Essentials of Human Anatomy & Physiology

Seventh Edition

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Chapter 3

Cells and Tissues

Slides 3.1 – 3.89

Lecture Slides in PowerPoint by Jerry L. Cook

Cells and Tissues

- Carry out all chemical activities needed to sustain life
- Cells are the building blocks of all living things
- Cells are bathed in a dilute saltwater solution called interstitial fluid derived from the blood
- Tissues are groups of cells that are similar in structure and function → organs → organ systems → organism

Anatomy of the Cell

- Cells are not all the same
  - Size, shape, and function very different
- All cells share general structures
- Cells are organized into three main regions
  - Nucleus
  - Cytoplasm
  - Plasma membrane

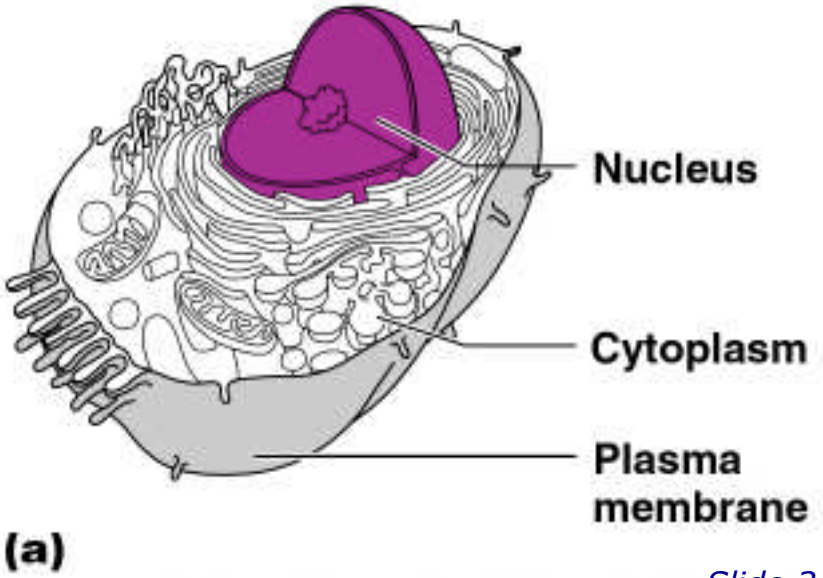


Figure 3.1a

The Nucleus

- Control center of the cell
  - Contains genetic material (DNA)
- Three regions
  - Nuclear membrane
  - Nucleolus
  - Chromatin

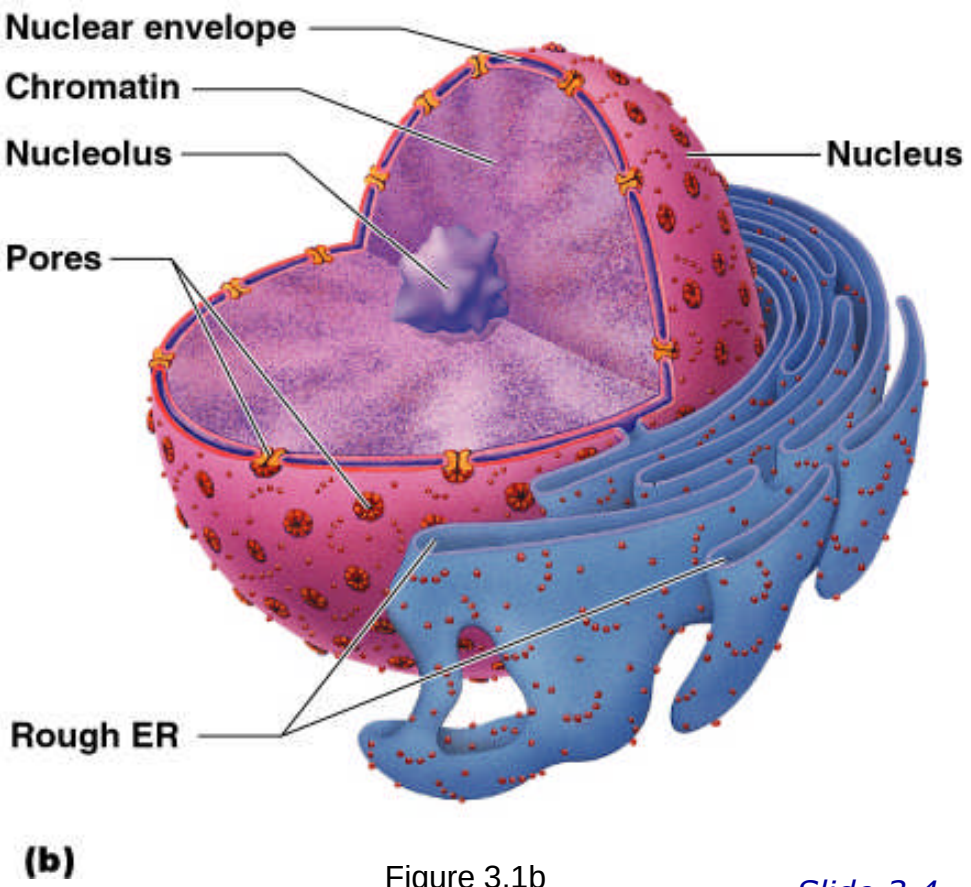


Figure 3.1b

Nuclear Membrane

- Barrier of the nucleus
- Consists of a selectively permeable, double phospholipid membrane
- Contains nuclear pores that allow for exchange of material with the rest of the cell
- Inside is the nucleoplasm containing the nucleoli and chromatin – fluid similar to cytoplasm

Nucleoli

- Nucleus contains one or more nucleoli (nucleolus - singular)
- Sites of ribosome production and partial assembly
  - Ribosomes then migrate to the cytoplasm through nuclear pores

Chromatin

- Composed of unwound DNA and protein – used for making proteins
- Scattered throughout the nucleus
- Chromatin condenses to form chromosomes when the cell divides

Plasma Membrane

- Barrier for cell contents
- Semi-permeable, Double phospholipid layer
  - Hydrophilic heads – water loving
  - Hydrophobic tails – water fearing
- Other materials in plasma membrane
  - Protein – receptors, cell recognition and communication, channels for transport
  - Cholesterol – keep membrane fluid and stable
  - Glycoproteins – receptors, cell-to-cell interactions

Plasma Membrane

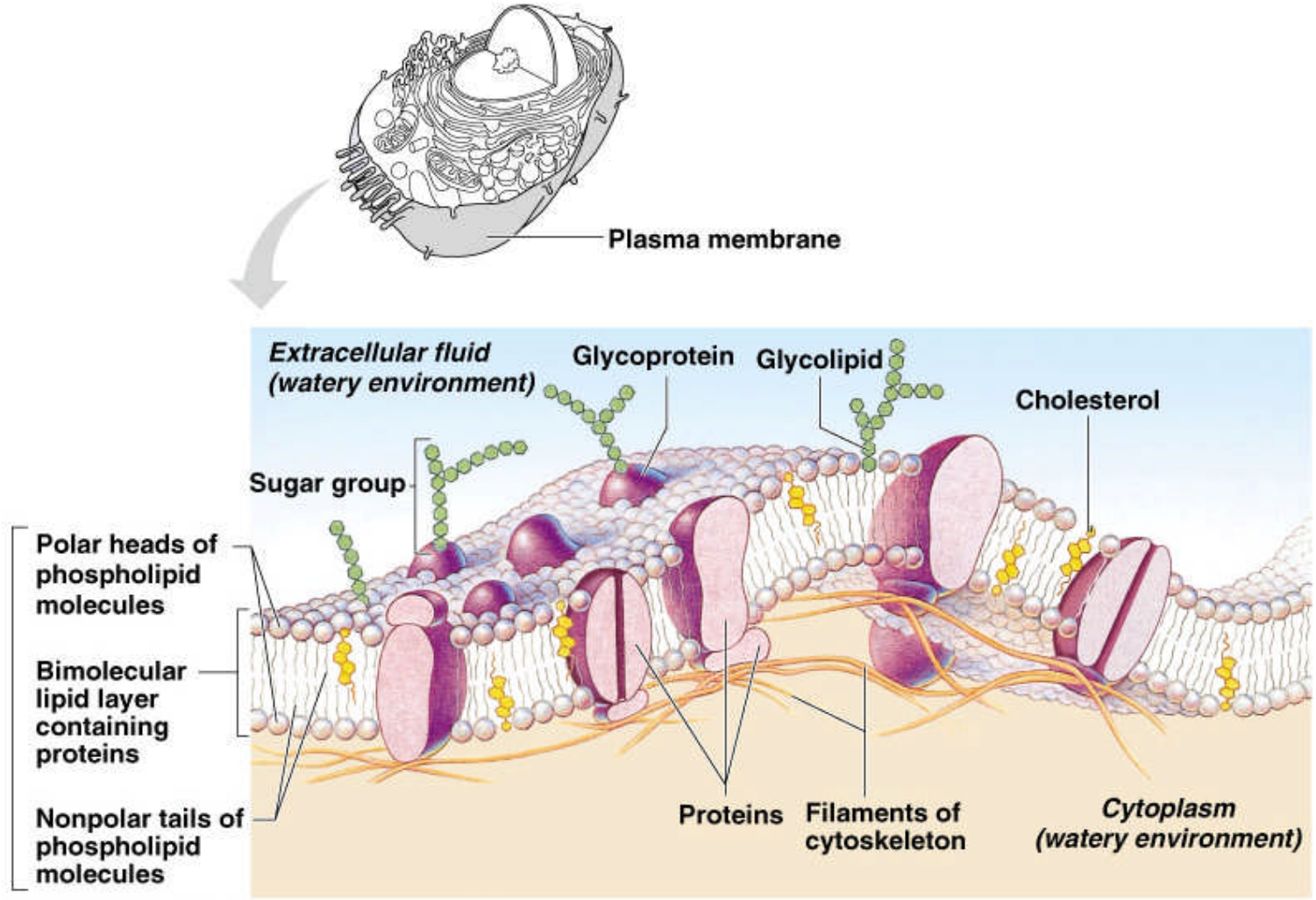


Figure 3.2

Plasma Membrane Specializations

- Microvilli
  - Finger-like projections that increase surface area for absorption

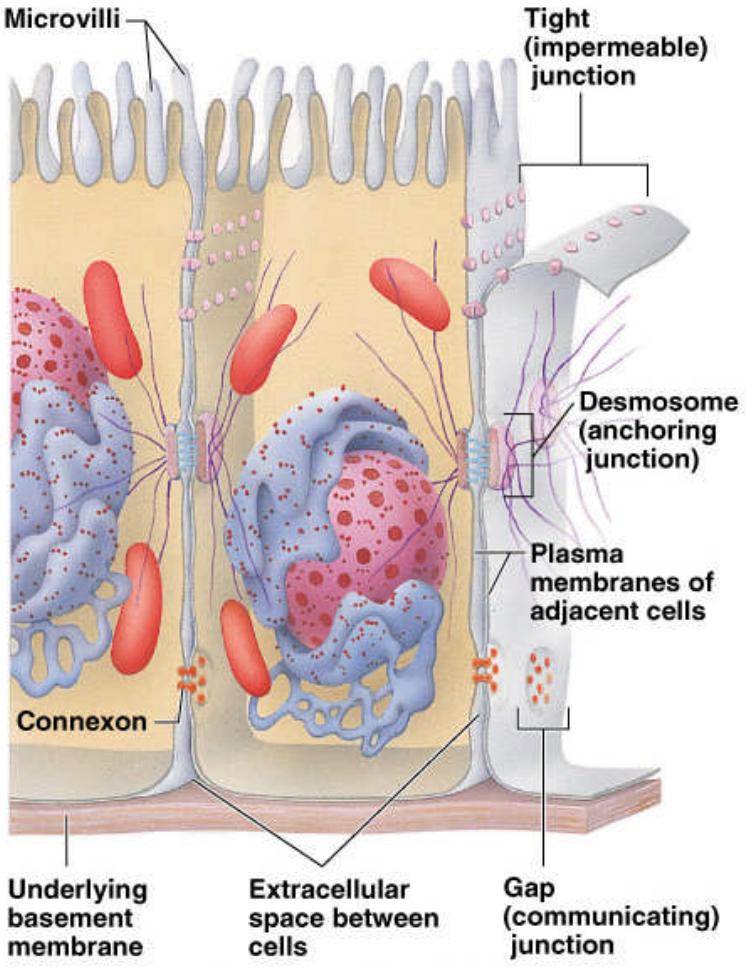


Figure 3.3

Plasma Membrane Specializations

- Membrane junctions
  - Tight junctions – impermeable, leakproof sheets
  - Desmosomes – anchorings that prevent cells from being separated
  - Gap junctions – allow communication between cells through connexons that span the two cell membranes

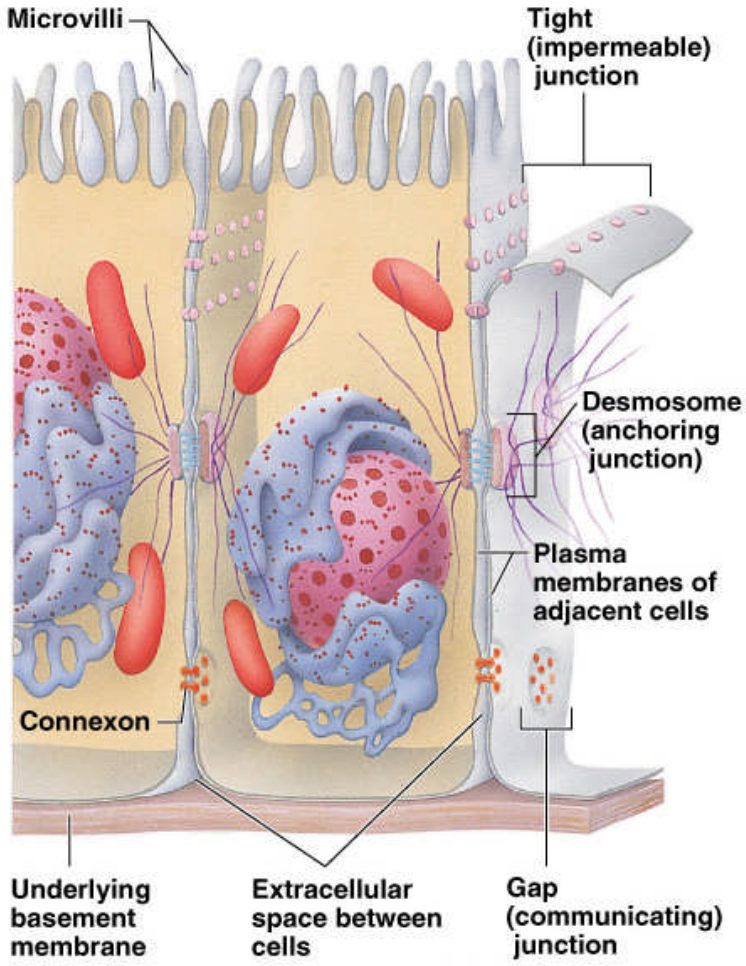


Figure 3.3

Cytoplasm

- Material outside the nucleus and inside the plasma membrane
  - Cytosol
    - Fluid containing nutrients dissolved in water that suspends other elements
  - Organelles
    - Metabolic machinery of the cell
  - Inclusions
    - Non-functioning units – stored nutrients such as fat droplets, glycogen granules, pigments, and mucus

