Hole's Human
Anatomy and Physiology

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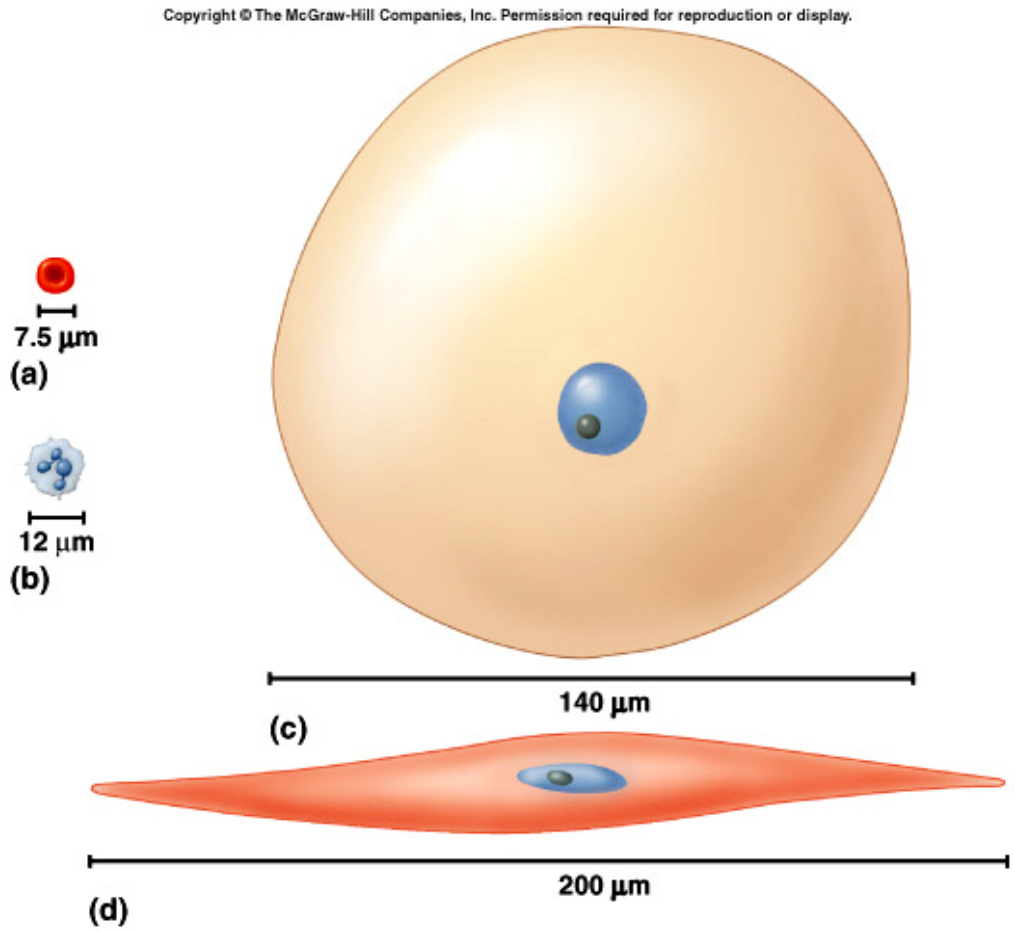
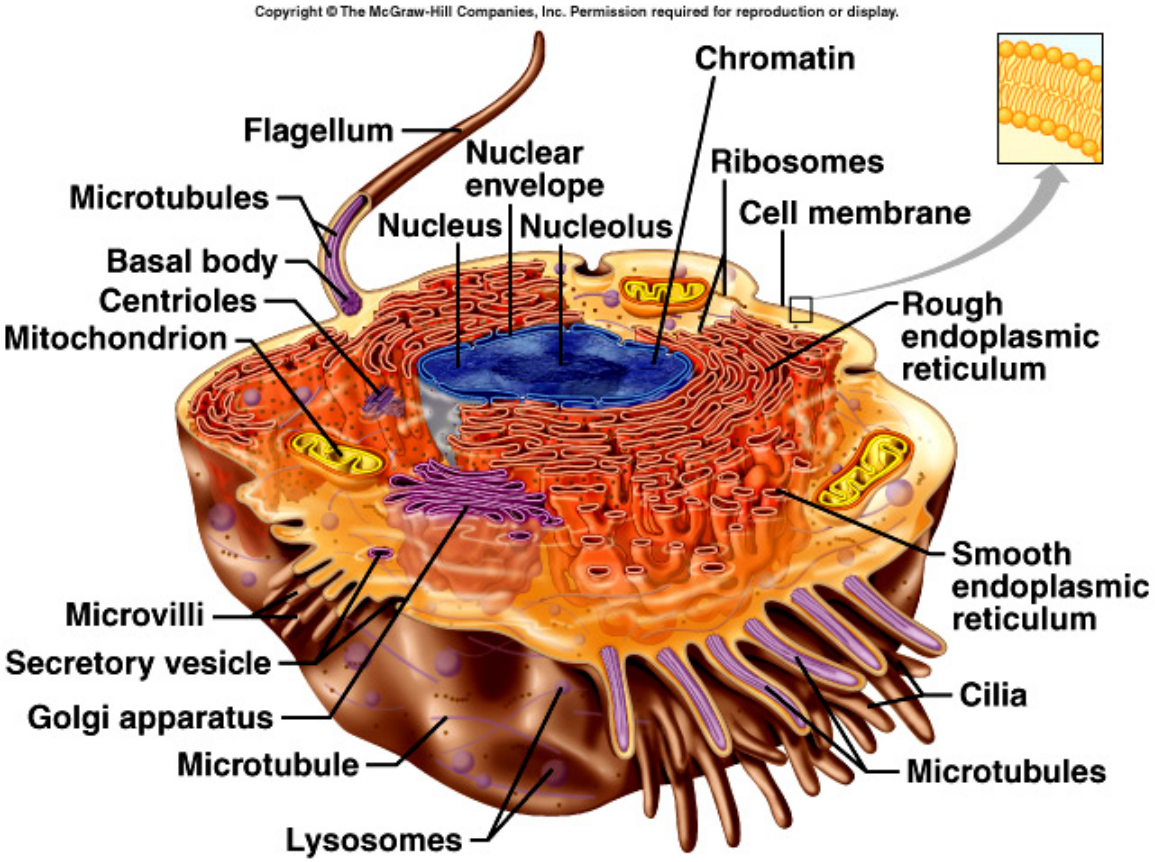
Chapter 3
Cells

