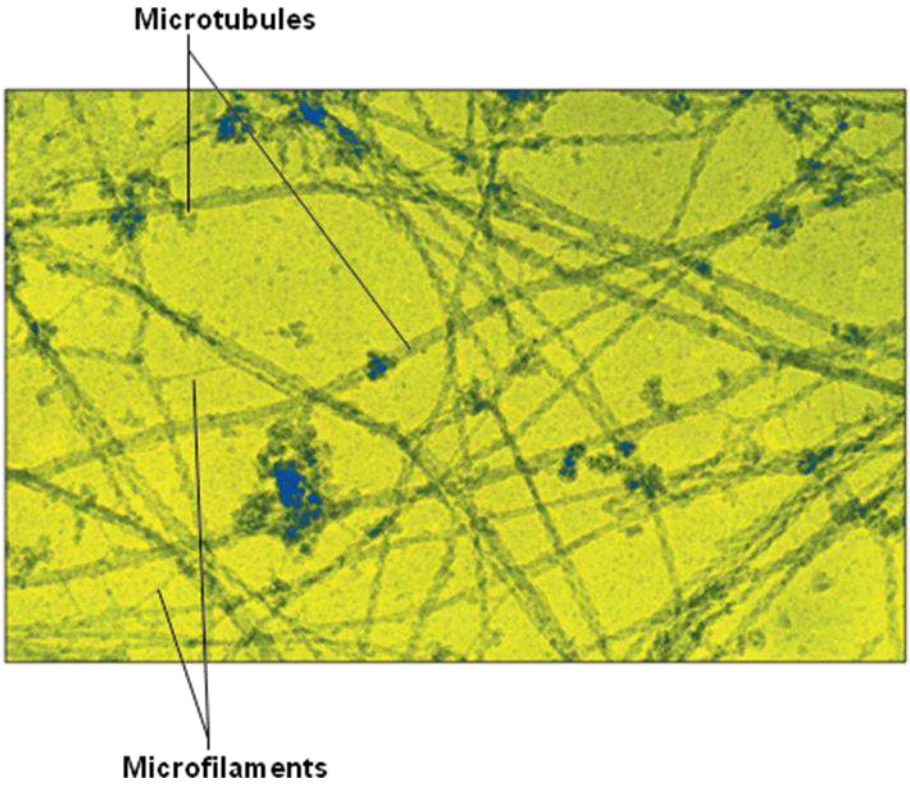


Figure14. Represente Microfilaments.

3. Mitosis and Cytokinesis Division

3.1. Cytoplasmic Division

- Also known as cytokinesis.
- Begins during anaphase.
- Continues through telophase.
- Contractile ring pinches cytoplasm in half.

3.1.1. Control of Cell Division

- Cell division capacities vary greatly among cell types.
    - Skin and blood cells divide often and continually.

    - Neuron cells divide a specific number of times then cease.
- Chromosome tips (telomeres) that shorten with each mitosis provide a mitotic clock .
- Cells divide to provide a more favorable surface area to volume relationship.
- Growth factors and hormones stimulate cell division
- Hormones stimulate mitosis of smooth muscle cells in uterus
- Epidermal growth factor stimulates growth of new skin
- Contact (density dependent) inhibition
- Tumors are the consequence of a loss of cell cycle control

3.1.2.Tumors

- Two types of tumors:
    - Benign – usually remains localized
    - Malignant – invasive and can metastasize; cancerous
- Two major types of genes cause cancer:
    - Oncogenes – activate other genes that increase cell division
    - Tumor suppressor genes – normally regulate mitosis; if inactivated they are unable to regulate mitosis
        - Cells are now known as “immortal”

3.1.3.Stem and Progenitor Cell

- Stem cell:
    - Can divide to form two new stem cells (Self-renewal)
    - Can divide to form a stem cell and a progenitor cell.
    - Totipotent – can give rise to every cell type
    - Pluripotent – can give rise to a restricted number of cell types
- Progenitor cell:
    - Committed cell
    - Can divide to become any of a restricted number of cells
    - Pluripotent

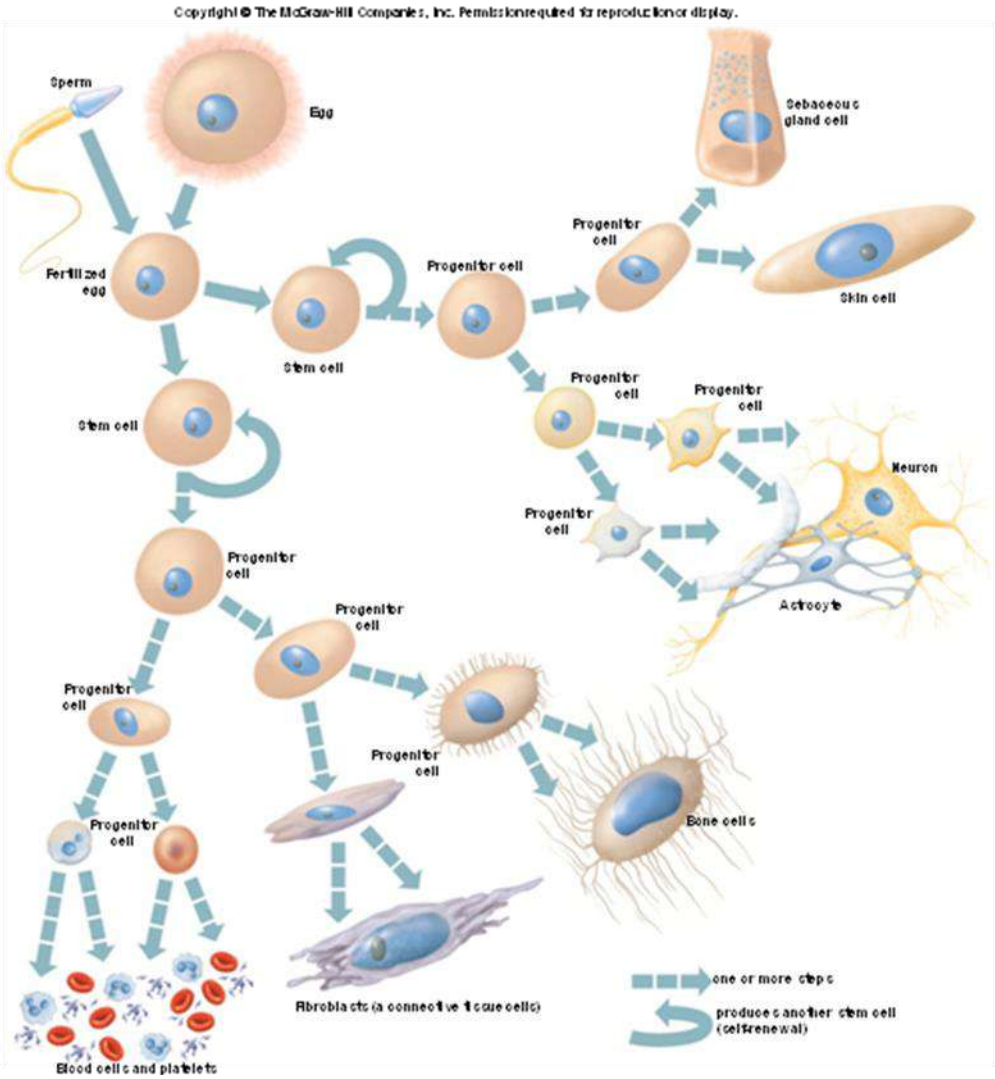


Figure15. Represente Stem and Progenitor Cells.

3.1.4.Cell Death

Apoptosis:

- Programmed cell death
- Acts as a protective mechanism
- Is a continuous process

4. Cellular Metabolism

Metabolic processes – all chemical reactions that occur in the body, There are two (2) types of metabolic reactions

- **Anabolism**
  - Larger molecules are made from smaller ones
  - Requires energy
- **Catabolism**
  - Larger molecules are broken down into smaller ones
  - Releases energy

- **Consists of two processes:**
  - Anabolism
  - Catabolism

Anabolism provides the materials needed for cellular growth and repair.

- **Dehydration synthesis**
  - Type of anabolic process
  - Used to make polysaccharides, triglycerides, and proteins
  - Produces water.

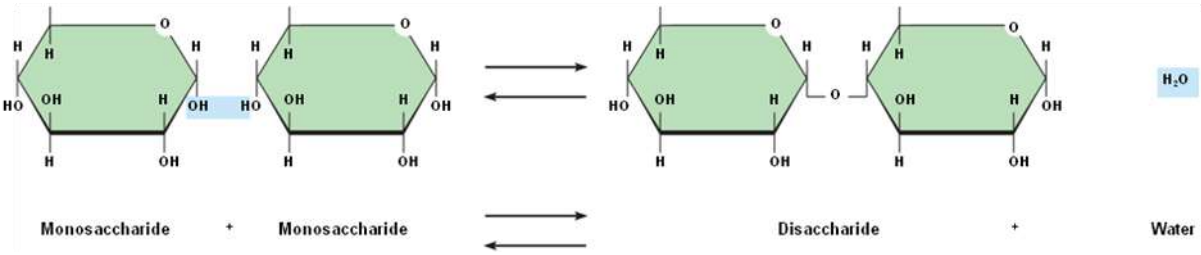


Figure16. Represente anabolism of disaccharides.

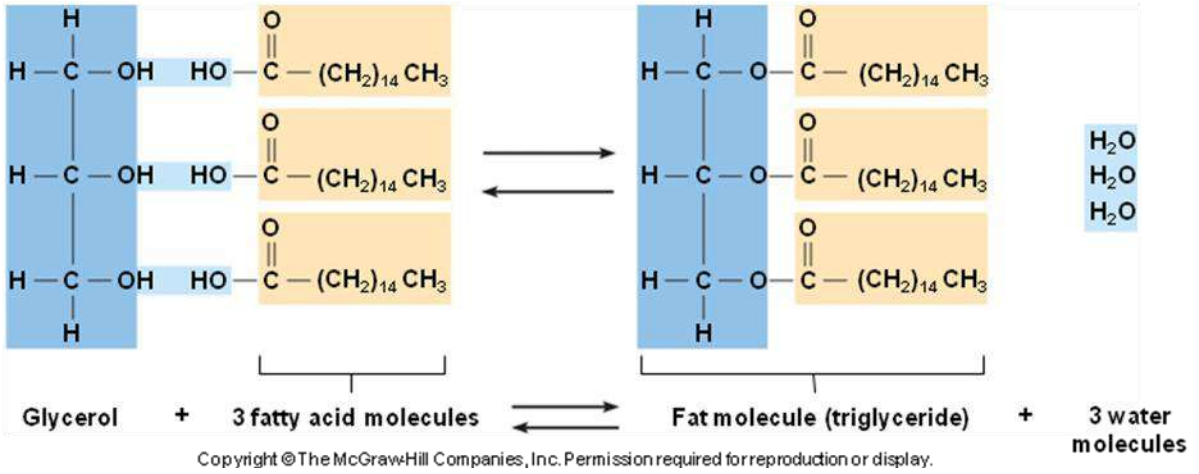


Figure17. Represente anabolism of Triglyceride.

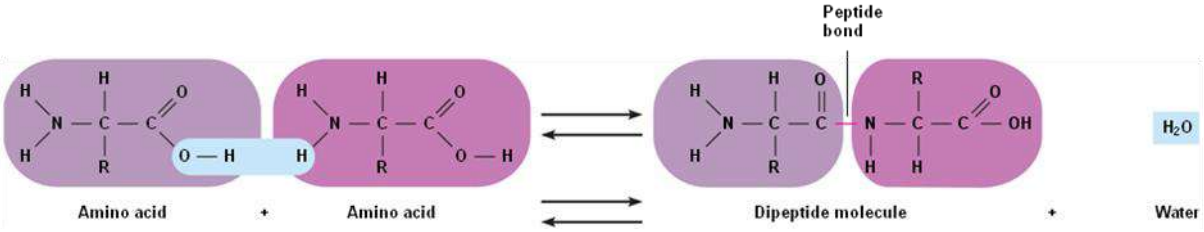


Figure18. Represente anabolism of Dipeptide.

- **Catabolism breaks down lrger molecules into smaller ones**
- **Hydrolysis**
  - A catabolic process.
  - Used to decompose carbohydrates, lipids, and proteins.

- Water is used to split the substances.
- Reverse of dehydration synthesis.

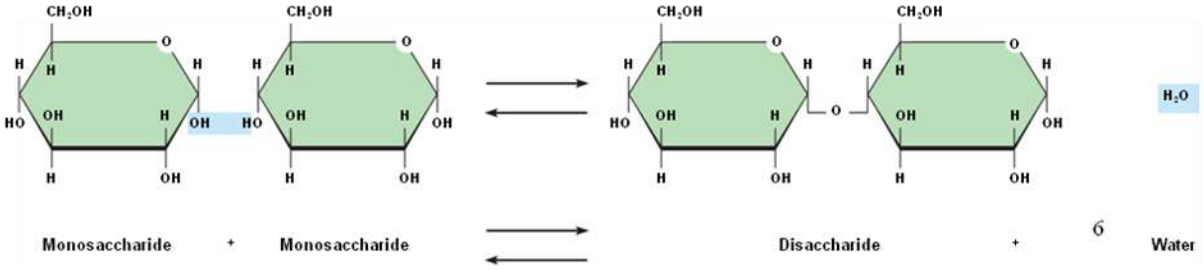
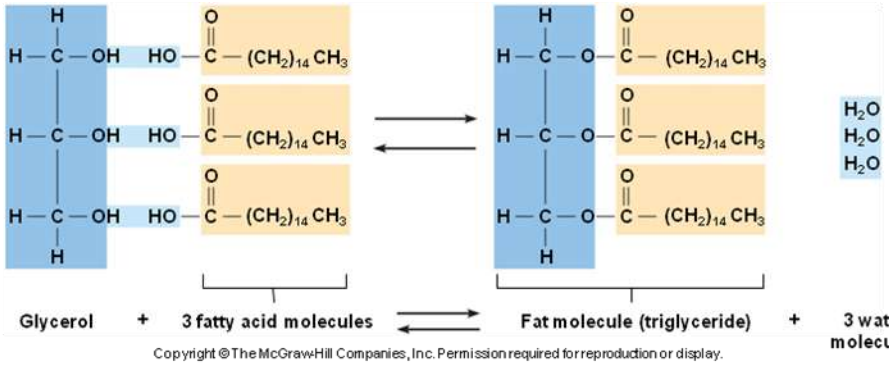


Figure19. Represente Catabolism of Disaccharide.



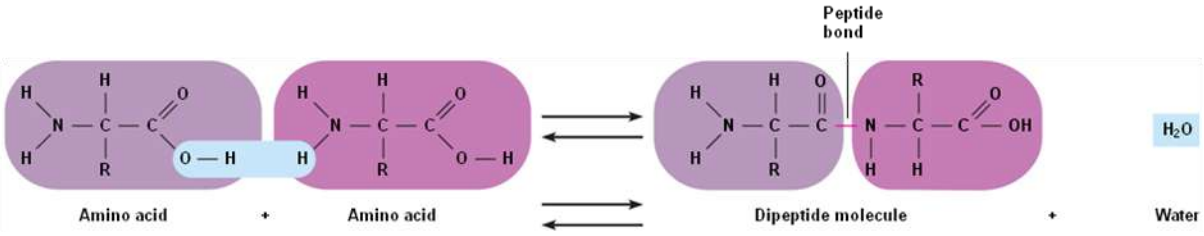


Figure20. Represente Catabolism of Dipeptide.

4.1. Control of Metabolic Reactions

- Enzymes.
- Control rates of metabolic reactions.
- Most are globular proteins with specific shapes.
- Lower activation energy needed to start reactions.
- Not consumed in chemical reactions.
- Substrate specific.
- Shape of active site determines substrate.

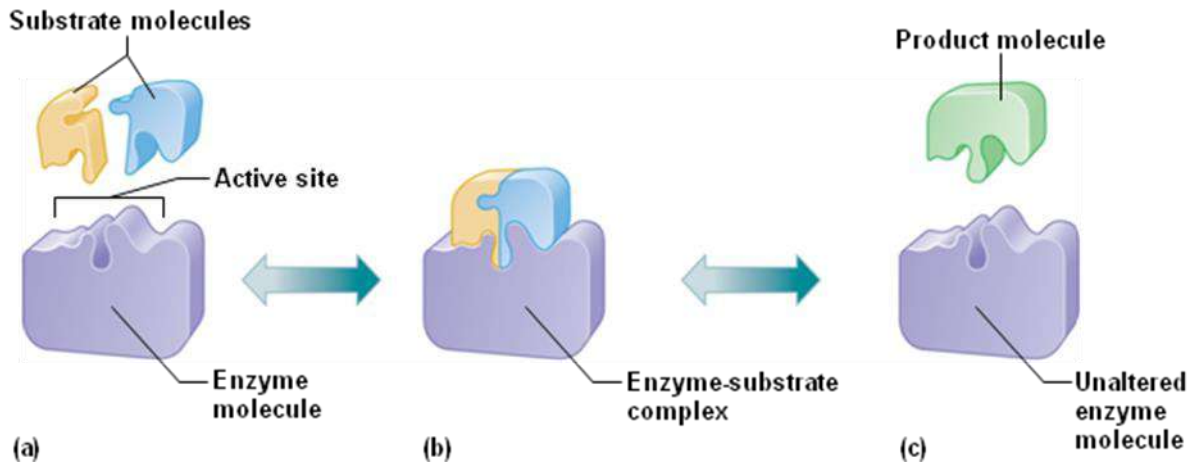


Figure21. Represente Proteine synthese metabolism.

4.2.Enzyme Action

- **Metabolic pathways**
  - Series of enzyme-controlled reactions leading to formation of a product
  - Each new substrate is the product of the previous reaction

- **Enzyme names commonly**
  - Reflect the substrate
  - Have the suffix – ase
  - Examples: sucrase, lactase, protease, lipase

4.3.Cofactors and Coenzymes

- **Cofactors**
  - Make some enzymes active.
  - Non-protein component.
  - Ions or coenzymes.
- **Coenzymes**
  - Organic molecules that act as cofactors
  - Vitamins

4.4. Factors That Alter Enzymes

- Heat.
- Radiation.
- Electricity.
- Chemicals.
- Changes in pH.

THIRD COURSE: TISSUES

1.Introduction

Similar cells with a common function are called tissues. The study of tissues is called histology.

There are four (4) primary or major tissue types:

- Epithelial Tissue
- Connective Tissue
- Muscle Tissue
- Nervous Tissue

2.Tissues

2.1.Epithelial Tissue

2.1.1. General characteristics

- Cover organs and the body
- Line body cavities
- Line hollow organs
- Have a free surface
- Have a basement membrane
- Are avascular
- Cells readily divide
- Cells tightly packed
- Cells often have desmosomes
- Function in protection, secretion, absorption, and excretion
- Classified according to cell shape and number of cell layers

2.1.1.Classification of Epithelial Tissue

2.1.1.1. squamous epithelium

2.1.1.1.1.Simple Epithelial Tissue

2.1.1.1.1.1. Simple squamous

- Single layer of flat cells
- Substances pass easily through
- Line air sacs
- Line blood vessels
- Line lymphatic vessels

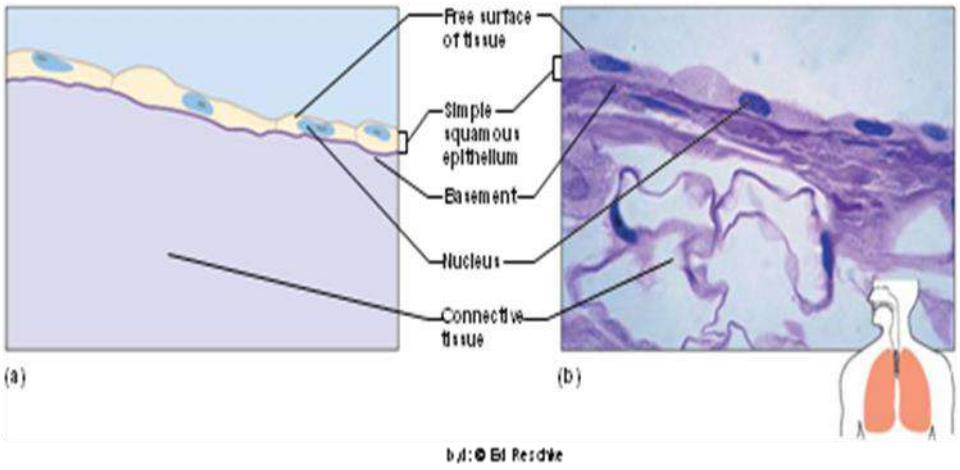


Figure22. Represente Simple squamous

2.1.1.1.1.2. Simple cuboidal

- Single layer of cube-shaped cells
- Line kidney tubules
- Cover ovaries
- Line ducts of some glands

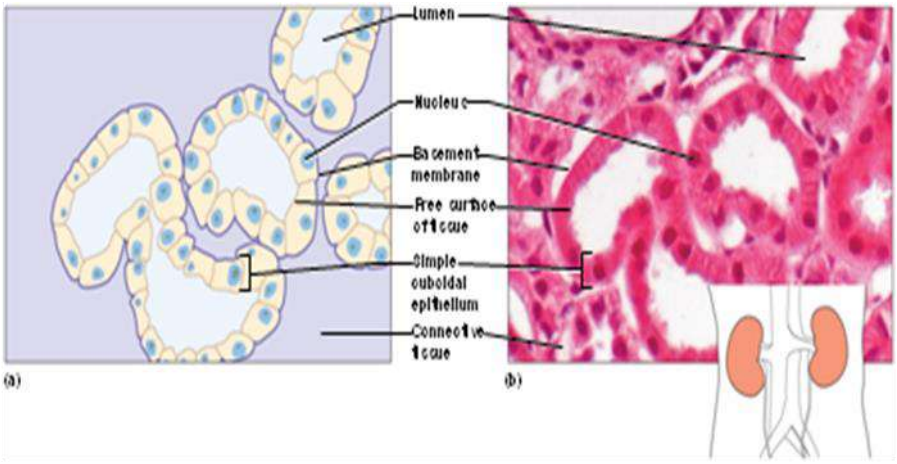


Figure23. Represente Simple cuboidal

2.1.1.1.1.3. Simple columnar

- Single layer of elongated cells
- Nuclei usually near the basement
- Membrane at same level
- Sometimes possess cilia
- Sometimes possess microvilli
- Often have goblet cells
- Line uterus, stomach, intestines

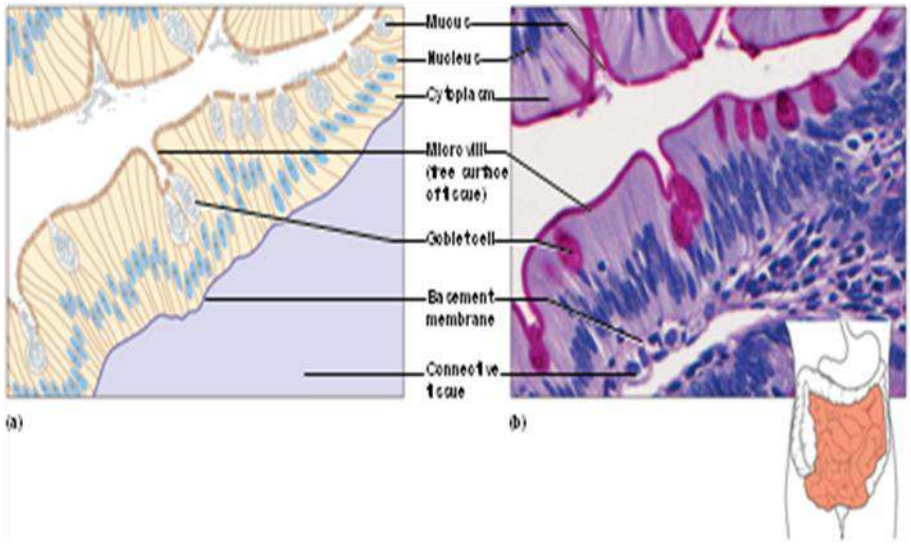


Figure24. Represente Simple columnar

2.1.1.1.2.Stratified Epithelial Tissue

2.1.1.1.2.1.Stratified columnar

- Top layer of elongated cells
- Cube-shaped cells in deeper layers
- Line part of male urethra and part of pharynx

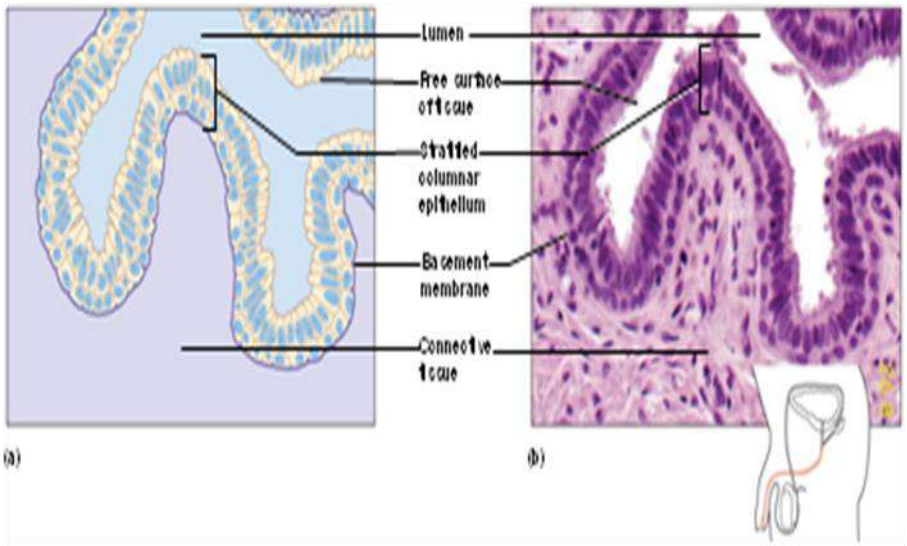


Figure25. Represente Stratified columnar

2.1.1.1.2.2.Stratified Transitional

- Many cell layers
- Cube-shaped and elongated cells
- Line urinary bladder, ureters, and part of urethra

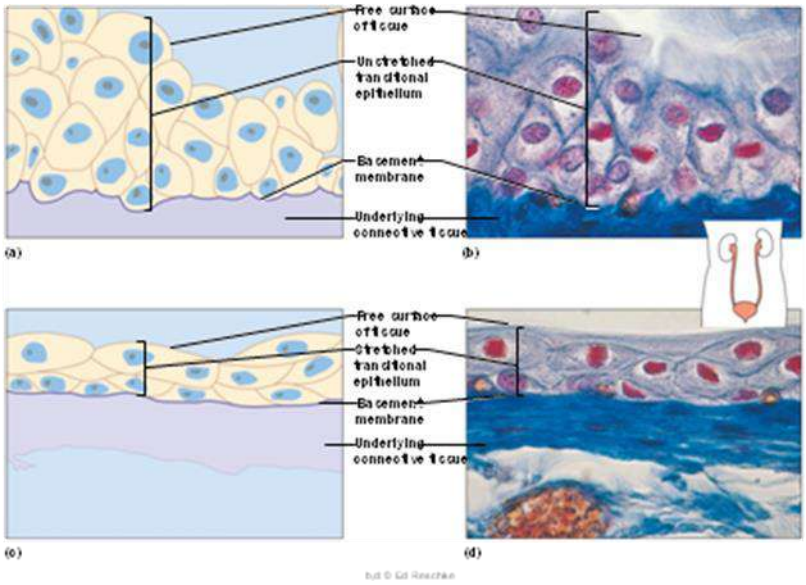


Figure26. Represente Stratified Transitional

2.1.1.2. Glandular Epithelium

Composed of cells that are specialized to produce and secrete substances

- There are two (2) types:
    - Endocrine glands are ductless (key word: hormone)
    - Exocrine glands have ducts

2.1.1.2. 1.Endocrine glands

are ductless (key word: hormone)

2.1.1.2. 2.Exocrine glands

have ducts:

2.1.1.2. 2.1.Unicellular exocrine gland

- Composed of one cell
- Goblet cell

2.1.1.2. 2.2. Multicellular exocrine gland

- Composed of many cells
- Sweat glands, salivary glands, etc.

- Simple and compound

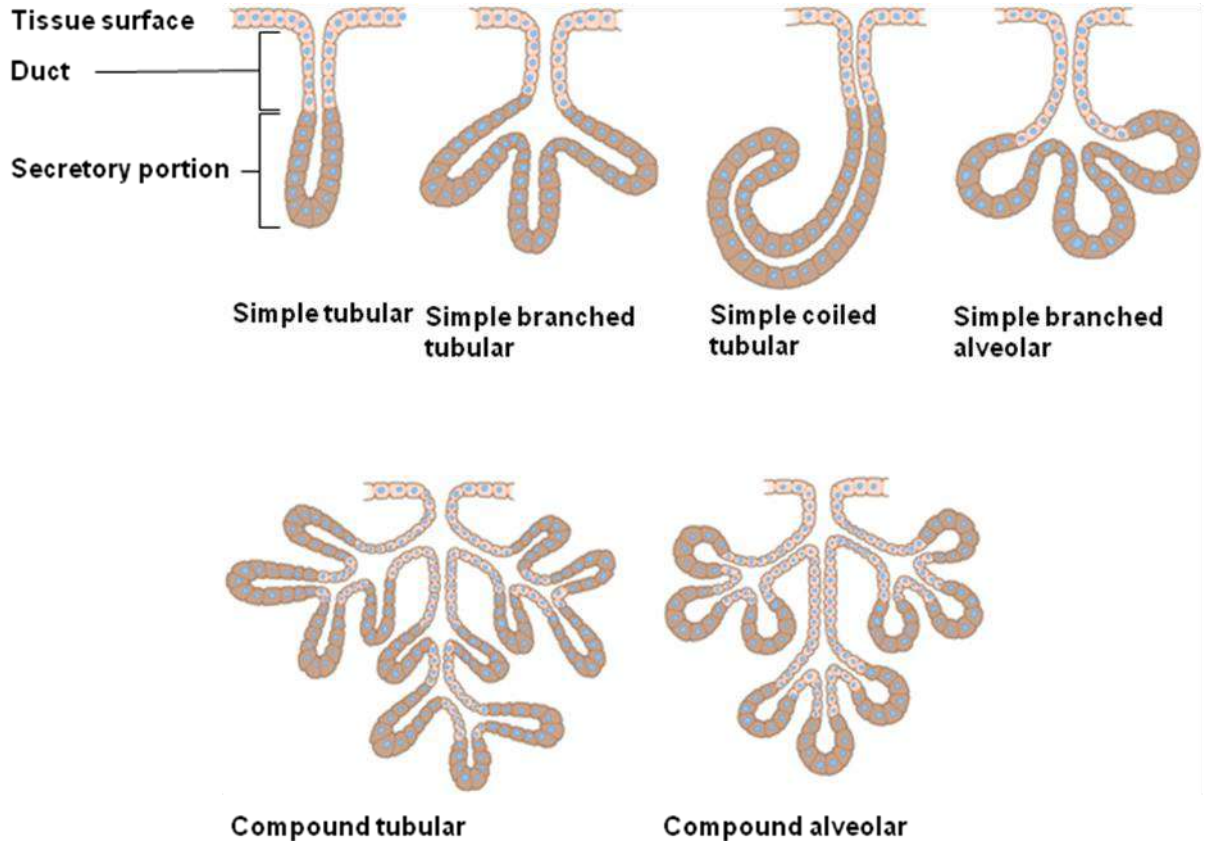


Figure27. Represente Structural Types of Exocrine Glands

2.1.2.Types of Glandular Secretions

2.1.2.1. Merocrine Glands

- Fluid product
- Salivary glands
- Pancreas gland (?)
- Sweat glands

2.1.2.2. Apocrine Glands

- Cellular product
- Portions of cells
- Mammary glands
- Ceruminous glands

2.1.2.3. Holocrine Glands

- Secretory products
- Whole cells
- Sebaceous glands

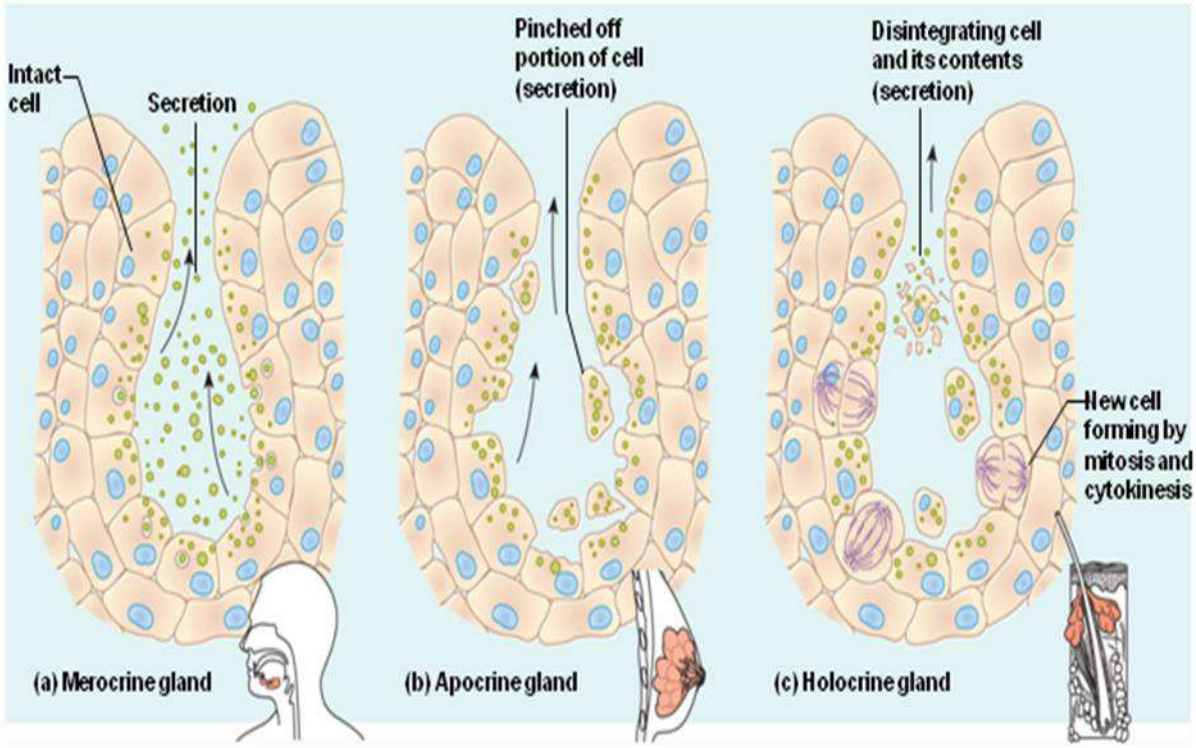


Figure28. Represente Types of Glandular Secretions

2.1.1.3. epithelial membranes

There are four (4) types of epithelial membranes:

2.1.1.3.1. Serous Membranes

- Line body cavities that do not open to the outside
- Reduce friction
- Inner lining of thorax and abdomen
- Cover organs of thorax and abdomen
- Secrete serous fluid

2.1.1.3.2. Mucous Membranes

- Line tubes and organs that open to outside world
- Lining of mouth, nose, throat, etc.
- Secrete mucus

2.1.1.3.3. Cutaneous Membranes

- Covers body
- Skin

2.1.1.3.4. Synovial Membranes

- Composed entirely of connective tissue.
- Lines joints.

2.2.Connective Tissues

2.2.1.Definition of Connective tissue

Connective tissue is one of the four primary types of biological tissue in the human body. It functions to support, connect, and separate different types of tissues and organs. It is characterized by an abundant extracellular matrix that includes fibers (such as collagen and elastin) and ground substance, which together provide structural and biochemical support to surrounding cells.

"Connective tissues provide structural support, bind tissues together, and play roles in protection, insulation, and nutrient transport. These tissues are composed of specialized cells embedded in an extracellular matrix of protein fibers and ground substance" (Marieb & Hoehn, 2019, p. 128).