Cytoplasmic Organelles

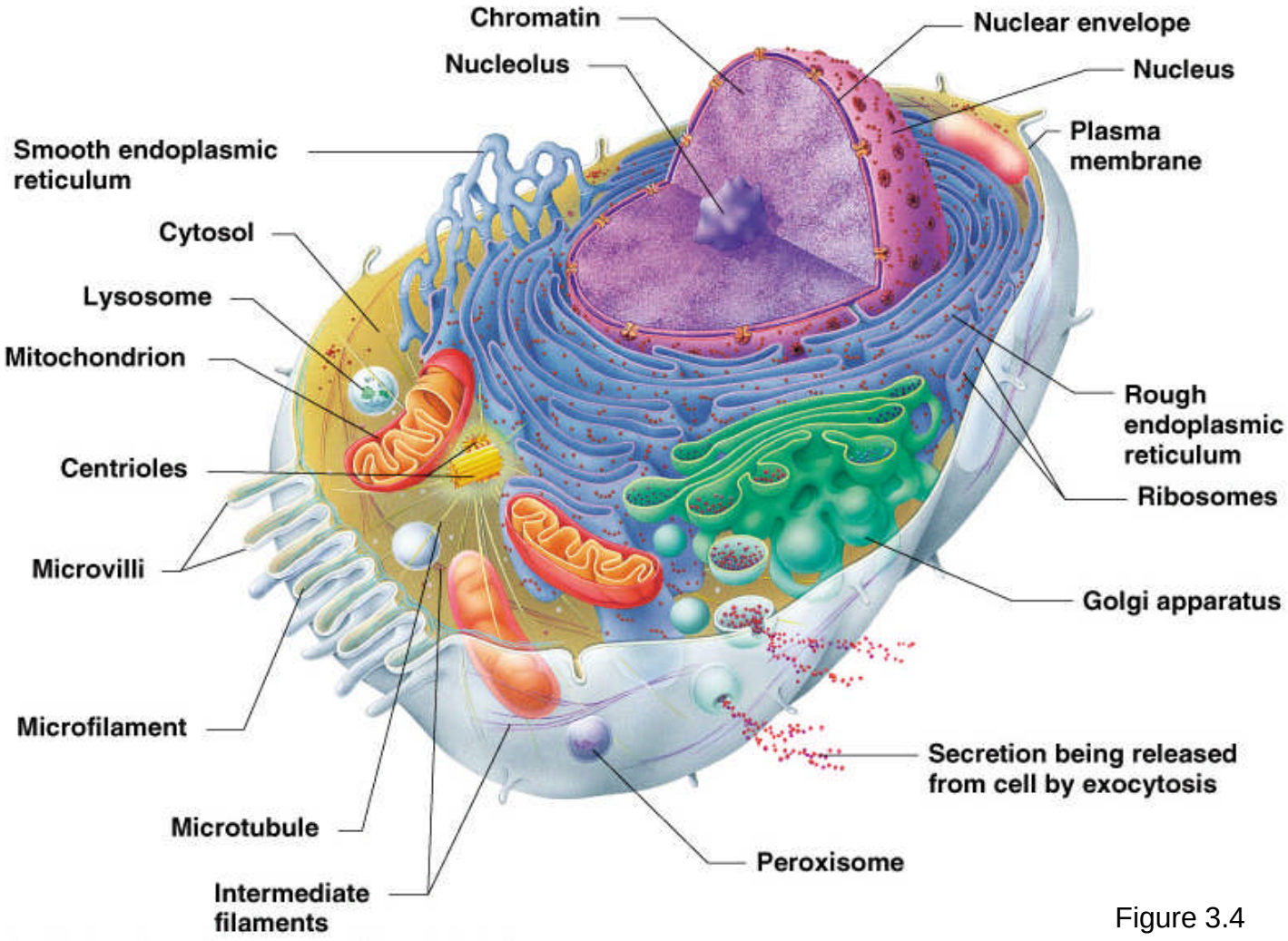


Figure 3.4

Cytoplasmic Organelles

- Mitochondria
  - “Powerhouses” of the cell
  - Change shape continuously
  - Has a double membrane and had its own DNA
  - Carry out reactions where oxygen is used to break down food – cell respiration
    - Provides ATP for cellular energy

Cytoplasmic Organelles

- Ribosomes
  - Made of protein and RNA
  - Sites of protein synthesis
  - Found at two locations
    - Free in the cytoplasm
    - Attached to rough endoplasmic reticulum

Cytoplasmic Organelles

- Endoplasmic reticulum (ER)
  - Fluid-filled tubules for carrying substances
  - Two types of ER
    - Rough Endoplasmic Reticulum
      - Studded with ribosomes
      - Site where building materials of cellular membrane are formed
    - Smooth Endoplasmic Reticulum
      - Functions in cholesterol synthesis and breakdown, fat metabolism, and detoxification of drugs

Cytoplasmic Organelles

- Golgi apparatus
  - Modifies and packages proteins
  - Produces different types of packages
    - Secretory vesicles – contain proteins for export
    - Cell membrane components to be added to the plasma membrane
    - Lysosomes – contain hydrolytic enzymes

Cytoplasmic Organelles

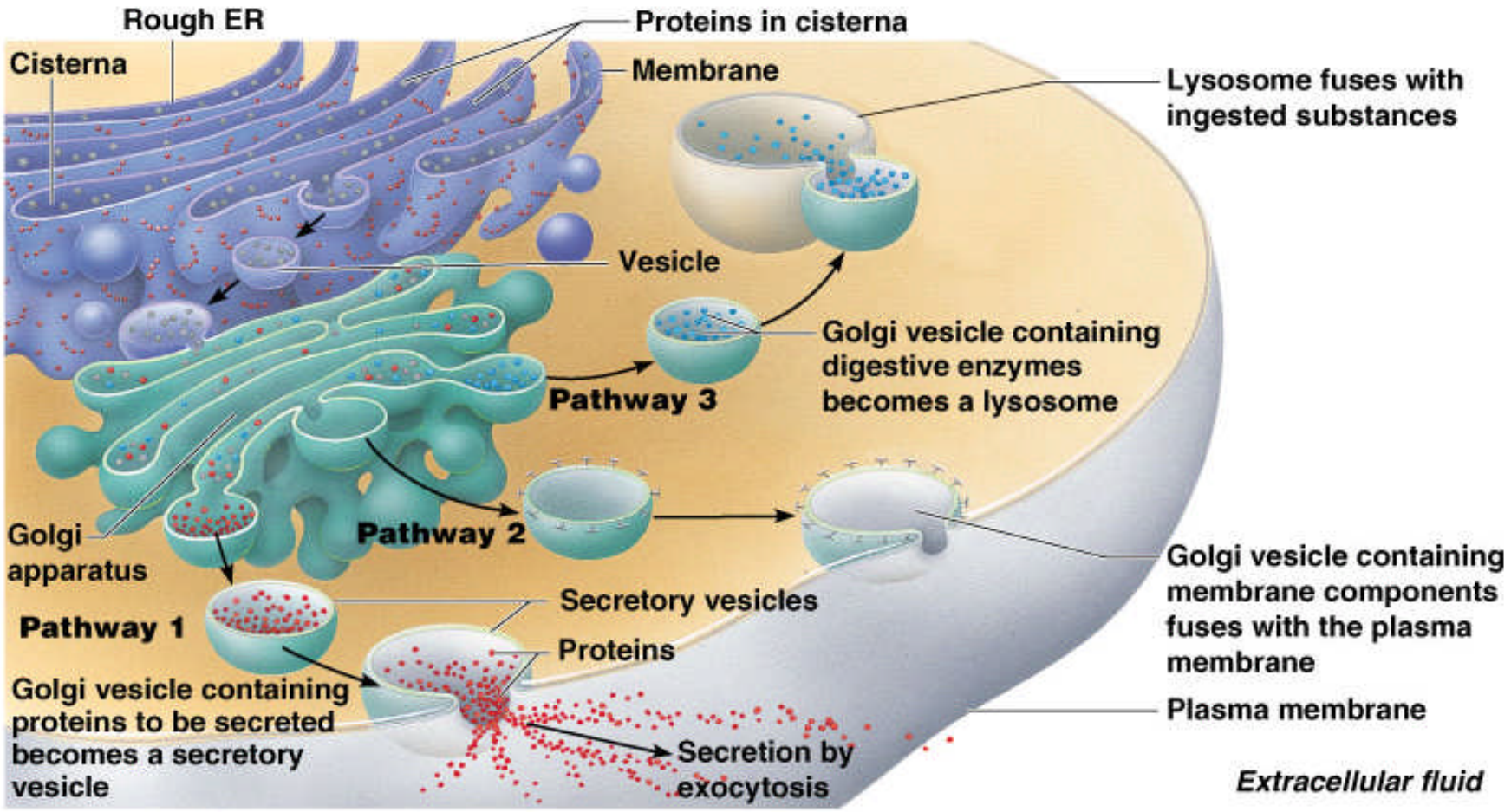


Figure 3.5

Cytoplasmic Organelles

- Lysosomes
  - Contain enzymes that digest non-usable materials within the cell such as old organelles as well as bacteria and viruses
- Peroxisomes
  - Membranous sacs of oxidase enzymes
    - Detoxify harmful substances using O_2
    - Break down free radicals (highly reactive chemicals with free electrons)
  - Replicate by pinching in half

Cytoplasmic Organelles

- Cytoskeleton
  - Network of protein structures that extend throughout the cytoplasm
  - Provides the cell with an internal framework
  - Determines cell shape, supports organelles, provides path for intracellular transport, involved in cell movement

Cytoplasmic Organelles

- Cytoskeleton
  - Three different types
    - Microfilaments – cell motility and changed in cell shape – actin and myosin
    - Intermediate filaments – help form desmosomes and internal guy wires
    - Microtubules – determine overall shape of a cell and location of organelles

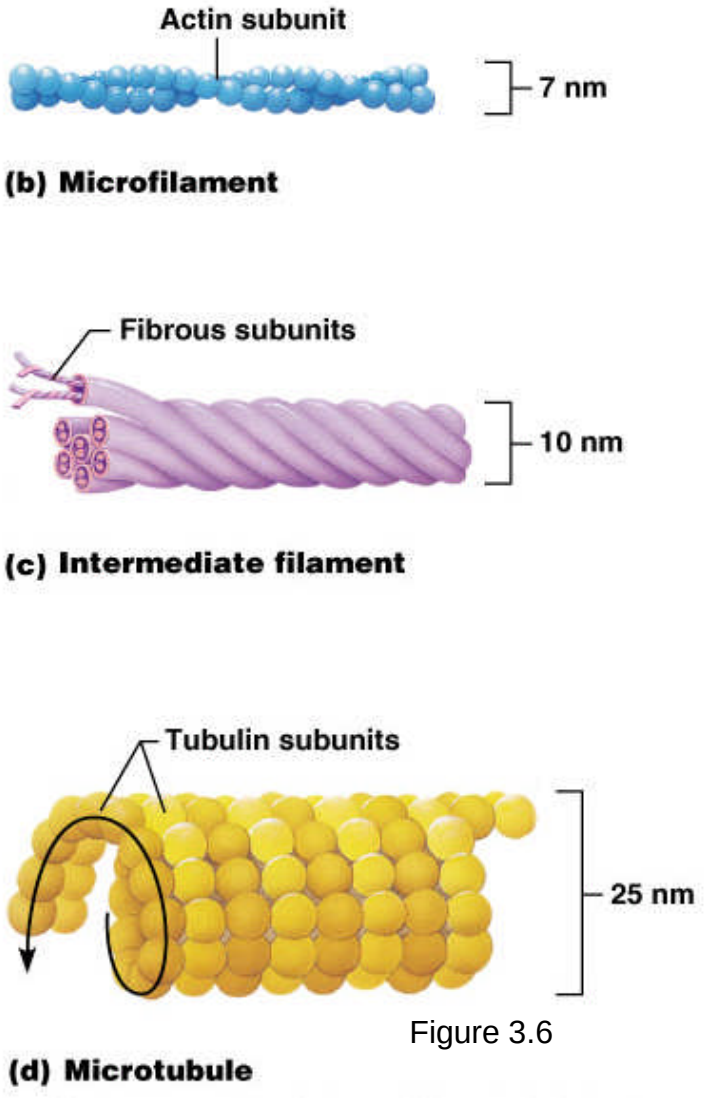


Figure 3.6

Cytoplasmic Organelles

- Centrioles
  - Rod-shaped bodies made of microtubules that lie at right angles to each other and near the nucleus
  - Direct formation of mitotic spindle during cell division

Cellular Projections

- Cilia and Flagella
  - Not found in all cells
  - Used for movement
    - Cilia moves materials across the cell surface – usually short and many
    - Flagellum propels the cell – usually long and few in number