- vary in size
- possess distinctive shapes
- measured in micrometers



A Composite Cell

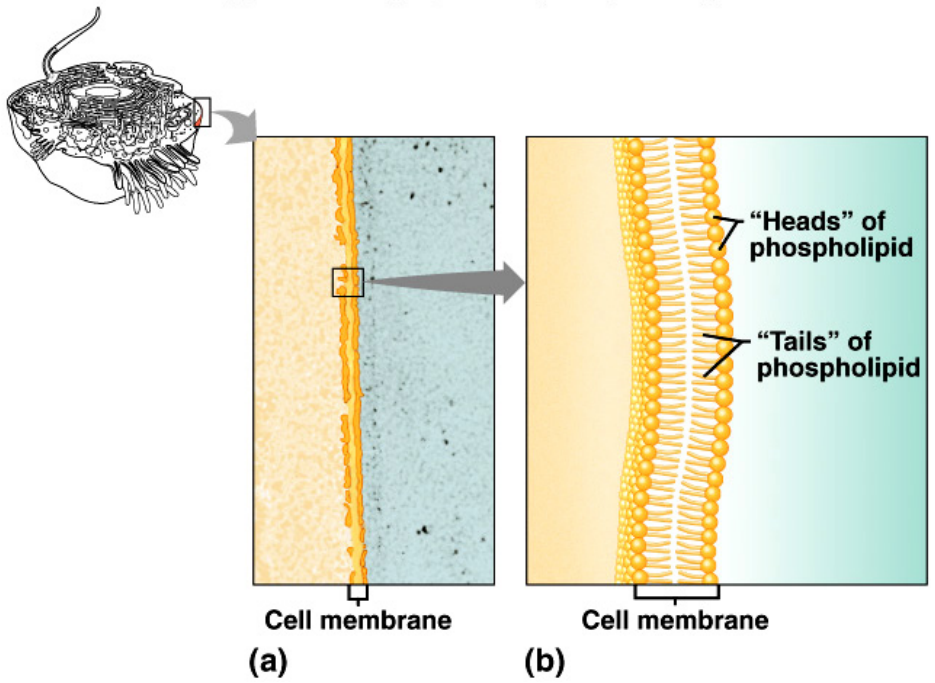
- hypothetical cell
- major parts
  - nucleus
  - cytoplasm
  - cell membrane