2.2.2.General Characteristics

- Bind structures
- Provide support and protection
- Serve as frameworks
- Fill spaces

- Store fat
- Produce blood cells
- Protect against infections
- Help repair tissue damage
- Have a matrix
- Have varying degrees of vascularity
- Have cells that usually divide

2.2.3.Major Cell Types Present in Connective Tissue

2.2.3.1. Fibroblasts

- Fixed cell
- Most common cell
- Large, star-shaped
- Produce fibers

2.2.3.2. Macrophages

- Wandering cell
- Phagocytic
- Important in injury or infection

2.2.3.3. Mast cells

- Fixed cell
- Release heparin
- Release histamine

2.2.4. Fiber Types Present in Connective Tissue

2.2.4.1. Collagenous fibers

- Thick
- Composed of collagen

- Great tensile strength
- Abundant in dense CT
- Hold structures together
- Tendons, ligaments

2.2.4.2. Elastic fibers

- Bundles of microfibrils embedded in elastin
- Fibers branch
- Elastic
- Vocal cords, air passages

2.2.4.3. Reticular fibers

- Very thin collagenous fibers
- Highly branched
- Form supportive networks

2.2.5. Classification of Connective tissue

Connective tissue is broadly classified into two main categories: connective tissue proper and specialized connective tissue. Connective tissue proper includes loose connective tissue, which provides cushioning and support; adipose tissue, which stores fat and serves as an energy reserve and insulator; reticular connective tissue, which forms the supportive framework of organs like the spleen and lymph nodes; dense connective tissue, characterized by tightly packed collagen fibers that provide tensile strength; and elastic connective tissue, which allows tissues to recoil after stretching. On the other hand, specialized connective tissue includes cartilage, a semi-rigid tissue that provides flexible support and reduces friction in joints; bone, a mineralized tissue responsible for structural support and protection; and blood, a fluid tissue that transports nutrients, gases, and wastes throughout the body. These diverse types of connective tissues perform crucial structural, metabolic, and protective roles in the human body (Marieb & Hoehn, 2019; Ross & Pawlina, 2021).

2.2.5.1. Connective Tissue Proper

2.2.5.1.1.Loose connective tissue

- Mainly fibroblasts

- Fluid to gel-like matrix
- Collagenous fibers
- Elastic fibers
- Bind skin to structures
- Beneath most epithelia
- Blood vessels nourish nearby epithelial cells Between muscles

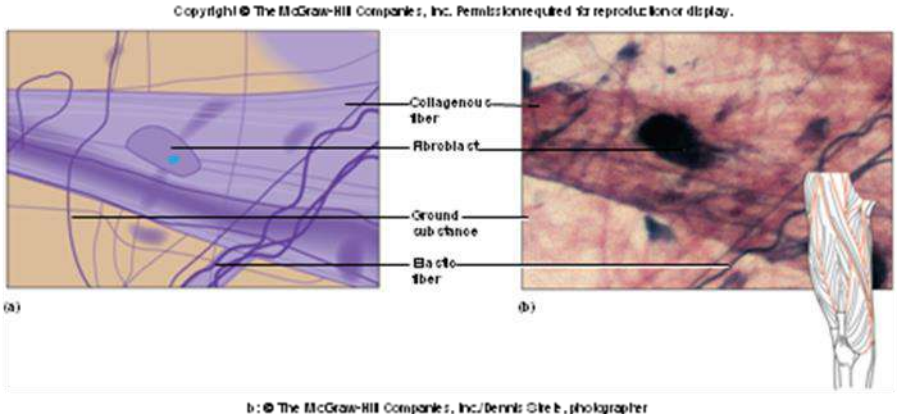


Figure29. Represente Loose connective tissue

2.2.5.1.2.Adipose connective tissue

- Adipocytes
- Cushions
- Insulates
- Store fats
- Beneath skin
- Behind eyeballs
- Around kidneys and heart

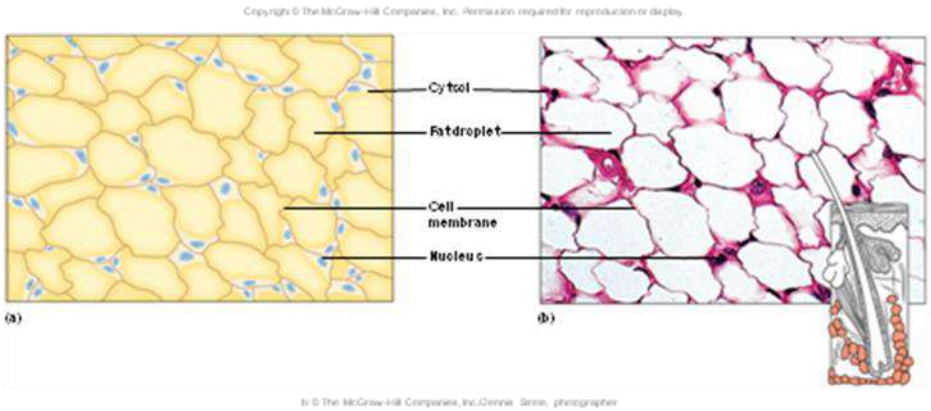


Figure30. Represente Adipose connective tissue

2.2.5.1.3.Reticular Connective Tissue

- Composed of reticular fibers
- Supports internal organ walls
- Walls of liver, spleen, lymphatic organs

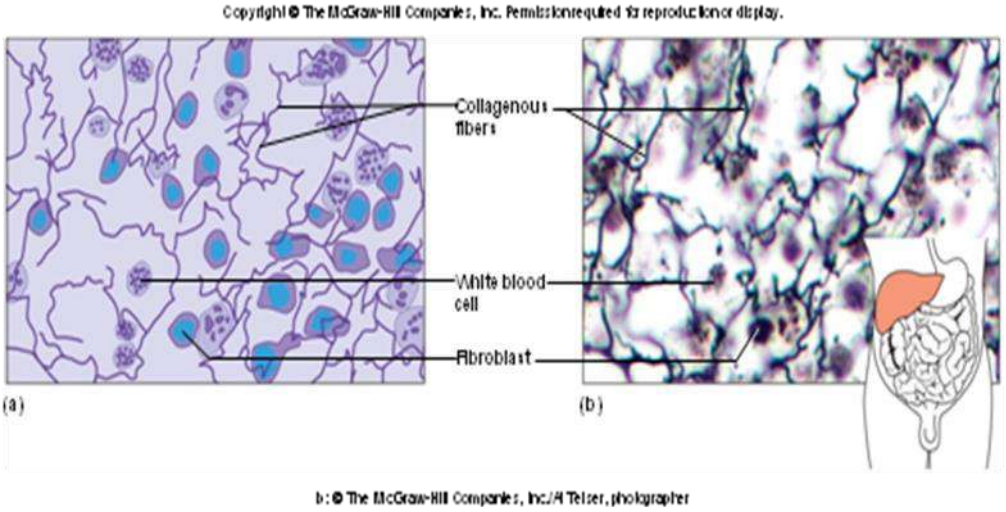
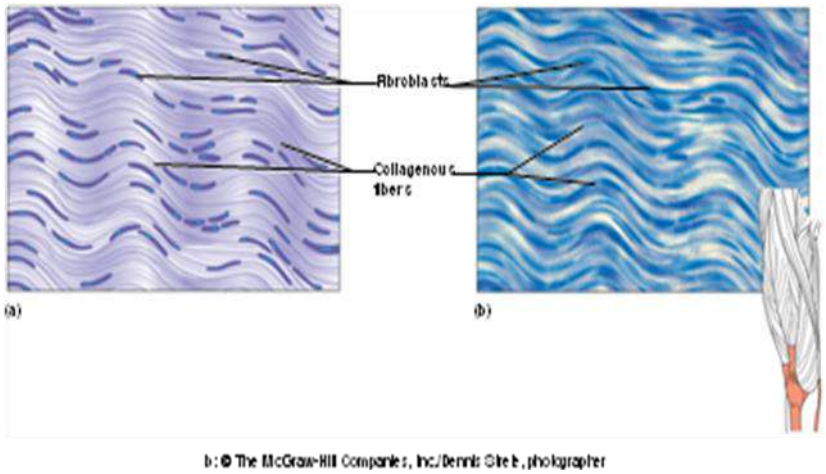


Figure31. Represente Reticular connective tissue.

2.2.5.1.4.Dense Connective Tissue

- Packed collagenous fibers
- Elastic fibers
- Few fibroblasts

- Bind body parts together
- Tendons, ligaments, dermis
- Poor blood supply



b: © The McGraw-Hill Companies, Inc./Dennis Strete, photographer

Figure31. Represente Dense connective tissue.

2.2.5.1.5.Elastic Connective Tissue

- Abundant in elastic fibers
- Some collagenous fibers
- Fibroblasts
- Attachments between bones
- Walls of large arteries, airways, heart

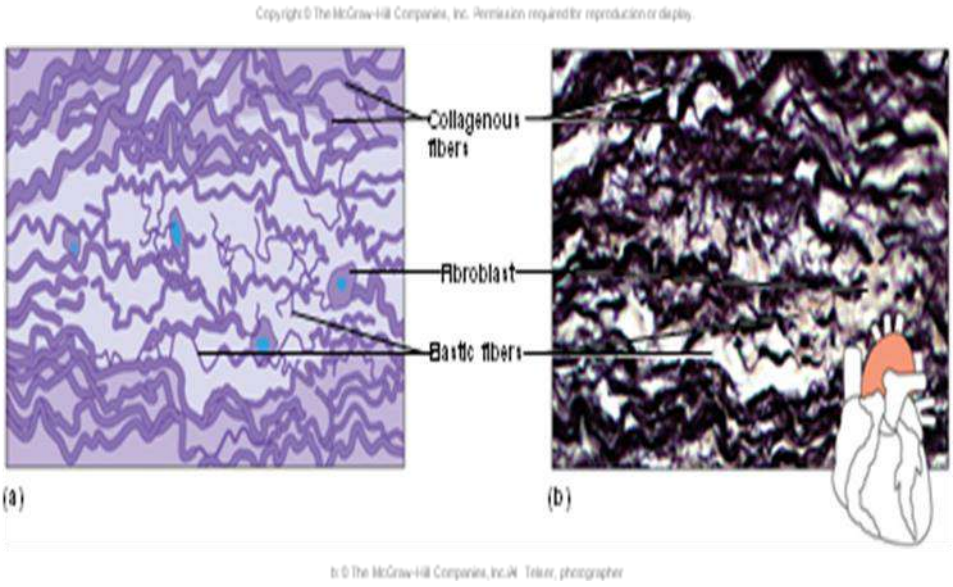


Figure32. Represente Elastic connective tissue.

2.2.5.2. Specialized Connective Tissue

2.2.5.1. Bone (Osseous Tissue)

- Solid matrix
- Supports
- Protects
- Forms blood cells
- Attachment for muscles
- Skeleton Osteocytes in lacunae

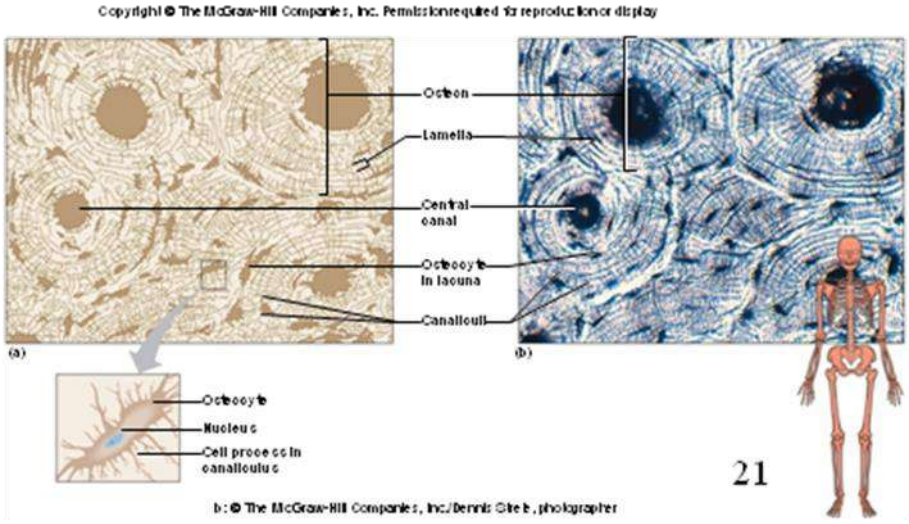


Figure33. Represente Bone (Osseous Tissue).

2.2.5.2. Cartilage

- Rigid matrix
- Chondrocytes in lacunae
- Poor blood supply
- Three (3) types:
    - Hyaline Cartilage
    - Elastic Cartilage
    - Fibrocartilage

2.2.5.2.1. Hyaline cartilage

- Most abundant
- Ends of bones
- Nose, respiratory passages
- Embryonic skeleton

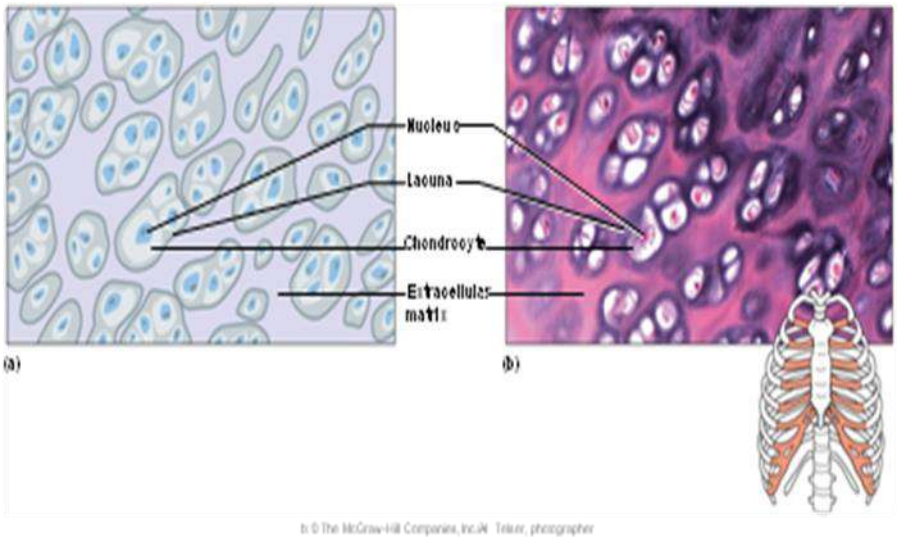


Figure34. Represente Hyaline cartilage

2.2.5.2.2. Elastic cartilage

- Flexible
- External ear, larynx

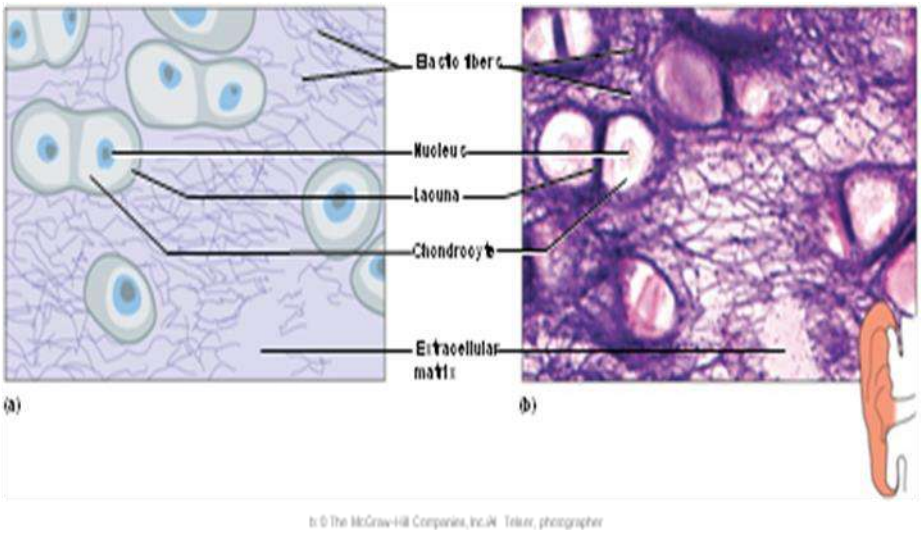


Figure35. Represente Elastic cartilage

2.2.5.2.3. Fibrocartilage

- Very tough
- Shock absorber
- Intervertebral discs
- Pads of knee and pelvic girdle
-

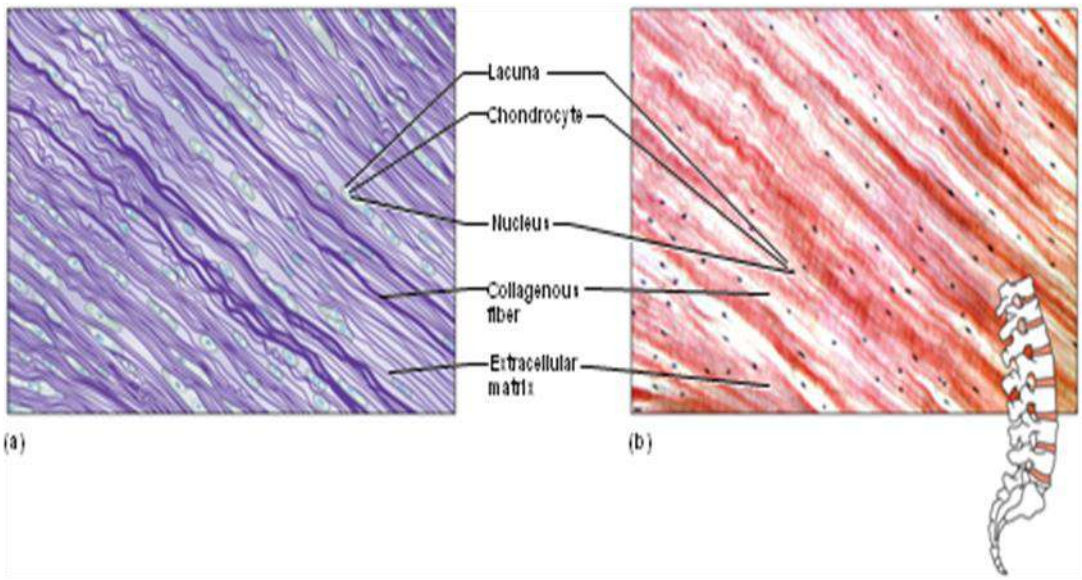


Figure36. Represente Fibrocartilage.

2.2.5.3.Blood

- Fluid matrix called plasma
- Red blood cells

- White blood cells
- Platelets
- Transports
- Defends
- Involved in clotting
- Throughout body in blood vessels
- Heart

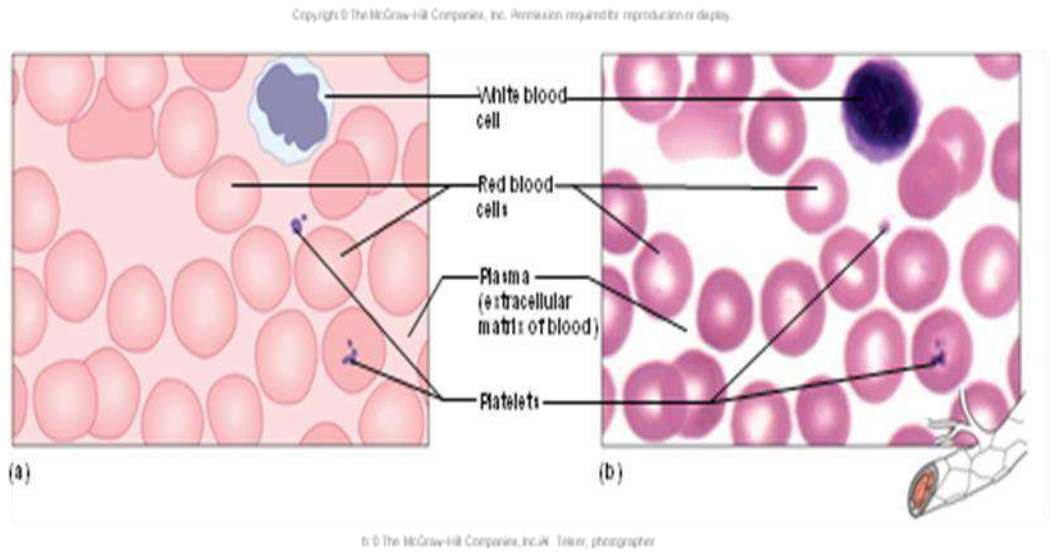


Figure37. Represente Blood Cells

2.3.Muscle Tissue

Muscle tissue is a specialized biological tissue responsible for producing movement through contraction. It is classified into **three major types** based on structure, function, and control mechanisms: **skeletal muscle**, **cardiac muscle**, and **smooth muscle**.

2.3.1.Classification of Muscle Tissue

2.3.1.1.Skeletal Muscle Tissue

Skeletal muscle is a voluntary, striated muscle attached to bones via tendons, enabling body movement and posture. It consists of long, cylindrical, multinucleated fibers with alternating light and dark bands (striations) visible under a microscope. Skeletal muscle contractions are under **conscious control**

via the somatic nervous system. In addition to movement, it plays roles in thermogenesis and joint stabilization (Marieb & Hoehn, 2019).

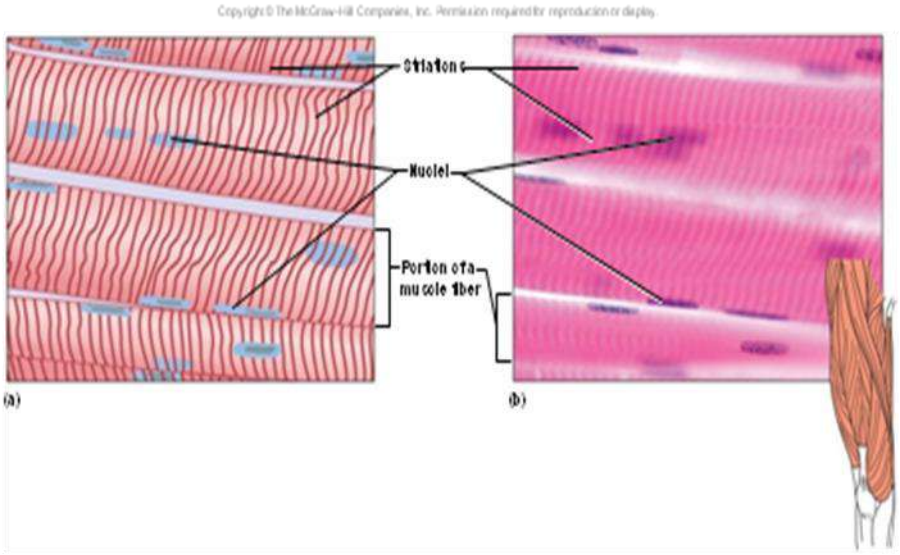


Figure37. Represente Skeletal Muscle Tissue

2.3.1.2.Cardiac Muscle Tissue

Cardiac muscle is an **involuntary**, striated muscle found exclusively in the walls of the **heart (myocardium)**. Its cells are **branched**, usually contain a **single central nucleus**, and are interconnected by **intercalated discs**, which allow rapid transmission of electrical impulses for synchronized contraction. Cardiac muscle is controlled by the **autonomic nervous system** and intrinsic conduction systems, allowing rhythmic, automatic contractions (Ross & Pawlina, 2021).

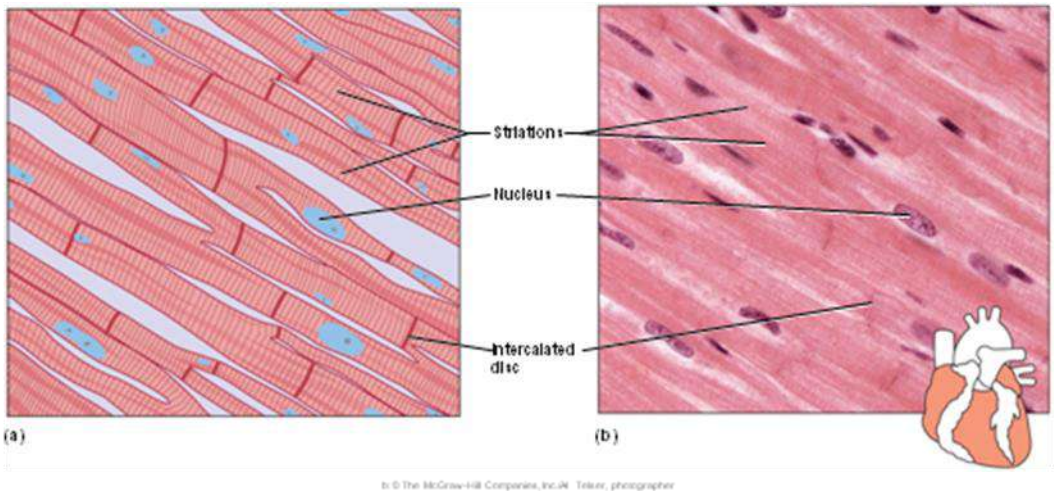


Figure38. Represente Cardiac Muscle Tissue

2.3.1.3.Smooth Muscle Tissue

Smooth muscle is **non-striated** and **involuntary**, found in the walls of hollow organs such as the intestines, blood vessels, bladder, and uterus. The spindle-shaped cells have a single nucleus and are capable of slow, sustained contractions. Unlike skeletal muscle, smooth muscle contracts in response to hormonal, neural, and mechanical stimuli, and is responsible for processes such as peristalsis, vasoconstriction, and organ emptying (Mescher, 2021).

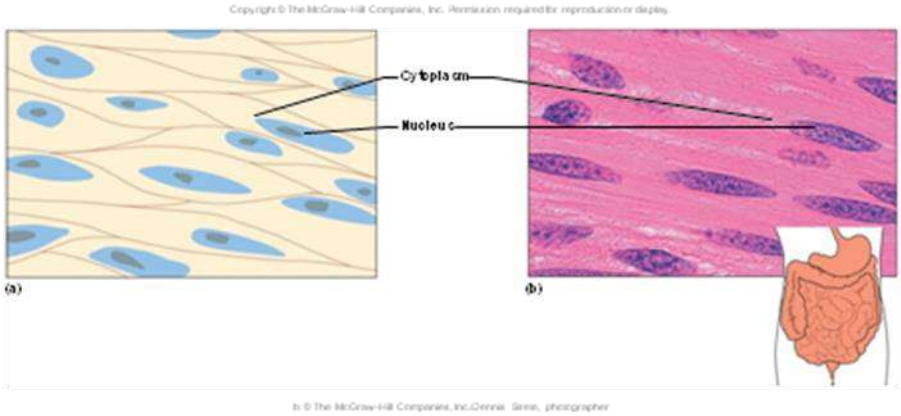


Figure39. Represente Smooth Muscle Tissue

Each muscle type plays a crucial role in maintaining homeostasis by enabling motion, circulation, and the regulation of internal organ functions.

2.4.Nervous Tissue

Nervous tissue is a highly specialized tissue responsible for sensing stimuli, transmitting signals, and coordinating bodily functions. It forms the **nervous system**, which includes the **central nervous system (CNS)** — the brain and spinal cord — and the **peripheral nervous system (PNS)**, comprising all neural elements outside the CNS. Nervous tissue is composed of two principal types of cells: **neurons** and **neuroglia (glial cells)**.

2.4.1. Neurons (Nerve Cells)

Neurons are the **structural and functional units** of the nervous system. These excitable cells generate and conduct **electrical impulses** called action potentials. A typical neuron consists of:

- **Cell body (soma):** Contains the nucleus and metabolic machinery.
- **Dendrites:** Branched extensions that receive signals from other neurons.
- **Axon:** A long process that transmits impulses to other neurons or effector cells.

Neurons are classified functionally into:

- **Sensory (afferent) neurons:** Carry signals from receptors to the CNS.
- **Motor (efferent) neurons:** Transmit signals from the CNS to muscles or glands.
- **Interneurons:** Connect neurons within the CNS, enabling complex processing.

2.4.2. Neuroglia (Glial Cells)

Glial cells **support, protect, and nourish** neurons. They do not transmit electrical signals but are essential for maintaining the neuronal environment. Types include:

- **CNS glial cells:**
  - **Astrocytes:** Regulate the extracellular ionic environment and maintain the blood-brain barrier.
  - **Oligodendrocytes:** Produce myelin sheaths around CNS axons.
  - **Microglia:** Act as immune cells, removing pathogens and debris.
  - **Ependymal cells:** Line ventricles and produce cerebrospinal fluid (CSF).
- **PNS glial cells:**
  - **Schwann cells:** Myelinate axons in the PNS.
  - **Satellite cells:** Support neurons in ganglia.

The integration of neurons and glial cells allows the nervous system to regulate sensory input, coordinate motor output, and support higher-order functions such as thought, memory, and emotion.

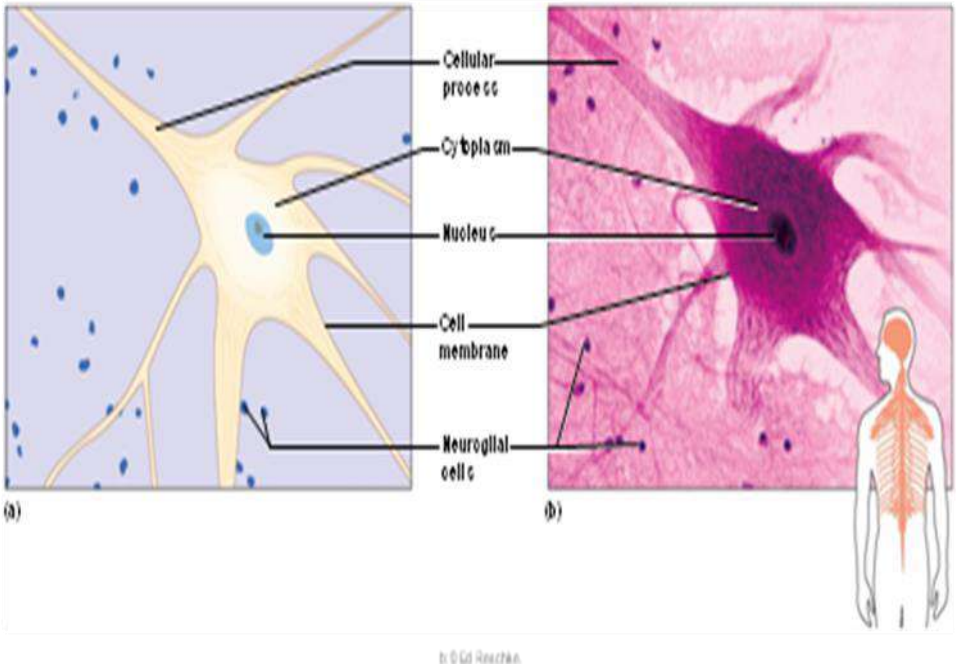


Figure40. Represente Nervous Tissue Cells

FOURTH COURSE: Skeletal System

1.Introduction

- Human skeleton initially cartilages and fibrous membranes
- Hyaline cartilage is the most abundant cartilage
- By age 25 the skeleton is completely hardened growth ceases
- 206 bones make up the adult skeleton (20% of body mass)
    - 126 bones of the appendicular skeleton
    - 80 bones of the axial skeleton

2.Bone Function

- Support, Movement & Protection
    - Gives shape to head, etc.
    - Supports body's weight
    - Protects lungs, etc.
    - Bones and muscles interact
    - When limbs or body parts move

3.Bone Structure

- Bones of the skeletal system vary greatly in size and shape

There is similarity in structure, development, and

Bone cells are called osteocytes

- Osteocytes transport nutrients and wastes
- The extracellular matrix of bone is largely collagen and inorganic salts
    - Collagen gives bone resilience
    - Inorganic salts make bone hard

3.1.Compact Bone Structure

- Osteon aka Haversian System
- Central canal
- Perforating canal aka Volkmann’s canal
- Osteocytes
- Lamellae
- Lacunae
- Bone matrix
- Canaliculi

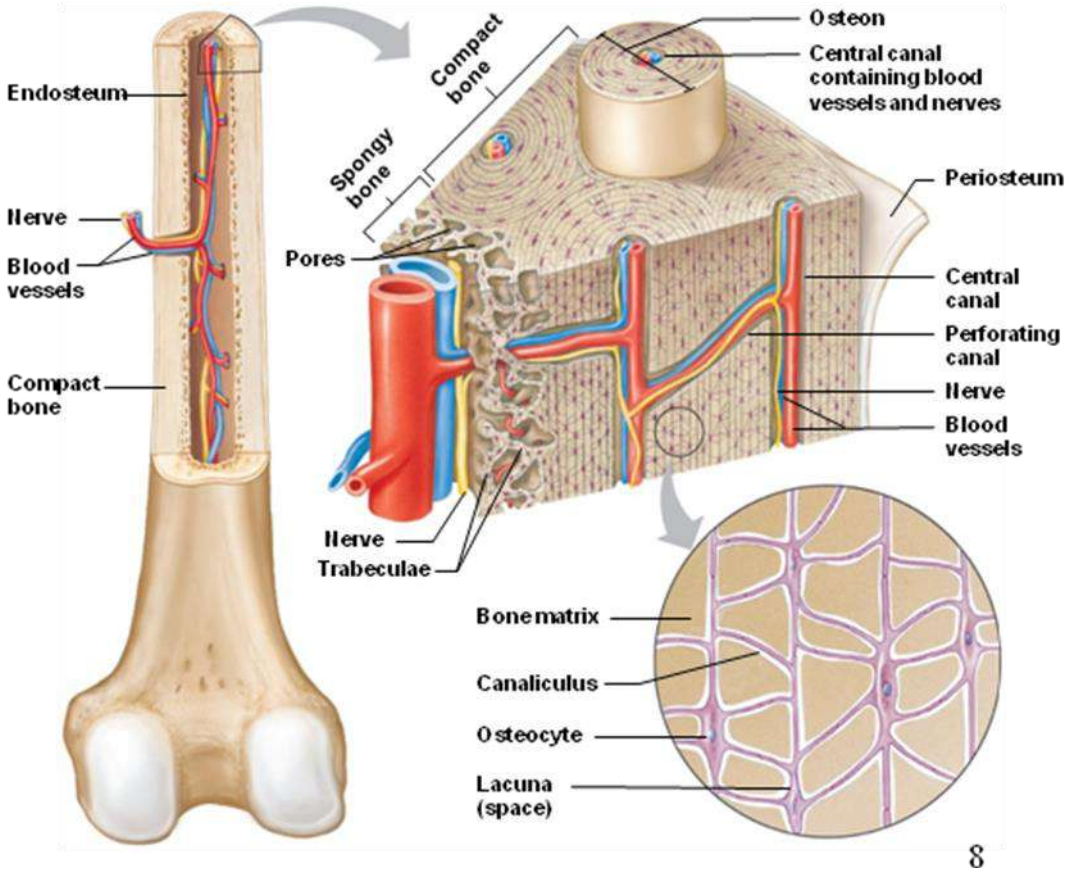


Figure41. Represente Compact Bone Structure

3.2.Spongy Bone

- Spongy bone is aka cancellous bone

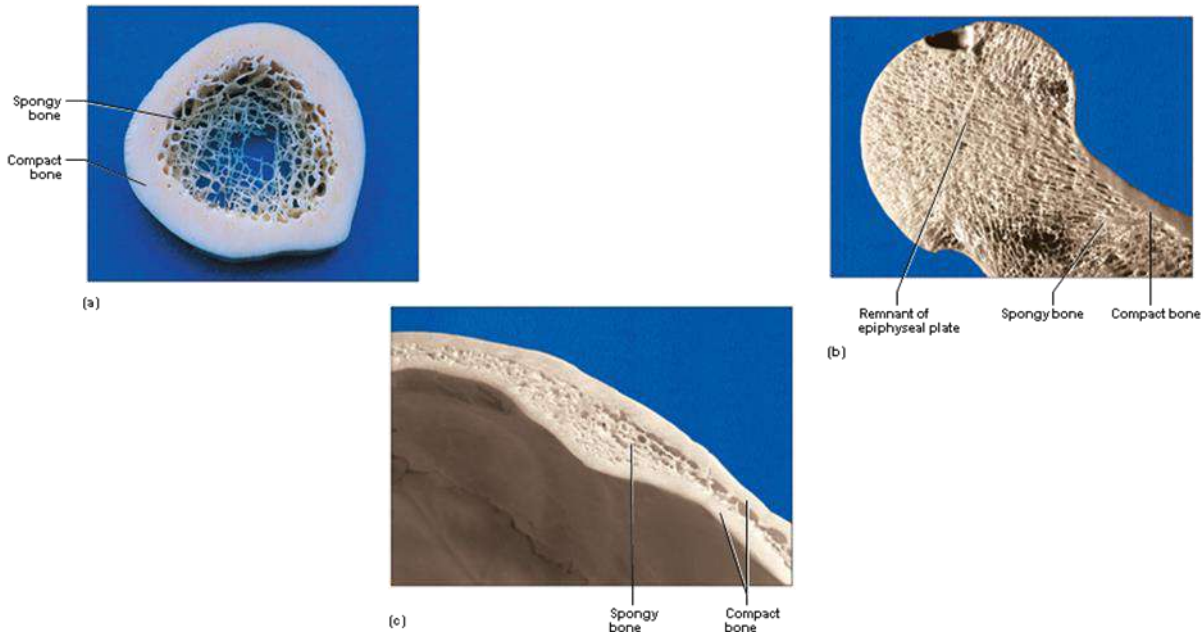


Figure41. Represente Spongy Bone Structure

4.Bone Developement and Growth

Parts of the skeletal system begin to develop during the first few weeks of prenatal development

Bones replace existing connective tissue in one of two ways:

- As intramembranous bones
- As endchondral bones

4.1. Intramembranous Bones

- These bones originate within sheetlike layers of connective tissues
- They are the broad, flat bones
    - Skull bones (except mandible)
- Are known as intramembranous bones

4.2. Endochondral Bones

- Bones begin as hyaline cartilage
  - Form models for future bones
- These are <u>most</u> bones of the skeleton

Are known as endochondral bones

4.3.Endochondral Ossification

- Hyaline cartilage model
- Primary ossification center
- Secondary ossification centers
- Epiphyseal plate
- Osteoblasts vs. osteoclasts

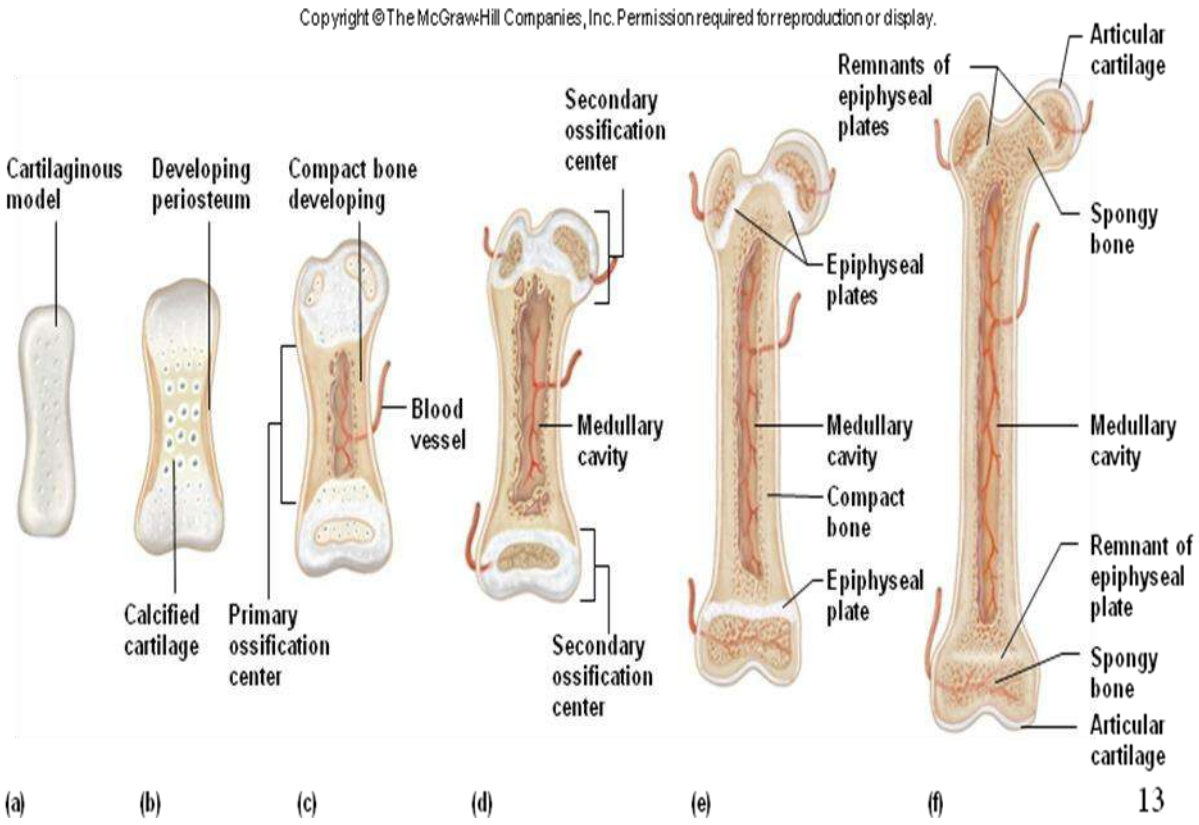


Figure42. Represente Endochondral Ossification.