Cell Diversity

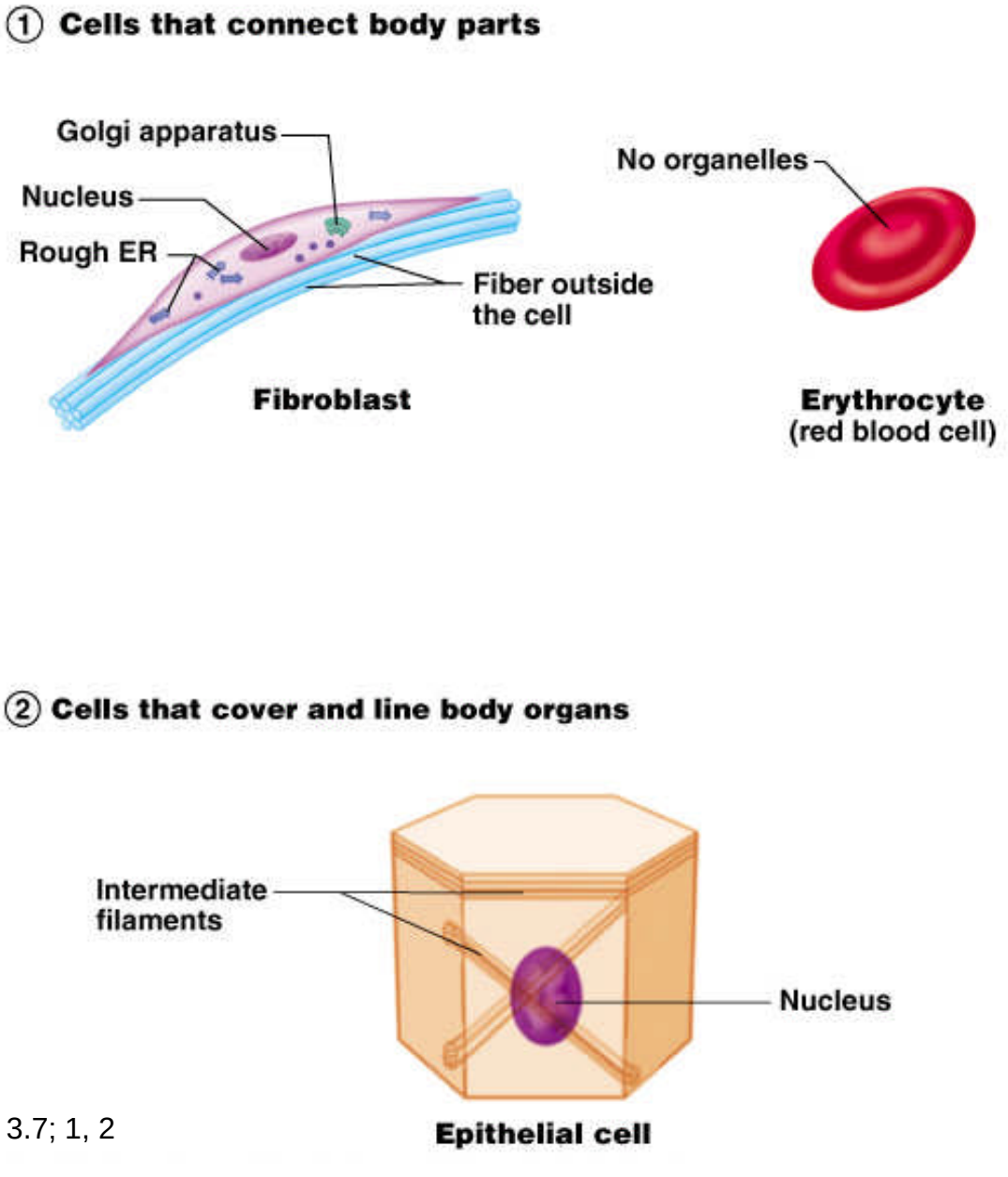


Figure 3.7; 1, 2

Cell Diversity

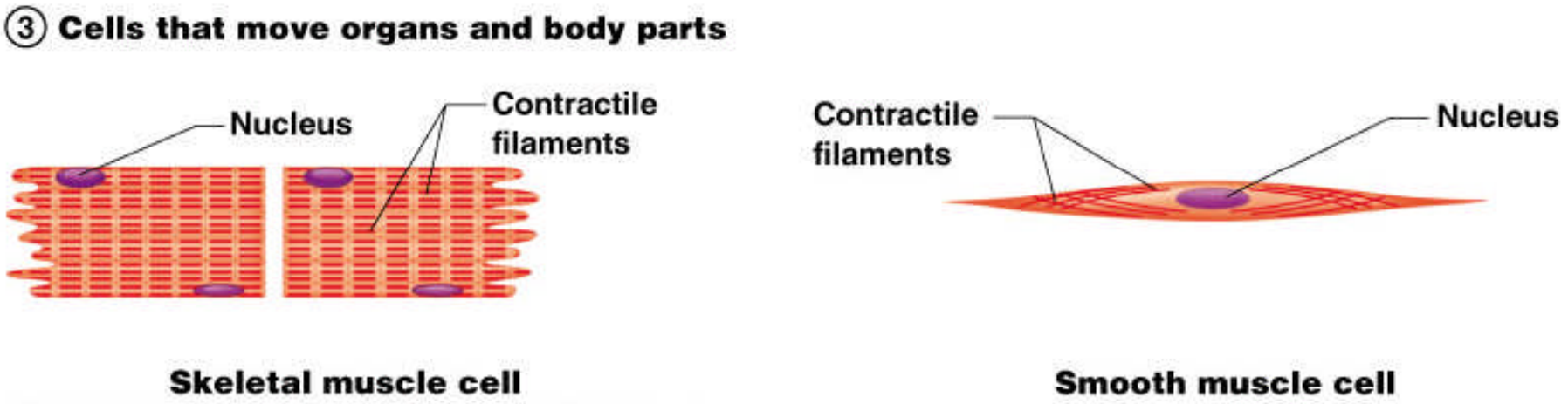


Figure 3.7; 3

Cell Diversity

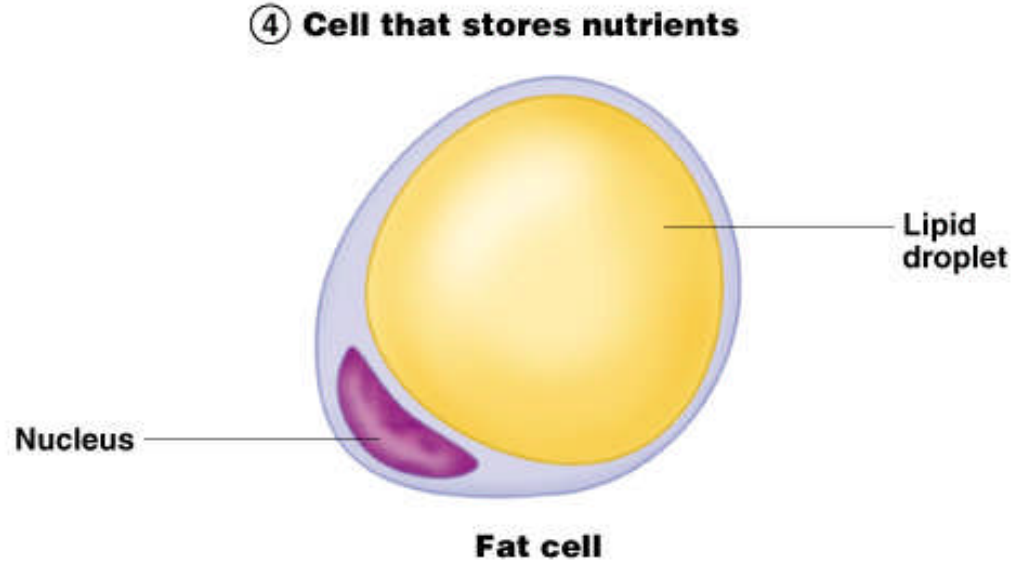
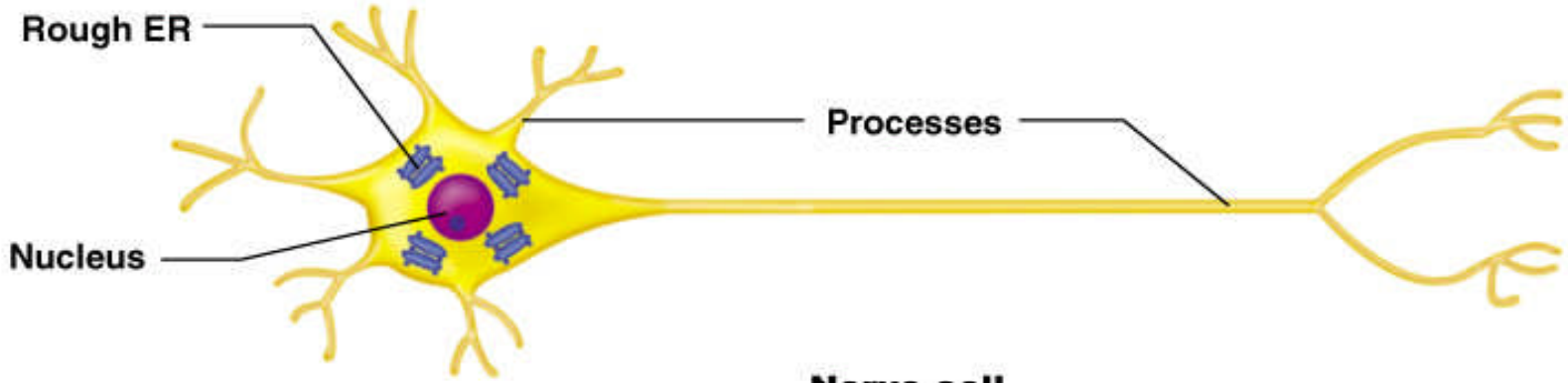


Figure 3.7; 4, 5

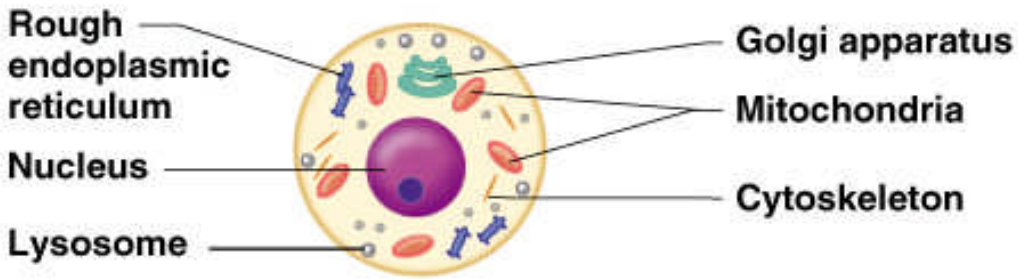
Cell Diversity

⑥ **Cell that gathers information and controls body functions**

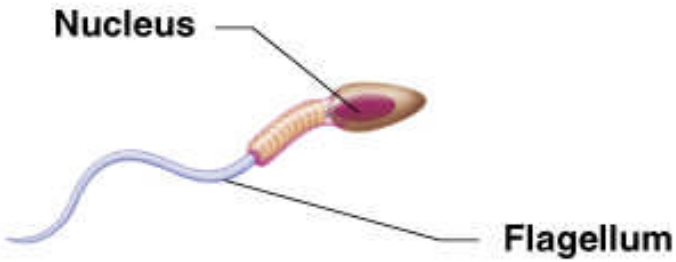


Nerve cell

⑦ **Cells of reproduction**



Ovum (egg)



Sperm

Figure 3.7; 6, 7

Solutions and Transport

- Solution – homogeneous mixture of two or more components
  - Solvent – dissolving medium
  - Solutes – components in smaller quantities within a solution
- Intracellular fluid – nucleoplasm and cytosol
- Interstitial fluid – fluid on the exterior of the cell

Cellular Physiology: Membrane Transport

- Membranes are selectively permeable –
- Membrane Transport – movement of substance into and out of the cell
- Transport is by two basic methods
  - Passive transport
    - No energy is required
  - Active transport
    - The cell must provide metabolic energy

Selective Permeability

- The plasma membrane allows some materials to pass while excluding others
- This permeability includes movement into and out of the cell

Passive Transport Processes

- Diffusion
  - Particles tend to distribute themselves evenly within a solution
  - Movement is from high concentration to low concentration, or down a concentration gradient

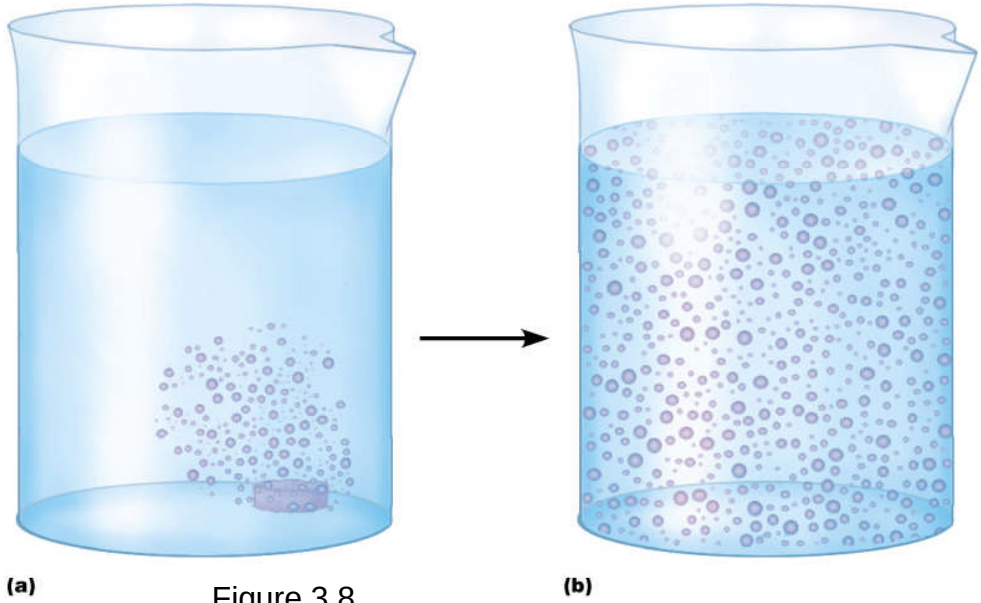


Figure 3.8

  - Movement is due to kinetic energy in the molecules and affected by size and temperature

Passive Transport Processes

- Types of diffusion
  - Simple diffusion – Passive diffusion
    - Unassisted process
    - Solutes are lipid-soluble materials or small enough to pass through membrane pores

Passive Transport Processes

- Types of diffusion
  - Osmosis – simple diffusion of water
    - Highly polar water easily crosses the plasma membrane
    - Occurs all the time
  - Facilitated diffusion
    - Substances require a protein carrier for passive transport
    - Still moving down concentration gradient and so no energy is needed