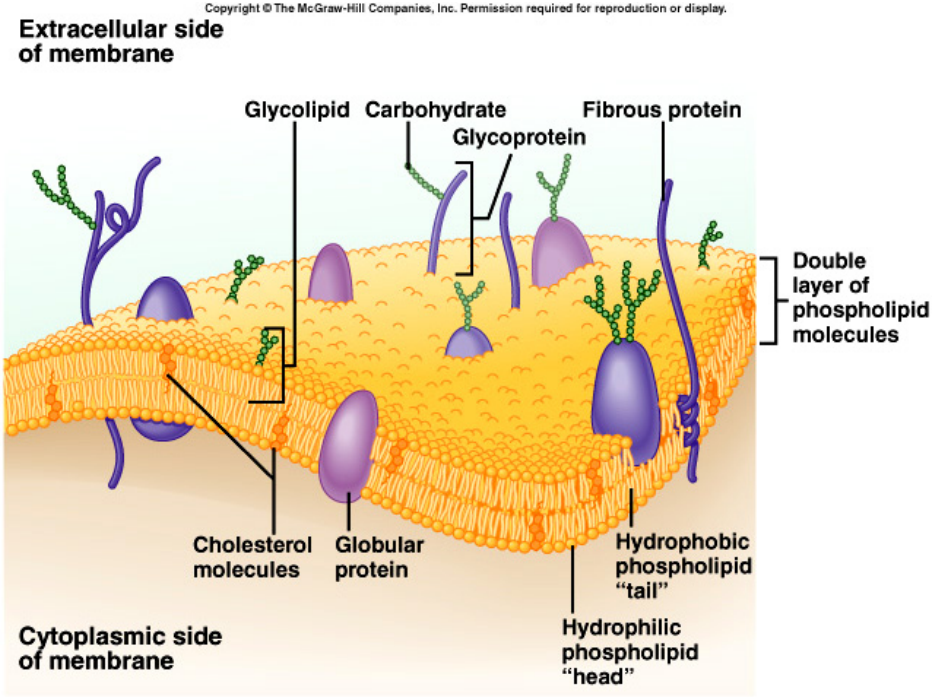


Cell Membrane

- **outer limit of cell**
- **controls what moves in and out of cell**
- **selectively permeable**
- **phospholipid bilayer**
  - **water-soluble “heads” form surfaces**
  - **water-insoluble “tails” form interior**
  - **permeable to lipid-soluble substances**
- **cholesterol stabilizes the membrane**
- **proteins**
  - **receptors**
  - **pores, channels, carriers**
  - **enzymes**
  - **CAMS**
  - **self-markers**

Cell Membrane





Intercellular Junctions

Tight junctions

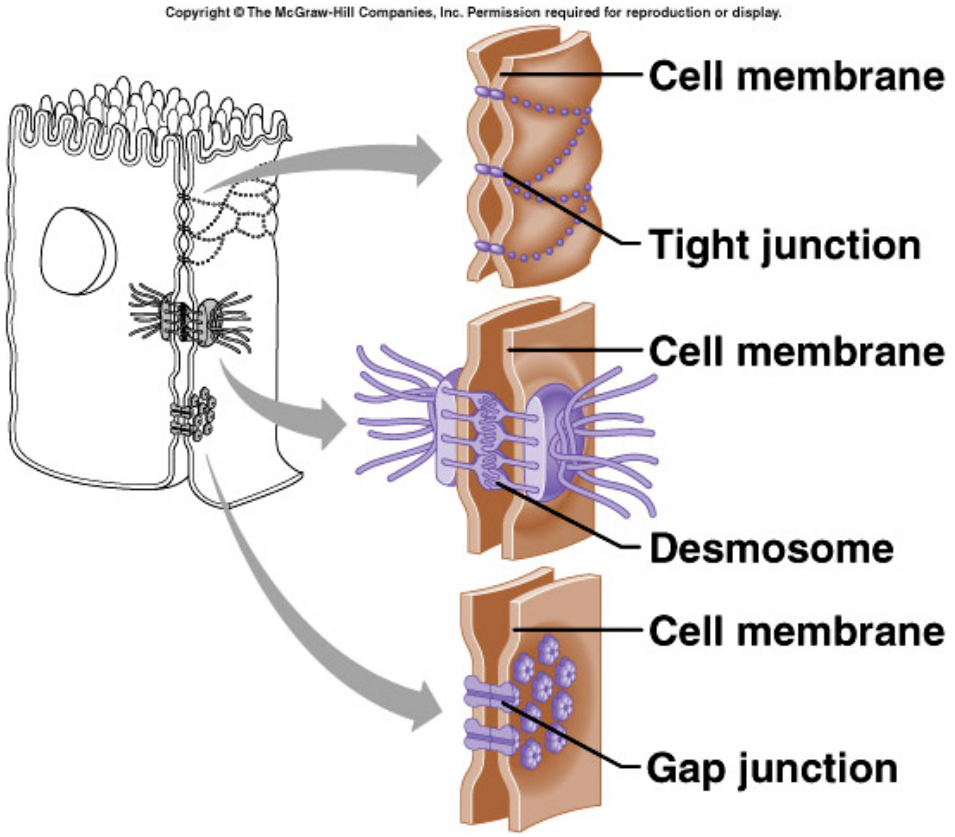
- close space between cells
- located among cells that form linings