5.Growth at the Epiphyseal Plate

5.1.First layer of cells

- Closest to the end of epiphysis
- Resting cells
- Anchors epiphyseal plate to epiphysis

5.2.Second layer of cells

- Many rows of young cells
- Undergoing mitosis

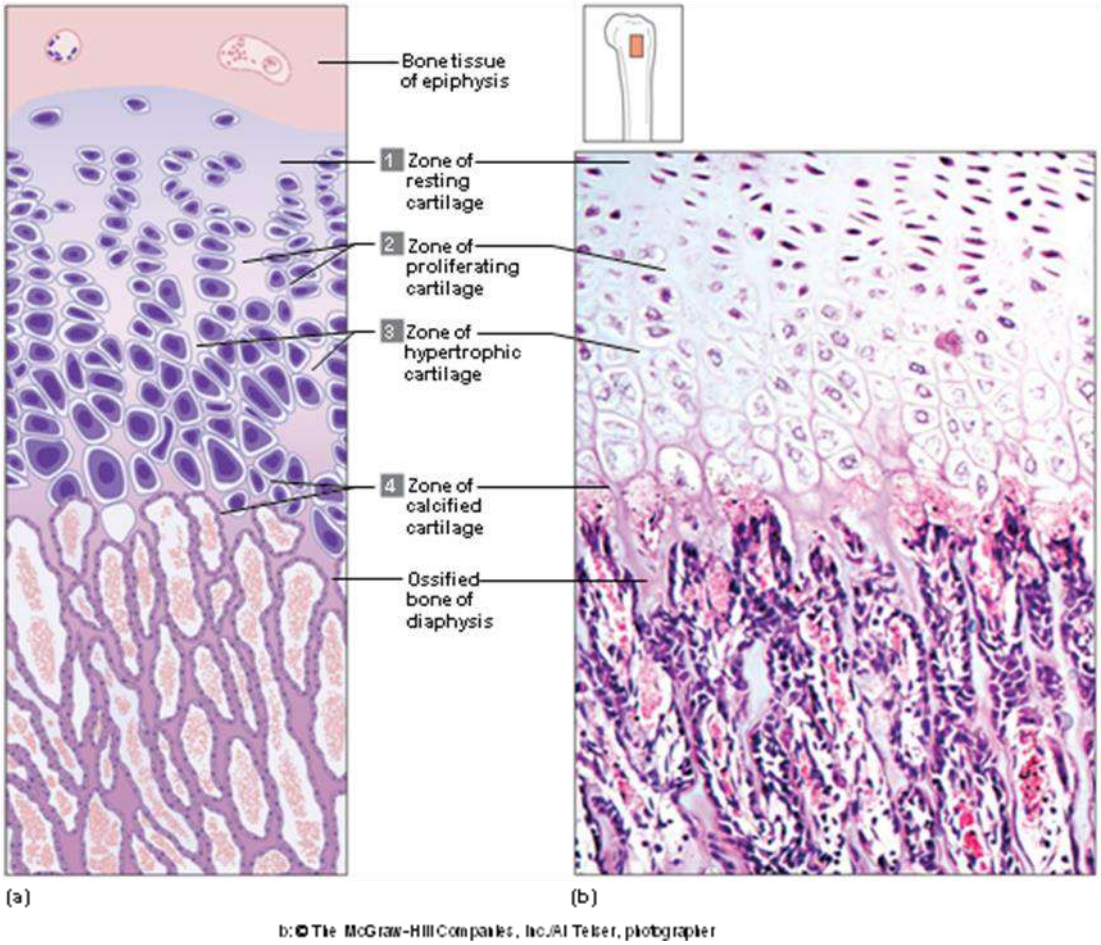


Figure43. Represente Growth at the Epiphyseal Plate.

5.3.Third layer of cells

- Older cells
- Left behind when new cells appear
- Cells enlarging and becoming calcified

5.4.Fourth layer of cells

- Thin
- Dead cells
- Calcified extracellular matrix

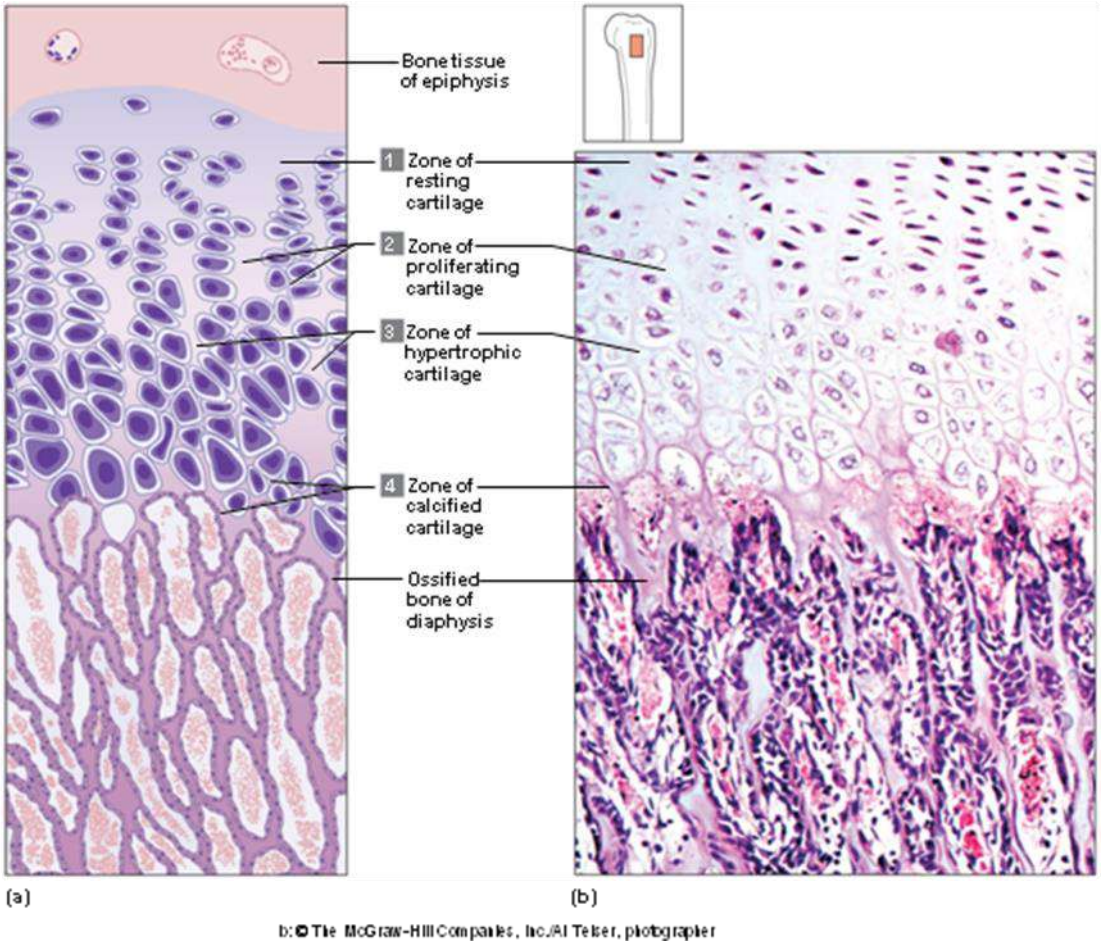


Figure44. Represente Growth at the Epiphyseal Plate (part2).

6. Homeostasis of Bone Tissue

- Bone Resorption – action of osteoclasts and parathyroid hormone aka parathormone aka PTH
- Bone Deposition – action of osteoblasts and calcitonin
- Occurs by direction of the thyroid and parathyroid glands.

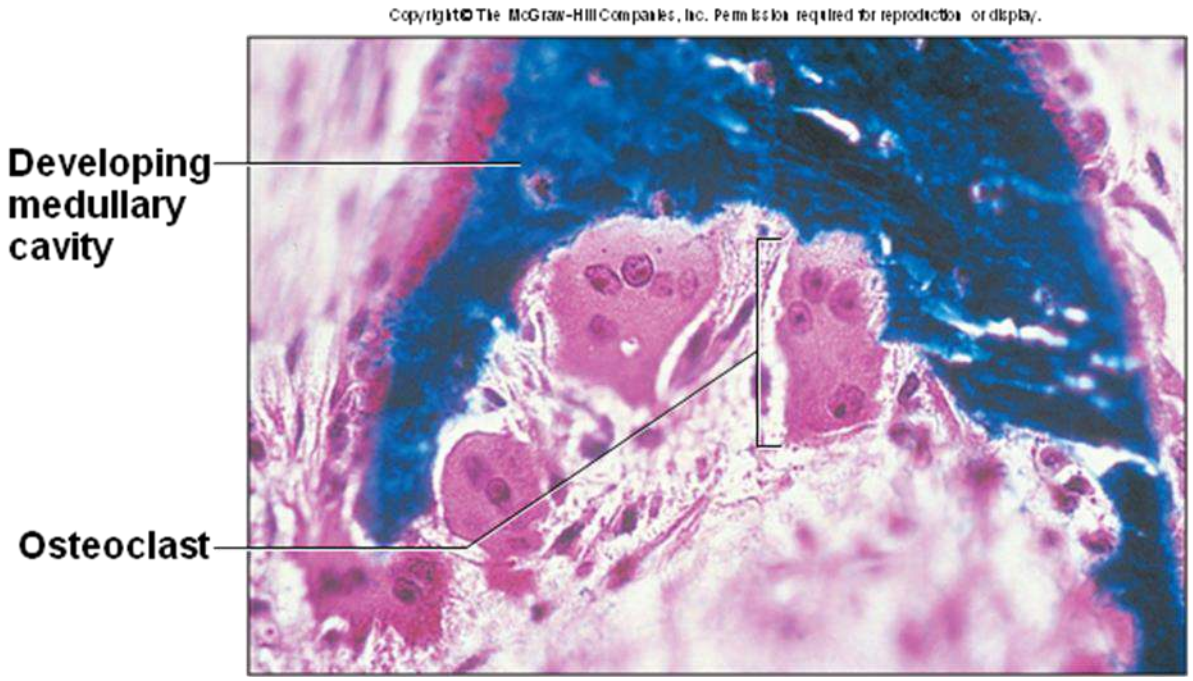


Figure45. Represente Homeostasis of Bone Tissue.

7. Factors Affecting Bone Development, Growth and Repair

- Deficiency of Vitamin A – retards bone development
- Deficiency of Vitamin C – results in fragile bones
- Deficiency of Vitamin D – rickets, osteomalacia
- Insufficient Growth Hormone – dwarfism
- Excessive Growth Hormone – gigantism, acromegaly
- Insufficient Thyroid Hormone – delays bone growth
- Sex Hormones – promote bone formation; stimulate ossification of epiphyseal plates
- Physical Stress – stimulates bone growth.

FIFTH COURSE : Joints of the Skeletal System

1.Introduction

Are known as articulations, Functional junctions between bones and Bind parts of skeletal system together. Make bone growth possible and Permit parts of the skeleton to change shape during childbirth and Enable body to move in response to skeletal muscle contraction

2.Classification of Joints

Three (3) classifications of joints will be considered:

2.1. Fibrous joints

- Dense connective tissues connect bones
- Between bones in close contact

There are three (3) types of fibrous joints (synarthroses):

- Syndesmosis
- Suture
- Gomphosis

2.1.1. Syndesmosis joints

- A sheet or bundle of fibrous tissue connecting bones
- Lies between tibia and fibula (interosseous membrane)

Figure46. Represente Syndesmosis joints

2.1.2. Suture joints

- Between flat bones
- See teeth-like projections
- Thin layer of connective tissue connects bones
- Skull

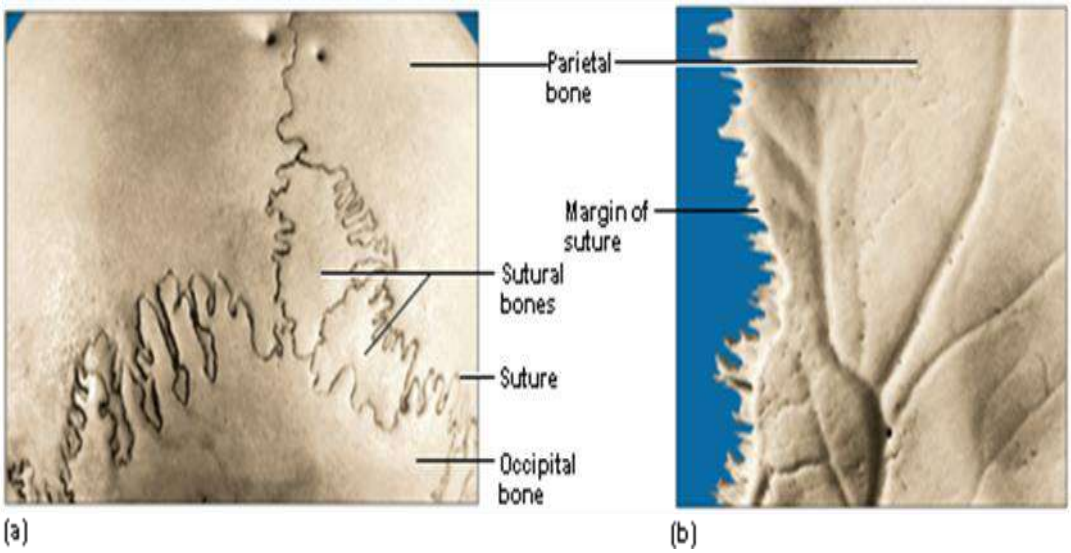


Figure47. Represente Suture joints

2.1.3. Gomphosis joints

- Cone-shaped bony process in a socket
- Tooth in jawbone

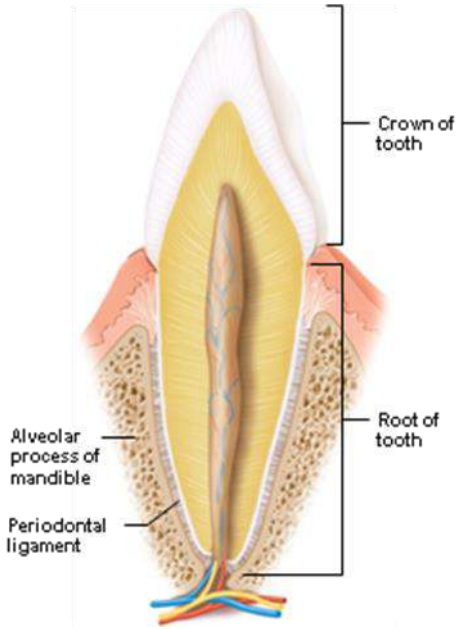


Figure48. Represente Gomphosis joints

2.2. Cartilaginous joints

There are two (2) types of cartilaginous joints (amphiarthroses):

- Synchondrosis
- Symphysis

2.2.1.Synchondrosis joints

- Bands of hyaline cartilage unite bones
- Epiphyseal plate (temporary)
- Between manubrium and the first rib (costal cartilages)

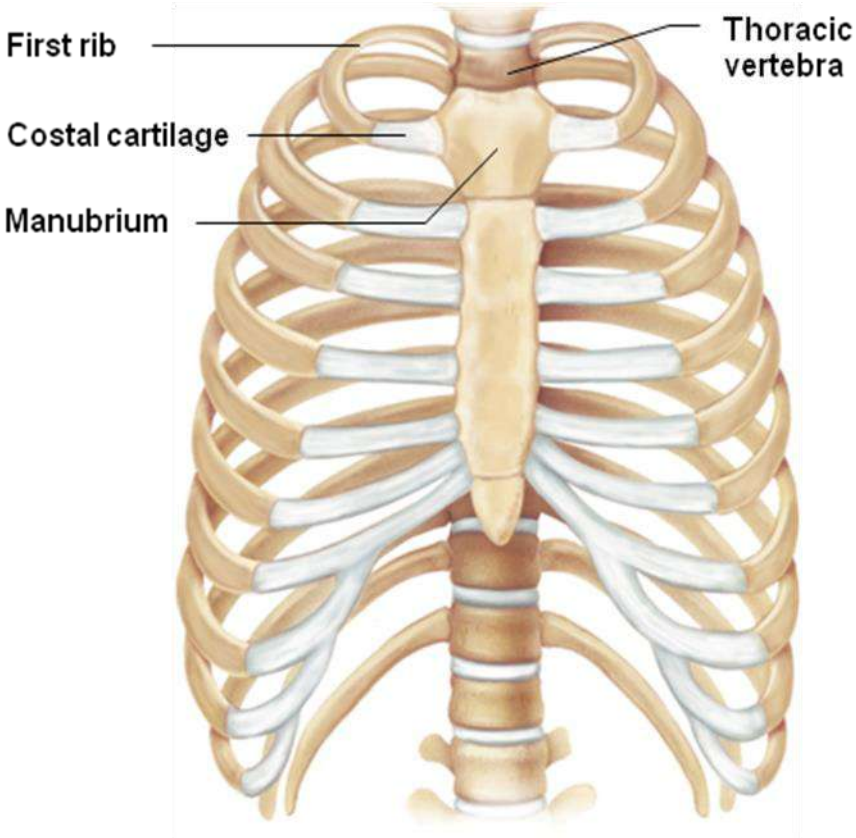


Figure49. Represente Synchondrosis joints

2.2.2. Symphysis joints

- Pad of fibrocartilage between bones
- Pubic symphysis
- Joint between bodies of adjacent vertebrae

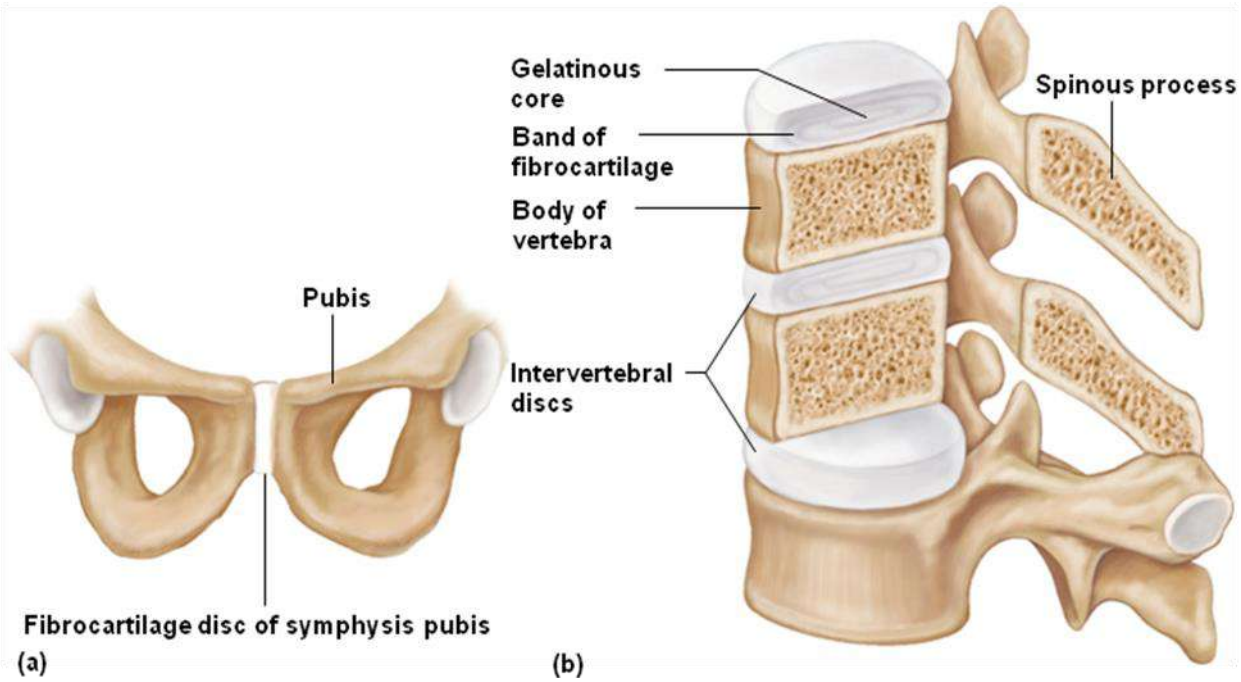


Figure50. Represente Symphysis joints

3.General Structure of a Synovial Joint

- Synovial joints are freely moveable (diarthroses)
- There are three (3) types of diarthroses
- There are specific parts of a diarthroses:
    - Articular cartilage
    - Joint cavity
    - Joint capsule
    - Synovial membrane
    - Synovial fluid
    - Meniscus
    - Bursae

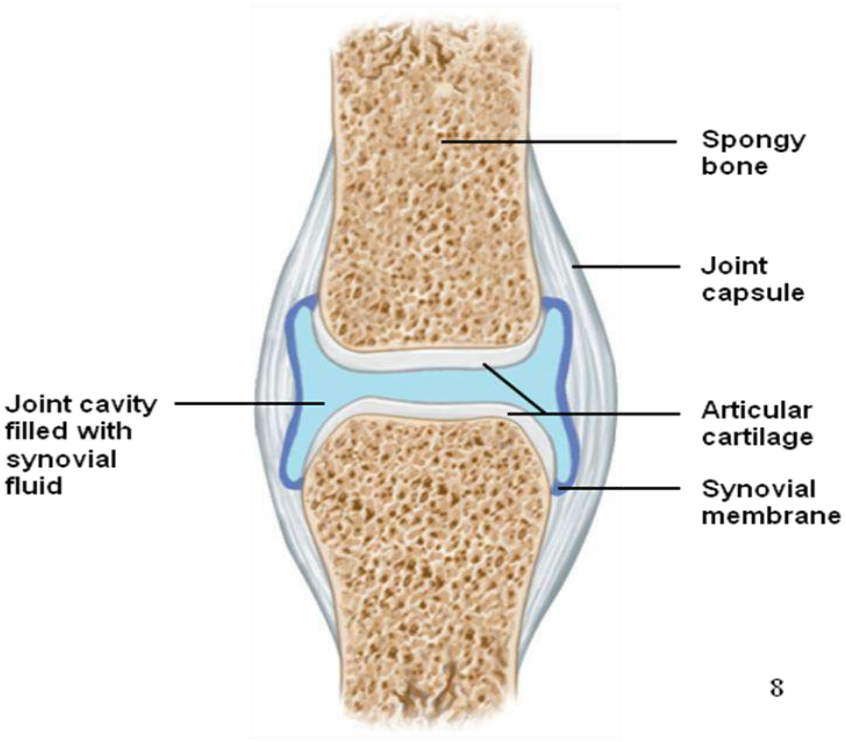


Figure51. Represente Synovial Joint

3.1.Type of a Synovial Joint

3.1.1. Pivot Joint

Between atlas (C1) and the dens of axis (C2

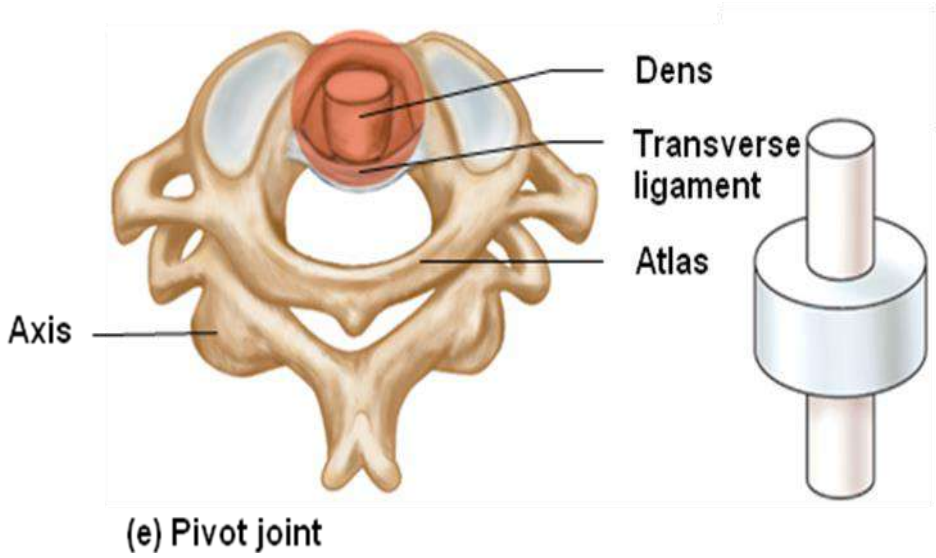


Figure52. Represente Pivot Joint

3.1.2. Hinge Joint

- Elbow joint
- Between phalanges

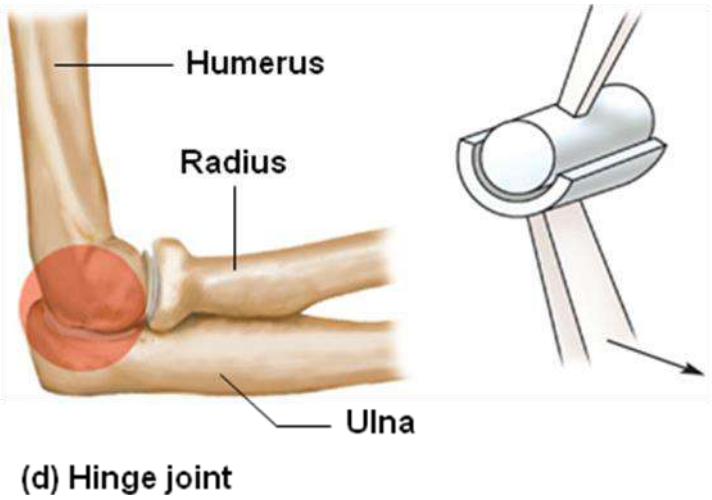


Figure53. Represente Hinge Joint

3.1.3. Saddle Joint

- Between carpal and 1st metacarpal (of thumb)

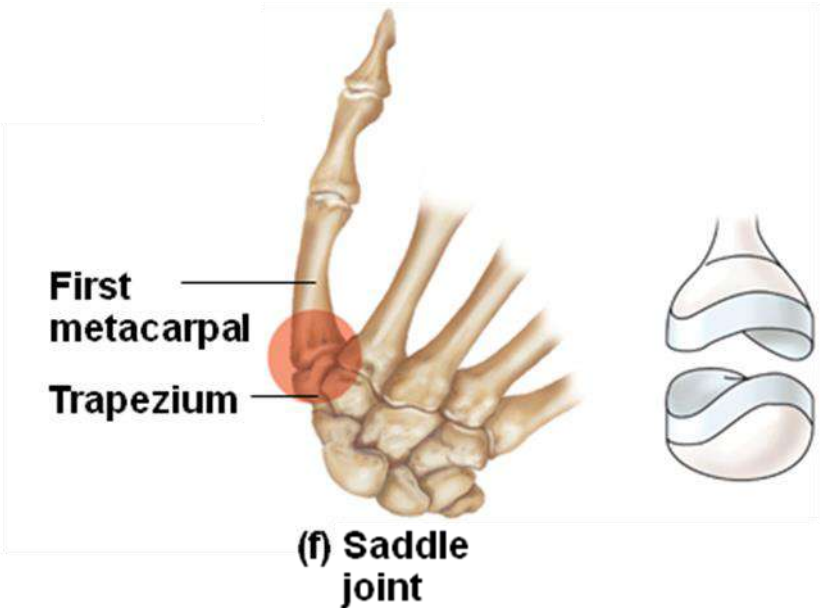


Figure54. Represente Saddle Joint

3.1.4. Condylar Joint

- Between metacarpals and phalanges
- Between radius and carpals

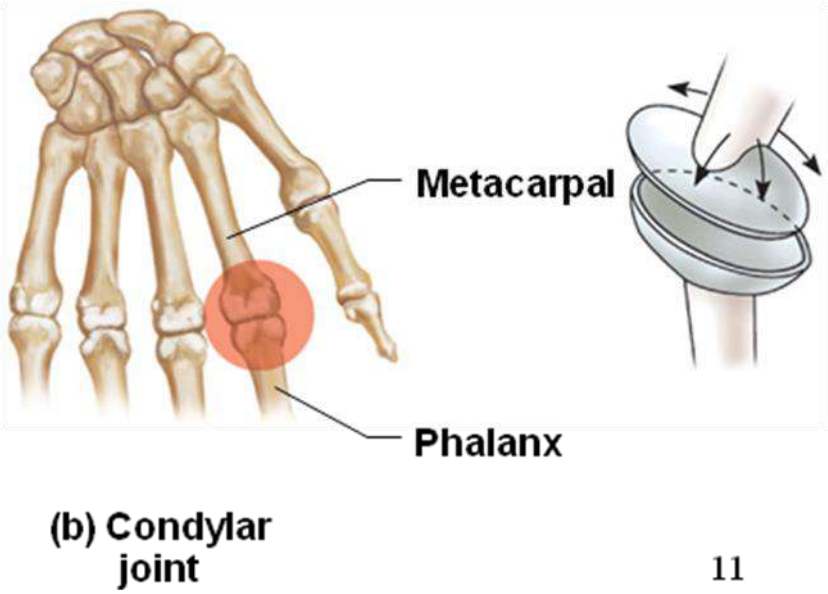


Figure55. Represente Condylar Joint

3.1.5. Ball-and-Socket Joint

- Hip joint
- Shoulder joint

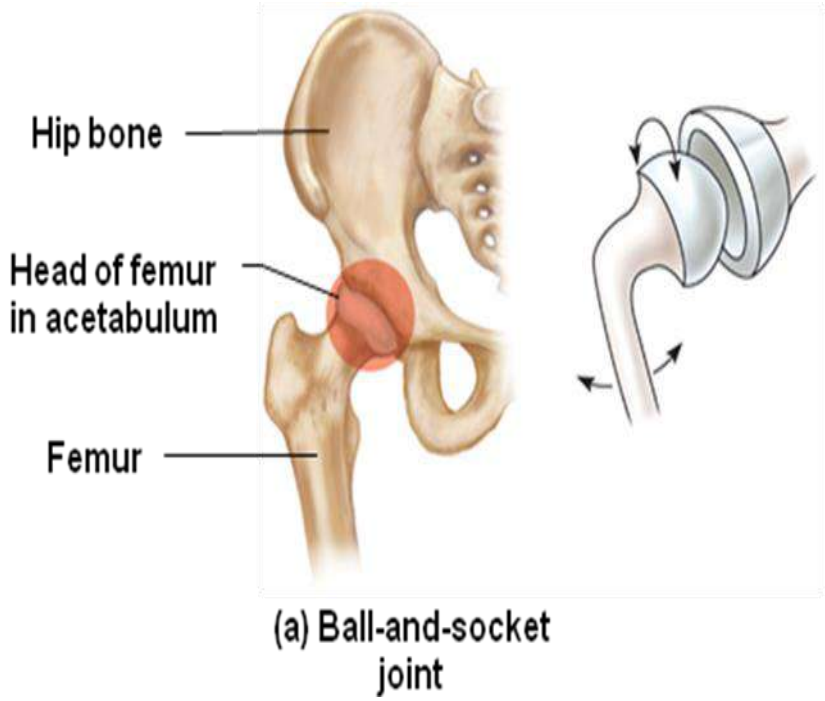


Figure56. Represente Ball-and-Socket Joint

3.1.6. Gliding Joint

- Between carpals
- Between tarsals
- Between facets of adjacent vertebrae

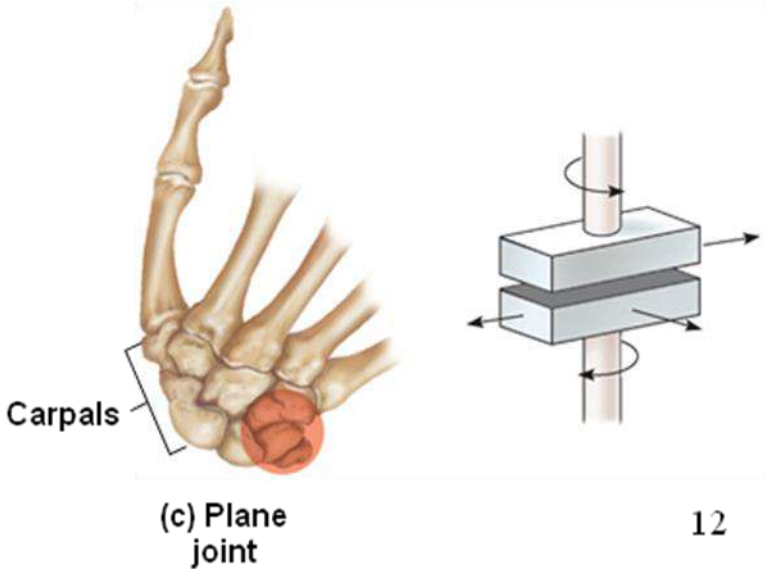


Figure57. Represente Gliding Joint

4. Types of Joint Movements

Movement at a joint occurs when a muscle contracts and its fibers pull its moveable end (insertion) towards its fixed end (origin).