Diffusion through the Plasma Membrane

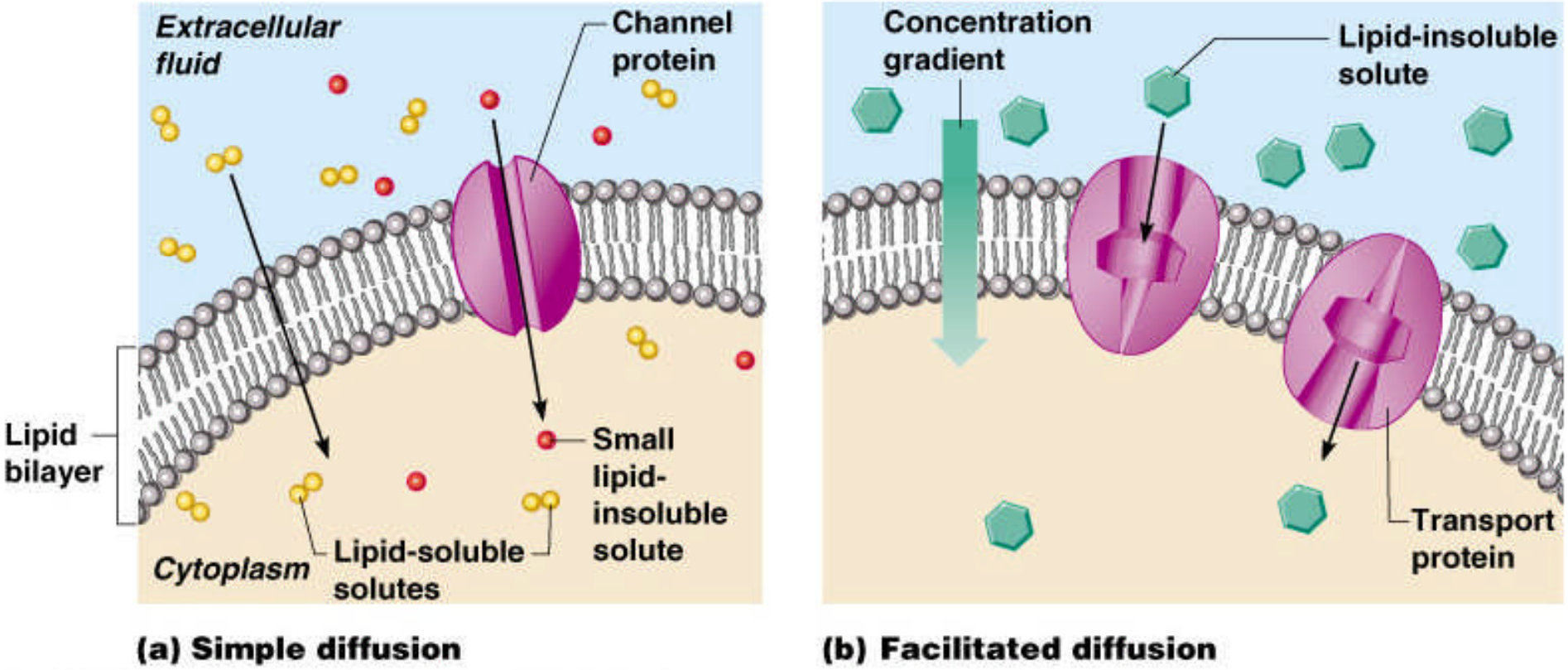


Figure 3.9

Passive Transport Processes

- Filtration
  - Water and solutes are forced through a membrane by fluid, or hydrostatic pressure
  - A pressure gradient must exist
    - Solute-containing fluid is pushed from a high pressure area to a lower pressure area
  - Not very selective on what is filtered out – size

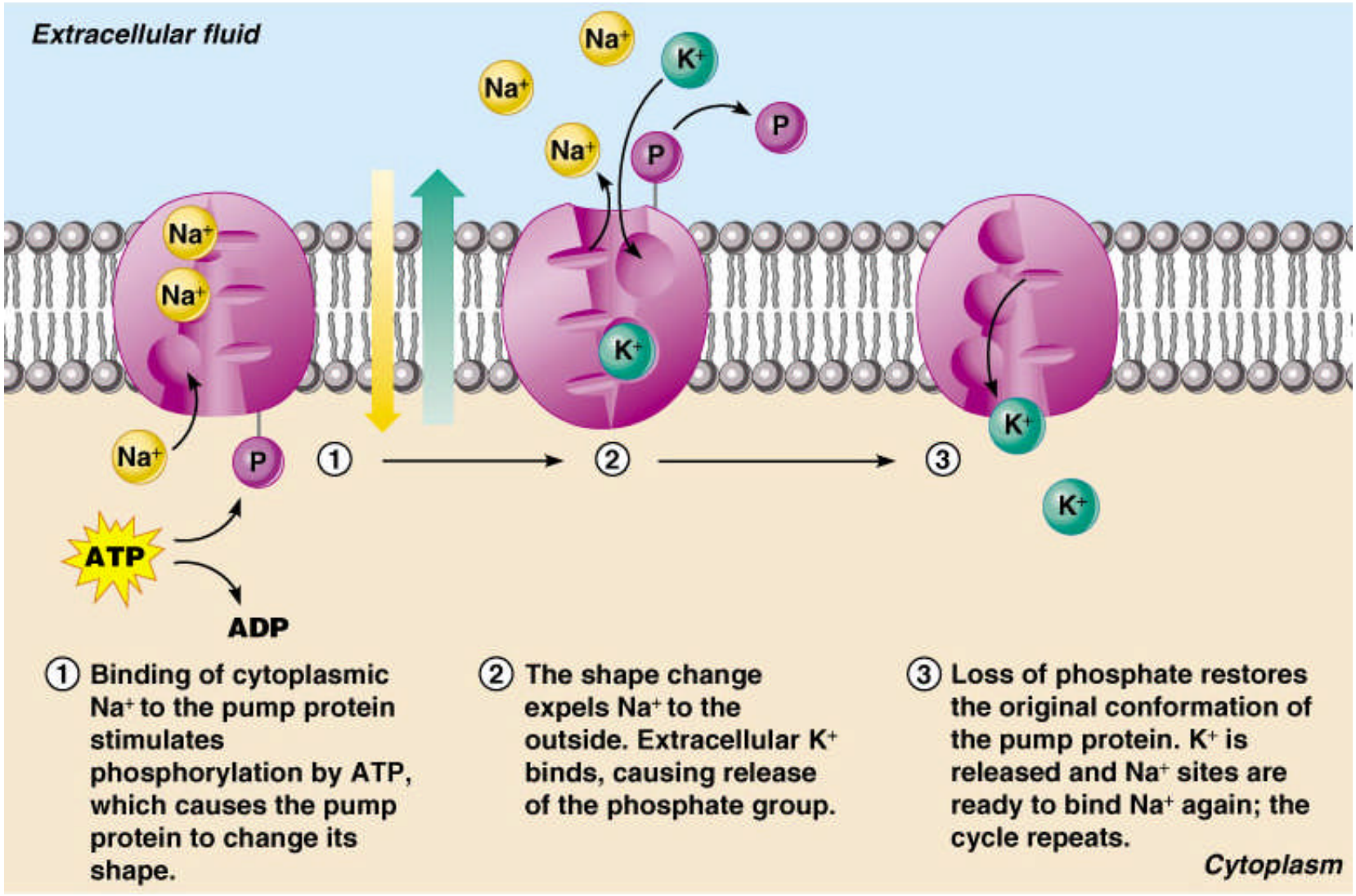
Active Transport Processes

- Transport substances that are unable to pass by diffusion
  - They may be too large
  - They may not be able to dissolve in the fat core of the membrane
  - They may have to move against a concentration gradient
- Two common forms of active transport
  - Solute pumping
  - Bulk transport

Active Transport Processes

- Solute pumping
  - Amino acids, some sugars and ions are transported by solute pumps
  - ATP energizes protein carriers, and in most cases, moves substances *against* concentration gradients
  - Can transport different molecules different directions such as the sodium-potassium pump

Active Transport Processes



① Binding of cytoplasmic Na^+ to the pump protein stimulates phosphorylation by ATP, which causes the pump protein to change its shape.

② The shape change expels Na^+ to the outside. Extracellular K^+ binds, causing release of the phosphate group.

③ Loss of phosphate restores the original conformation of the pump protein. K^+ is released and Na^+ sites are ready to bind Na^+ again; the cycle repeats.

Figure 3.10

Active Transport Processes

- Bulk transport
  - Exocytosis
    - Moves materials out of the cell
    - Material is carried in a membranous vesicle
    - Vesicle migrates to plasma membrane
    - Vesicle combines with plasma membrane
    - Material is emptied to the outside

Active Transport Processes

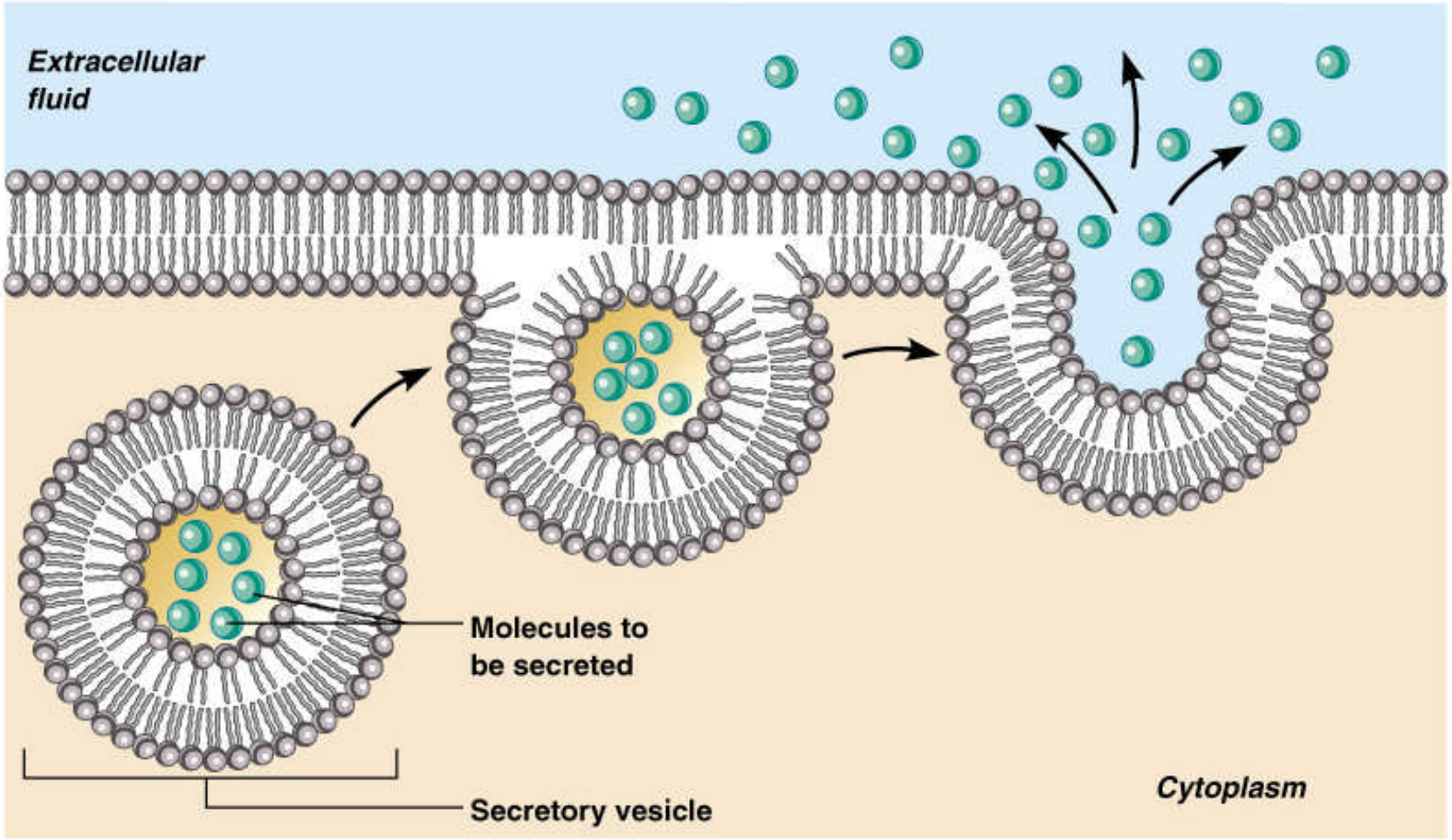
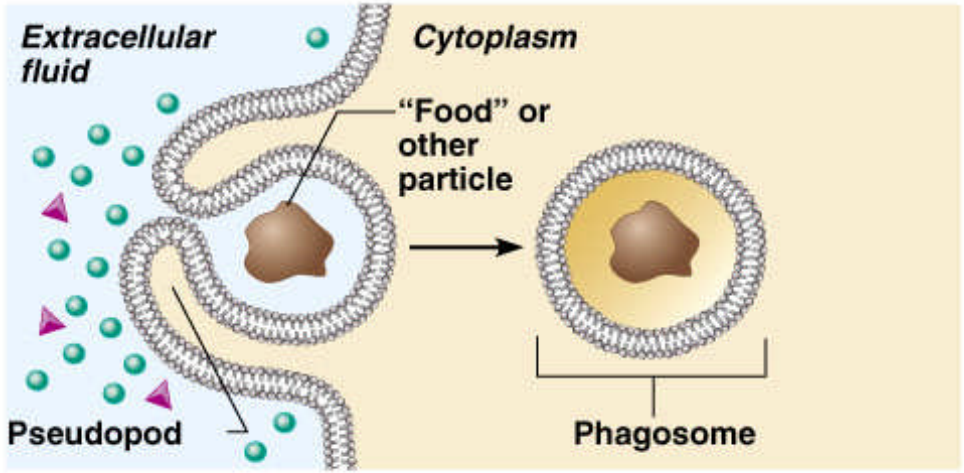


Figure 3.11

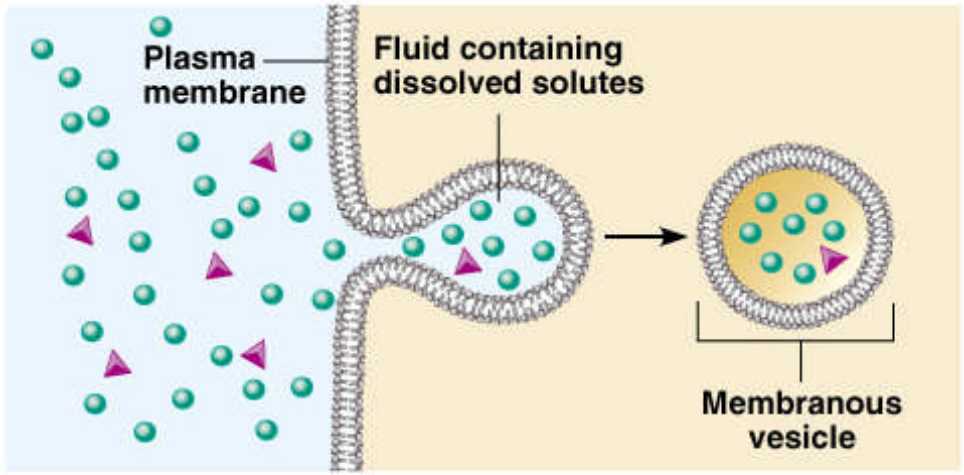
Active Transport Processes

- Bulk transport
  - Endocytosis
    - Extracellular substances are engulfed by being enclosed in a membranous vescicle
  - Types of endocytosis
    - Phagocytosis – cell eating
    - Pinocytosis – cell drinking

Active Transport Processes



(a) Phagocytosis



(b) Bulk-phase endocytosis

Figure 3.12

Cell Life Cycle

- Series of changes a cell goes through from the time it is formed until it divides
- Cells have two major periods
  - Interphase – metabolic phase
    - Longest phase where the cell grows
    - Cell carries on metabolic processes
  - Cell division
    - Cell replicates itself
    - Function is to produce more cells for growth and repair processes