- Abduction/adduction
- Dorsiflexion/plantar flexion
- Flexion/extension/hyperextension
- Lateral flexion

Figure58. Represente Joint Movements

- Rotation
- Circumduction
- Supination/pronation

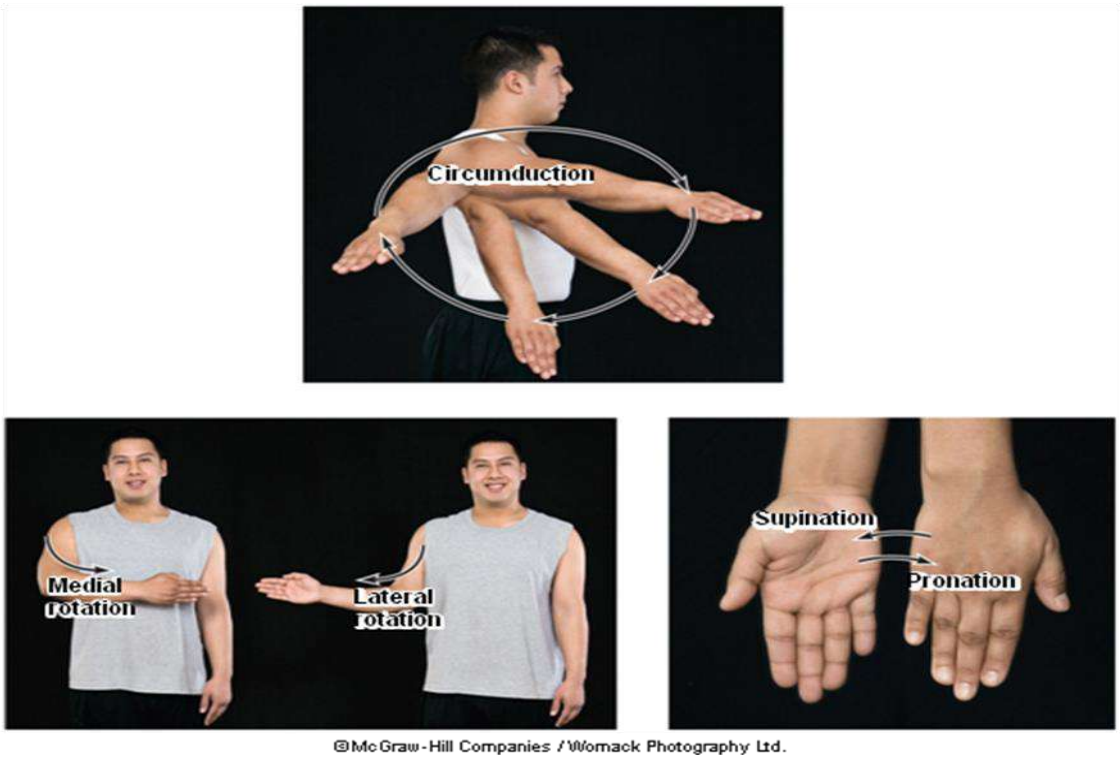


Figure59. Represente Joint Movements

5. Lifespan Changes

- Joint stiffness is an early sign of aging
- Fibrous joints first to change; can strengthen however over a lifetime
- Changes in symphysis joints of vertebral column diminish flexibility and decrease height (remember water loss from the IVDs)
- Synovial joints lose elasticity
- Disuse hampers the blood supply
- Activity and exercise can keep joints functional longer.

SIXTH COURSE : Muscular System

Introduction

Three (3) Types of Muscle Tissues:

- Skeletal Muscle
    - Usually attached to bones
    - Under conscious control
    - Somatic Striated
- Cardiac Muscle
    - Wall of heart
    - Not under conscious control
    - Autonomic Striated
- Smooth Muscle
    - Walls of most viscera, blood vessels and skin
    - Not under conscious control
    - Autonomic
    - Not striated

1. Skeletal Muscle

- Organ of the muscular system
    - Skeletal muscle tissue
    - Nervous tissue
    - Blood
    - Connective tissues
- Fascia

- Tendons
- Aponeuroses

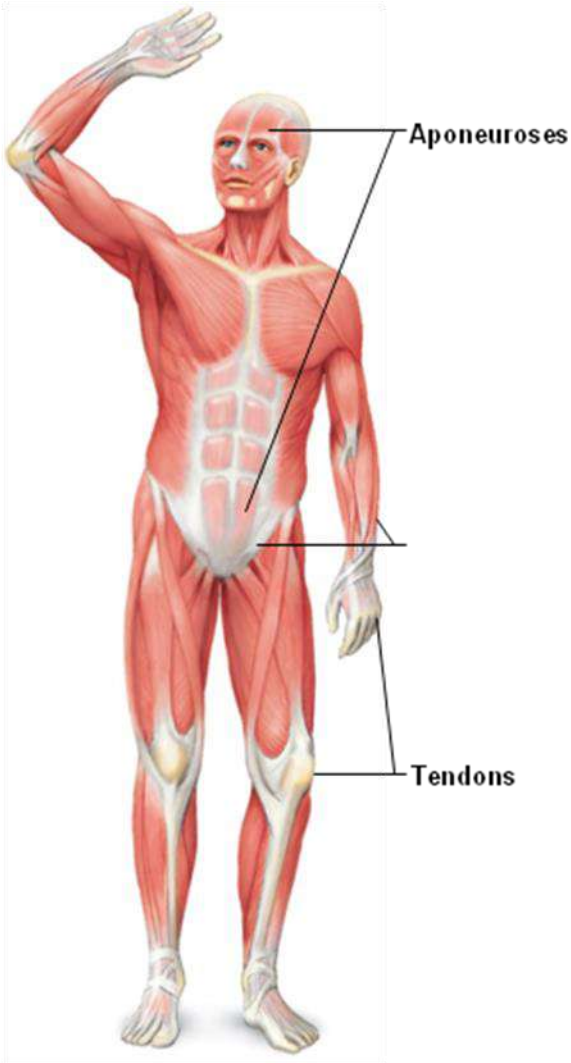


Figure60. Represente Skeletal Muscle

1.1. Connective Tissue Coverings

- Muscle coverings:
  - Epimysium
  - Perimysium
  - Endomysium
- Muscle organ

- Fascicles
- Muscle cells or fibers
- Myofibrils
- Thick and thin myofilaments
    - Actin and myosin proteins
    - Titin is an elastic myofilament

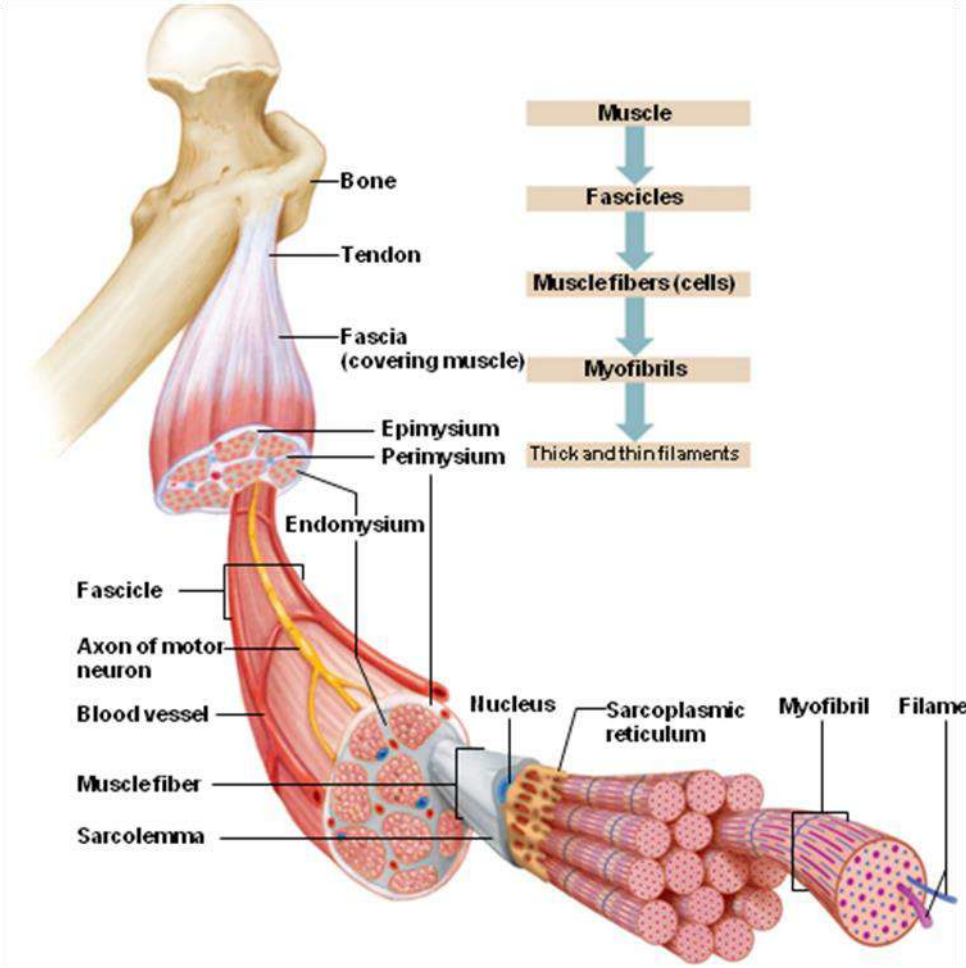


Figure61. Represente Connective Tissue Coverings

1.2.Skeletal Muscle Fibers

- Sarcolemma
- Sacroplasm

- Sarcoplasmic reticulum (SR)
- Transverse (‘T’) tubule
- Triad
    - Cisternae of SR
    - T tubule
- Myofibril
- Actin myofilaments
- Myosin myofilaments
- Sarcomere

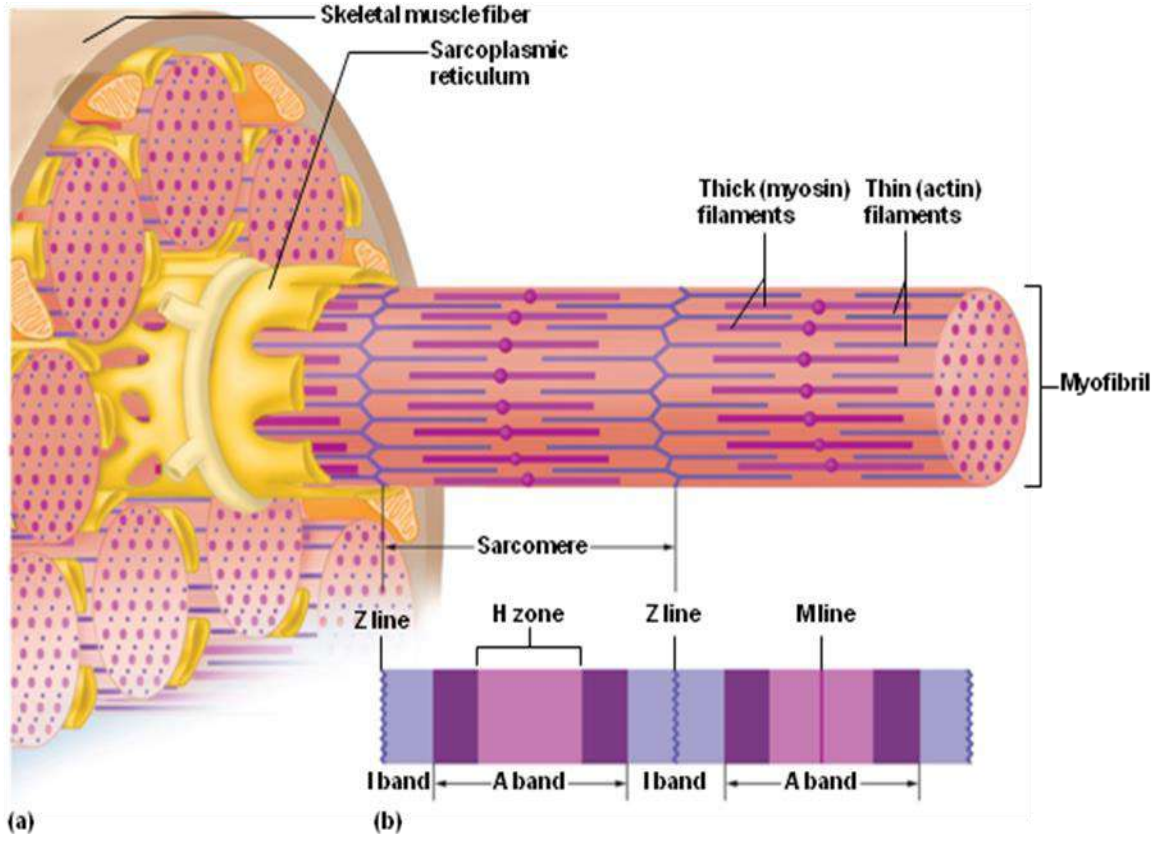


Figure62. Represente Skeletal Muscle Fibers

1.2.1. Thick myofilaments

- Composed of myosin protein
- Form the cross-bridges

1.2.2. Thin myofilaments

- Composed of actin protein
- Associated with troponin and tropomyosin proteins

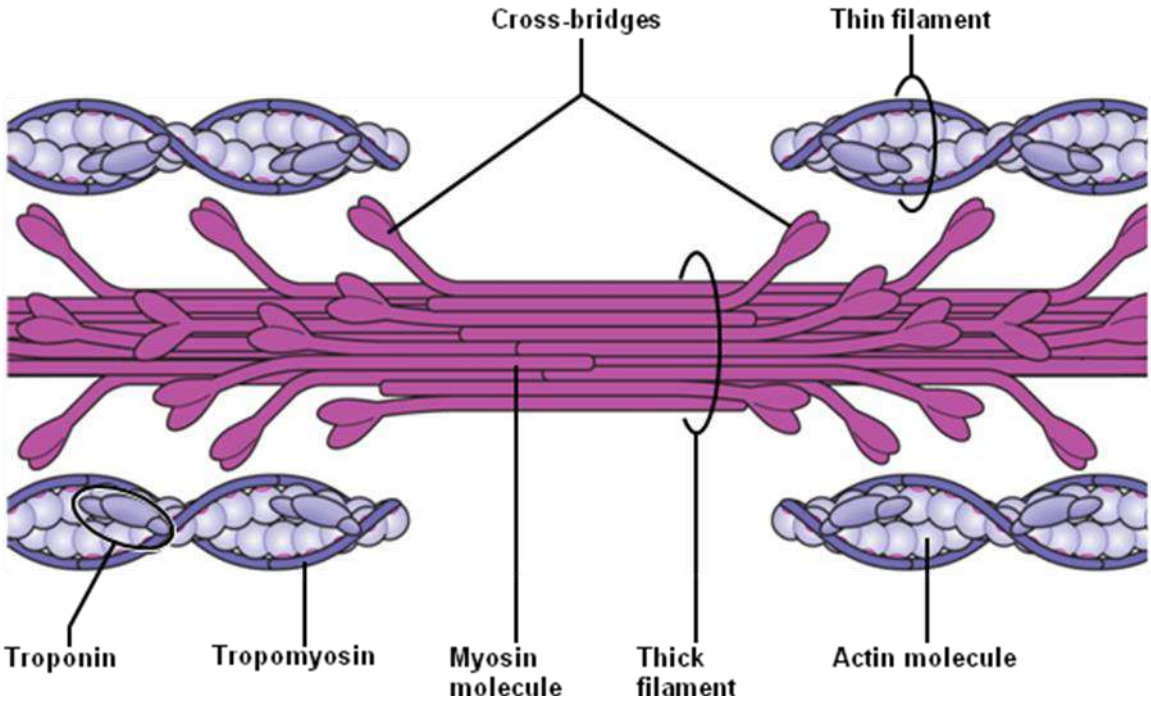


Figure63. Represente Thick and Thin myofilaments

1.3.Neuromuscular Junction

- Also known as NMJ or myoneural junction
- Site where an axon and muscle fiber meet
- Parts to know:
  - Motor neuron
  - Motor end plate
  - Synapse

- Synaptic cleft
- Synaptic vesicles
- Neurotransmitters

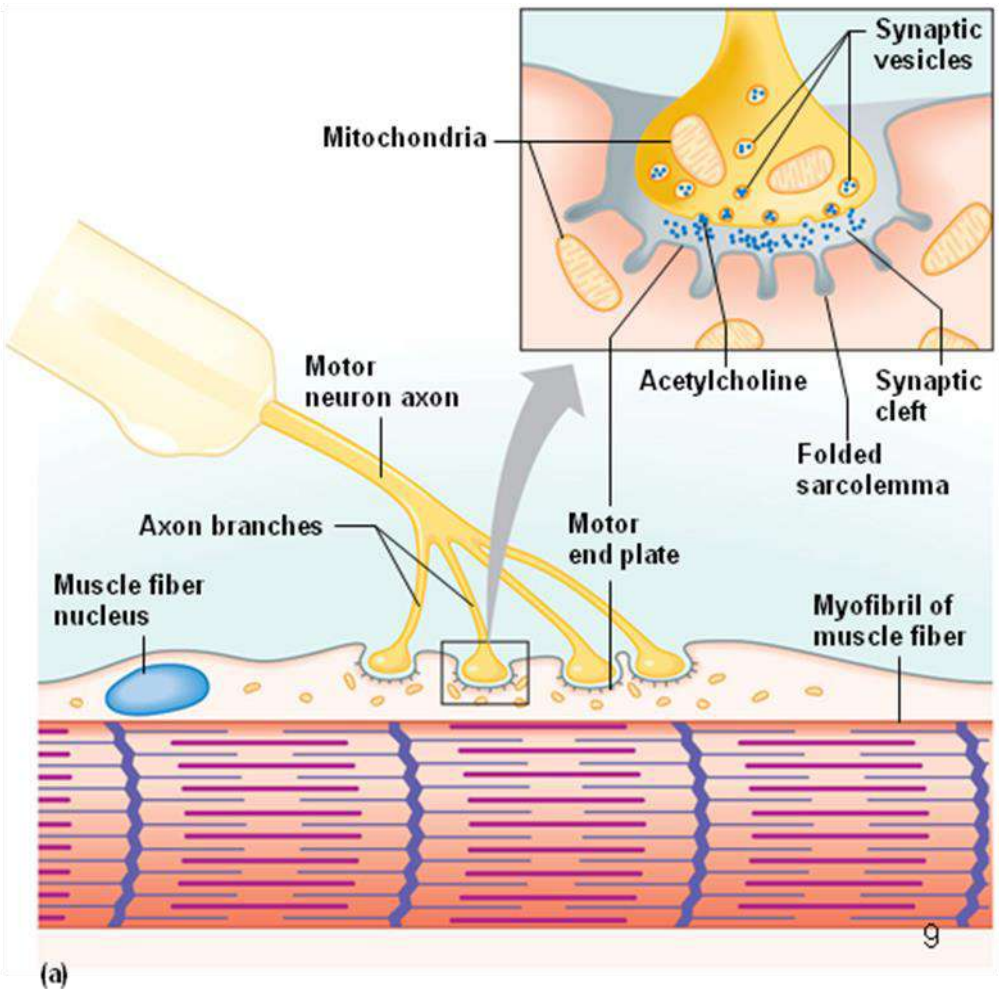


Figure63. Represente Neuromuscular Junction

1.4. Single motor neuron

- All muscle fibers controlled by motor neuron
- As few as four fibers
- As many as 1000's of muscle fibers

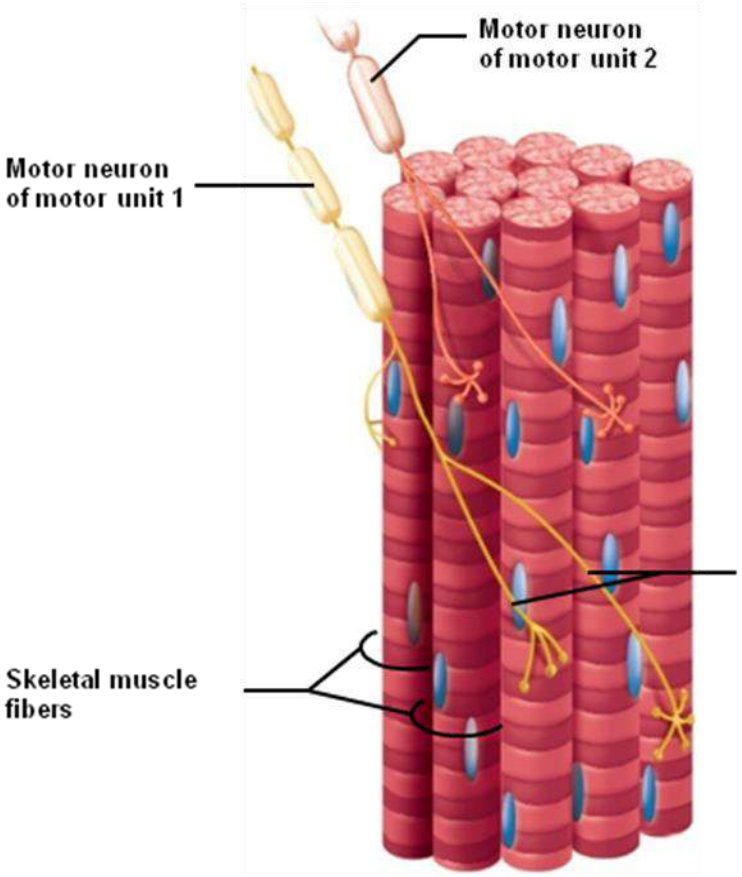


Figure64. Represente Single motor neuron

1.5.Stimulus for Contraction

- Acetylcholine (ACh)
- Nerve impulse causes release of ACh from synaptic vesicles
- ACh binds to ACh receptors on motor end plate
- Generates a muscle impulse
- Muscle impulse eventually reaches the SR and the cisternae

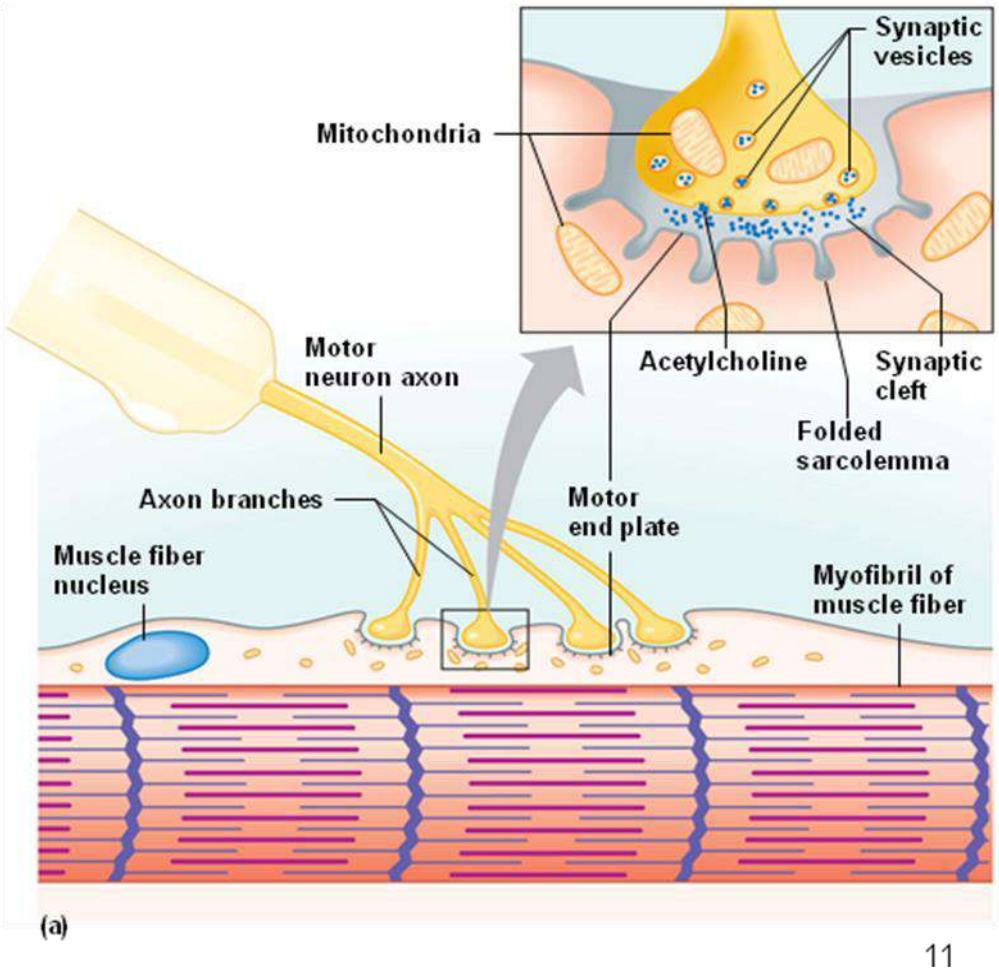


Figure65. Represente Stimulus for Contraction

1.6. Excitation-Contraction Coupling

- Muscle impulses cause SR to release calcium ions into cytosol
- Calcium binds to troponin to change its shape
- The position of tropomyosin is altered
- Binding sites on actin are now exposed
- Actin and myosin molecules bind via myosin cross-bridges

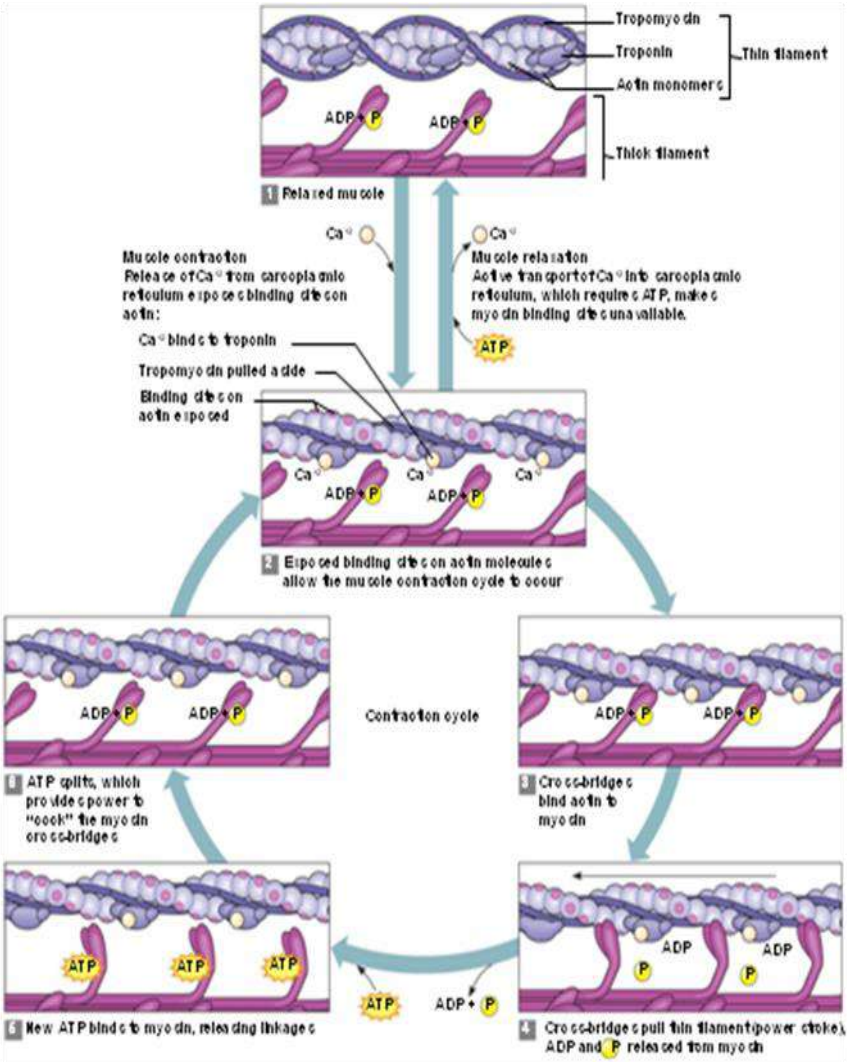


Figure66. Represente Excitation-Contraction Coupling

1.7. The Sliding Filament Model of Muscle Contraction

- When sarcromeres shorten, thick and thin filaments slide past one another
- H zones and I bands narrow
- Z lines move closer together

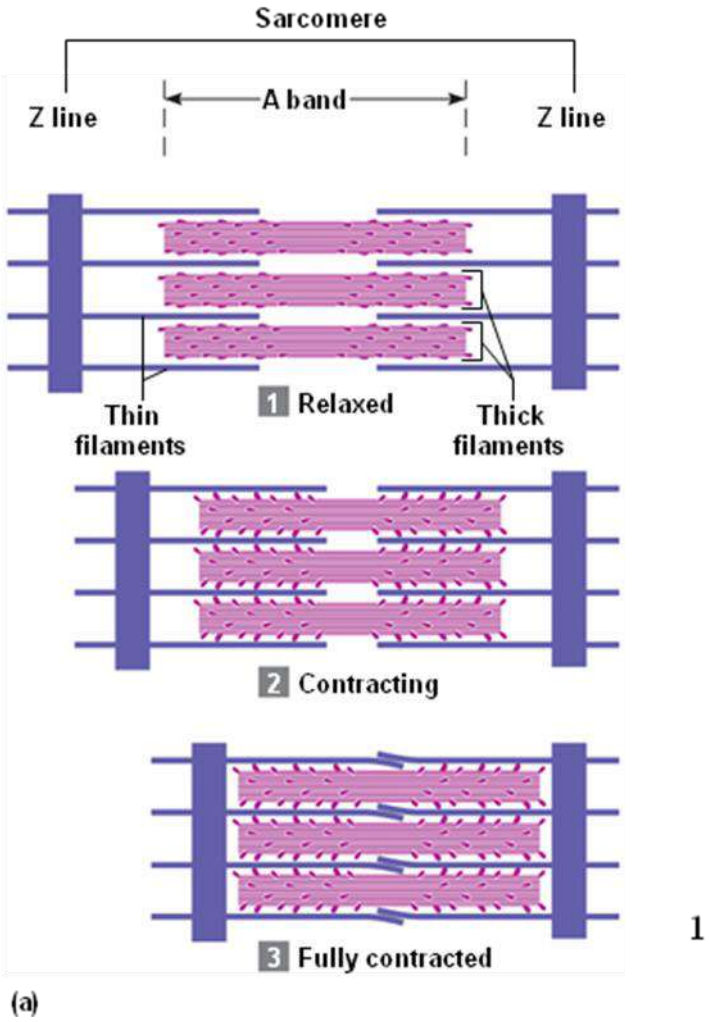


Figure67. Represente The Sliding Filament Model of Muscle Contraction

1.8. Myosin cross-bridge attaches to actin binding site

- Myosin cross-bridge pulls thin filament
- ADP and phosphate released from myosin
- New ATP binds to myosin
- Linkage between actin and myosin cross-bridge break
- ATP splits
- Myosin cross-bridge goes back to original position Cross Bridge Cycling

Relaxation:

- Acetylcholinesterase – rapidly decomposes Ach remaining in the synapse
- Muscle impulse stops
- Stimulus to sarcolemma and muscle fiber membrane ceases
- Calcium moves back into sarcoplasmic reticulum (SR)
- Myosin and actin binding prevented
- Muscle fiber relaxes

1.9.Muscular Responses

Muscle contraction can be observed by removing a single skeletal muscle fiber and connecting it to a device that senses and records changes in the overall length of the muscle fiber.

- Recording a Muscle Contraction Twitch
    - Latent period
    - Period of contraction
    - Period of relaxation
- Refractory period
- All-or-none response

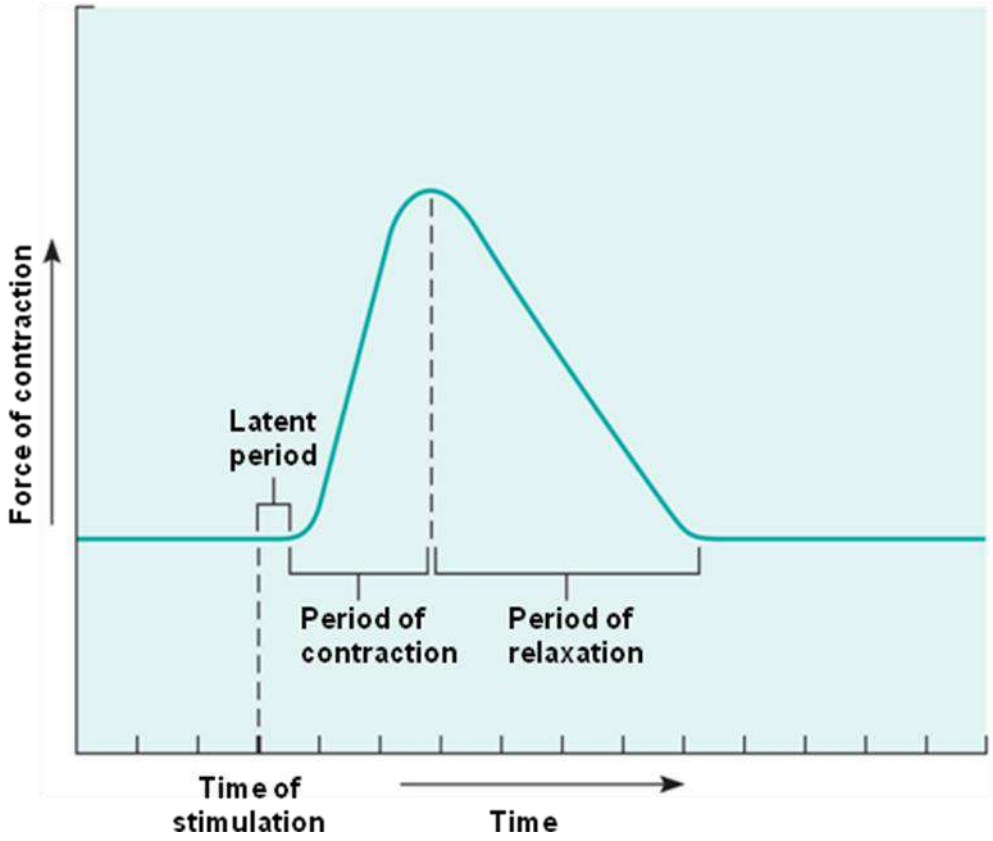


Figure68. Represente Muscular Responses

1.10.Length-Tension Relationship

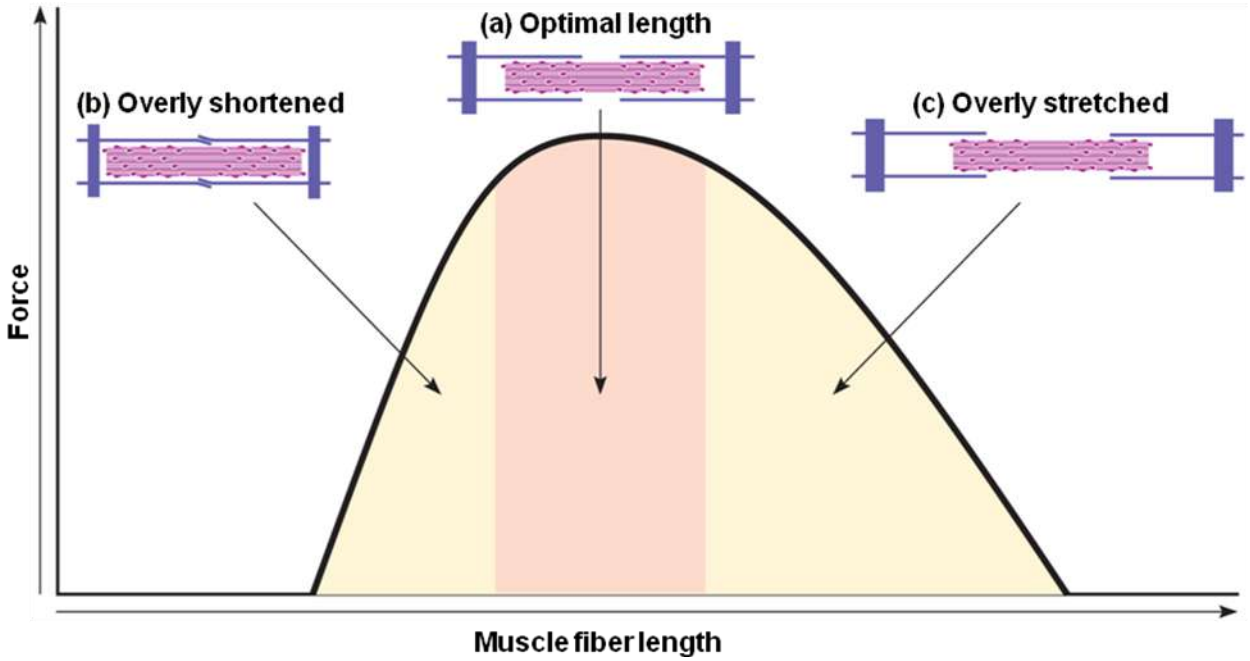


Figure69. Represente Length-Tension Relationship

1.11.Summation

- Process by which individual twitches combine
- Produces sustained contractions
- Can lead to tetanic contractions

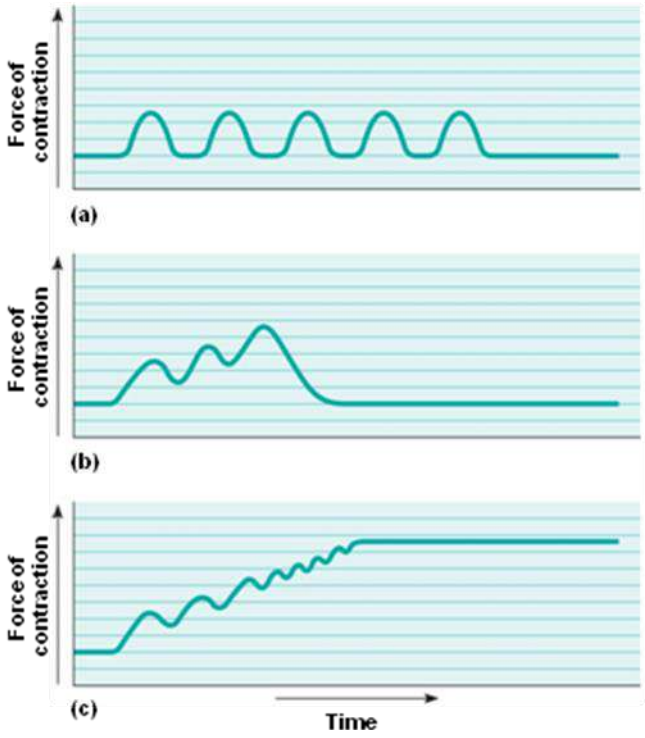


Figure70. Represente Length-Tension Relationship

1.12.Recruitment of Motor Units

- Recruitment - increase in the number of motor units activated
- Whole muscle composed of many motor units
- More precise movements are produced with fewer muscle fibers within a motor unit
- As intensity of stimulation increases, recruitment of motor units continues until all motor units are activated

1.13.Sustained Contractions

- Smaller motor units (smaller diameter axons) - recruited first
- Larger motor units (larger diameter axons) - recruited later
- Produce smooth movements
- Muscle tone – continuous state of partial contraction

1.14.Types of Contractions

1.13.1. Isotonic – muscle

contracts and changes length

1.13.2. Isometric – muscle

contracts but does not change length

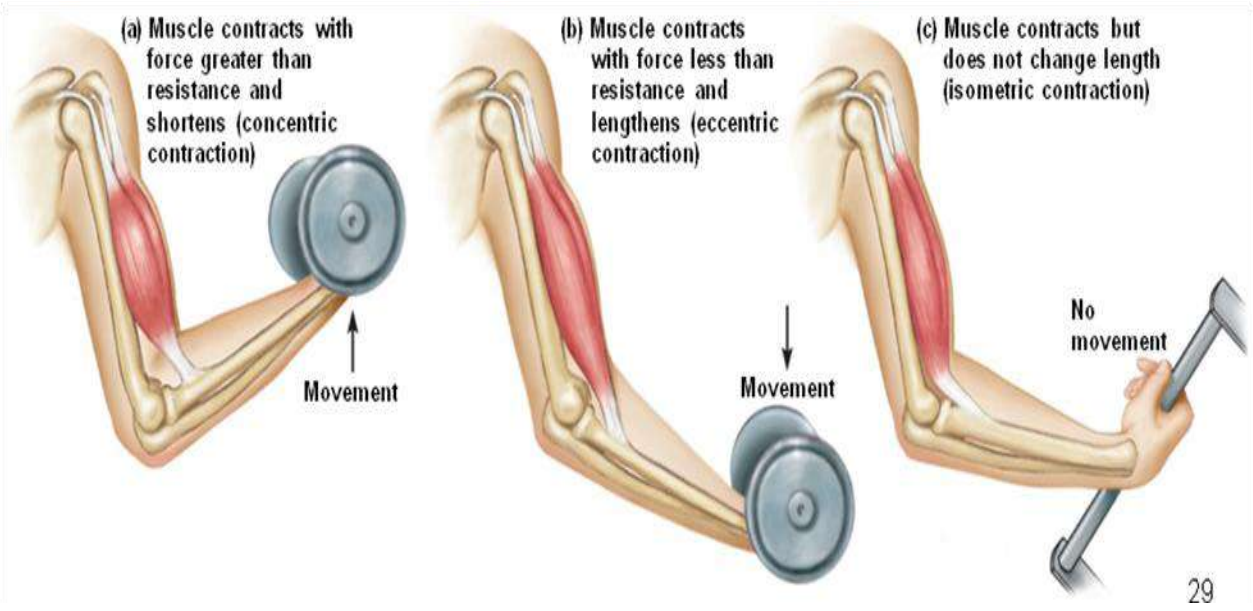


Figure71. Represente Types of Contractions

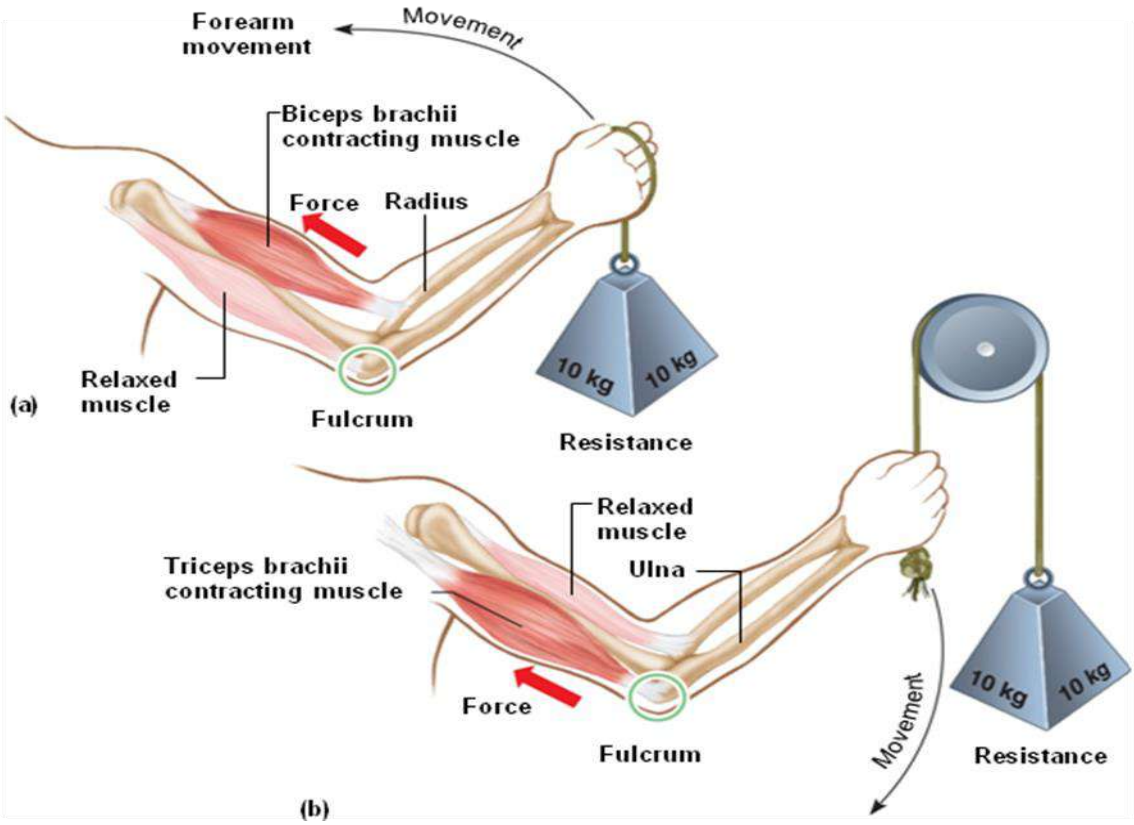


Figure72. Represente Types of Contractions

1.15. Skeletal Muscle Actions

Skeletal muscles generate a great variety of body movements. The action of each muscle mostly depends upon the kind of joint it is associated with and the way the muscle is attached on either side of that joint.

Four Basic Components of Levers:

- Rigid bar – bones
- Fulcrum – point on which bar moves; joint
- Object - moved against resistance; weight
- Force – supplies energy for movement; muscles

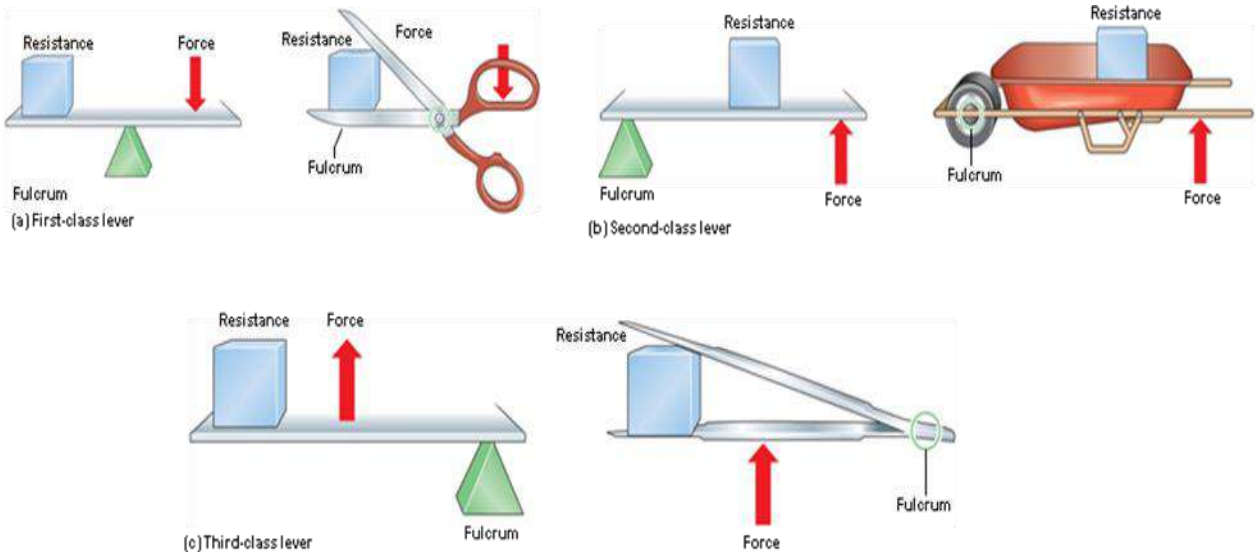


Figure73. Represente Types of Contractions

1.16.Fast Twitch and Slow Twitch Muscle Fibers

1.16.1. Slow-twitch fibers (Type I)

- Always oxidative
- Resistant to fatigue
- Red fibers
- Most myoglobin
- Good blood supply

1.16.2. Fast-twitch glycolytic fibers (Type IIa)

- White fibers (less myoglobin)
- Poorer blood supply
- Susceptible to fatigue

1.16.3. Fast-twitch fatigue-resistant fibers (Type IIb)

- Intermediate fibers
- Oxidative
- Intermediate amount of myoglobin
- Pink to red in color
- Resistant to fatigue

2.Smooht Muscles

Compared to skeletal muscle fibers, smooth muscle fibers are:

- Shorter
- Single, centrally located nucleus
- Elongated with tapering ends
- Myofilaments randomly organized
- Lack striations
- Lack transverse tubules
- Sarcoplasmic reticula (SR) not well developed

2.1.Smooth Muscle Fibers

2.1.1. Visceral Smooth Muscle

- Single-unit smooth muscle
- Sheets of muscle fibers

- Fibers held together by gap junctions
- Exhibit rhythmicity
- Exhibit peristalsis
- Walls of most hollow organs

2.1.2. Visceral Smooth Muscle

- Multi-unit Smooth Muscle
    - Less organized
    - Function as separate units
    - Fibers function separately
    - Iris of eye
    - Walls of blood vessels

2.2.Smooth Muscle Contraction

Resembles skeletal muscle contraction in that:

- Interaction between actin and myosin
- Both use calcium and ATP
- Both are triggered by membrane impulses

Different from skeletal muscle contraction in that:

- Smooth muscle lacks troponin
- Smooth muscle uses calmodulin

- Two neurotransmitters affect smooth muscle
    - Acetlycholine (Ach) and norepinephrine (NE)
- Hormones affect smooth muscle
- Stretching can trigger smooth muscle contraction
- Smooth muscle slower to contract and relax
- Smooth muscle more resistant to fatigue
- Smooth muscle can change length without changing tautness

3. **Cardiac Muscle**

- Located only in the heart
- Muscle fibers joined together by intercalated discs
- Fibers branch
- Network of fibers contracts as a unit
- Self-exciting and rhythmic
- Longer refractory period than skeletal muscle

3.1. Characteristics of Muscle Tissue

TABLE 9.2 | Characteristics of Muscle Tissues

	Skeletal	Smooth	Cardiac
Dimensions			
Length	Up to 30 cm	30–200 µm	50–100 µm
Diameter	10–100 µm	3–6 µm	14 µm
Major location	Skeletal muscles	Walls of hollow organs	Wall of the heart
Major function	Movement of bones at joints; maintenance of posture	Movement of walls of hollow organs; peristalsis; vasoconstriction	Pumping action of the heart
Cellular characteristics			
Striations	Present	Absent	Present
Nucleus	Multiple nuclei	Single nucleus	Single nucleus
Special features	Transverse tubule system is well developed	Lacks transverse tubules	Transverse tubule system is well developed; intercalated discs separate cells
Mode of control	Voluntary	Involuntary	Involuntary
Contraction characteristics	Contracts and relaxes relatively rapidly	Contracts and relaxes relatively slowly; some types self-exciting; rhythmic	Network of fibers contracts as a unit; self-exciting; rhythmic; remains refractory until contraction ends

SEVENTH COURSE: Cardiovascular System (CVS)

Introduction

Primary function of the cardiovascular system is to supply body cells with O2 and nutrients and carry away CO2 and waste products.

Cardiovascular system is a closed circuit system, composed:

- Heart

- Arteries

- Capillaries

- Veins

- Blood

We can divide the primary function of CVS into two major divisions

- **Pulmonary circulation:** 1). carries blood to the lungs 2). Eliminates CO2 via the lungs and 3). returns blood to the heart

- **Systemic circulation:** 1). Supplies blood to the rest of the body 2). Delivers O2 to all the body 3). And carries away wastes.

1.The Heart

The heart is a cone-shaped, hollow, muscular pump.

Size: the adult heart has a mass of between 250- 350 gram and is about the size of a clenched fist, around 14 cm long and 9 cm wide.

Location: the heart lies in the mediastinal area of thoracic cavity between the lungs.

Surrounding structures:

- Posterior to sternum

- Medial to lungs

- Anterior to vertebral column

- On the top of diaphragm

- About 2/3 of heart lies left to midline.

Base: is formed by left and right atria. Mostly the left atrium found beneath the 2nd rib.

Apex: lies in the left 5th intercostal space, Formed by the left ventricle.

Inferior/ diaphragmatic: liens on underside. It formed by left and right ventricles.

Anterior/ Sternocostal: lies just behind the sternum and the ribs. Formed mostly by the right ventricle.

Left/ pulmonary: formed mostly by left ventricle.

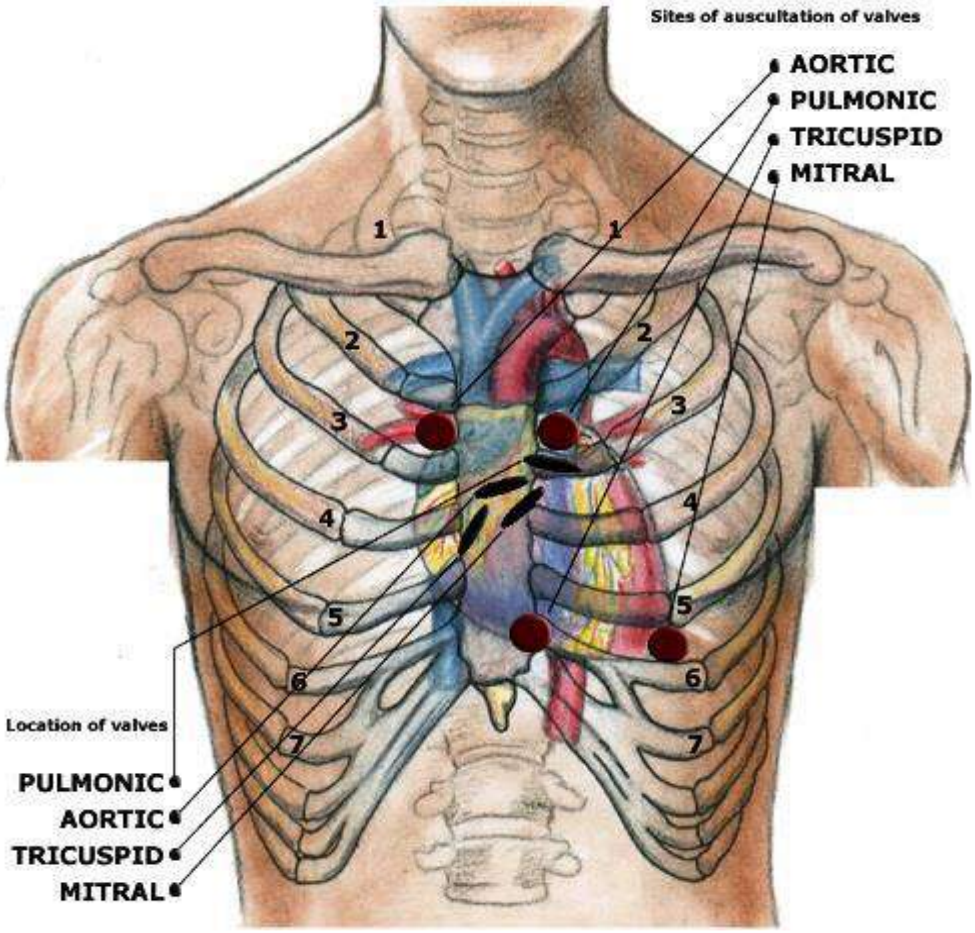


Figure74. Represente the position of the heart in the body

Pericardium

A sac called pericardium covers the heart. The pericardium restricts heart movements in the thoracic cavity and prevents overfilling with blood.

The pericardium is composed of 2 parts:

1. Fibrous pericardium: is the outer part of pericardium and it composed of tough dense connective tissue.
2. Serous pericardium: is the inner part of pericardium and it composed of 2 subdivisions

a). a parietal layer: that lines the inner surface of the fibrous pericardium.

b). visceral layer (epicardium): that covers the outside of the heart.

c). pericardial cavity: a thin space between the parietal and visceral layers of pericardium which contains a **serous fluid**. The serous fluid lubricates the membranes and reduce prevents the friction during heartbeat.

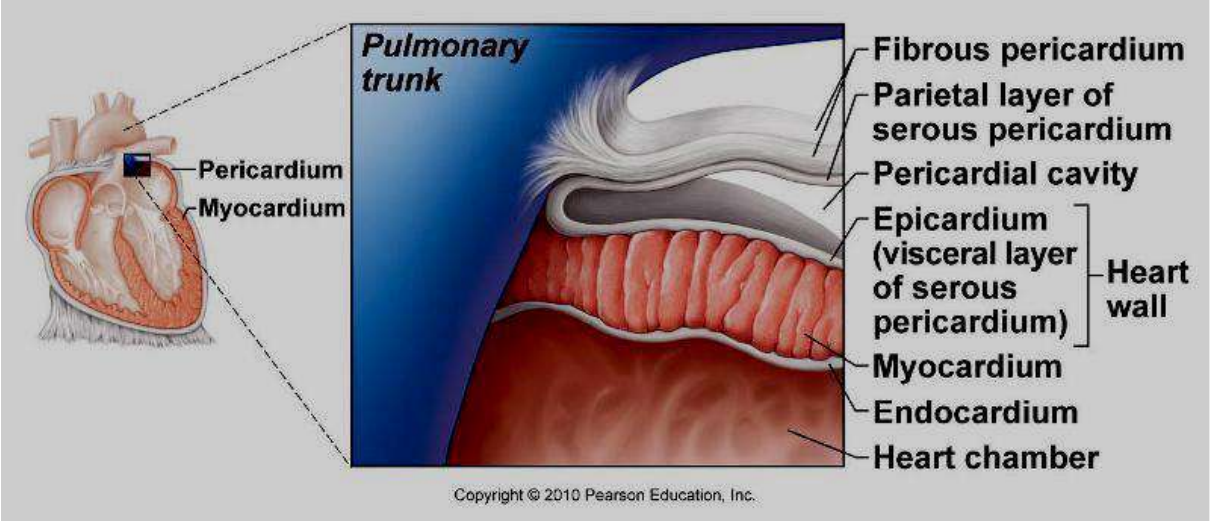


Figure75. Represente the structure of pericardium

1.1.Heart wall Structure

The heart wall consists of three layers:

1.1.1.The epicardium (epi = upon or above): is the outer layer of the heart, composed mainly of simple squamous epithelium and areolar connective tissue.

1.1.2.The myocardium (myo= muscle): Is the middle layer of the heart wall .and, is composed of cardiac muscle tissue. The myocardium is the thickest of the three heart wall layers.

1.1.3.endocardium (endon= within): is the inner layer of the heart wall and it composed of simple squamous epithelium and a layer of areolar connective

tissue. The endocardium also covers the surface of valves and continues as the endothelium of blood vessels

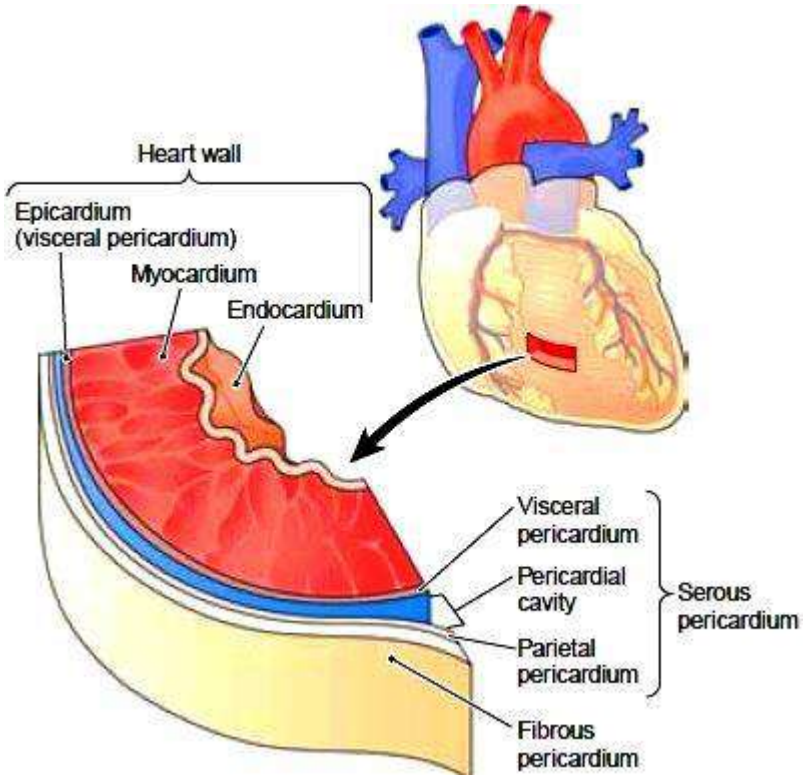


Figure76. Represente the structure of fibrous pericardium

1.1.4.Chambers of the Heart

Heart consists 4 chambers, the 2 superior chambers are known as **atria** (**right atrium** and **left atrium**). The 2 inferior chambers are known as **ventricles** (**right ventricle** and **left ventricle**).

Right Atrium: it receives deoxygenated blood and passes it the right ventricle.

Opening into the right atrium:

-**Superior vena cava** (blood comes from head neck, upper limbs and superior regions of the trunk and enters into right atrium)

- **Inferior vena cava** (blood comes from lower limbs, and trunk and enters into right atrium.

-**Coronary sinus** (blood comes from the heart wall and enters into right atrium).

-**Right atrioventricular opening** (blood leaves right atrium and enters into right ventricle). This opening is guarded by tricuspid valve.

-**Interatrial septum** forms a thin wall between the right and left atria.

Fossa ovalis: is an oval depression in the interatrial septum. It represents a remnant of fetal foramen ovale.

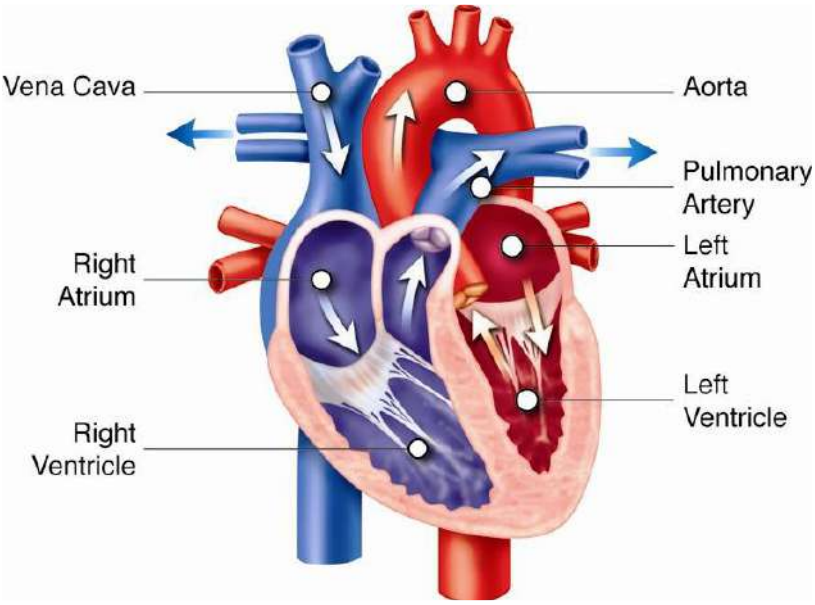
-Right Ventricle: The right ventricle forms most of the anterior surface of the heart. Deoxygenated blood flows into the right ventricle from the right atrium.

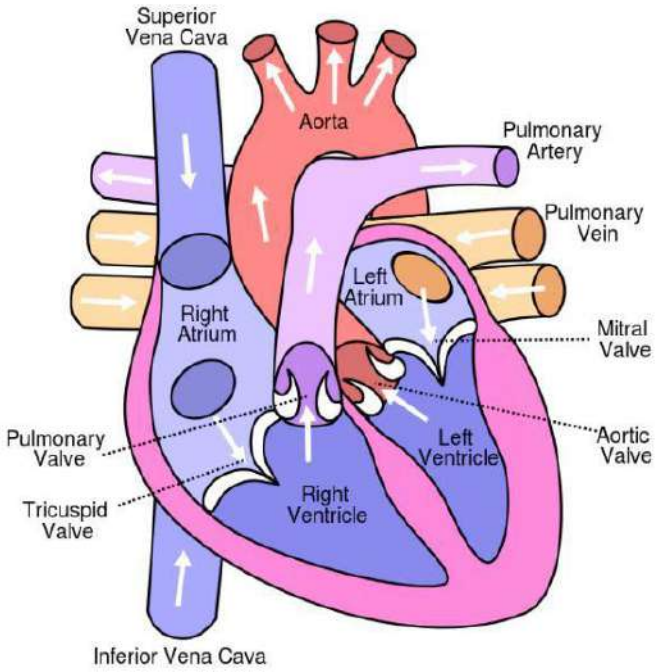
Opening of the right ventricle:

*Right aterioventricular opening (via tricuspid valve) blood enters ventricle

* Pulmonary trunk (blood leaves the right ventricle and enters into pulmonary artery.

An interventricular septum forms a thick wall between the right and left ventricles





Figures77. Represente Chambers of the Heart

Left Atrium: oxygenated blood enters the left atrium from the pulmonary veins.

Opening of the left atrium:

- Pulmonary veins (blood comes from lungs and enters left atrium).
- Left atrioventricular opening: blood leaves left atrium and enter the left ventricle.this opening is guarded by mitral (bicuspid) valve.
- Left Ventricle: oxygenated blood flows into the left ventricle from the left atrium. The wall of left ventricle is 2-3 times as thick as right ventricle.

Opening in the left ventricle:

*Left atrioventicular opening (blood comes from the left atrium).

*Aortic (blood leaves left ventricle to flows into aortic artery). It is guarded by aortic valve.

The valves: are connective tissue flaps that lined by epithelial tissue. Their function is to permit the passage of the blood in one direction and prevent backflow.

In the heart, there are 4 valves; two as atriovanticular and two as semilunar.

Atrioventricular valves:

1. Right atriovantricular valve (tricuspid) is made of three cusps.
2. Left atriovantricular valve (mitral or bicuspid) is made of two cusps.

The free edges of the cusps are attached to papillary muscles through the cord like structures called cordae tendineae.

Papillary muscles: these muscles are cone shaped which originated from the ventricular wall. There apex are connected to cordae tendineae.

Cordae tendineae: are fine tendinous cords which are attached from papillary muscles to the border of cusps.

This attachment is to prevent the bulging of the valves into the atria during ventricles contract.

Semilunar Valves:

1. Aortic valve: present at the opening the aorta in left ventricle. (has 3 cusps).
2. Pulmonary valve: present at the opening of pulmonary trunk. (has 3 cusps).

These valves open when ventricles contract to allow the blood to flow from right ventricle to pulmonary artery and from left ventricle to aorta.

They close when ventricle relax.

2.Arteries

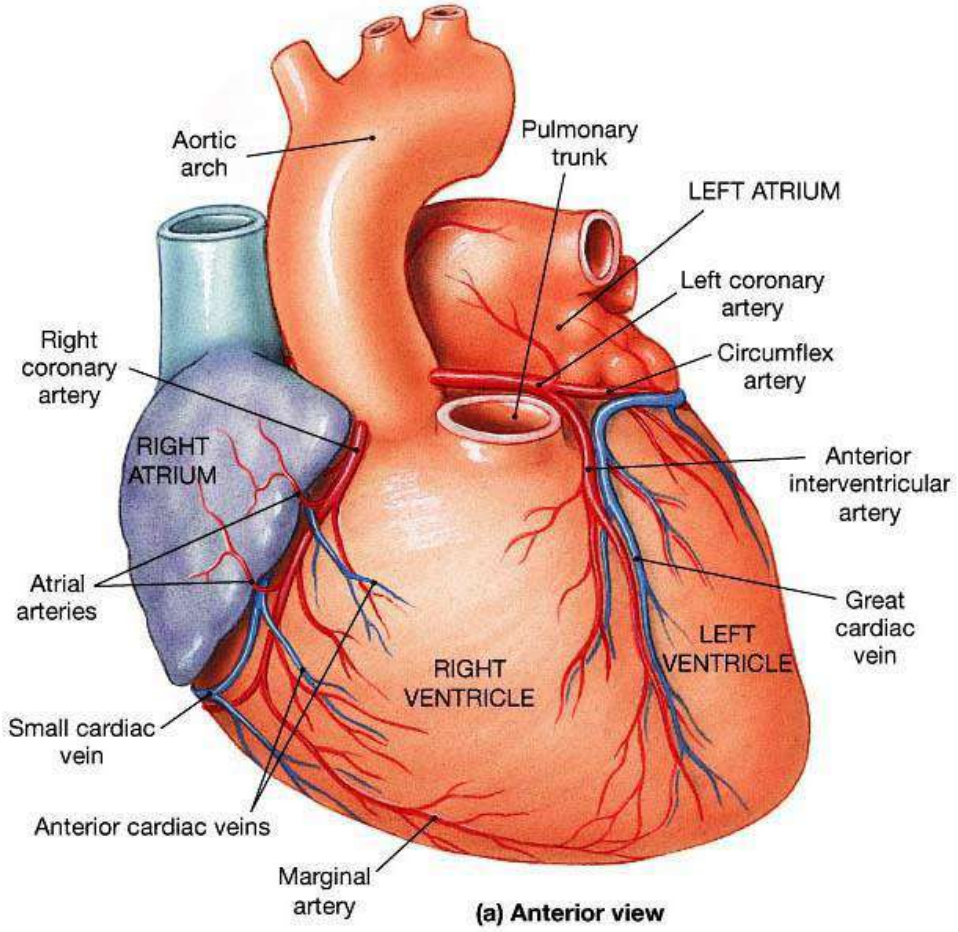
- Left and **right coronary arteries**: their origin is ascending aorta.

- Right coronary artery it gives two branches:

1. *Right marginal artery*: it supplies the right border of the heart.
2. *Posterior interventricular artery*: it supplies the right and left ventricles.

- Left coronary artery it gives the following branches:

1. *Anterior interventricular artery* (left anterior descending artery): it supplies the anterior surface of both ventricles.
2. *Circumflex artery*: supplies the left atrium and ventricle



Figures78. Represente Arteries of the Heart

Sympathetic: derived from thoracic spinal cord T1-T2.
Stimulation of the heart by sympathetic nervous system leads to **increase heart rate (tachycardia), increase force of contraction,** and **dilation of coronary arteries.**

Parasympathetic: branches of vagus nerve (cranial nerve X)
Stimulation of the heart by parasympathetic nervous system leads to:

Slowing of the heart (bradycardia), reduction in the force of contraction, and constriction of coronary arteries.

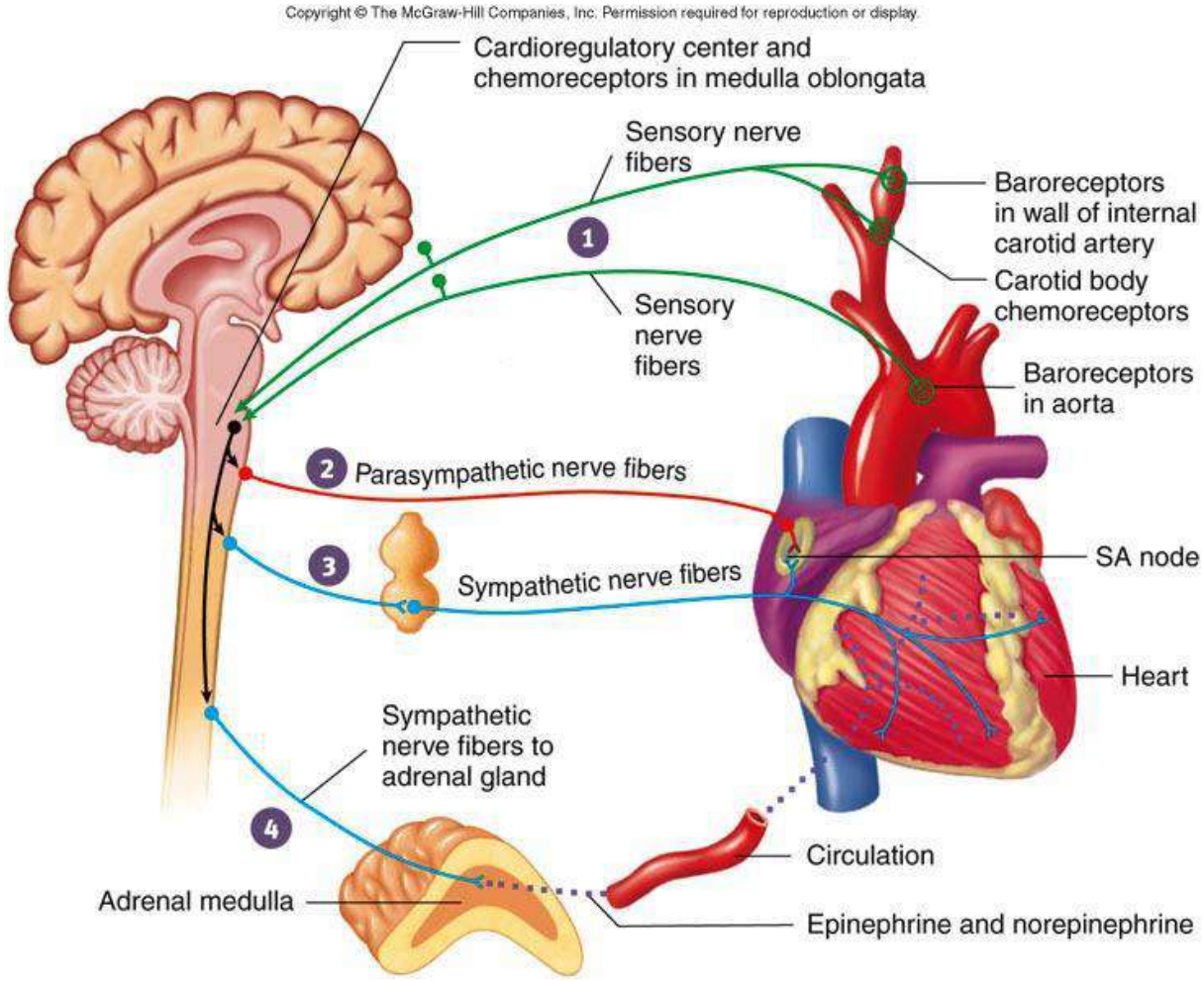


Figure79. Represente Sympathetic and Parasympathetic nerves of the Heart

3.Conducting System of the Heart

The heartbeat originates in a **specialized cardiac muscle cells (cardiac conducting system)** and spreads via this system to all parts of the myocardium.
Parts of conducting system:
1. **Sinoatrial (SA) node** is located in the **posterior wall of right atrium** (at the junction of the superior vena cava with the right atrium).
2. **Atrioventricular (AV) node** is located in the right posterior portion of interaterial septum
3. **Bundle of His:** located in the interventricular septum and divided into branches right and left.
4. **Purkinje fibers:** begin within the apex of the heart and extend through the walls of the ventricles.