DNA Replication

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

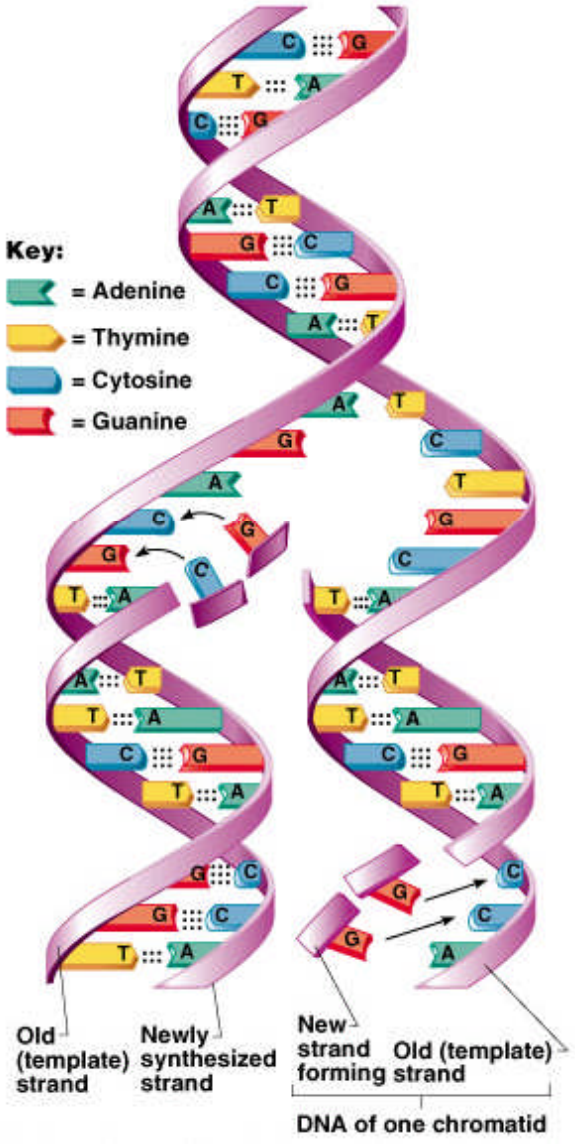


Figure 3.13

Events of Cell Division

- Mitosis
  - Division of the nucleus
  - Results in the formation of two daughter nuclei
- Cytokinesis
  - Division of the cytoplasm
  - Begins when mitosis is near completion
  - Results in the formation of two daughter cells

Stages of Mitosis

- Interphase
  - No cell division occurs
  - The cell carries out normal metabolic activity and growth
- Prophase
  - First part of cell division
  - Centromeres migrate to the poles and direct the assembly of the mitotic spindle
  - Chromosomes form

Stages of Mitosis

- Metaphase
  - Spindle from centromeres are attached to chromosomes that are aligned in the center of the cell

Stages of Mitosis

- Anaphase
  - Daughter chromosomes are pulled toward the poles
  - The cell begins to elongate
- Telophase
  - Daughter nuclei begin forming
  - A cleavage furrow (for cell division) begins to form and finished dividing the cell into two by the end of cytokinesis
  - Everything from prophase is reversed

Stages of Mitosis

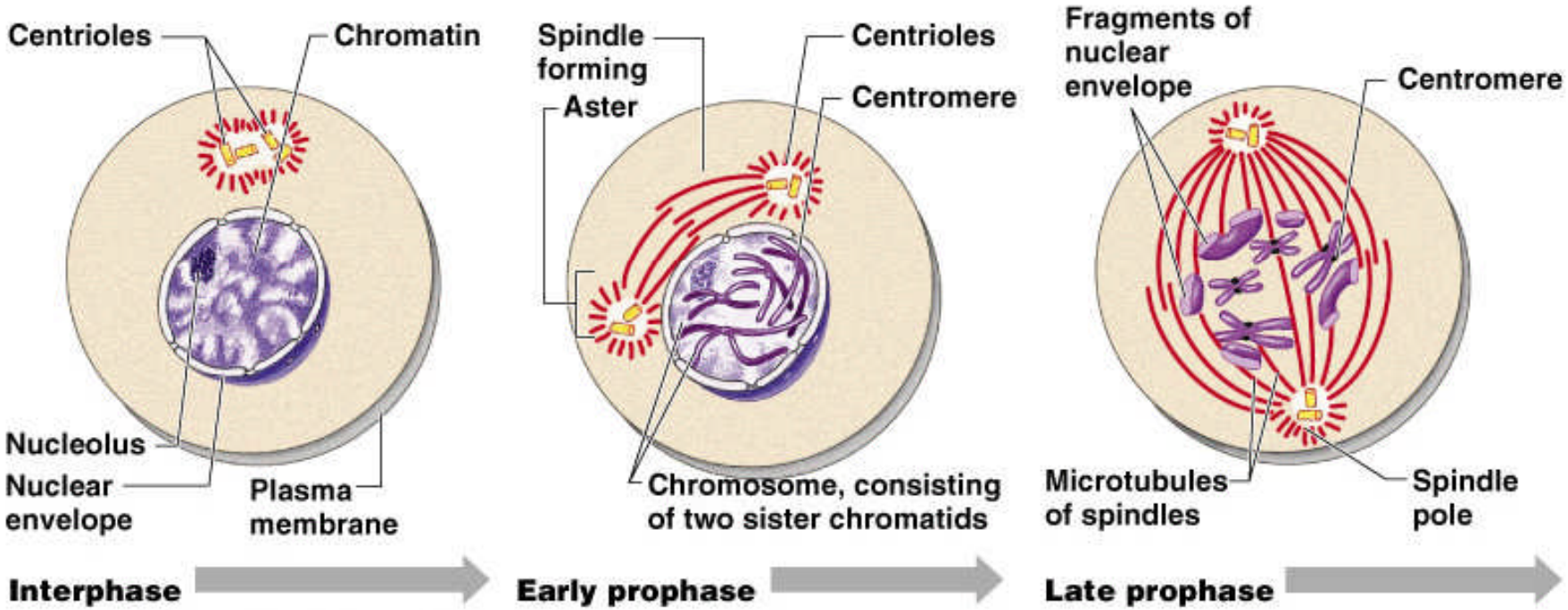


Figure 3.14; 1

Stages of Mitosis

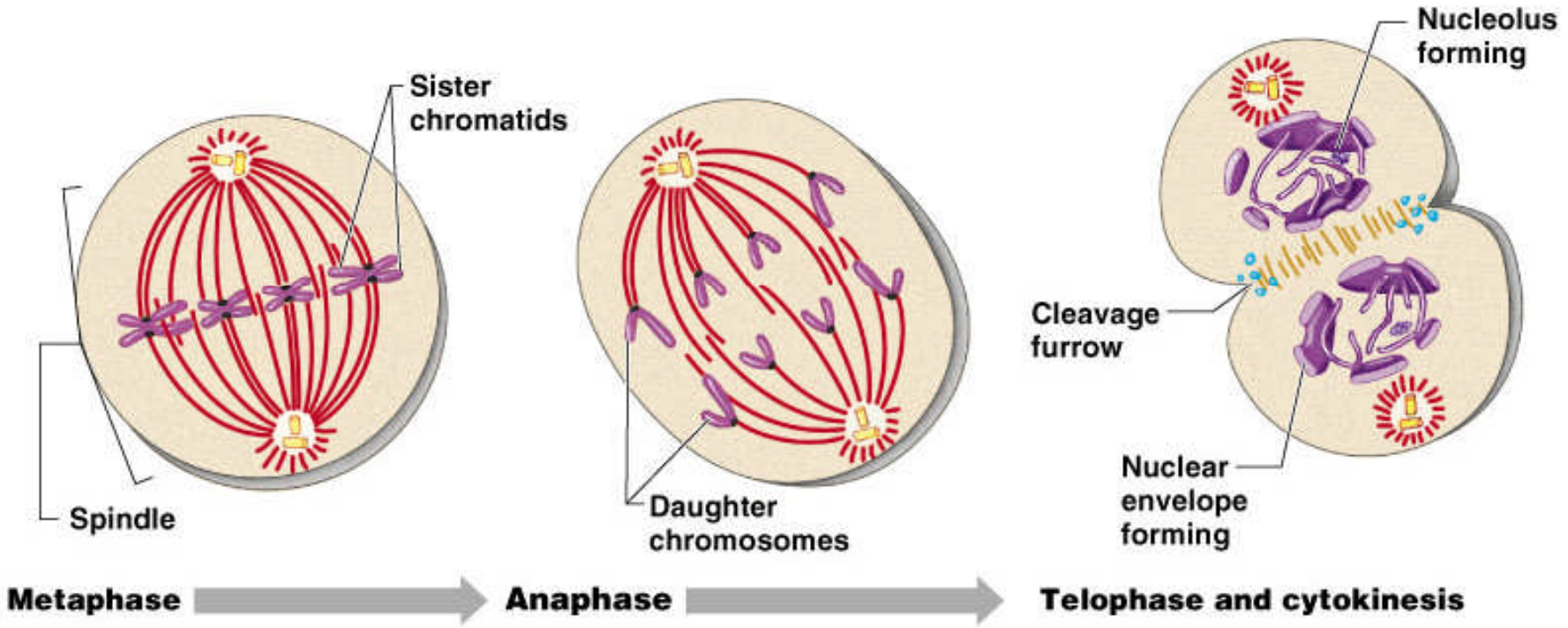


Figure 3.14; 2

Protein Synthesis

- Gene – DNA segment that carries a blueprint for building one protein
- Proteins have many functions
  - Building materials for cells
  - Act as enzymes (biological catalysts)
- RNA is essential for protein synthesis

Role of RNA

- Transfer RNA (tRNA)
  - Transfers appropriate amino acids to the ribosome for building the protein
- Ribosomal RNA (rRNA)
  - Helps form the ribosomes along with proteins where proteins are built
- Messenger (mRNA)
  - Carries the instructions for building a protein from the nucleus to the ribosome

Transcription and Translation

- Transcription
  - Transfer of information from DNA's base sequence to the complimentary base sequence of mRNA – switching T for U
- Translation
  - Base sequence of mRNA is translated to an amino acid sequence based on codon/anticodon complements
    - Amino acids are the building blocks of proteins

Protein Synthesis

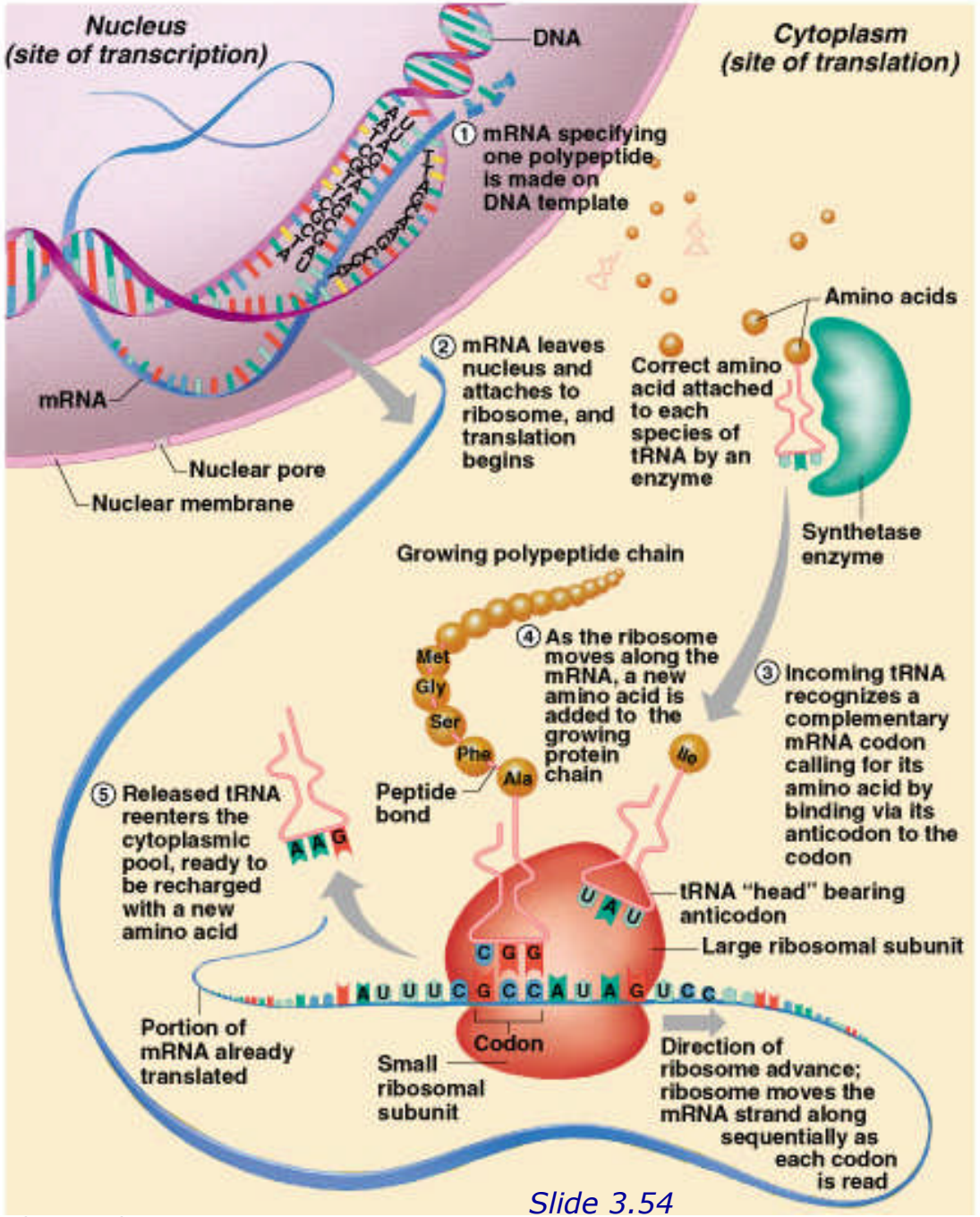


Figure 3.15

Slide 3.54

Body Tissues

- Cells are specialized for particular functions
- Tissues
  - Groups of cells with similar structure and function
  - Four primary types
    - Epithelium - covering
    - Connective tissue - support
    - Nervous tissue - control
    - Muscle - movement

Epithelial Tissues

- Found in different areas
  - Body coverings
  - Body linings
  - Glandular tissue
- Functions
  - Protection
  - Absorption
  - Filtration
  - Secretion

Epithelium Characteristics

- Cells fit closely together
- Tissue layer always has one free surface – unattached, the apical surface
- The lower surface is bound by a basement membrane – structureless material secreted by the cells
- Avascular (have no blood supply) – depend on diffusion
- Regenerate easily if well nourished

Classification of Epithelium

- Number of cell layers
  - Simple – one layer
  - Stratified – more than one layer