This system has ability to stimulate cardiac contraction without any innervations.

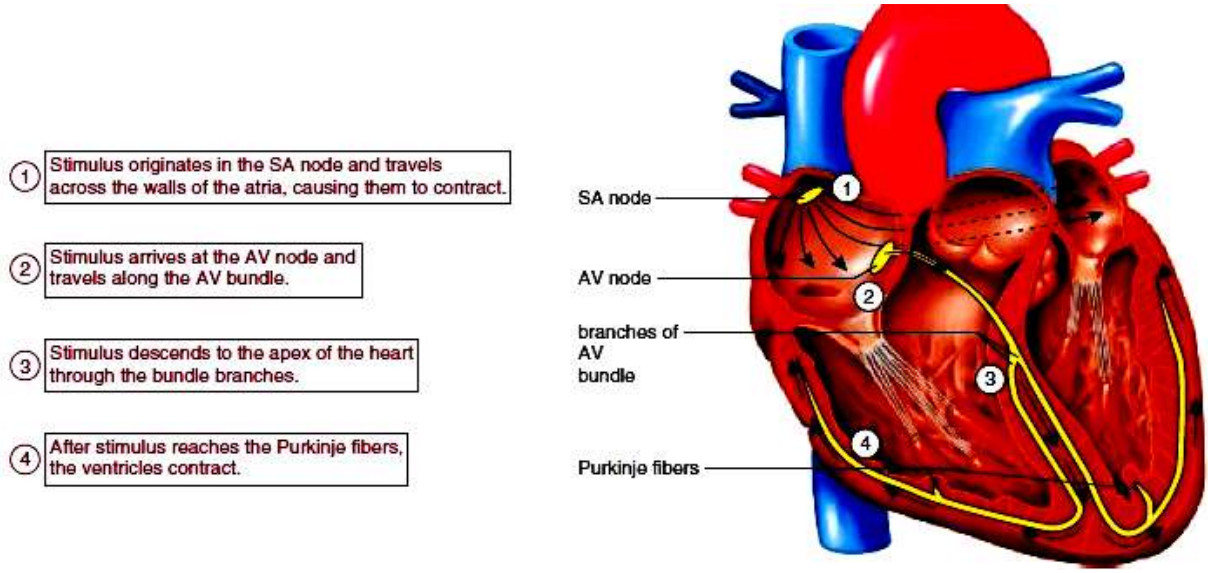


Figure80. Represente Conducting System of the Heart

4.Cardiac cycle

It is the inclusive period of time from the start of one heartbeat to the initiation of the next.

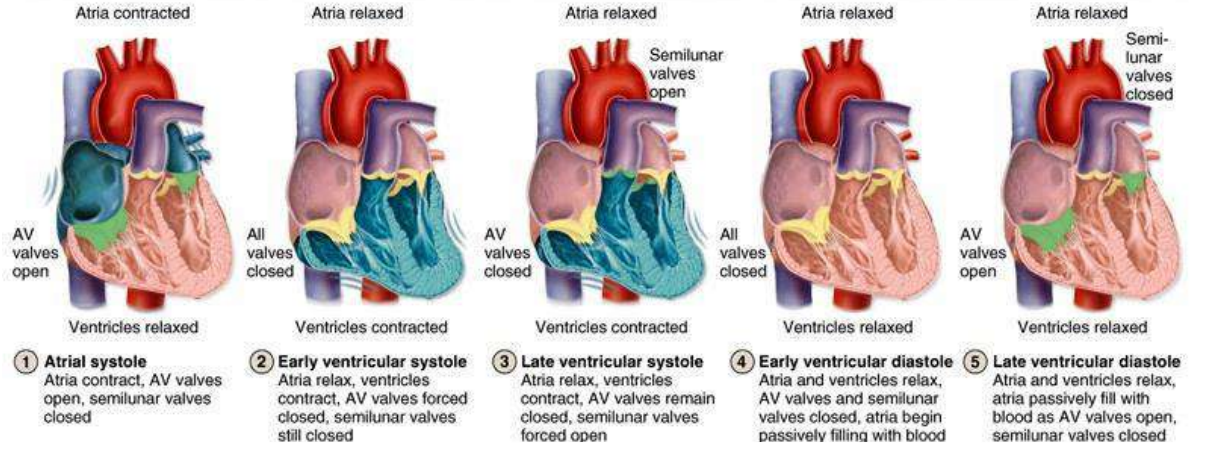
In each cardiac cycle, there are alternate contractions and relaxation of all chambers.

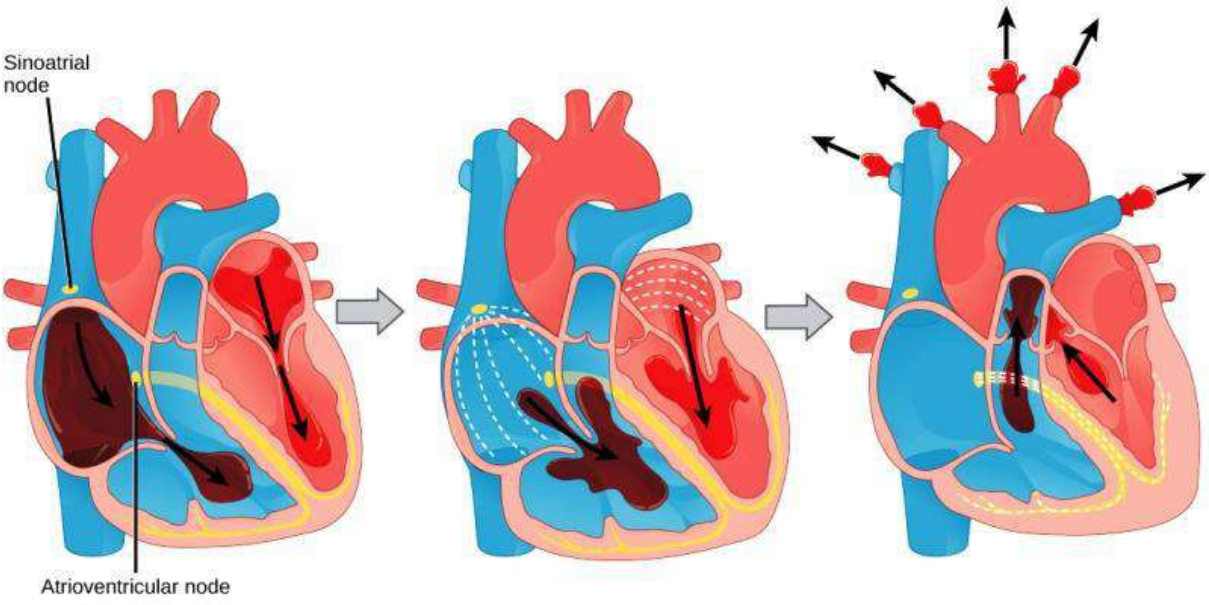
Each contraction is called **systole** and each relaxation is called **diastole.**

The events at single cardiac cycle:

1. **Atrial systole:** contraction of both atria (left and right) simultaneously leads to move blood (20%) from atria to the ventricles (from right atrium to the right ventricle through tricuspid valve. And from left atrium to the left ventricle through mitral valve).
2. Atrial diastole:
3. **Ventricular systole:** In this period, the tricuspid and mitral valves are closed, and the blood forced into the blood vessels through semilunar valves (from left ventricle to the pulmonary artery. And from left ventricle to the aorta).
4. **Ventricular diastole:** most of blood (80%) flows passively from relaxing atria into the ventricles through the open aterioventricle valves.

Structure \ Phase	Atrial systole	Early ventricular systole ⟷ Late ventricular systole	Early ventricular diastole ⟷ Late ventricular diastole
Atria	Contract	Relax	Relax
Ventricles	Relax	Contract	Relax
AV valves	Open	Closed	Open
Semilunar valves	Closed	Open	Closed





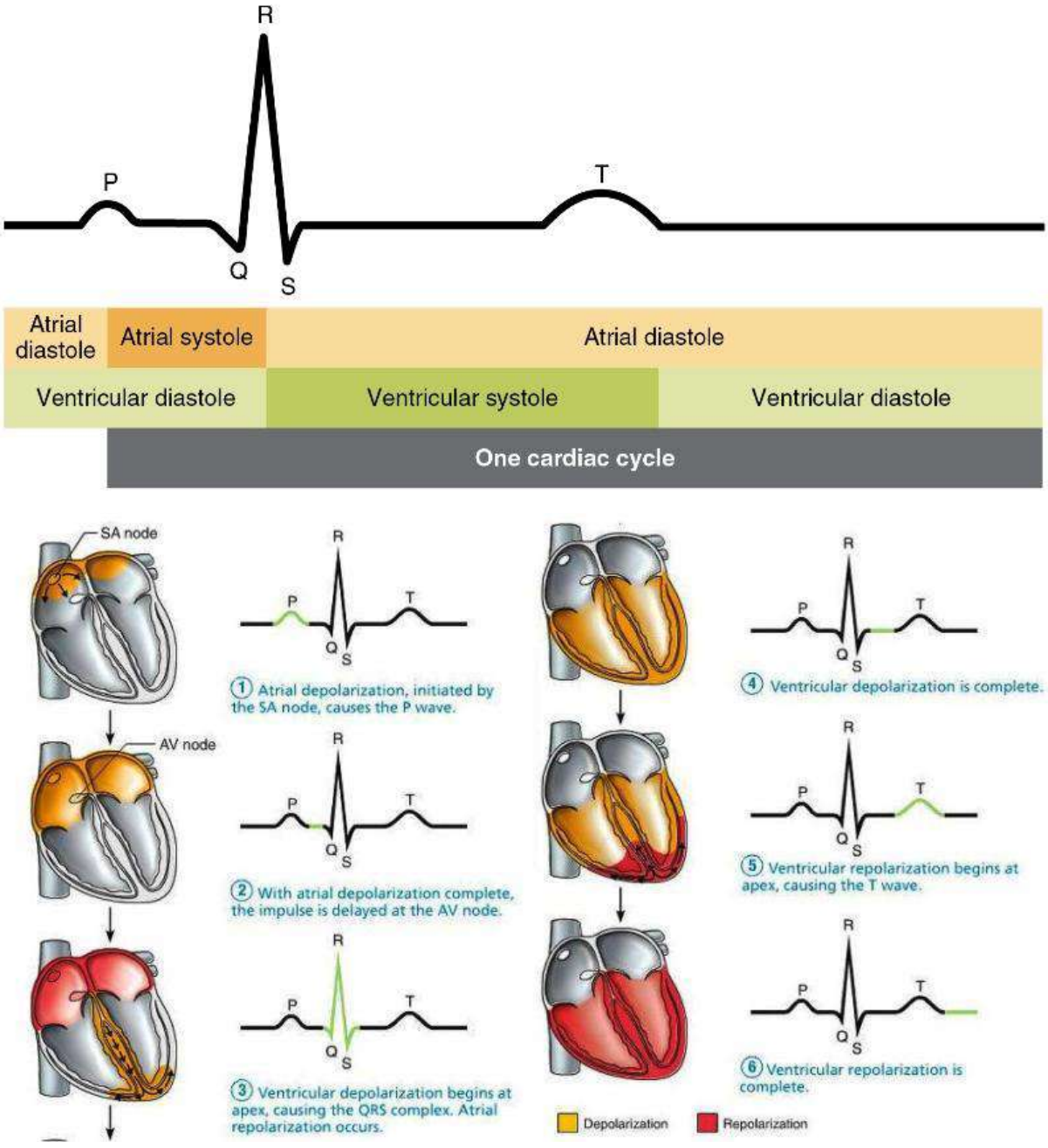
Figures81. Represente Cardiac cycle

5.Normal Electrocardiogram (ECG or EKG)

It refers to the record of the potential fluctuation during the cardiac cycle. Due to sequential spread of the excitation in the:

1. Atria
2. Interventricular septum.
3. Ventricular wall
4. Repolarization of the myocardium

These events appear in the ECG as a **series of positive and negative waves** (P, Q, R, S, and T).



Figures82. Represente Waves of ECG

5.1.Intervals and segments

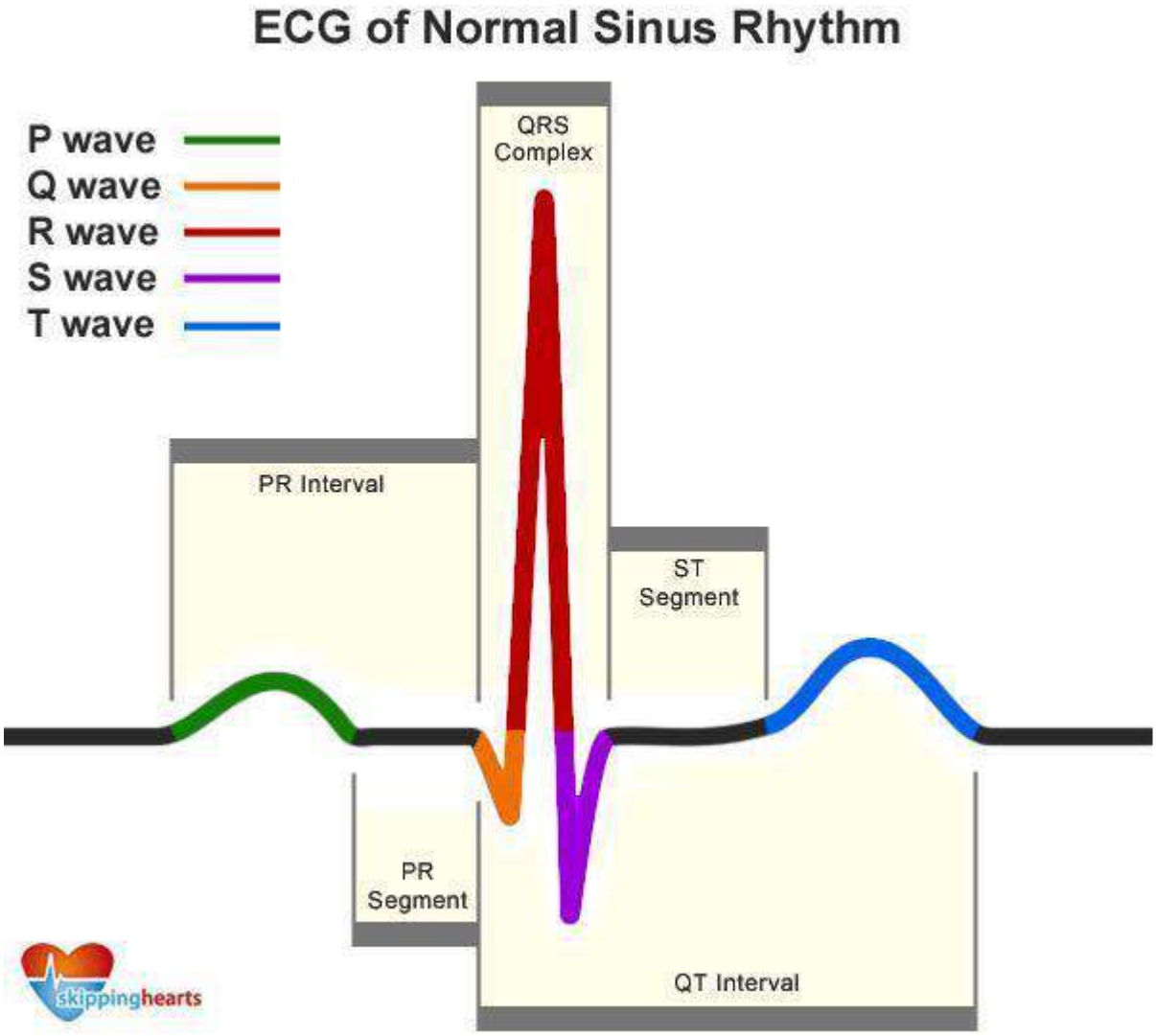
P-R interval: it measured from the onset of P wave to the onset QRS complex. It measures the AV conduction time. Its duration varies from 0.12- 0.2sec.

QT interval: it is the time from the start of the QRS complex to the end of T wave.

It indicates total systolic time of ventricle (ventricular depolarization and repolarization).

PQ segment:

ST segment: it is an isoelectric period between the end of QRS and beginning of T wave.
Its duration is about 0.32 sec.



Figures83. Represente Waves of ECG

6.Cardiac Output

It means the amount of blood ejected by each ventricle per minute.
Stroke volume: is the amount of blood ejected by each ventricle per beat
Cardiac output = *stroke volume* **x** *heart rate*

EIGHTH COURSE: Respiratory System

Introduction

Major Functions of the respiratory system are :

- Air distribution
- Gas exchange
- Other functions
- Filter, warm and humidify air

Is also associated with olfaction (smell) and speech

1.Process

a collective term for the following processes:

- Pulmonary ventilation - movement of air into the lungs (inspiration) and movement of air out of the lungs (expiration)
- External respiration - movement of oxygen from the lungs to the blood and movement of carbon dioxide from the blood to the lungs
- Transport of respiratory gases -Transport of oxygen from the lungs to the tissues and transport of carbon dioxide from the tissues to the lungs
- Internal respiration - Movement of oxygen from blood to the tissue cells and movement of carbon dioxide from tissue cells to blood

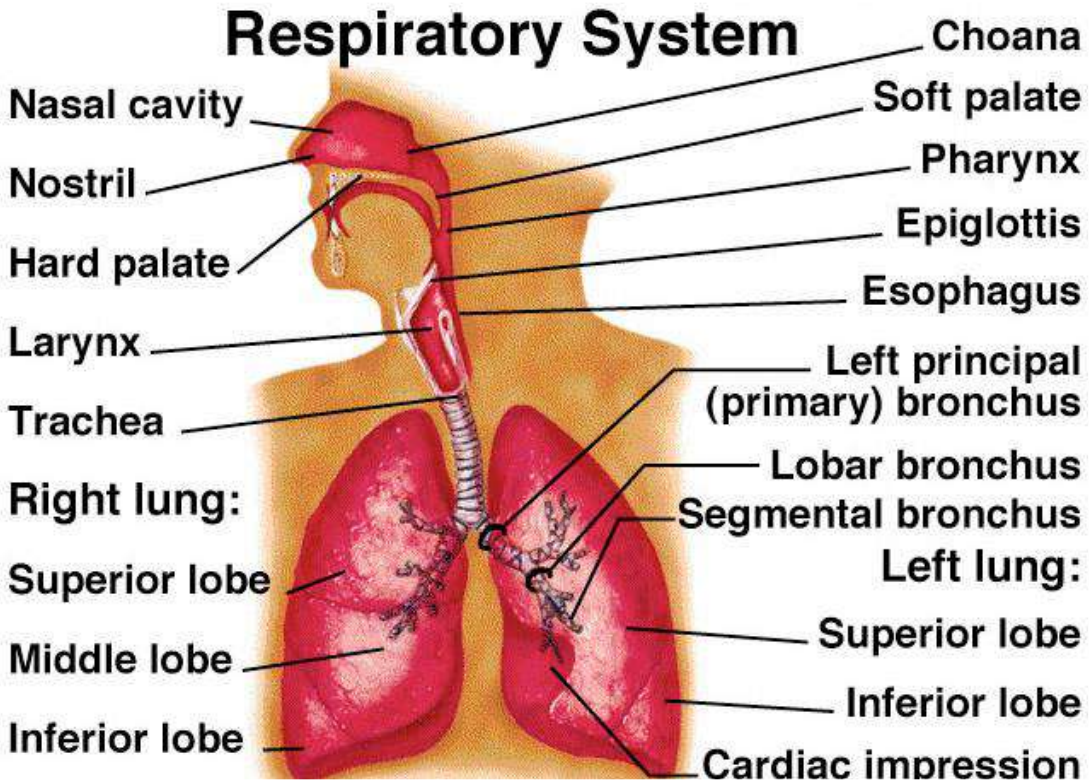


Figure84. Represente the most important components of the respiratory

2. PRINCIPAL ORGANS OF THE RESPIRATORY SYSTEM

2.1. Pharynx (throat)

Three regions of the pharynx

Nasopharynx – air passage (pseudostratified columnar epithelium)

Oropharynx – passageway for air, food, and drink (stratified squamous epithelium)

Laryngopharynx – passageway for air, food, and drink (stratified squamous epithelium)

2.2. Larynx (voice box)

Keeps food and drink out of the airway

Sound production Acts as a sphincter during abdominal straining (ex. During defecation and heavy lifting)

2.3. Trachea (windpipe)

Air passageway. Cleans, warms, and moistens incoming air

2.4. Bronchi

Solely an air passageway

Anatomical features

Left and right primary bronchi branch off from trachea Once the left and right primary bronchi enter the lungs they are subdivided into smaller tubes:

Secondary bronchi (one for each lobe) →tertiary bronchi → bronchioles → terminalbronchioles → respiratory bronchioles →alveolar ducts → alveolar sacs

Alveolar sacs are clusters of alveoli -the site of gas exchange

Cell populations present in alveoli

Type I alveolar cells – allow for diffusion of gases (simple squamous epithelia)

Type II alveolar cells – secrete surfactant (simple cuboidal epithelia)

Dust cells – alveolar macrophages (leukocytes)

2.5. Lungs

Left Lung: Divided into 2 lobes; Smaller than the right lung because the cardiac notch accommodates the heart Right Lung: Divided into 3 lobes

3. MECHANISM OF PULMINARY VENTILATION

Two phases of Pulmonary Ventilation – involves diaphragm, Intercostal muscles, Pectoralis minormuscle and the gas laws.

Physiology of Pulmonary Ventilation & the Gas Laws

Airflow is governed by basic pressure, flow, and resistance principles Atmospheric pressure is the weight of the air is the force that moves air into the lungs. Boyle's law - at constant temperature, the pressure of a given quantity of gas is inversely proportional to its volume. Charles' Law – the volume of a given quantity of gas is directly proportional to its absolute temperature As the inhaled air is warmed, it expands and inflates the lungs.

Inspiration, or inhalation – a very active process that requires input of energy

Air flows into the lungs when the thoracic pressure falls below atmospheric pressure.

The diaphragm moves downward and flattens, when stimulated by phrenic nerves. External (inspiratory) intercostals muscles and thoracic muscles can be stimulated to contract and expand the thoracic cavity.

Expiration, or exhalation – a passive process that takes advantage of the recoil properties of elastic fibers. Air is forced out of the lungs when the thoracic pressure rises above atmospheric pressure.

The diaphragm and expiratory muscles relax. The elasticity of the lungs and the thoracic cage allows them to return to their normal size and shape. To exhale more than usual, internal (expiratory) intercostals muscles and other muscles can be stimulated.

Physical factors influencing pulmonary ventilation

Resistance to airflow

Pulmonary compliance – the ease at which lungs expand. Compliance can be reduced by degenerative lung disease, such as tuberculosis.

Diameter of bronchioles – controlled by smooth muscle

Bronchoconstriction – reduce airflow

Bronchodialation - increase airflow

Alveolar surface tension – surfactant reduces the surface tension in the alveoli and keep them from collapsing during expiration.

Neural control of pulmonary ventilation

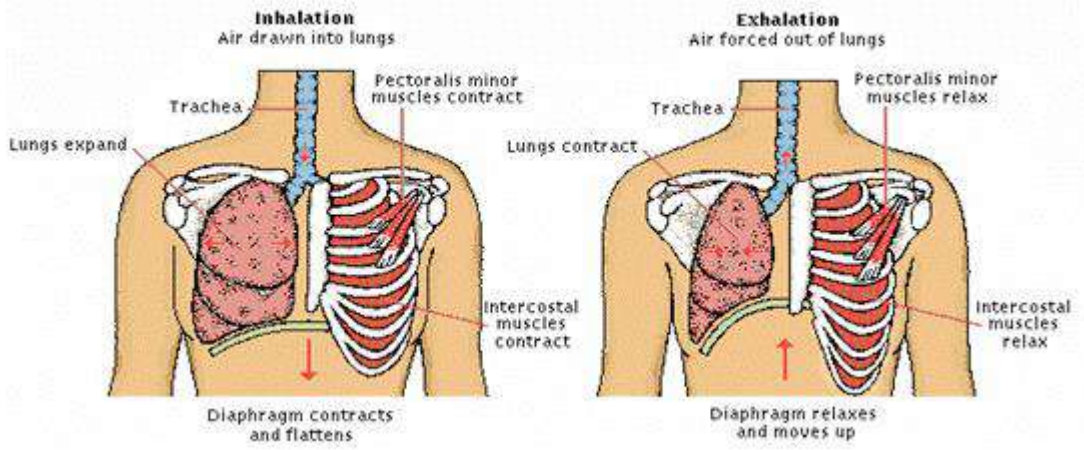


Figure 85.Mechanism Of Pulminary Ventilation

4. Control centers in the brainstem

Respiratory control centers – found in the pons and the medulla oblongata

Control breathing

Adjusts the rate and depth of breathing according to oxygen and carbon dioxide levelsAfferent connections to the brainstem

Hypothalmus and limbic system send signals to respiratory control centers

Chemoreceptors in the brainstem and arteries monitor pH, oxygen, and carbon dioxide levels

Vagus nerve (X) transmits sensory signals to the respiratory centers when irritated by smoke, dust, noxious fumes, etc.

Inflation reflex – prevents the lungs from over-inflating

Voluntary control – controlled by the motor cortex of the cerebrum Very limited voluntary control exists

Patterns of Breathing

Apnea – temporary cessation of breathing (one or more skipped breaths)

Dyspnea – labored, gasping breathing; shortness of breath

Eupnea – normal, relaxed, quiet breathing

Hyperpnea – increased rate and depth of breathing in response to exercise, pain, or other conditions

Hyperventilation – increased pulmonary ventilation in excess of metabolic demand

Hypoventilation – reduced pulmonary ventilation

Orthopnea – Dyspnea that occurs when a person is lying down

Respiratory Arrest – permanent cessation of breathing

Tachypnea – accelerated respiration

5. Measures of Pulmonary Ventilation

5.1.Respiratory Volumes– values determined by using a spirometer Tidal Volume (TV) – amount of air inhaled or exhaled with each breath under resting conditions

Inspiratory Reserve Volume (IRV) – amount of air that can be inhaled during forced breathing in addition to resting tidal volume

Expiratory Reserve Volume (ERV) – amount of air that can be exhaled during forced breathing in addition to tidal volume

Residual Volume (RV) – amount of air remaining in the lungs after a forced exhalation.

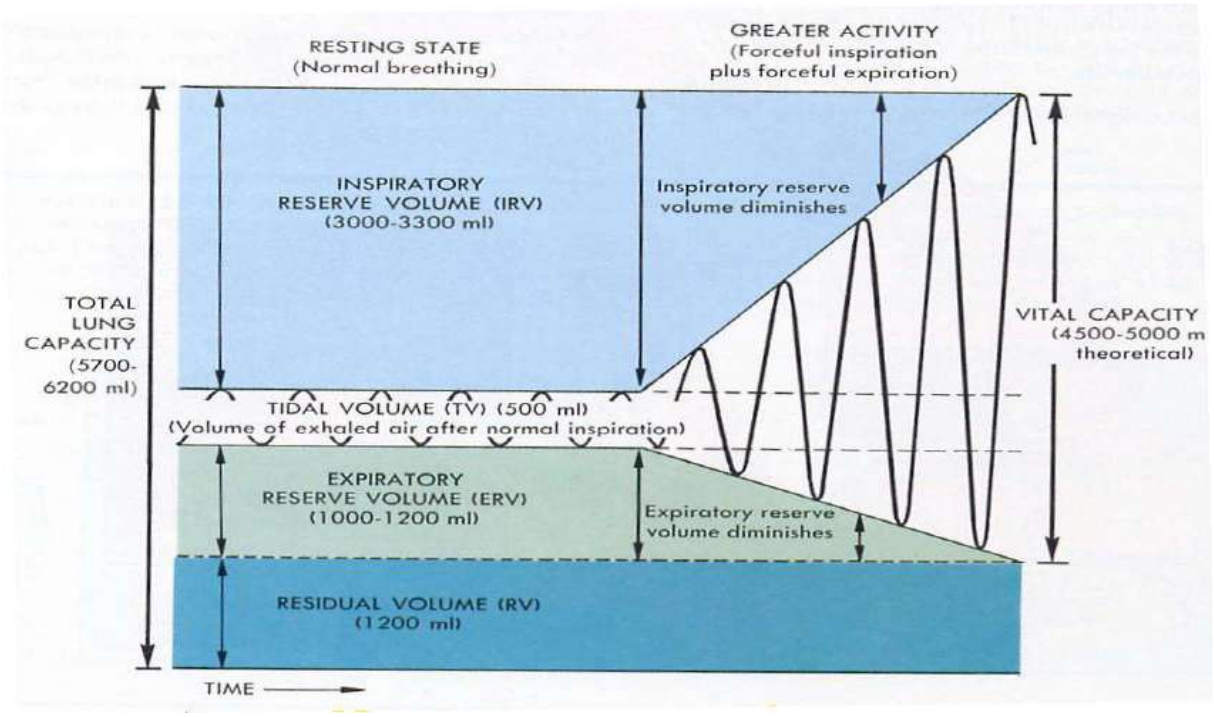


Figure86. Represente Measures of Pulmonary Ventilation

5.2.Respiratory Capacities – values determined by adding two or more of the respiratory volumes

5.3.Vital Capacity – maximum amount of air that can be expired after taking the deepest breath possible (VC = TV + IRV + ERV)

Inspiratory Capacity – maximum volume of air that can be inhaled following exhalation of resting tidal volume (IC = TV + IRV)

5.4.Functional Residual Capacity – volume of air remaining in the lungs following exhalation of resting volume (FRC = ERV + RV)

5.5.Total Lung Capacity – total volume of air that the lungs can hold (TLC = VC + RV)

5.6.Dead space

Anatomical dead space –areas of the conducting zone that contains air that never contributes to the gas exchange in the alveoli

Alveolar dead space – alveoli that or collapsed or obstructed and are not able to participate in gas Exchange

Pulmonary Function Tests - enable obstructive pulmonary disorders to be distinguished from restrictive disorders.

Obstructive Disorders – do not reduce respiratory volumes, but the narrow the airway and interfere with airflow Restrictive Disorders – disorders that stiffen the lungs and thus reduce compliance and vital Capacity

NINTH COURSE: Nervous System

Introduction

Cell types in neural tissue:

- Neurons
- Neuroglial cells (also known as neuroglia, glia, and glial)

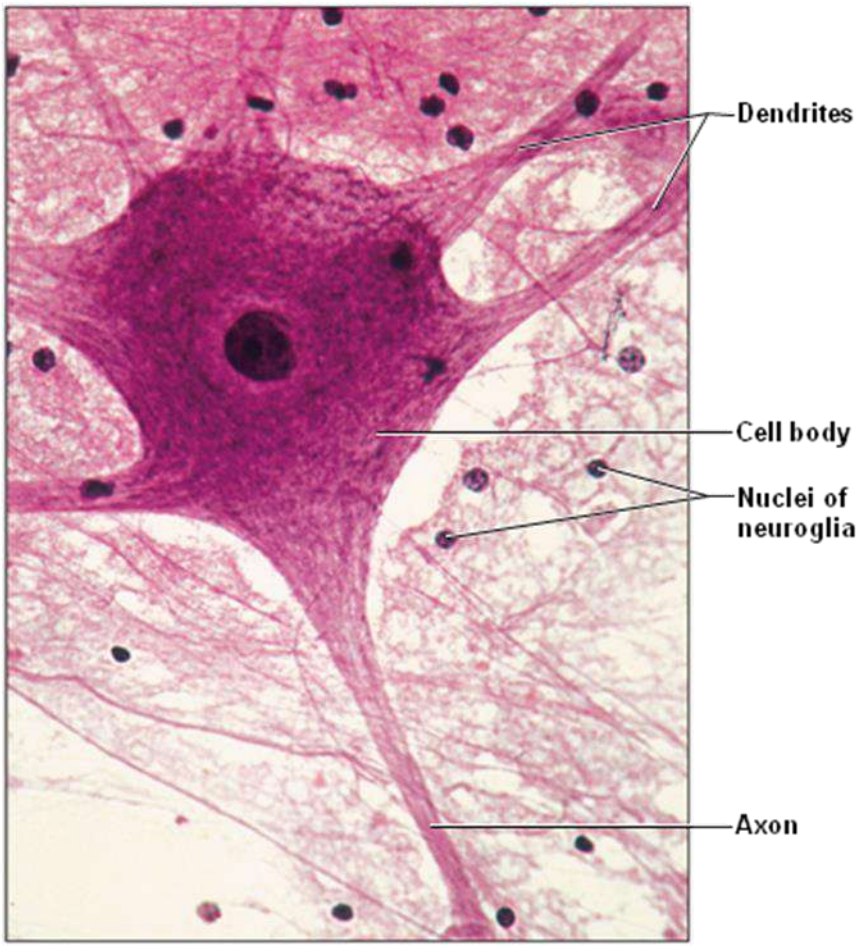


Figure87. Represente Nervous cell

1. General Functions of the Nervous System

The three general functions of the nervous system:

- Receiving stimuli = sensory function
- Deciding about stimuli = integrative function
- Reacting to stimuli = motor function

1.1. Sensory Function

- Sensory receptors gather information
- Information is carried to the CNS

1.2. Motor Function

- Decisions are acted upon
- Impulses are carried to effectors

1.3. Integrative Function

- Sensory information used to create:
  - Sensations
  - Memory
  - Thoughts
  - Decisions

2. Description of Cells of the Nervous System

- Neurons vary in size and shape
- They may differ in length and size of their axons and dendrites
- Neurons share certain features:
  - Dendrites
  - A cell body