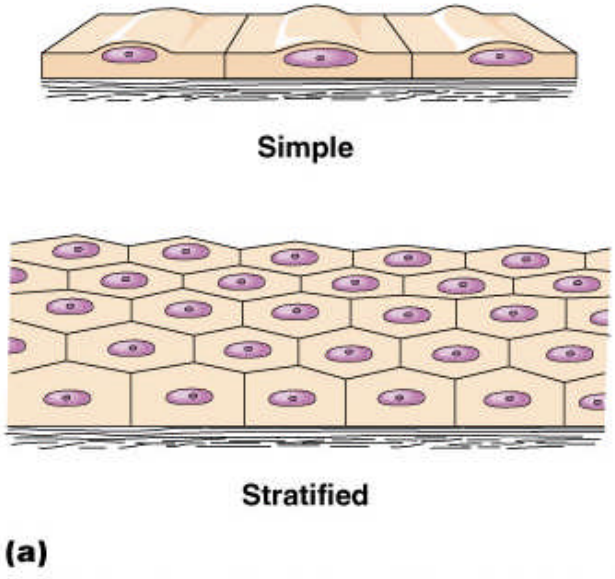


Figure 3.16a

Classification of Epithelium

- Shape of cells
  - Squamous – flattened
  - Cuboidal – cube-shaped
  - Columnar – column-like

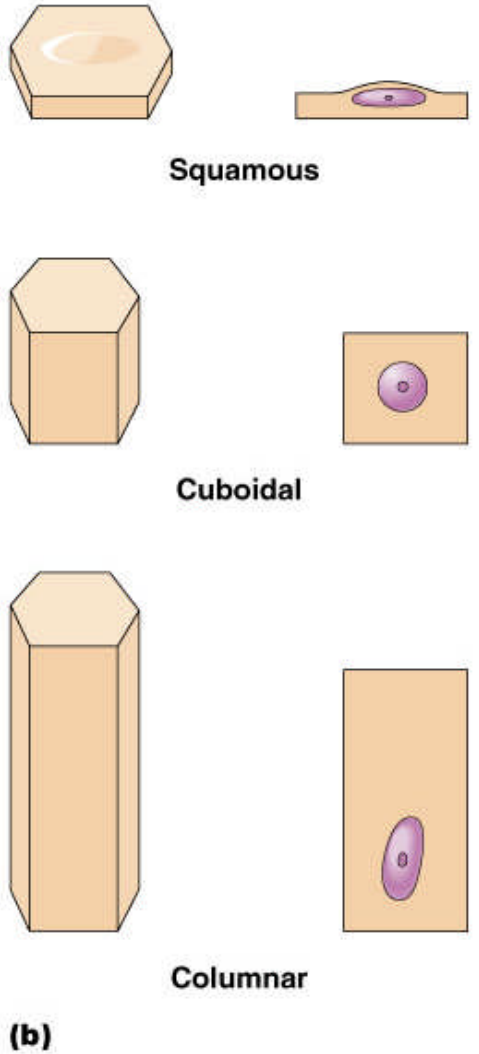
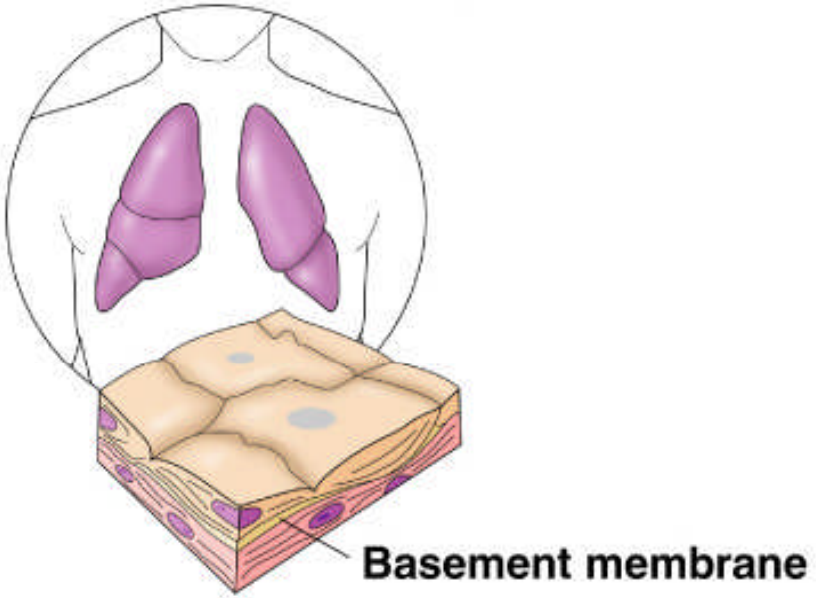


Figure 3.16b (b)

Simple Epithelium

- Simple squamous
  - Single layer of flat cells
  - Usually forms membranes where filtration or exchange occurs
    - Lines body cavities – serous membranes
    - Lines lungs and capillaries



(a) Simple squamous

Figure 3.17a

Simple Epithelium

- Simple cuboidal
  - Single layer of cube-like cells
  - Common in glands and their ducts
  - Forms walls of kidney tubules
  - Covers the ovaries

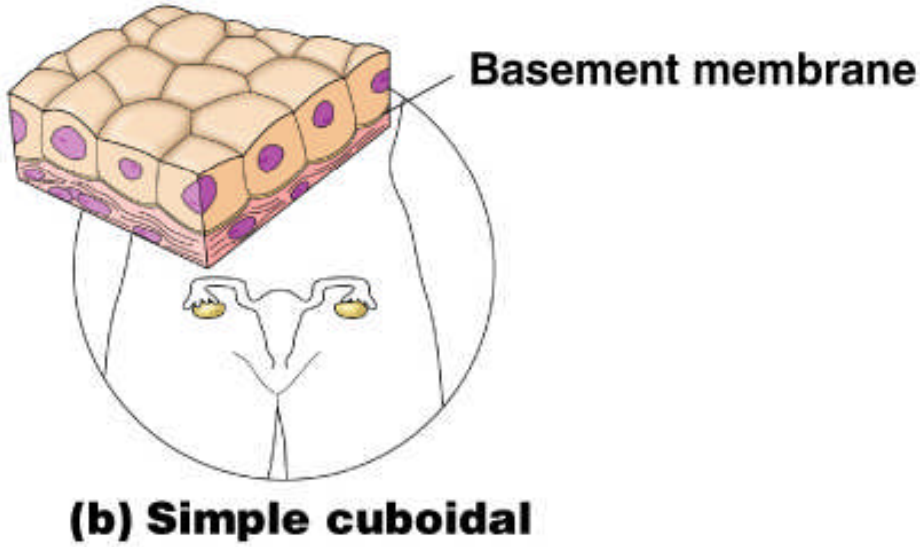


Figure 3.17b

Simple Epithelium

- Simple columnar
  - Single layer of tall cells that fit closely together
  - Often includes goblet cells, which produce mucus
  - Lines digestive tract
  - Mucosae – mucous membranes line body cavities open to the body exterior

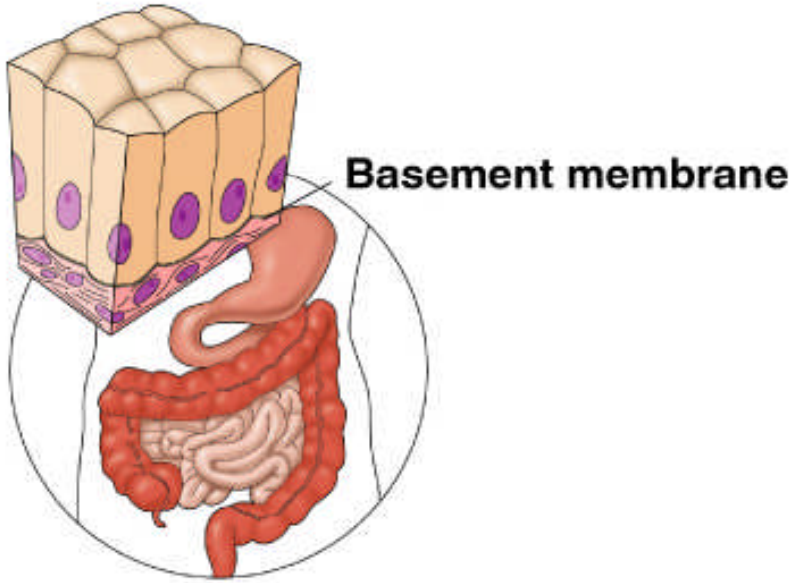


Figure 3.17c

Simple Epithelium

- Pseudostratified columnar
  - Single layer, but some cells are shorter than others
  - Often looks like a double cell layer
  - Sometimes ciliated, such as in the respiratory tract
  - May function in absorption or secretion

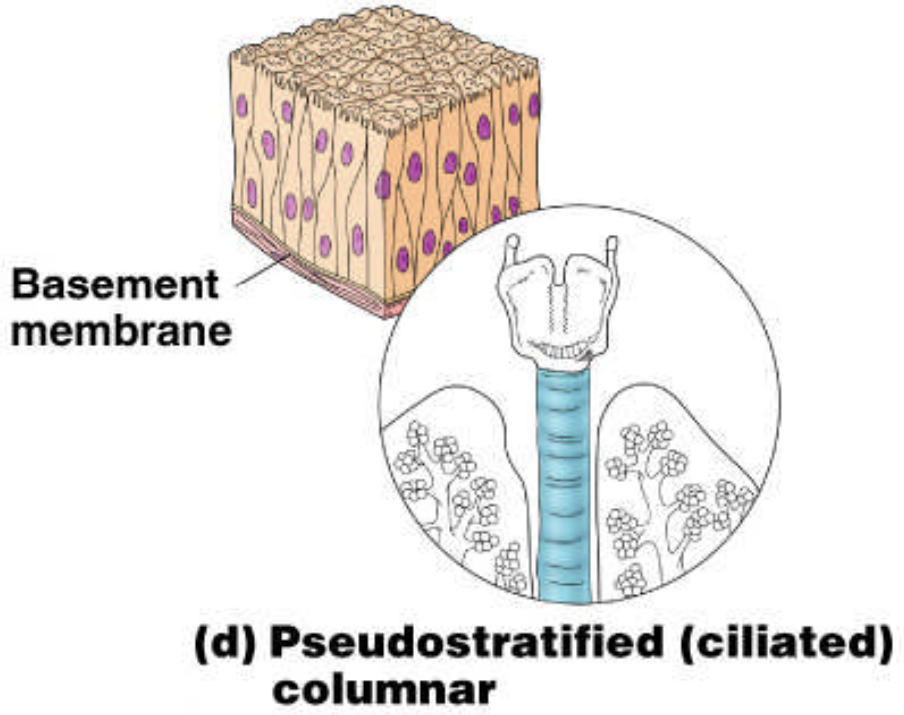


Figure 3.17d

Stratified Epithelium – 2+ layers

- Stratified squamous
  - Cells at the free edge are flattened while cells close to the basement membrane are cuboidal or columnar
  - Found as a protective covering where friction is common
  - Locations
    - Skin
    - Mouth
    - Esophagus

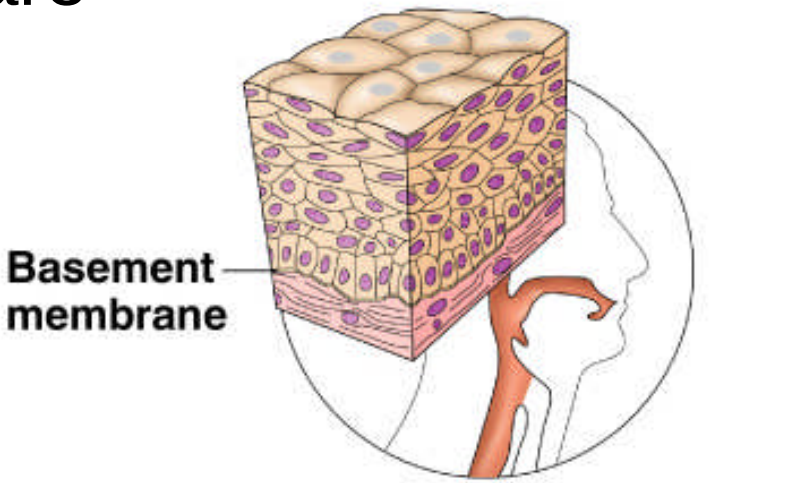


Figure 3.17e

Stratified Epithelium

- Stratified cuboidal
  - Two layers of cuboidal cells
- Stratified columnar
  - Surface cells are columnar, cells underneath vary in size and shape
- Stratified cuboidal and columnar
  - Rare in human body
  - Found mainly in ducts of large glands

Stratified Epithelium

- Transitional epithelium
  - Shape of cells depends upon the amount of stretching
  - Cells of the basal layer are cuboidal or columnar while those at the free surface vary
  - Lines organs of the urinary system

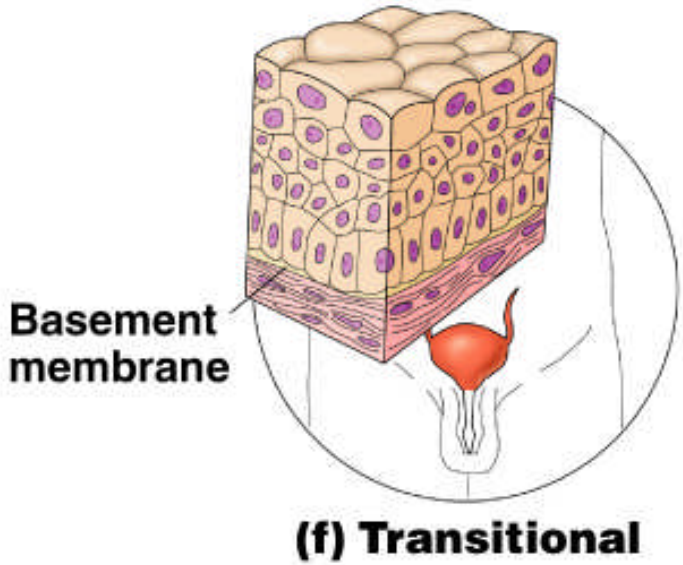


Figure 3.17f

Glandular Epithelium

- Gland – one or more cells that secretes a particular product – a secretion, which contains protein molecules in an aqueous fluid
- Two major gland types
  - Endocrine gland
    - Ductless
    - Secretions are hormones – diffuse into blood
  - Exocrine gland
    - Empty through ducts to the epithelial surface
    - Include sweat and oil glands

Connective Tissue

- Found everywhere in the body
- Includes the most abundant and widely distributed tissues
- Functions
  - Binds body tissues together
  - Supports the body
  - Provides protection

Connective Tissue Characteristics

- Variations in blood supply
  - Some tissue types are well vascularized
  - Some have poor blood supply or are avascular such as tendons, ligaments, and cartilage
- Extracellular matrix
  - Non-living material that surrounds living cells

Extracellular Matrix

- Two main elements
  - Ground substance – mostly water along with adhesion proteins and polysaccharide molecules
  - Fibers
    - Produced by the cells
    - Three types
      - Collagen fibers
      - Elastic fibers
      - Reticular fibers

Connective Tissue Types

- Bone (osseous tissue)
  - Composed of:
    - Bone cells in lacunae (cavities)
    - Hard matrix of calcium salts
    - Large numbers of collagen fibers
  - Used to protect and support the body