- An axon

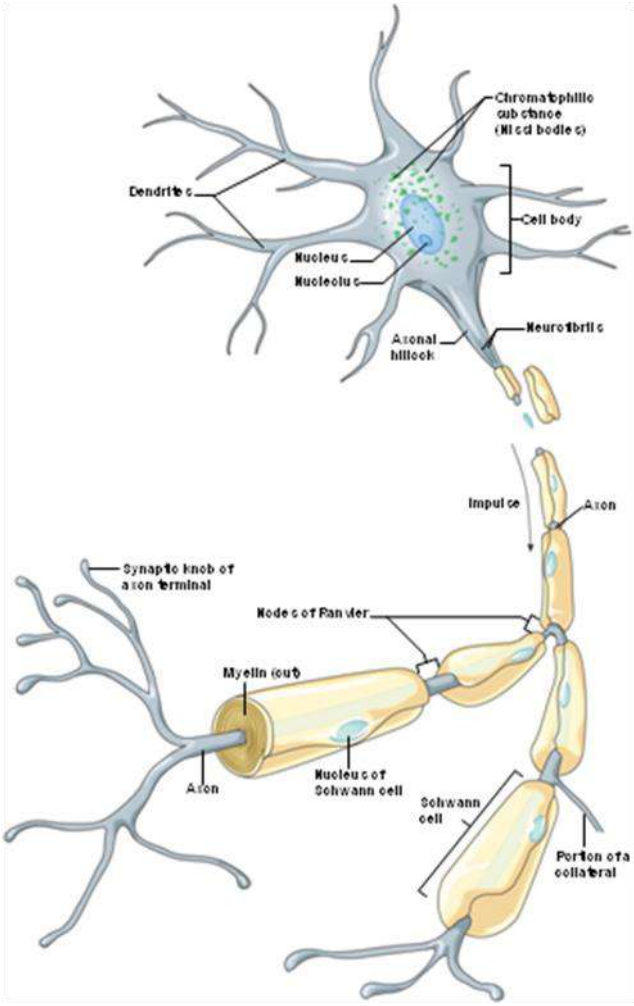


Figure88. Represente Neuron Structure

2.1. Myelination of Axons

2.1.1. White Matter

- Contains myelinated axons
- Considered fiber tracts

2.1.2. Gray Matter

- Contains unmyelinated structures
- Cell bodies, dendrites

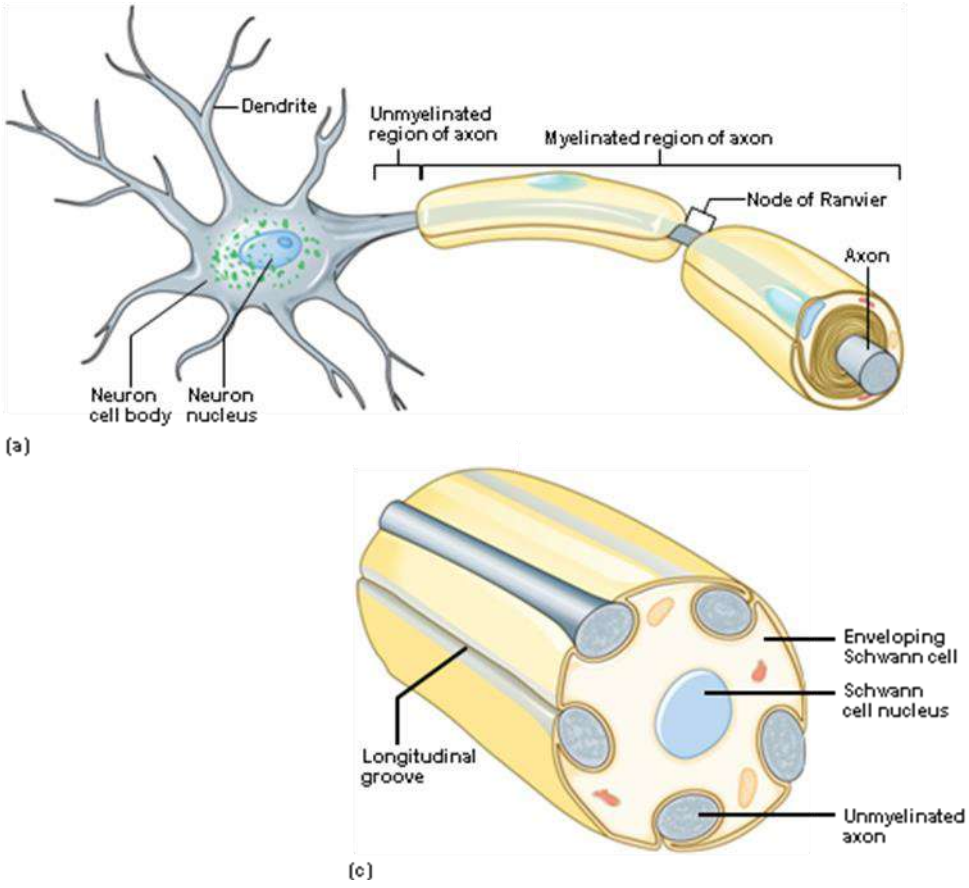


Figure89. Represente Myelination of Axons Structure

3. Classification of Neurons and Neuroglia

- Neurons vary in function
    - They can be sensory, motor, or integrative neurons
- Neurons vary in size and shape, and in the number of axons and dendrites that they may have
- Due to structural differences, neurons can be classified into three (3) major groups:
    - Bipolar neurons
    - Unipolar neurons
    - Multipolar neurons

4. Classification of Neurons: Functional Differences

4.1. Sensory Neurons

- Afferent
- Carry impulse to CNS
- Most are unipolar
- Some are bipolar

4.2. Interneurons

- Link neurons
- Aka association neurons or internuncial neurons
- Multipolar Located in CNS
-

4.3.Motor Neurons

- Multipolar
- Carry impulses away from CNS
- Carry impulses to effectors

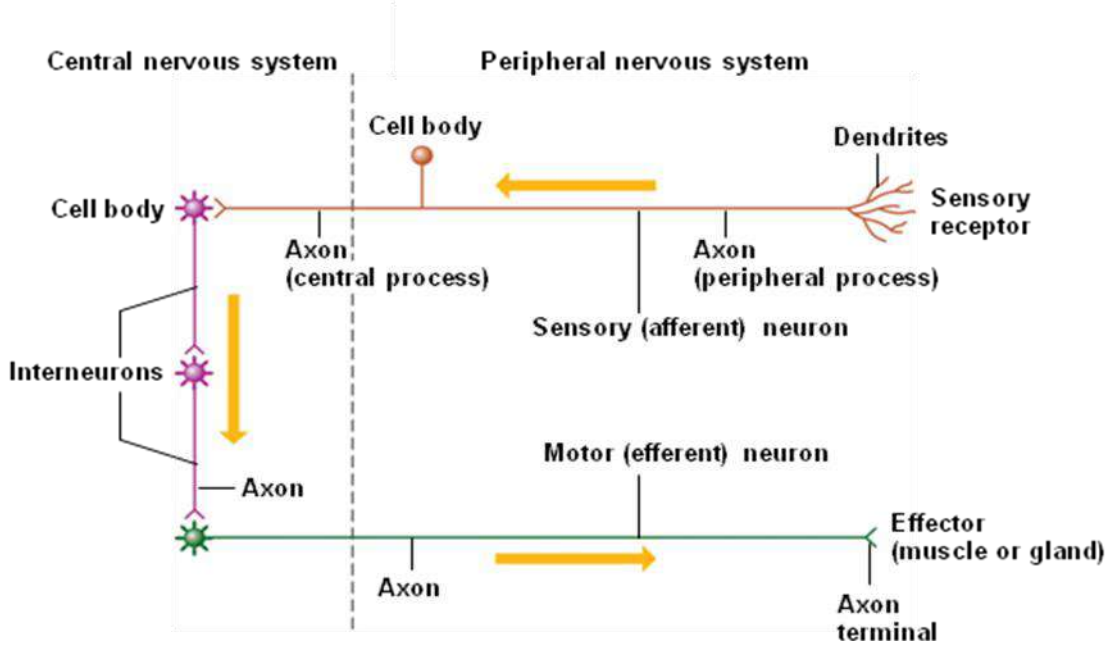


Figure90. Represente Neurons Differences

5. Types of Neuroglial Cells in the PNS

5.1. Schwann Cells

- Produce myelin found on peripheral myelinated neurons

- Speed up neurotransmission

5.2. Satellite Cells

- Support clusters of neuron cell bodies (ganglia)

6. Types of Neuroglial Cells in the CNS

6.1.Microglia

- CNS
- Phagocytic cell

6.2.Astrocytes

- CNS
- Scar tissue
- Mop up excess ions, etc.
- Induce synapse formation
- Connect neurons to blood vessels

6.3.Oligodendrocytes

- CNS
- Myelinating cell

6.4. Ependyma or ependymal

- CNS
- Ciliated
- Line central canal of spinal cord
- Line ventricles of brain

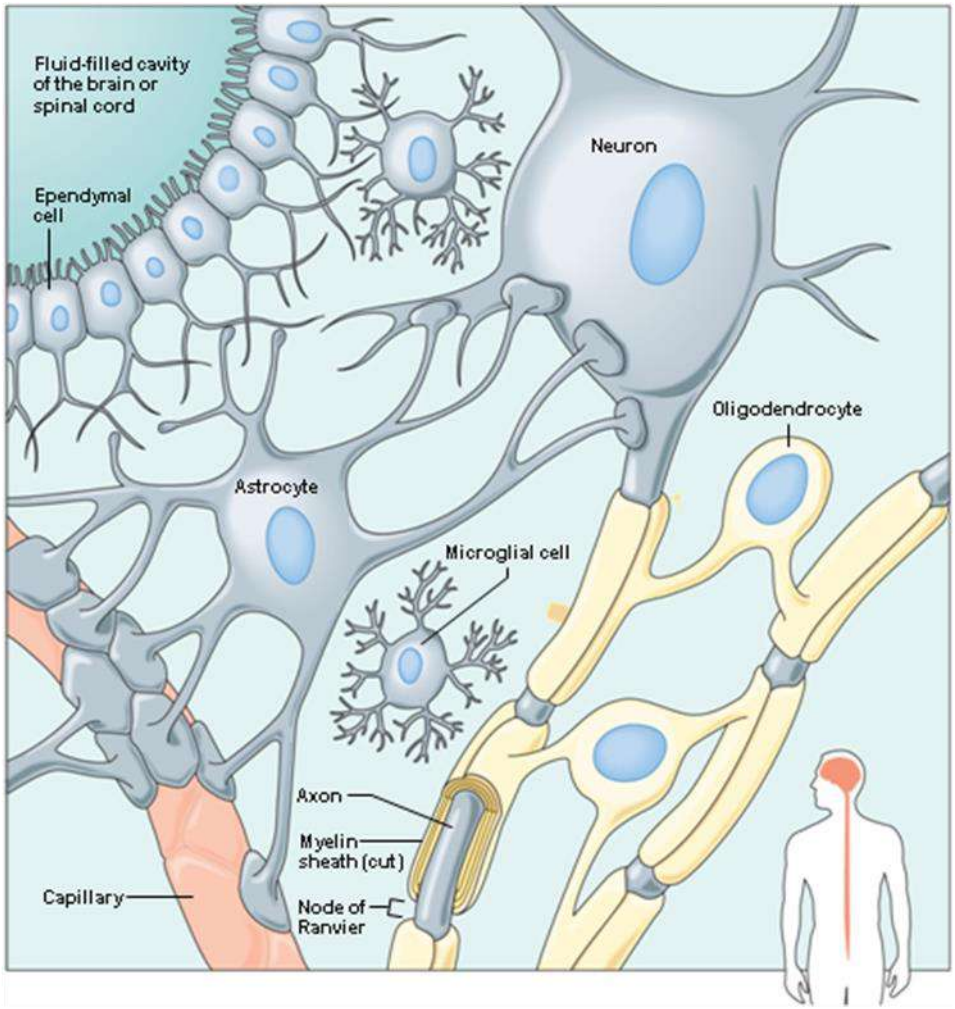


Figure91. Represente Types of Neuroglial Cells

7. Regeneration of A Nerve Axon

The process of Regeneration of a Nerve Axon occurs in five main stages, as illustrated in the following diagram.

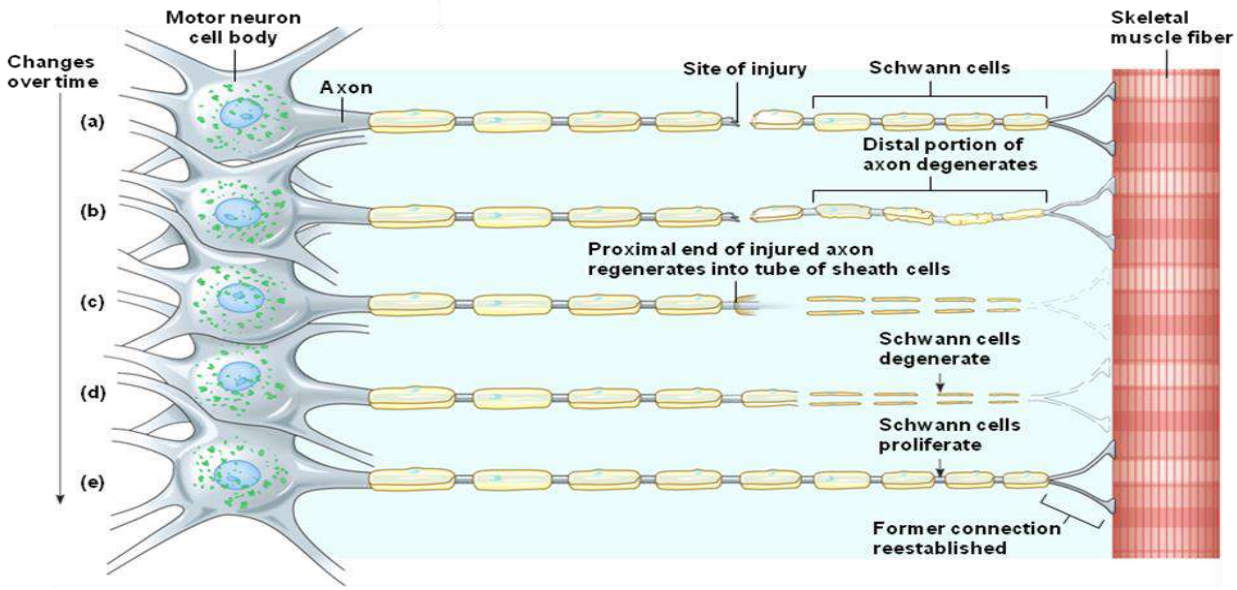


Figure92. Represente Types of Neuroglial Cells

8. Synaptic Transmission

This is where released neurotransmitters cross the synaptic cleft and react with specific molecules called receptors in the postsynaptic neuron membrane.Effects of neurotransmitters vary. Some neurotransmitters may open ion channels and others may close ion channels. Nerve impulses pass from neuron to neuron at synapses, moving from a pre-synaptic neuron to a post-synaptic neuron.

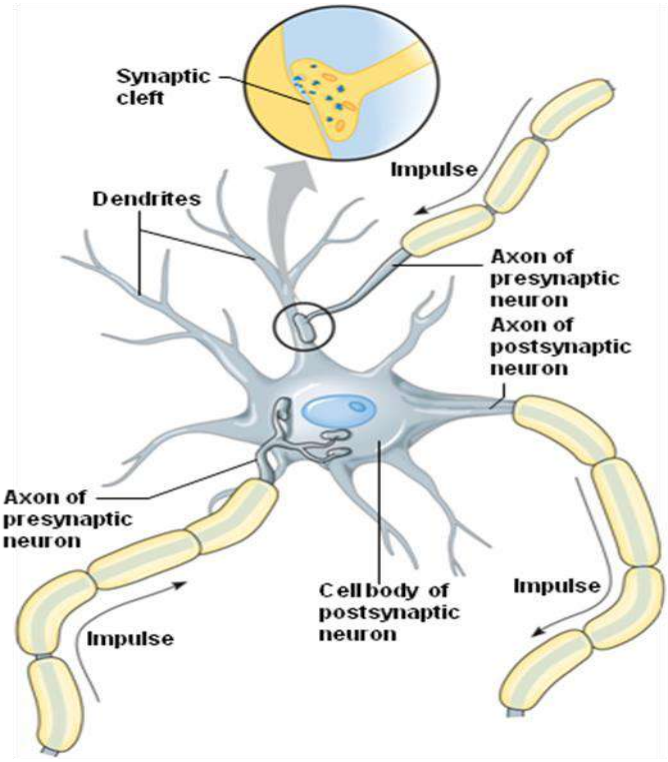


Figure93. Represente Synaps structure

- A cell membrane is usually electrically charged, or polarized, so that the inside of the membrane is negatively charged with respect to the outside of the membrane (which is then positively charged).
- This is as a result of unequal distribution of ions on the inside and the outside of the membrane.
- Potassium (K^+) ions are the major intracellular positive ions (cations).
- Sodium (Na^+) ions are the major extracellular positive ions (cations).
- This distribution is largely created by the Sodium/Potassium Pump (Na^+/K^+ pump).
- This pump actively transports sodium ions out of the cell and potassium ions into the cell.
- Resting Membrane Potential (RMP):
- 70 mV difference from inside to outside of cell
- It is a polarized membrane

- Inside of cell is negative relative to the outside of the cell
- RMP = -70 mV
- Due to distribution of ions inside vs. outside
- Na+/K+ pump restores
- Caused by various stimuli:
- Temperature changes
- Light
- Pressure
- Environmental changes affect the membrane potential by opening a gated ion channel
- Channels are 1) chemically gated, 2) voltage gated, or 3) mechanically gated

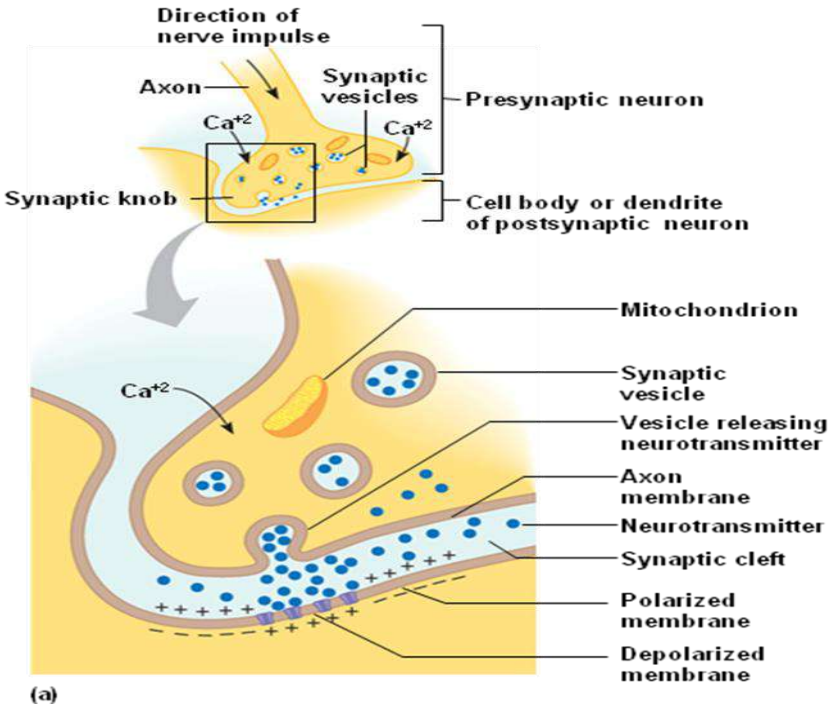


Figure94. Represente Synaptic Transmission

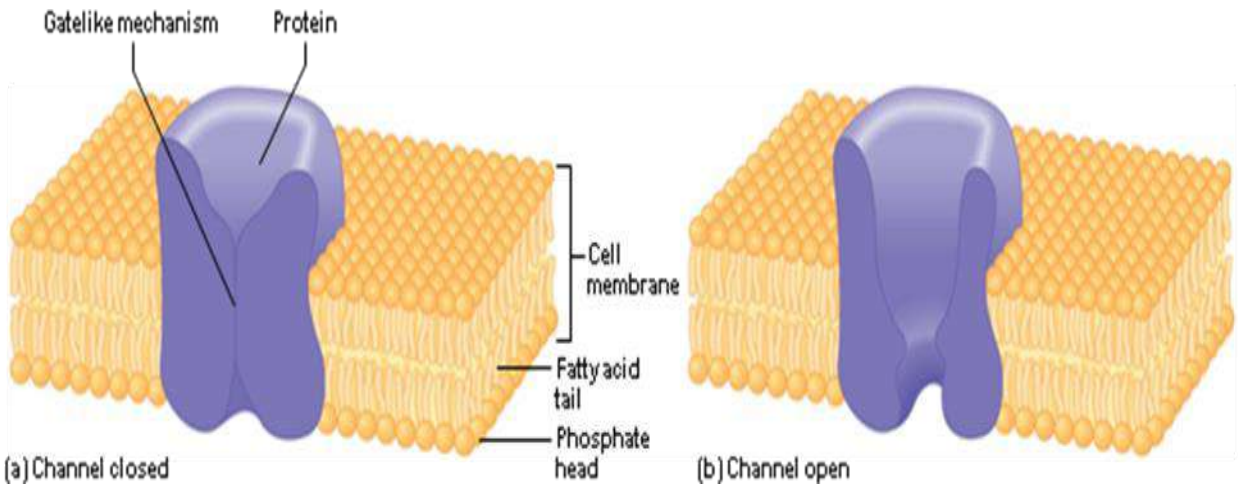
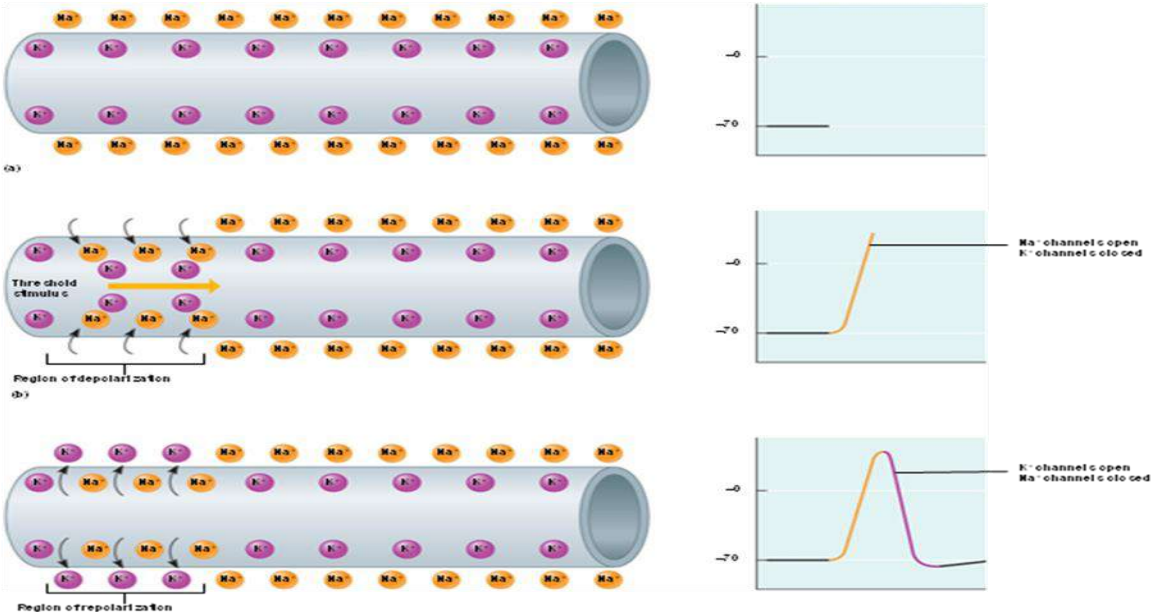
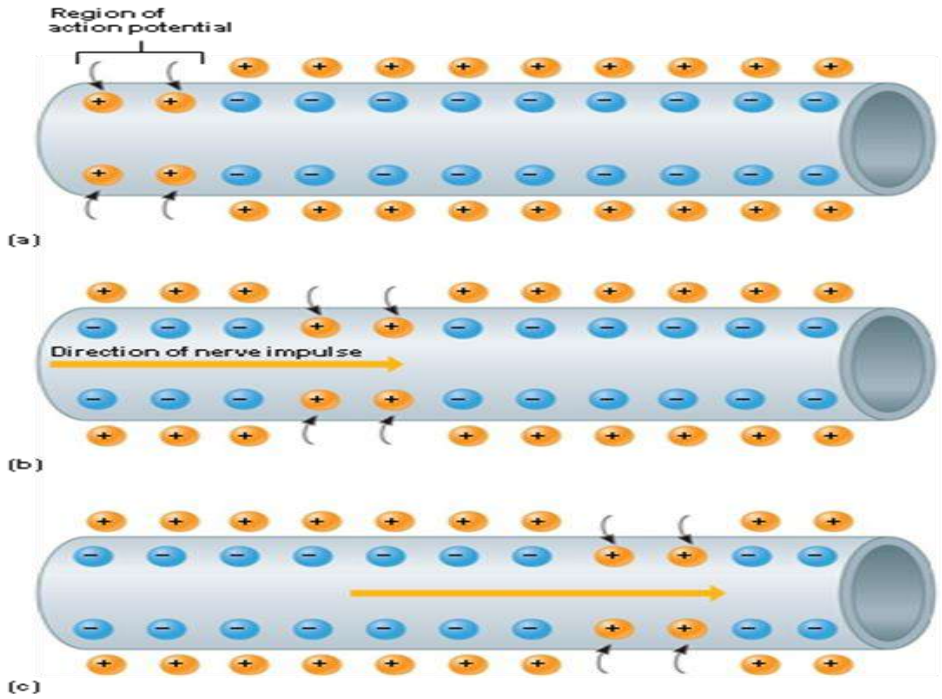


Figure95. Represente Cell Membrane Potential

9.Action Potentials

- At rest, the membrane is polarized (RMP = -70)
- Threshold stimulus reached (-55)
- Sodium channels open and membrane depolarizes (toward 0)
- Potassium leaves cytoplasm and membrane repolarizes (+30)
- Brief period of hyperpolarization (-90)





Figures96. Represente Cell Membrane Potential

9.1.All-or-None Response

- If a neuron responds at all, it responds completely
- A nerve impulse is conducted whenever a stimulus of threshold intensity or above is applied to an axon
- All impulses carried on an axon are the same strength

9.2.Refractory Period

- Absolute Refractory Period
    - Time when threshold stimulus does not start another action potential
- Relative Refractory Period
    - Time when stronger threshold stimulus can start another action potential

9.3.Impulse Conduction

TABLE 10.3 | Events Leading to Nerve Impulse Conduction

1. Nerve cell membrane maintains resting potential by diffusion of Na^+ and K^+ down their concentration gradients as the cell pumps them up the gradients.
2. Neurons receive stimulation, causing local potentials, which may sum to reach threshold.
3. Sodium channels in the trigger zone of the axon open.
4. Sodium ions diffuse inward, depolarizing the membrane.
5. Potassium channels in the membrane open.
6. Potassium ions diffuse outward, repolarizing the membrane.
7. The resulting action potential causes an electric current that stimulates adjacent portions of the membrane.
8. Action potentials occur sequentially along the length of the axon as a nerve impulse.

10.Impulse Processing

Way the nervous system processes nerve impulses and acts upon them

10.1.Neuronal Pools

- Interneurons
- Work together to perform a common function
- May excite or inhibit

- Groups of interneurons that make synaptic connections with each other
- Interneurons work together to perform a common function
- Each pool receives input from other neurons
- Each pool generates output to other neuron

10.2.Convergence

- Neuron receives input from several neurons
- Incoming impulses represent information from different types of sensory receptors
- Allows nervous system to collect, process, and respond to information
- Makes it possible for a neuron to sum impulses from different sources

10.3.Divergence

- One neuron sends impulses to several neurons
- Can amplify an impulse
- Impulse from a single neuron in CNS may be amplified to activate enough motor units needed for muscle contra

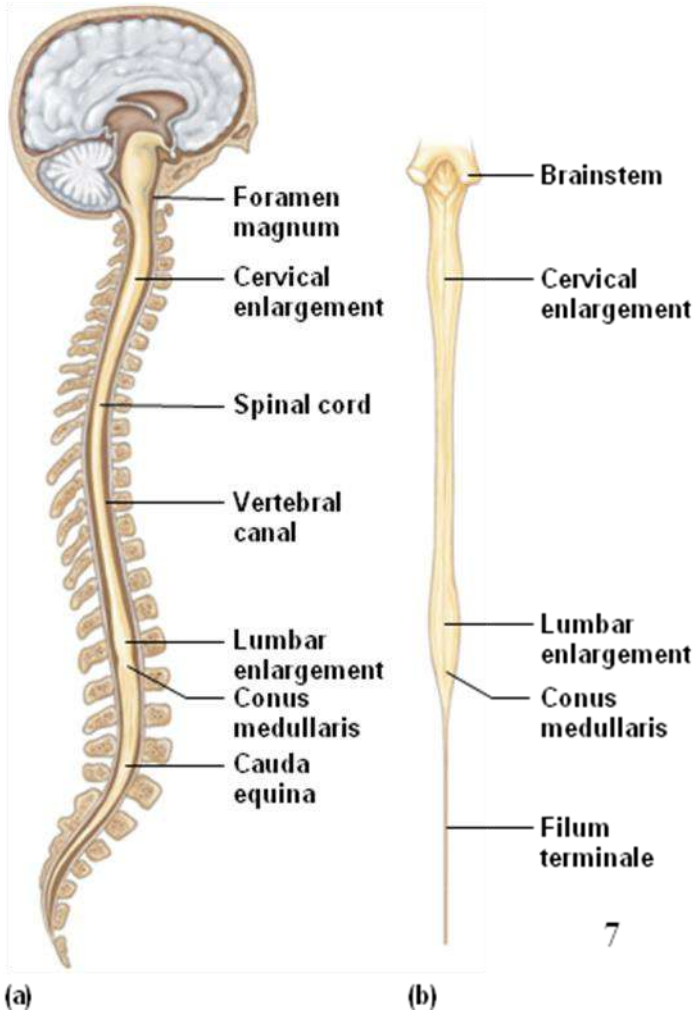
11.Divisions of the Nervous System

The central nervous system (CNS) consists of the brain and spinal cord. The brainstem connects the brain to the spinal cord. Communication to the peripheral nervous system (PNS) is by way of the spinal cord.

11.1. Central Nervous System (CNS)

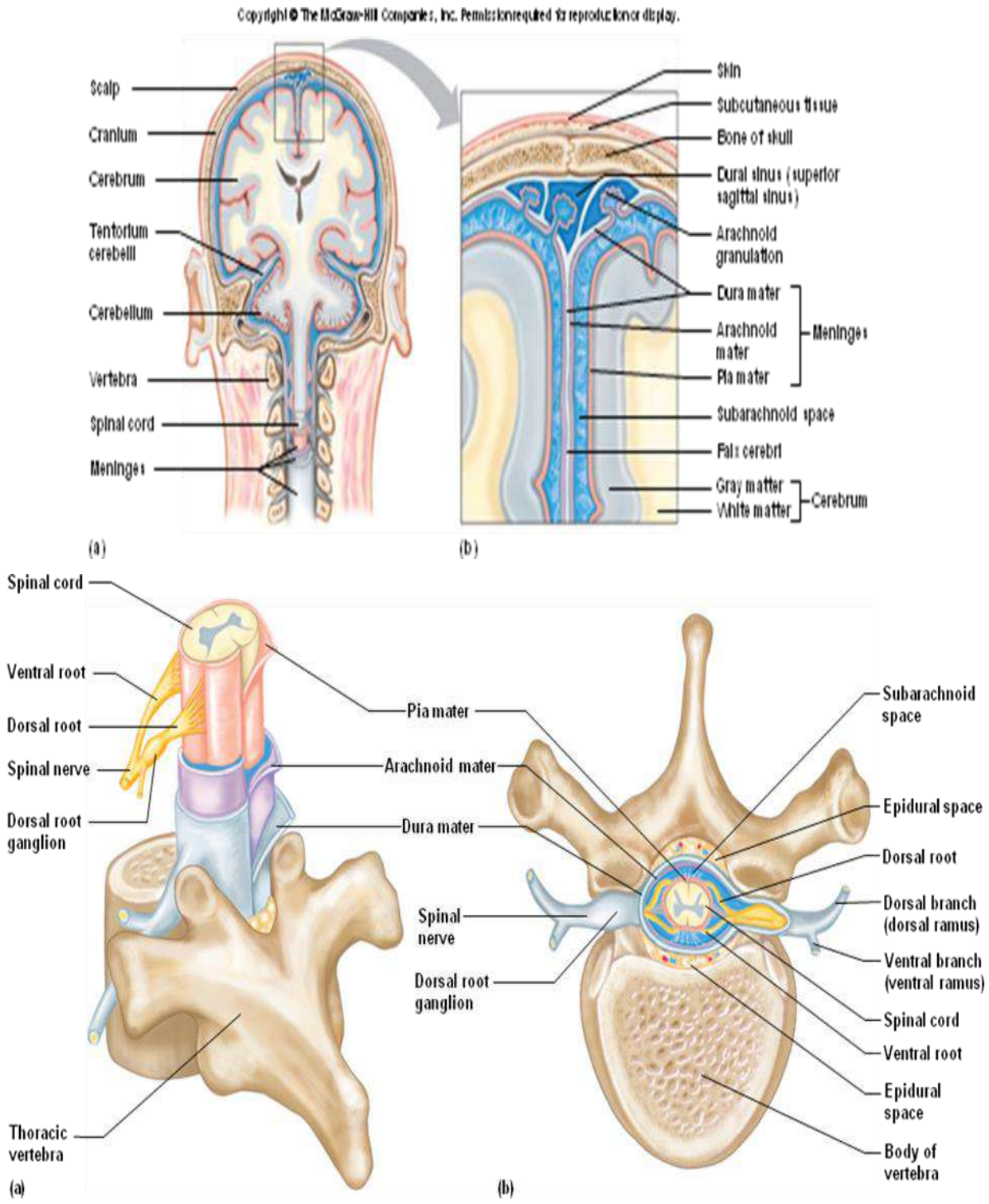
11.1.1. spinal cord

- Slender column of nervous tissue continuous with brain and brainstem
- Extends downward through vertebral canal
- Begins at the foramen magnum and terminates at the first and second lumbar vertebrae (L1/L2) interspace
- Conduit for nerve impulses to and from the brain and brainstem
- Center for spinal reflexes



Figures97. Represente spinal cord

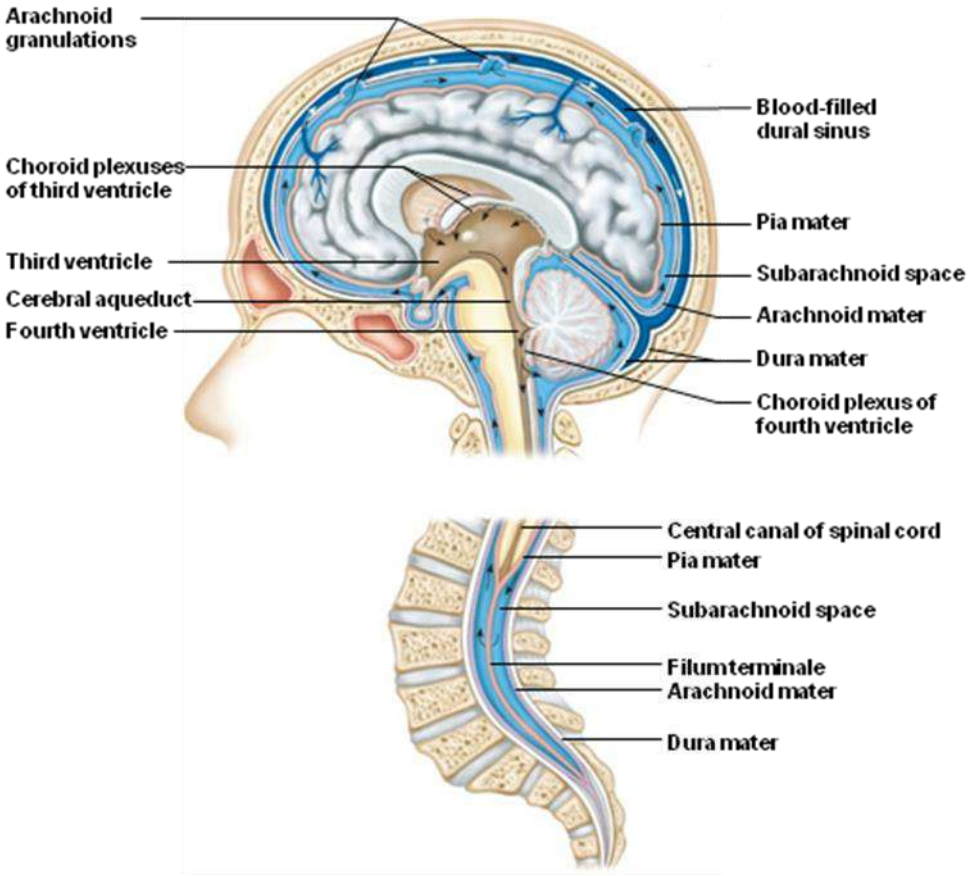
- The meninges
    - Membranes of CNS
    - Protect the CNS
    - Three (3) layers:
        - Dura mater
            - “Tough mother”
        - Arachnoid mater
            - “Spiderweb-like”
            - Space contains cerebrospinal fluid (CSF)
        - Pia mater
            - “Faithful mother”
            - Encapsulates blood vessels



Figures98. Represente The meninges of the spinal cord

11.1.1.2. Ventricles and Cerebrospinal Fluid

- There are four (4) ventricles
- The ventricles are interconnected cavities within cerebral hemispheres and brain stem
- The ventricles are continuous with the central canal of the spinal cord
- They are filled with cerebrospinal fluid (CSF)
- Secreted by the choroid plexus (Can you recall the specific cells?)
- Circulates in ventricles, central canal of spinal cord, and the subarachnoid space
- Completely surrounds the brain and spinal cord
- Excess or wasted CSF is absorbed by the arachnoid granulations
- Clear fluid similar to blood plasma
- Volume is only about 120-140 ml.
- Nutritive and protective
- Helps maintain stable ion concentrations in the CNS