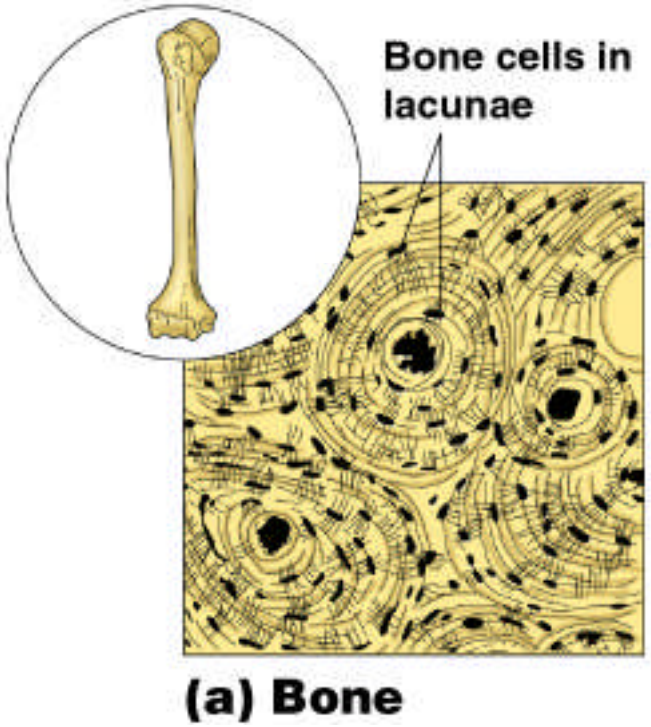


Figure 3.18a

Connective Tissue Types

- Hyaline cartilage
  - Most common cartilage
  - Composed of:
    - Abundant collagen fibers
    - Rubbery matrix
  - Entire fetal skeleton is hyaline cartilage

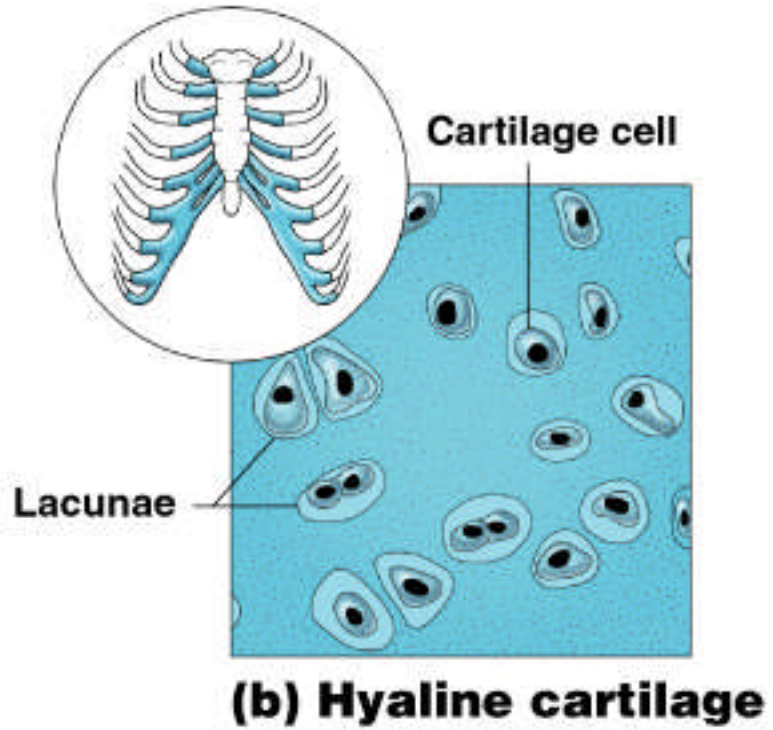


Figure 3.18b

Connective Tissue Types

- Fibrocartilage
  - Highly compressible
  - Example: forms cushion-like discs between vertebrae

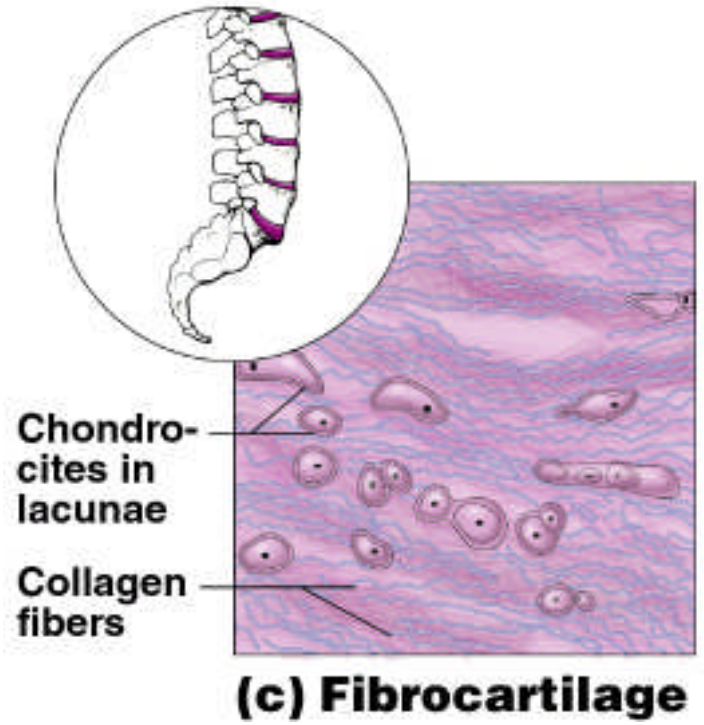
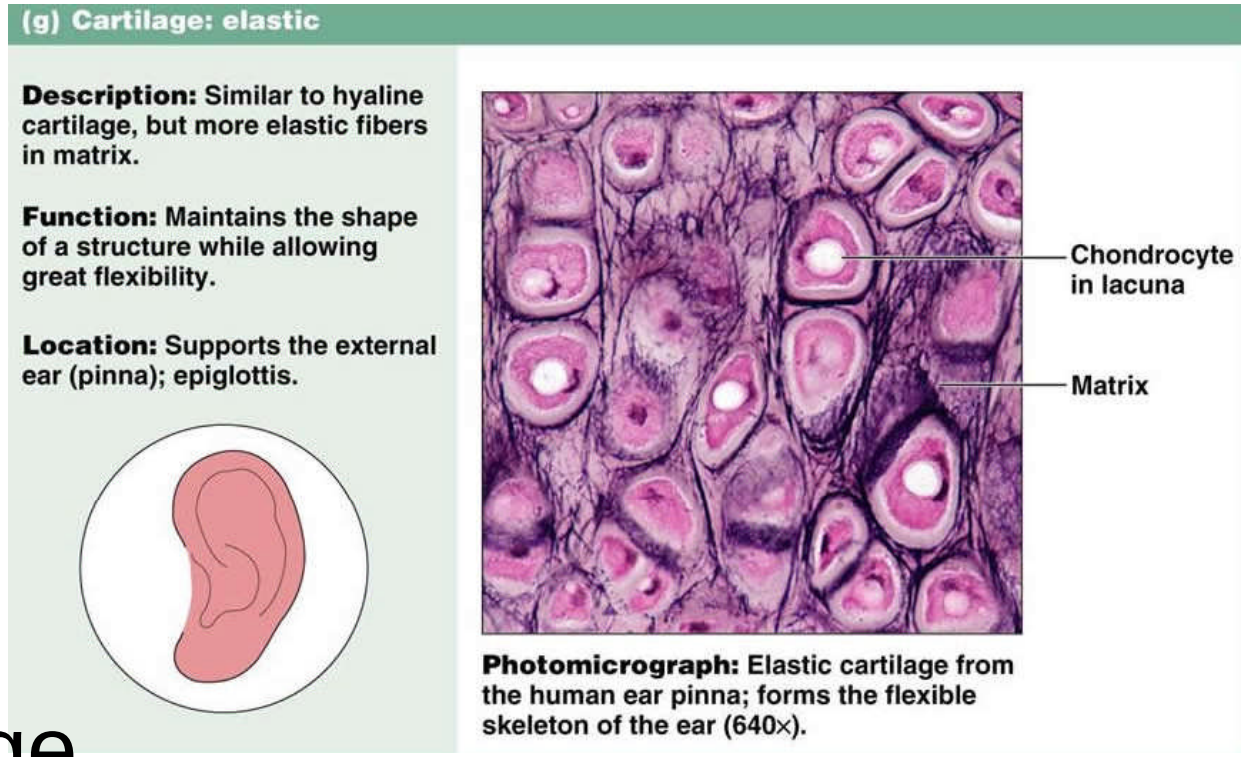


Figure 3.18c

Connective Tissue Types



- Elastic cartilage
  - Provides elasticity
  - Example: supports the external ear

Connective Tissue Types

- Dense connective tissue
  - Main matrix element is collagen fibers
  - Crowed between the collagen fibers are rows of cells called fibroblasts
  - Examples
    - Tendon – attach muscle to bone
    - Ligaments – attach bone to bone

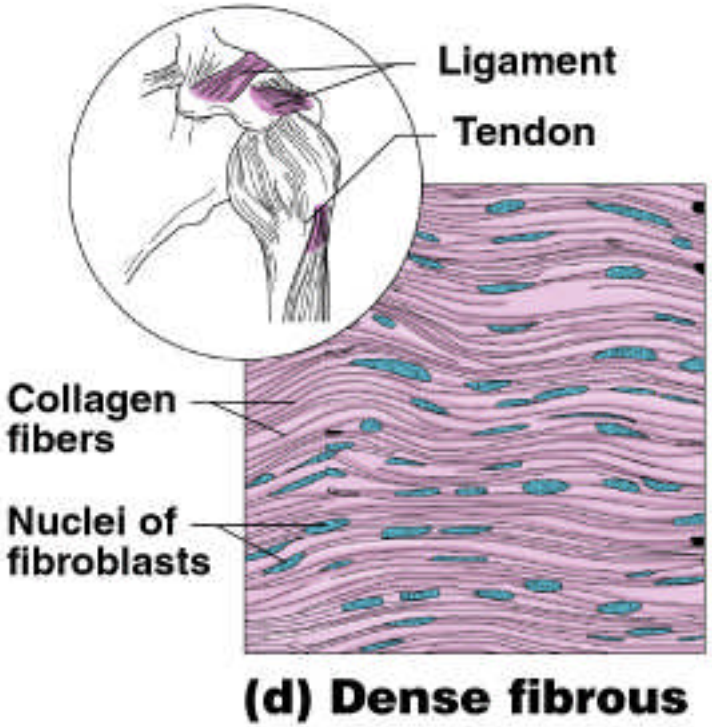


Figure 3.18d

Loose Connective Tissue Types

- Areolar connective tissue
  - Most widely distributed connective tissue
  - Soft, pliable tissue
  - Functions as universal packing tissue and connective tissue glue
  - Contains all fiber types
  - Can soak up excess fluid

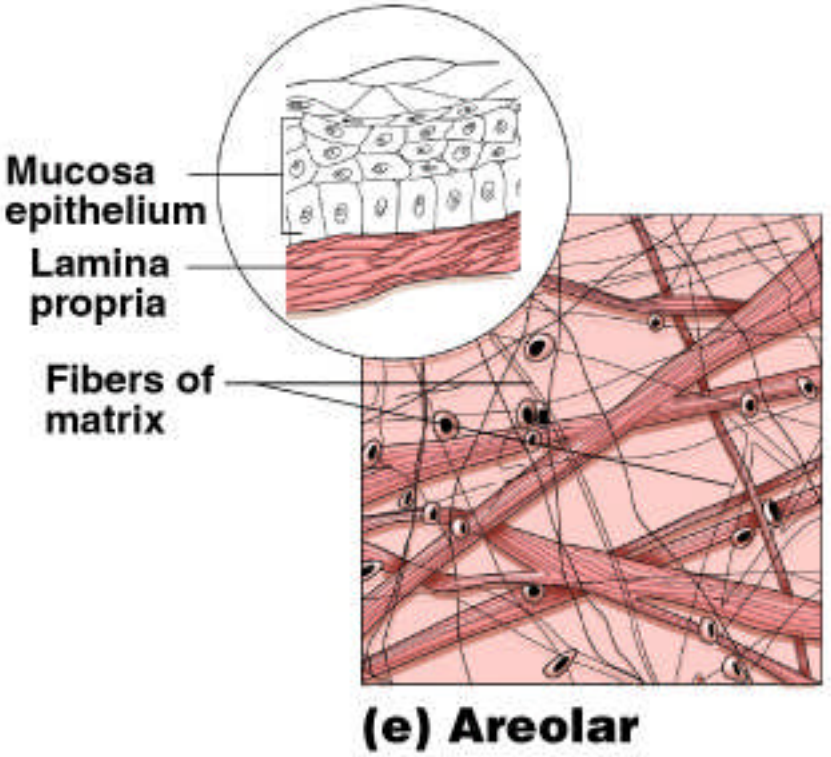


Figure 3.18e

Connective Tissue Types

- Adipose tissue
  - Matrix is an areolar tissue in which fat globules predominate
  - Many cells contain large lipid deposits
  - Functions
    - Insulates the body
    - Protects some organs
    - Serves as a site of fuel storage

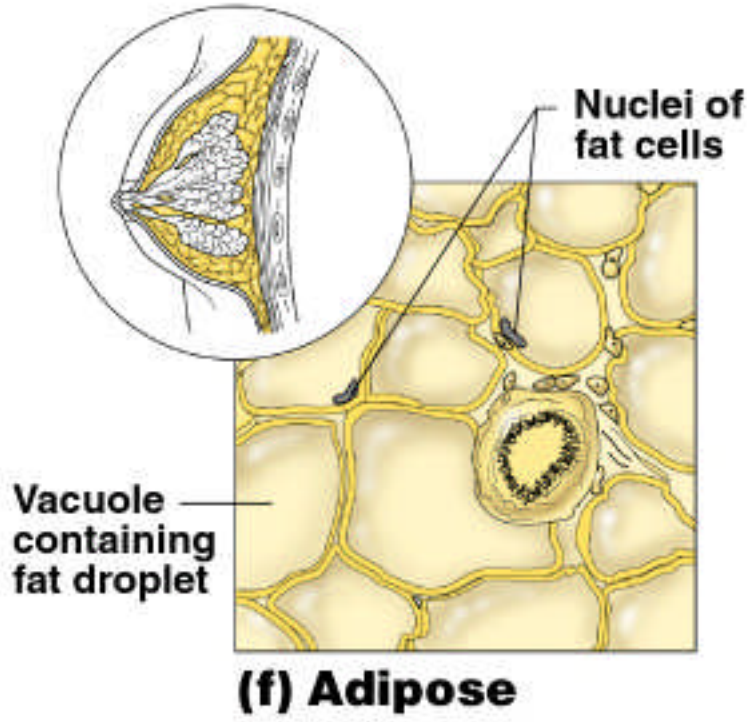


Figure 3.18f

Connective Tissue Types

- Reticular connective tissue
  - Delicate network of interwoven fibers
  - Forms stroma (internal supporting network) of lymphoid organs
    - Lymph nodes
    - Spleen
    - Bone marrow

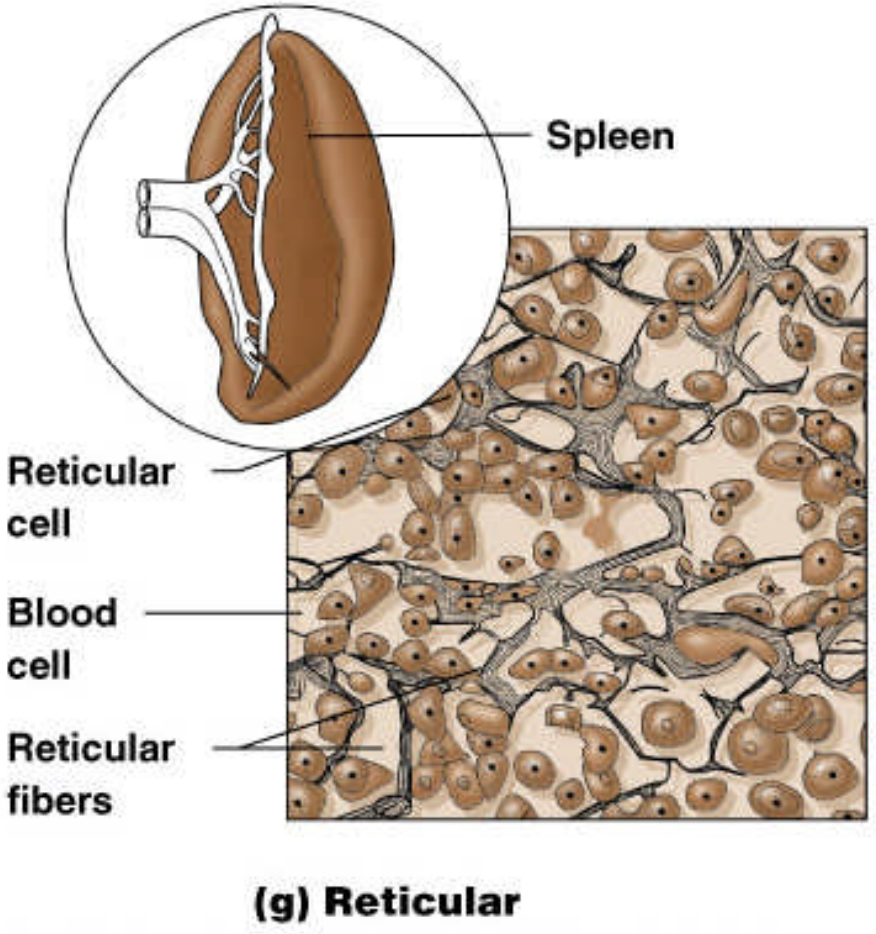


Figure 3.18g

Connective Tissue Types

- Blood
  - Blood cells surrounded by fluid matrix
  - Fibers are visible during clotting
  - Functions as the transport vehicle for materials

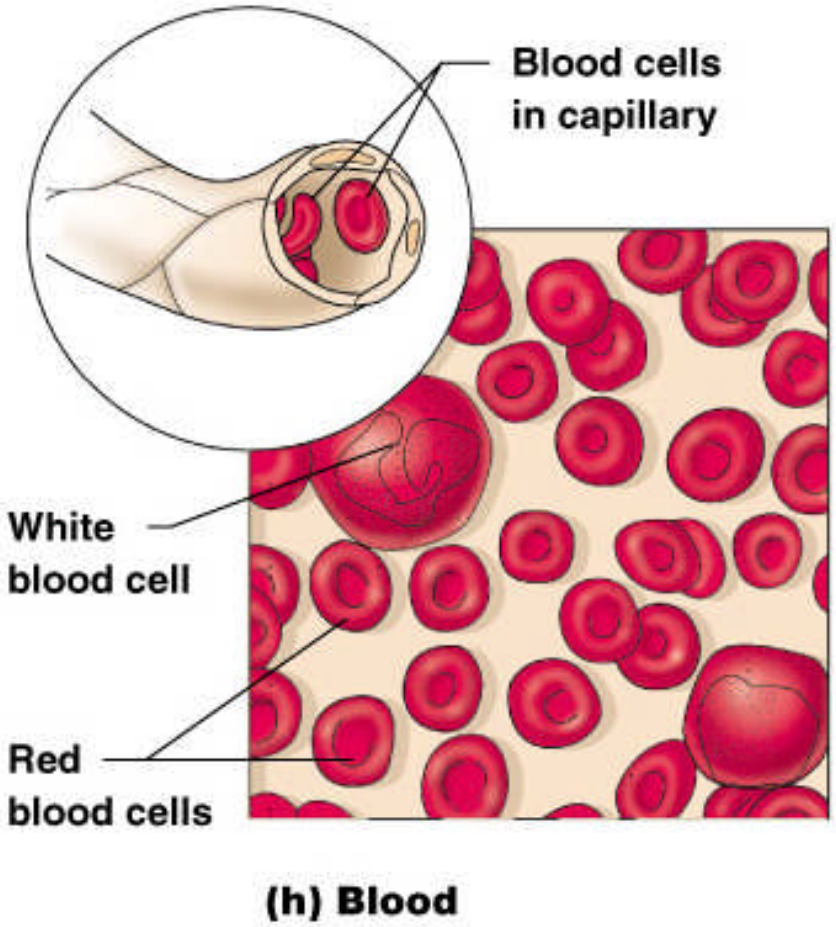


Figure 3.18h

Muscle Tissue

- Function is to produce movement by contracting or shortening
- Three types
  - Skeletal muscle
  - Cardiac muscle
  - Smooth muscle

Muscle Tissue Types

- Skeletal muscle
  - Can be controlled voluntarily
  - Cells attach to connective tissue
  - Cells are striated
  - Cells have more than one nucleus

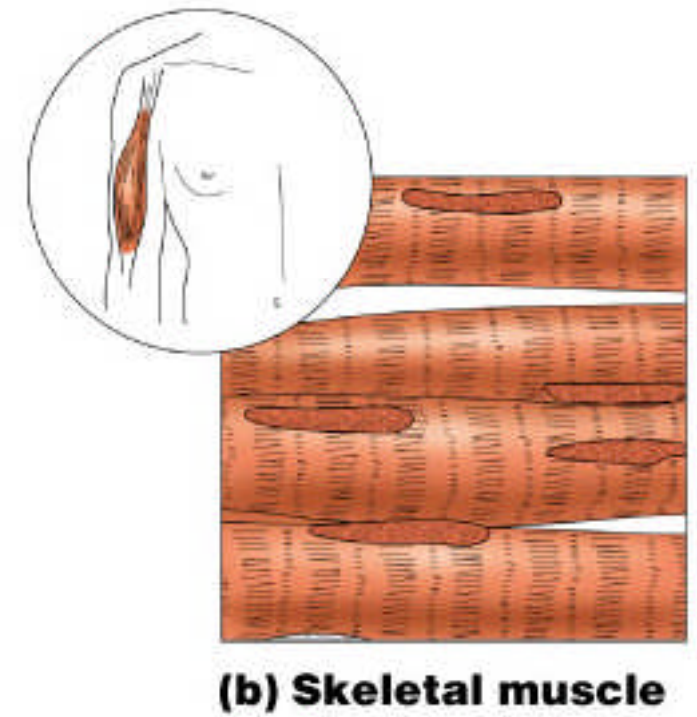


Figure 3.19b

Muscle Tissue Types

- Cardiac muscle
  - Found only in the heart
  - Function is to pump blood (involuntary)
  - Cells attached to other cardiac muscle cells at intercalated disks
  - Cells are striated
  - One nucleus per cell

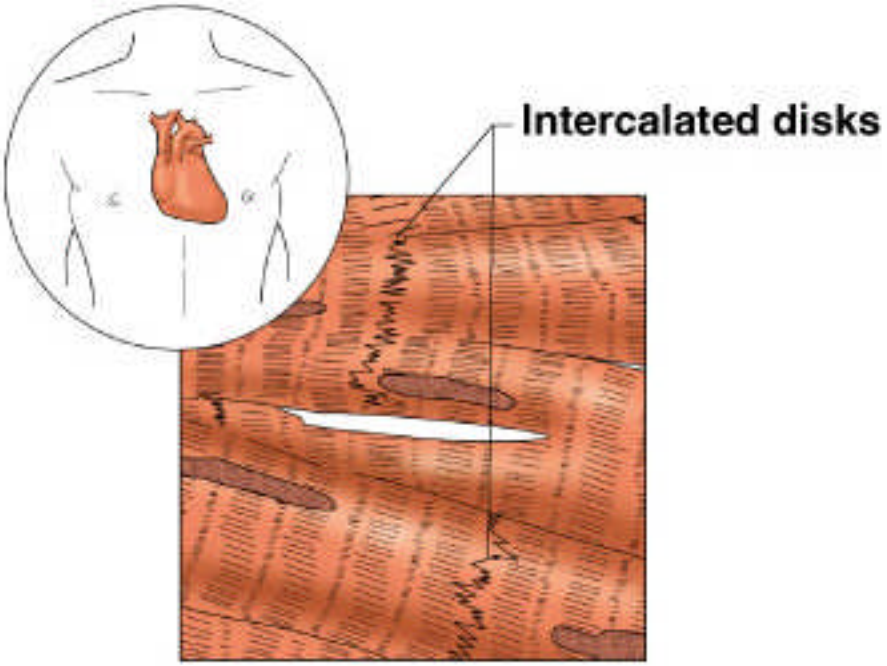


Figure 3.19c

Muscle Tissue Types

- Smooth muscle – visceral muscle
  - Involuntary muscle
  - Surrounds hollow organs
  - Attached to other smooth muscle cells
  - No visible striations
  - One nucleus per cell
  - Spindle shaped

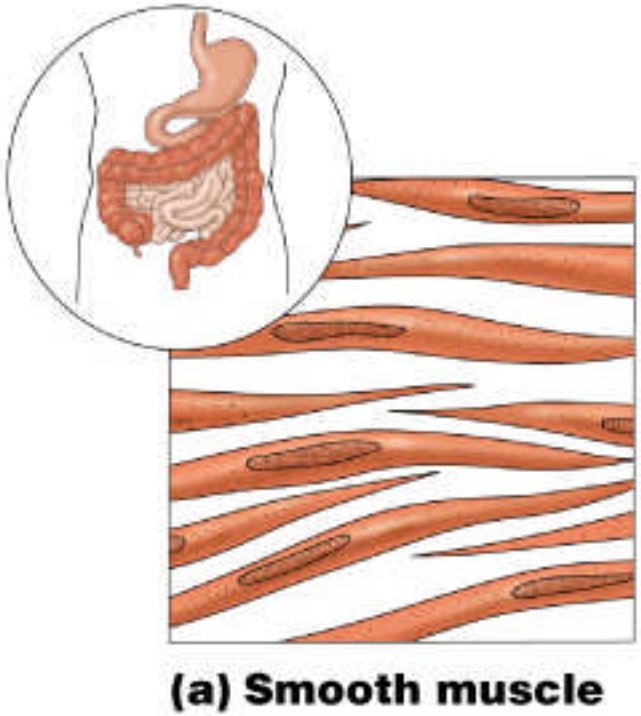


Figure 3.19a

Nervous Tissue

- Neurons and nerve supporting cells (those that insulate, support, and protect neurons)
- Function is to receive and send impulses to other areas of the body
  - Irritability
  - Conductivity

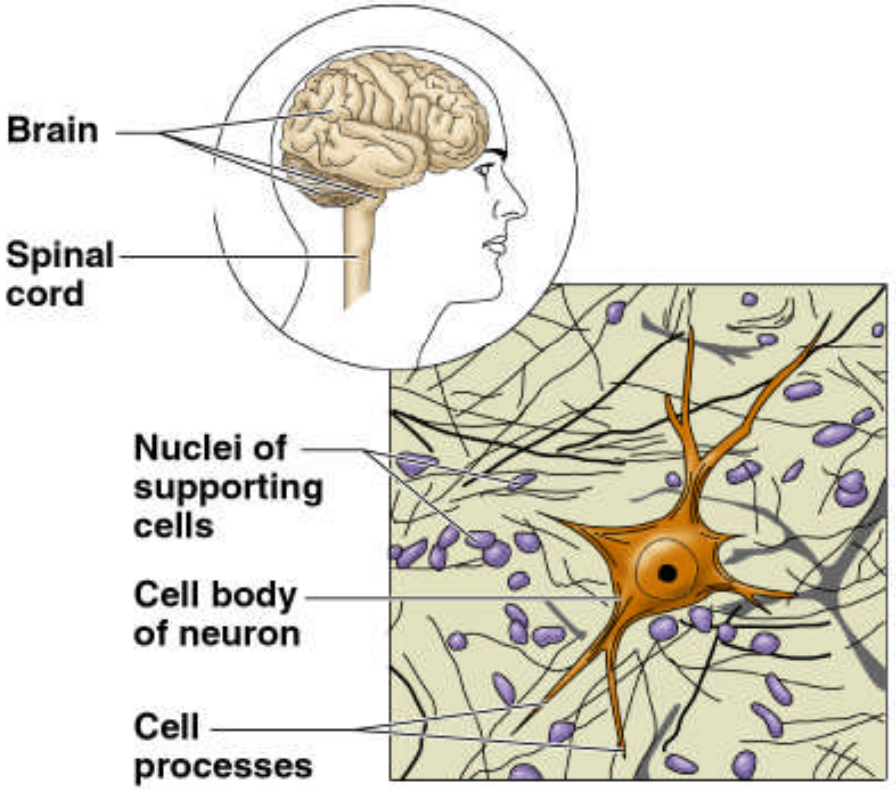


Figure 3.20

Tissue Repair (wound Healing)

- Regeneration
  - Replacement of destroyed tissue by the same kind of cells
- Fibrosis
  - Repair by dense fibrous connective tissue (scar tissue)
- Determination of method
  - Type of tissue damaged
  - Severity of the injury

Events in Tissue Repair

- Capillaries become very permeable
  - Introduce clotting proteins to make clot
  - Wall off injured area to prevent blood loss and infection
- Formation of granulation tissue
  - Contains capillaries and phagocytes
- Regeneration of surface epithelium just below the scab

Regeneration of Tissues

- Tissues that regenerate easily
  - Epithelial tissue
  - Fibrous connective tissue and bone
- Tissues that regenerate poorly
  - Skeletal muscle
- Tissues that are replaced largely with scar tissue
  - Cardiac muscle
  - Nervous tissue within the brain and spinal cord

Developmental Aspects of Tissue

- Epithelial tissue arises from all three primary germ layers
- Muscle and connective tissue arise from the mesoderm
- Nervous tissue arises from the ectoderm
- With old age there is a decrease in mass and viabililty in most tissues