Figures99. Represente Cerebrospinal Fluid

11.1.1. 3.Structure of Spinal Cord

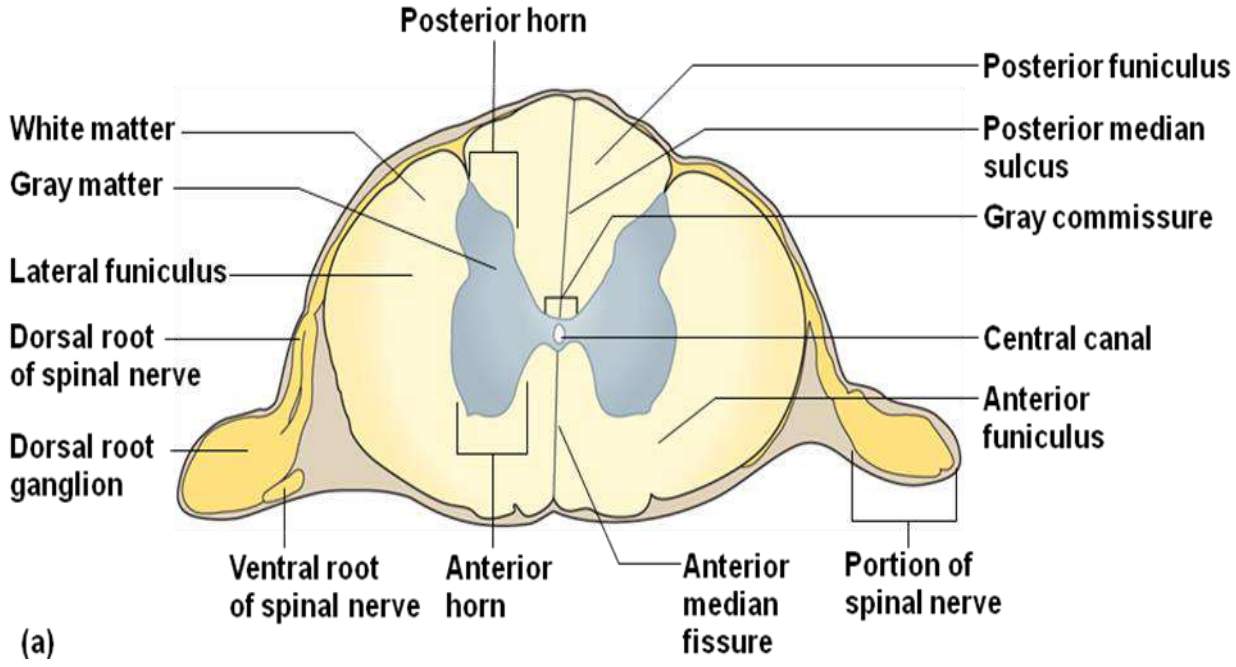


Figure100. Represente Structure of Spinal Cord

11.1.1. 4.Reflex Arcs

- Reflexes are automatic, subconscious responses to stimuli within or outside the body
- Simple reflex arc (sensory – motor)
- Most common reflex arc (sensory – association – motor)

TABLE 11.2 | Parts of a Reflex Arc

Part	Description	Function
Receptor	The receptor end of a dendrite or a specialized receptor cell in a sensory organ	Sensitive to a specific type of internal or external change
Sensory neuron	Dendrite, cell body, and axon of a sensory neuron	Transmits nerve impulse from the receptor into the brain or spinal cord
Interneuron	Dendrite, cell body, and axon of a neuron within the brain or spinal cord	Serves as processing center; conducts nerve impulse from the sensory neuron to a motor neuron
Motor neuron	Dendrite, cell body, and axon of a motor neuron	Transmits nerve impulse from the brain or spinal cord out to an effector
Effector	A muscle or gland	Responds to stimulation by the motor neuron and produces the reflex or behavioral action

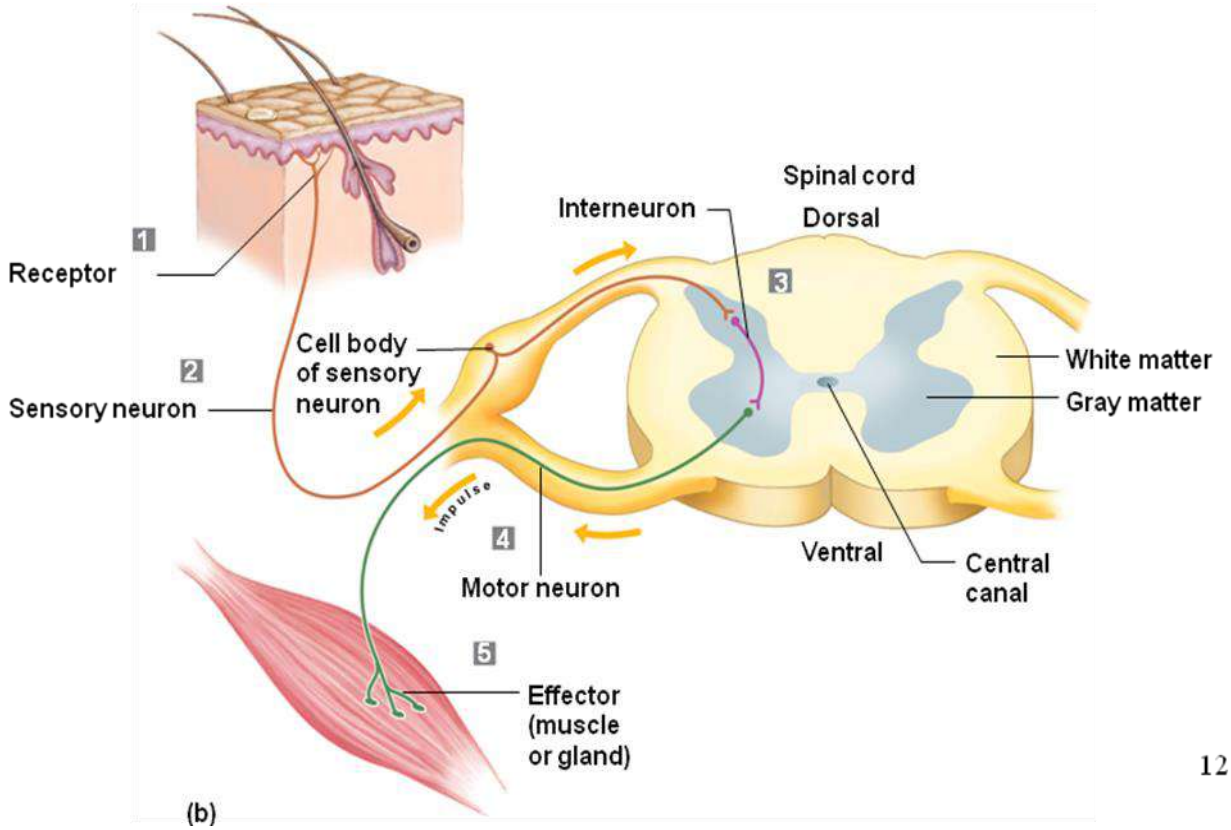


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Figure101. Represente General Components of a Spinal Reflex

11.1.1. 5. Nerve Tracts of the Spinal Cord

TABLE 11.3 | Nerve Tracts of the Spinal Cord

Tract	Location	Function
Ascending Tracts		
1. Fasciculus gracilis and fasciculus cuneatus	Posterior funiculi	Conduct sensory impulses associated with the senses of touch, pressure, and body movement from skin, muscles, tendons, and joints to the brain
2. Spinothalamic tracts (lateral and anterior)	Lateral and anterior funiculi	Conduct sensory impulses associated with the senses of pain, temperature, touch, and pressure from various body regions to the brain
3. Spinocerebellar tracts (posterior and anterior)	Lateral funiculi	Conduct sensory impulses required for the coordination of muscle movements from muscles of the lower limbs and trunk to the cerebellum
Descending Tracts		
1. Corticospinal tracts (lateral and anterior)	Lateral and anterior funiculi	Conduct motor impulses associated with voluntary movements from the brain to skeletal muscles
2. Reticulospinal tracts (lateral, anterior, and medial)	Lateral and anterior funiculi	Conduct motor impulses associated with the maintenance of muscle tone and the activity of sweat glands from the brain
3. Rubrospinal tracts	Lateral funiculi	Conduct motor impulses associated with muscular coordination and the maintenance of posture from the brain

11.1.2.Brain

- Functions of the brain:
    - Interprets sensations
    - Determines perception
    - Stores memory
    - Reasoning
    - Makes decisions
    - Coordinates muscular movements
    - Regulates visceral activities

- Determines personality

Major parts of the brain:

11.1.2.1. Cerebrum

Structure of the Cerebrum is:

- Corpus callosum
    - Connects cerebral hemispheres (a commissure)
- Gyri
    - Bumps or convolutions
- Sulci
    - Grooves in gray matter
        - Central sulcus of Rolando
- Fissures
    - Longitudinal: separates the cerebral hemispheres
    - Transverse: separates cerebrum from cerebellum
    - Lateral fissure of Sylvius

Cerebrum consiste Five (5) lobes bilaterally:

- Frontal lobe
- Parietal lobe
- Temporal lobe
- Occipital lobe
- Insula aka ‘Island of Reil’

Its functional are:

- Interpreting impulses
- Initiating voluntary movements
- Storing information as memory
- Retrieving stored information
- Reasoning
- Seat of intelligence and personality

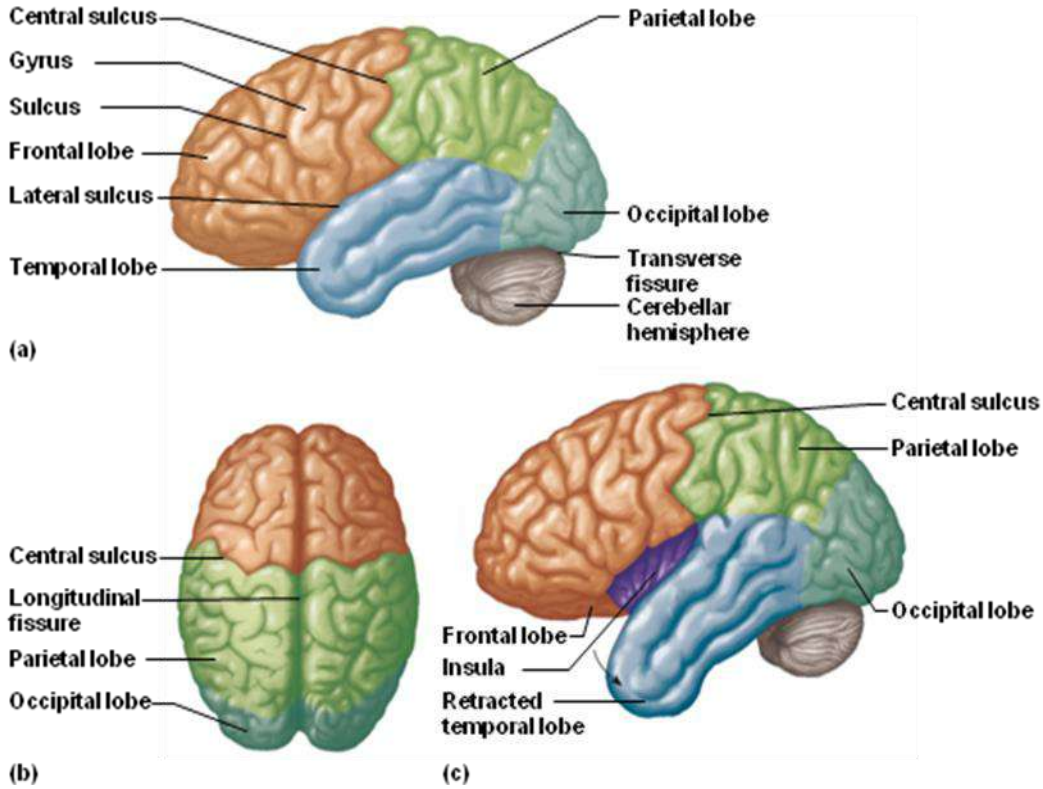


Figure102. Represente structure of the cerebrum

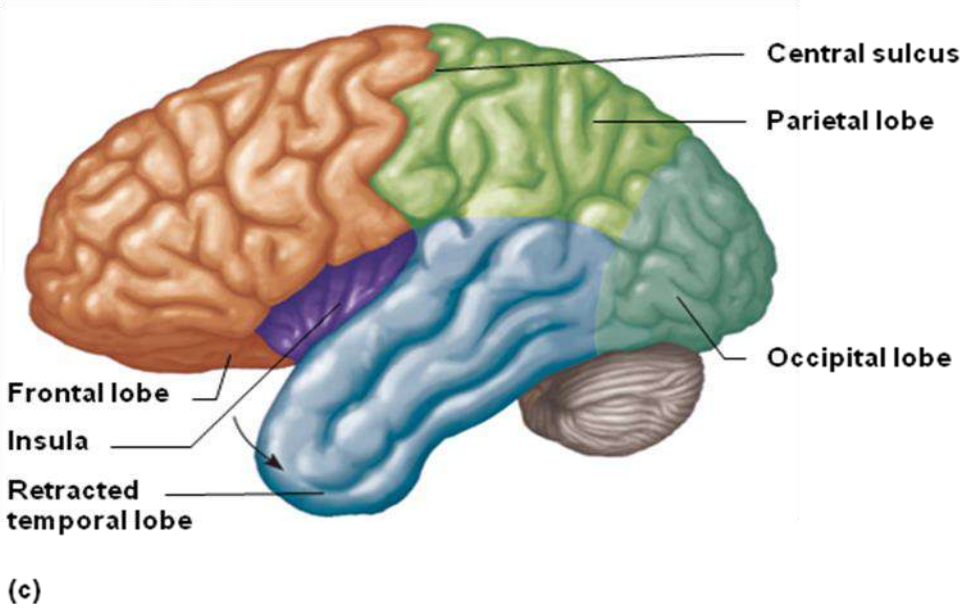


Figure103. Represente Lobes of the cerebrum

11.1.2.2. Diencephalon

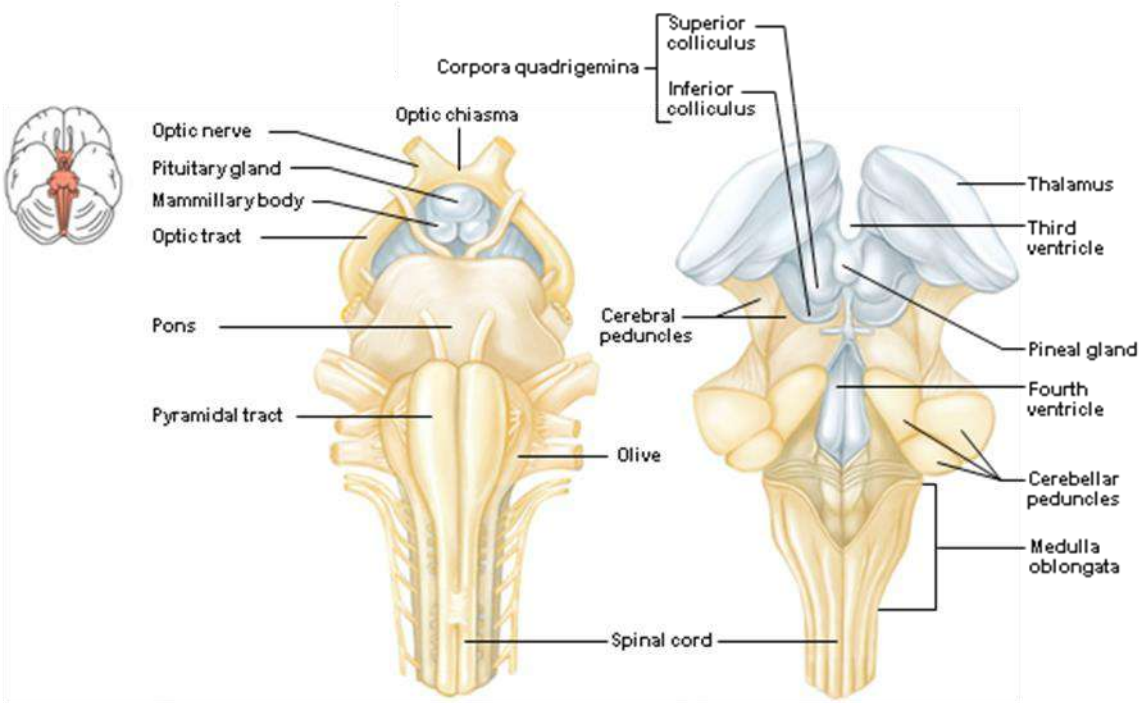
- Between cerebral hemispheres and above the brainstem
- Surrounds the third ventricle
- Thalamus
- Hypothalamus
- Optic tracts
- Optic chiasm
- Posterior pituitary
- Pineal gland

11.1.2.2.1.Thalamus

- Gateway for sensory impulses heading to cerebral cortex
- Receives all sensory impulses (except smell)
- Channels impulses to appropriate part of cerebral cortex for interpretation

11.1.2.2.2.Hypothalamus

- Maintains homeostasis by regulating visceral activities
- Links nervous and endocrine systems (hence some say the neuroendocrine system



- **Figure104. Represente Structure of the Diencephalon**

11.1.2.3. Brainstem

Three parts:

- Midbrain
- Pons
- Medulla Oblongata

11.1.2.3.1. Midbrain

- Between diencephalon and pons
- Contains bundles of fibers that join lower parts of brainstem and spinal cord with higher part of brain
- Cerebral aqueduct
- Cerebral peduncles (bundles of nerve fibers)

- Corpora quadrigemina (centers for visual and auditory reflexes)

11.1.2.3.2. Pons

- Rounded bulge on underside of brainstem
- Between medulla oblongata and midbrain
- Helps regulate rate and

depth of breathing

- Relays nerve impulses to and from medulla oblongata and cerebellum

11.1.2.3.3. Medulla Oblongata

- Enlarged continuation of spinal cord
- Conducts ascending and descending impulses between brain and spinal cord
- Contains cardiac, vasomotor, and respiratory control centers
- Contains various nonvital reflex control centers (coughing, sneezing, swallowing, and vomiting)

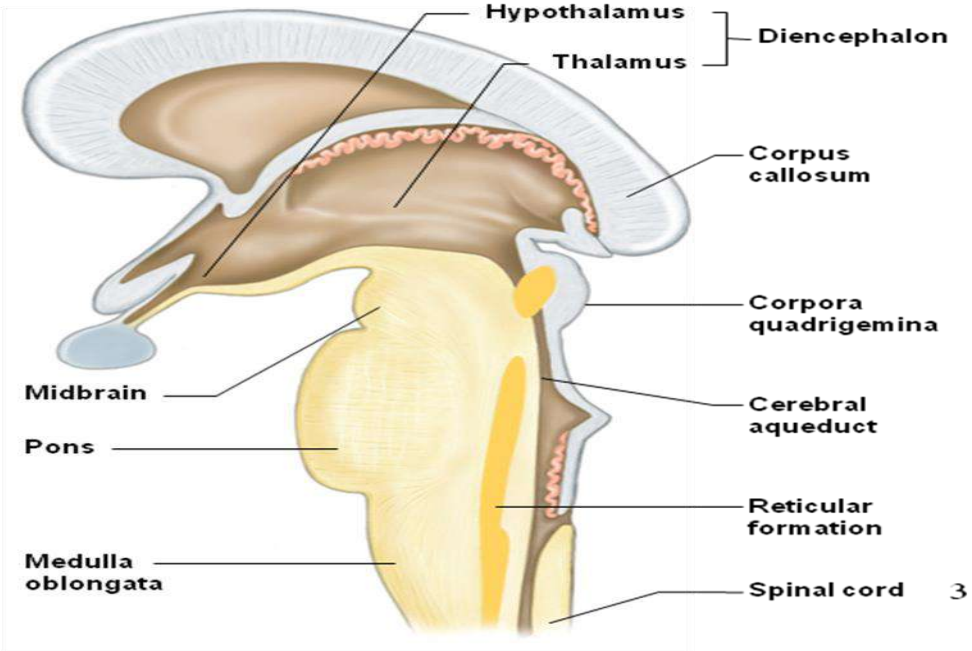


Figure105. Represente Structure of the Brainstem

TABLE 11.7 | Major Parts of the Brain

Part	Characteristics	Functions
1. Cerebrum	Largest part of the brain; two hemispheres connected by the corpus callosum	Controls higher brain functions, including interpreting sensory impulses, initiating muscular movements, storing memory, reasoning, and determining intelligence
2. Basal nuclei (ganglia)	Masses of gray matter deep within the cerebral hemispheres	Relay stations for motor impulses originating in the cerebral cortex and passing into the brainstem and spinal cord
3. Diencephalon	Includes masses of gray matter (thalamus and hypothalamus)	The thalamus is a relay station for sensory impulses ascending from other parts of the nervous system to the cerebral cortex; the hypothalamus helps maintain homeostasis by regulating visceral activities and by linking the nervous and endocrine systems
4. Brainstem	Connects the cerebrum to the spinal cord	
a. Midbrain	Contains masses of gray matter and bundles of nerve fibers that join the spinal cord to higher regions of the brain	Contains reflex centers that move the eyes and head, and maintains posture
b. Pons	A bulge on the underside of the brainstem that contains masses of gray matter and nerve fibers	Relays nerve impulses to and from the medulla oblongata and cerebrum; helps regulate rate and depth of breathing
c. Medulla oblongata	An enlarged continuation of the spinal cord that extends from the foramen magnum to the pons and contains masses of gray matter and nerve fibers	Conducts ascending and descending impulses between the brain and spinal cord; contains cardiac, vasomotor, and respiratory control centers and various nonvital reflex control centers
5. Cerebellum	A large mass of tissue inferior to the cerebrum and posterior to the brainstem; includes two lateral hemispheres connected by the vermis	Communicates with other parts of the CNS by nerve tracts; integrates sensory information concerning the position of body parts; and coordinates muscle activities and maintains posture

11.2. Peripheral Nervous System (PNS)

- Cranial nerves arising from the brain
    - Somatic fibers connecting to the skin and skeletal muscles
    - Autonomic fibers connecting to viscera
- Spinal nerves arising from the spinal cord
    - Somatic fibers connecting to the skin and skeletal muscles
    - Autonomic fibers connecting to viscera

TABLE 11.8 | Subdivisions of the Nervous System

1. Central nervous system (CNS)
a. Brain
b. Spinal cord
2. Peripheral nervous system (PNS)
a. Cranial nerves arising from the brain
(1) Somatic fibers connecting to the skin and skeletal muscles
(2) Autonomic fibers connecting to viscera
b. Spinal nerves arising from the spinal cord
(1) Somatic fibers connecting to the skin and skeletal muscles
(2) Autonomic fibers connecting to viscera

11.2.1.Cranial Nerves

TABLE 11.9 | Functions of Cranial Nerves

Nerve		Type	Function
I	Olfactory	Sensory	Sensory fibers transmit impulses associated with the sense of smell.
II	Optic	Sensory	Sensory fibers transmit impulses associated with the sense of vision.
III	Oculomotor	Primarily motor	Motor fibers transmit impulses to muscles that raise the eyelids, move the eyes, adjust the amount of light entering the eyes, and focus the lenses.
			Some sensory fibers transmit impulses associated with proprioceptors.
IV	Trochlear	Primarily motor	Motor fibers transmit impulses to muscles that move the eyes.
			Some sensory fibers transmit impulses associated with proprioceptors.
V	Trigeminal	Mixed	
	Ophthalmic division		Sensory fibers transmit impulses from the surface of the eyes, tear glands, scalp, forehead, and upper eyelids.
	Maxillary division		Sensory fibers transmit impulses from the upper teeth, upper gum, upper lip, lining of the palate, and skin of the face.
	Mandibular division		Sensory fibers transmit impulses from the scalp, skin of the jaw, lower teeth, lower gum, and lower lip.
			Motor fibers transmit impulses to muscles of mastication and to muscles in the floor of the mouth.
VI	Abducens	Primarily motor	Motor fibers transmit impulses to muscles that move the eyes.
			Some sensory fibers transmit impulses associated with proprioceptors.
VII	Facial	Mixed	Sensory fibers transmit impulses associated with taste receptors of the anterior tongue.
			Motor fibers transmit impulses to muscles of facial expression, tear glands, and salivary glands.
VIII	Vestibulocochlear	Sensory	
	Vestibular branch		Sensory fibers transmit impulses associated with the sense of equilibrium.
	Cochlear branch		Sensory fibers transmit impulses associated with the sense of hearing.
IX	Glossopharyngeal	Mixed	Sensory fibers transmit impulses from the pharynx, tonsils, posterior tongue, and carotid arteries.
			Motor fibers transmit impulses to salivary glands and to muscles of the pharynx used in swallowing.
X	Vagus	Mixed	Somatic motor fibers transmit impulses to muscles associated with speech and swallowing; autonomic motor fibers transmit impulses to the viscera of the thorax and abdomen.
			Sensory fibers transmit impulses from the pharynx, larynx, esophagus, and viscera of the thorax and abdomen.
XI	Accessory	Primarily motor	
	Cranial branch		Motor fibers transmit impulses to muscles of the soft palate, pharynx, and larynx.
	Spinal branch		Motor fibers transmit impulses to muscles of the neck and back; some proprioceptor input.
XII	Hypoglossal	Primarily motor	Motor fibers transmit impulses to muscles that move the tongue; some proprioceptor input.

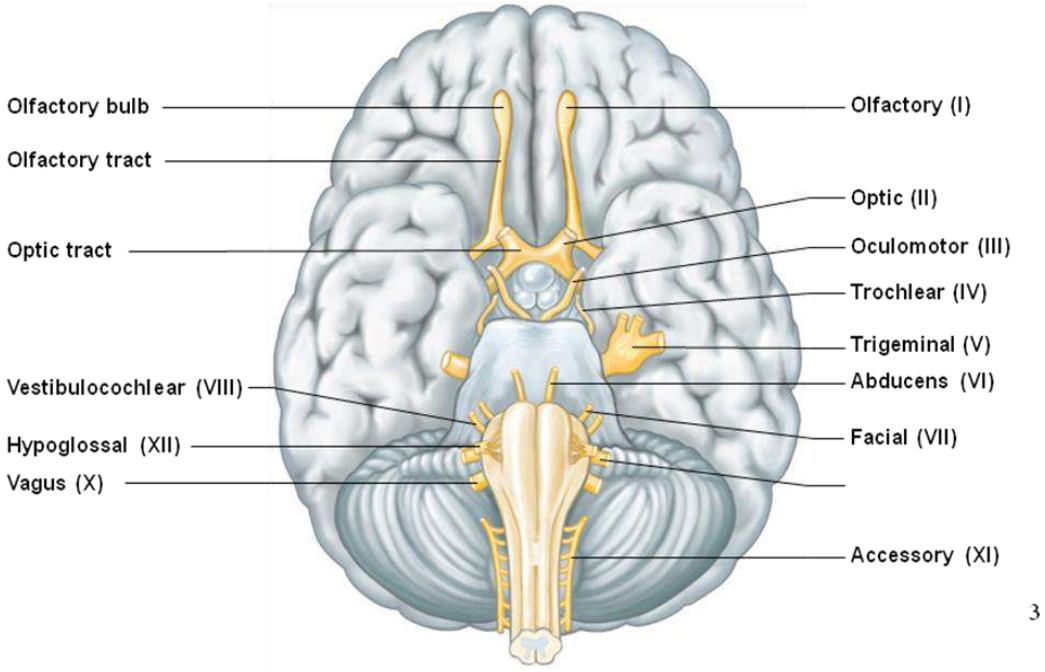


Figure106. Represente Cranial Nerves

11.2.2.Spinal Nerves

- ALL are mixed nerves (except the first pair)
- 31 pairs of spinal nerves:
  - 8 cervical nerves
    - (C1 to C8)
  - 12 thoracic nerves
    - (T1 to T12)
  - 5 lumbar nerves
    - (L1 to L5)
  - 5 sacral nerves
    - (S1 to S5)
  - 1 coccygeal nerve
    - (Co or Cc)

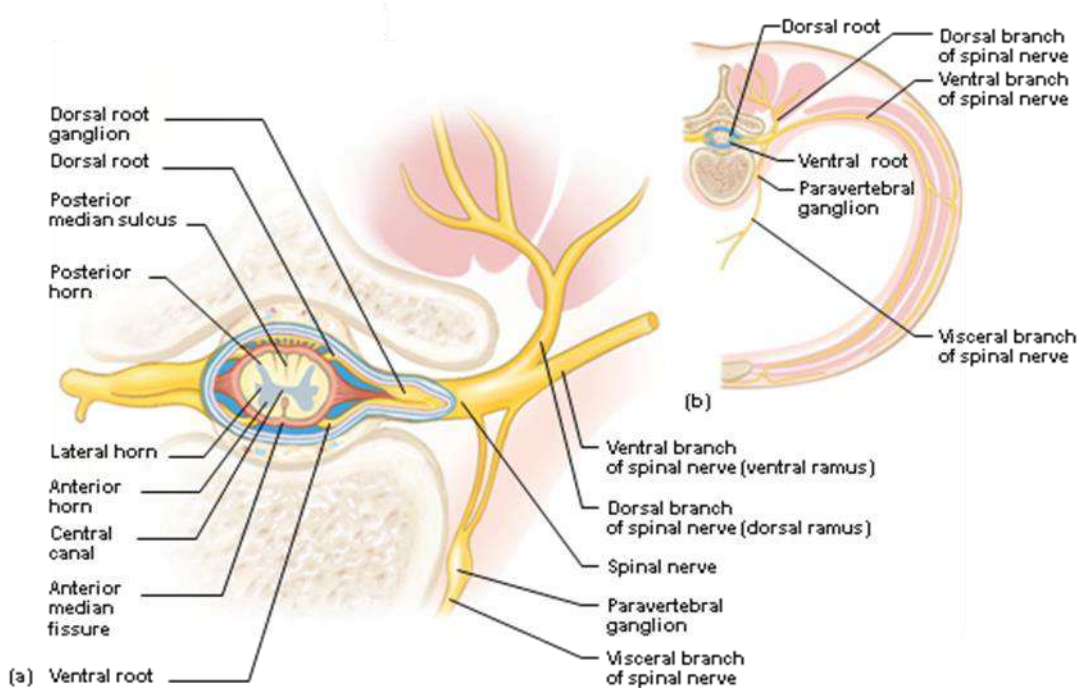


Figure107. Represente Spinal Nerves

11.3. Autonomic Nervous System

- Functions without conscious effort
- Controls visceral activities
- Regulates smooth muscle, cardiac muscle, and glands
- Efferent fibers typically lead to ganglia outside of the CNS
- Two autonomic divisions regulate:

- Sympathetic division (speeds up)
    - Prepares body for ‘fight or flight’ situations
- Parasympathetic division (slows down)
    - Prepares body for ‘resting and digesting’ activities

11.3.1.Sympathetic Division

- Thoracolumbar division – location of preganglionic neurons

- Preganglionic fibers leave spinal nerves through white rami and enter paravertebral ganglia

- Paraverterbral ganglia and fibers that connect them make up the sympathetic trunk

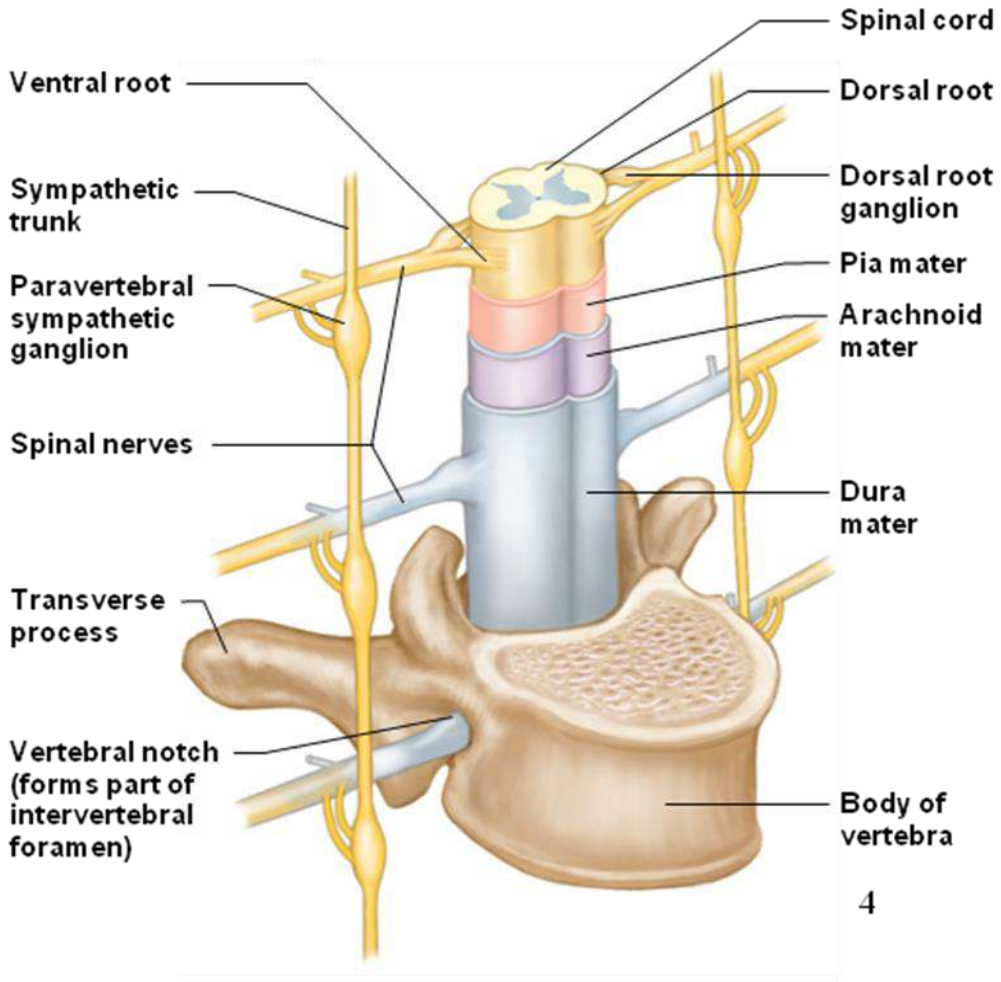


Figure108. Represente .Sympathetic Division

11.3.2.Para Sympathetic Division

- Craniosacral division – location of preganglionic neurons
- Ganglia are near or within various organs
    - Terminal ganglia
- Short postganglionic fibers
    - Continue to specific muscles or glands
- Preganglionic fibers of the head are included in nerves III, VII, and IX
- Preganglionic fibers of thorax and abdomen are parts of nerve X

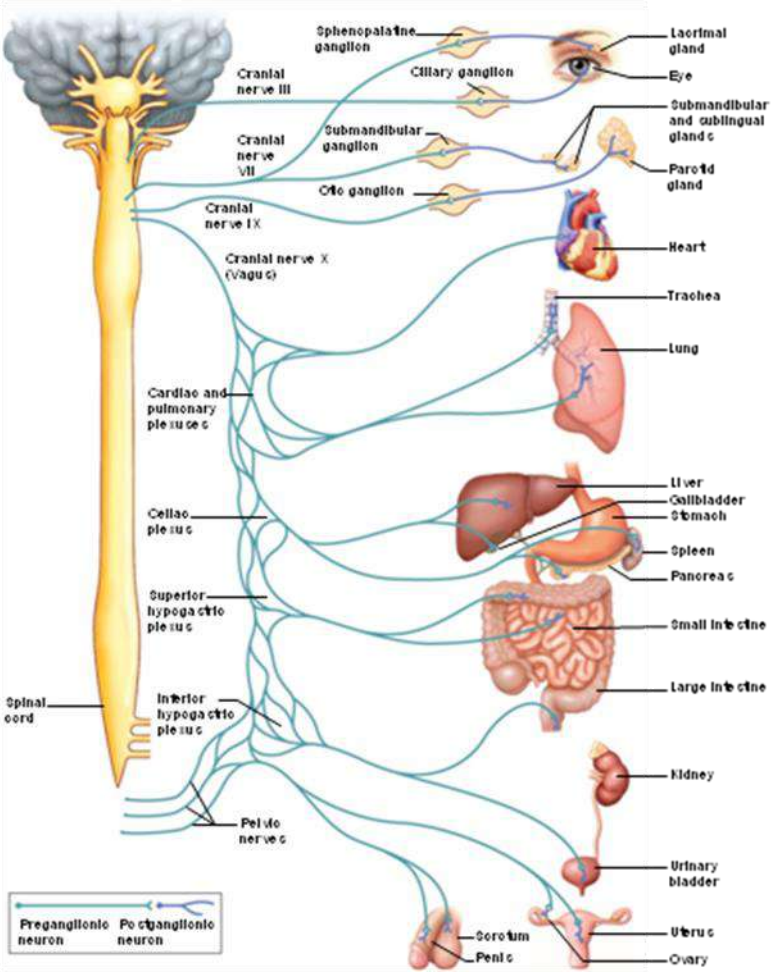


Figure109. Represente Para Sympathetic Division

12.Lifespan Changes

- Brain cells begin to die before birth
- Over average lifetime, brain shrinks 10%
- Most cell death occurs in temporal lobes
- By age 90, frontal cortex has lost half its neurons
- Number of dendritic branches decreases
- Decreased levels of neurotransmitters
- Fading memory
- Slowed responses and reflexes
- Increased risk of falling
- Changes in sleep patterns that result in fewer sleeping hours

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