Desmosomes

- form “spot welds” between cells
- located among outer skin cells

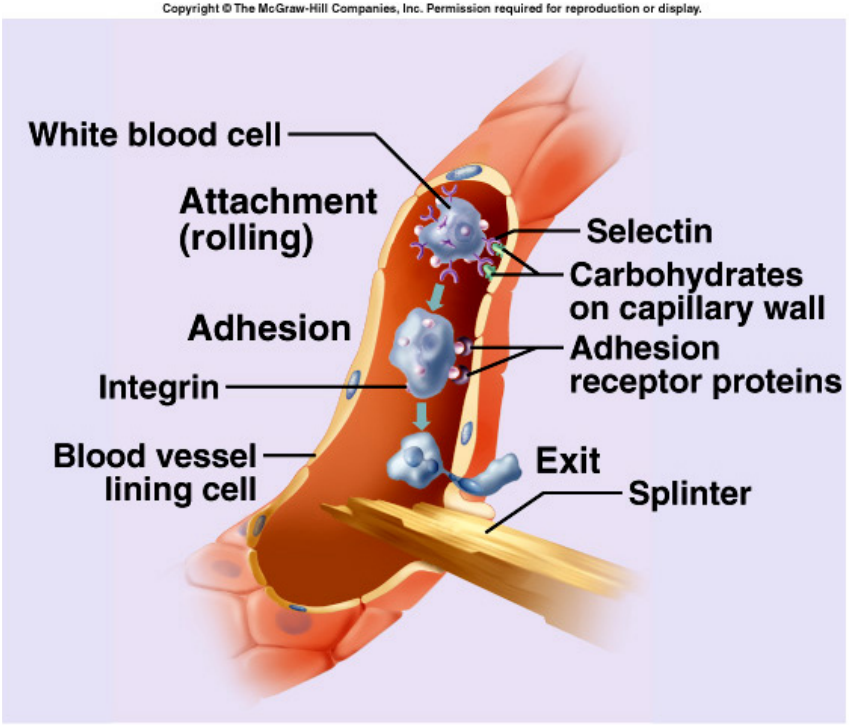
Gap junctions

- tubular channels between cells
- located in cardiac muscle cells



Cell Adhesion Molecules

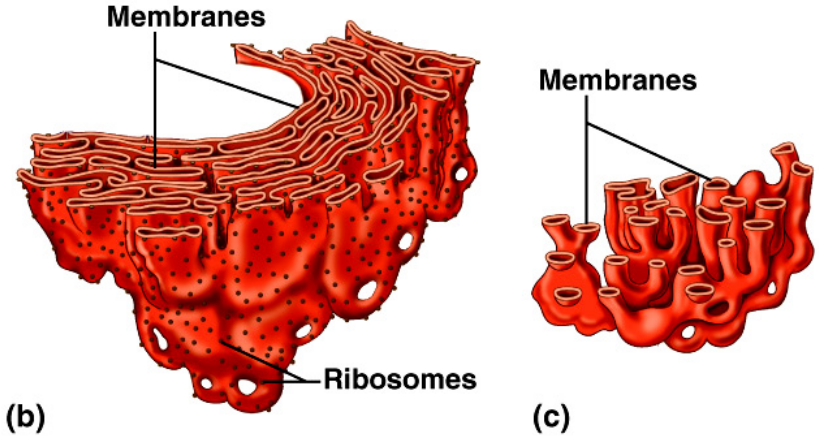
- guide cells on the move
- selectin – allows white blood cells to “anchor”
- integrin – guides white blood cells through capillary walls
- important for growth of embryonic tissue
- important for growth of nerve cells



Cytoplasmic Organelles

Endoplasmic Reticulum

- connected, membrane-bound sacs, canals, and vesicles
- transport system
- rough ER
  - studded with ribosomes
  - protein synthesis
- smooth ER
  - lipid synthesis
    - added to proteins arriving from rough ER
  - break down of drugs



Ribosomes

- free floating or connected to ER
- provide structural support

Cytoplasmic Organelles

Golgi apparatus

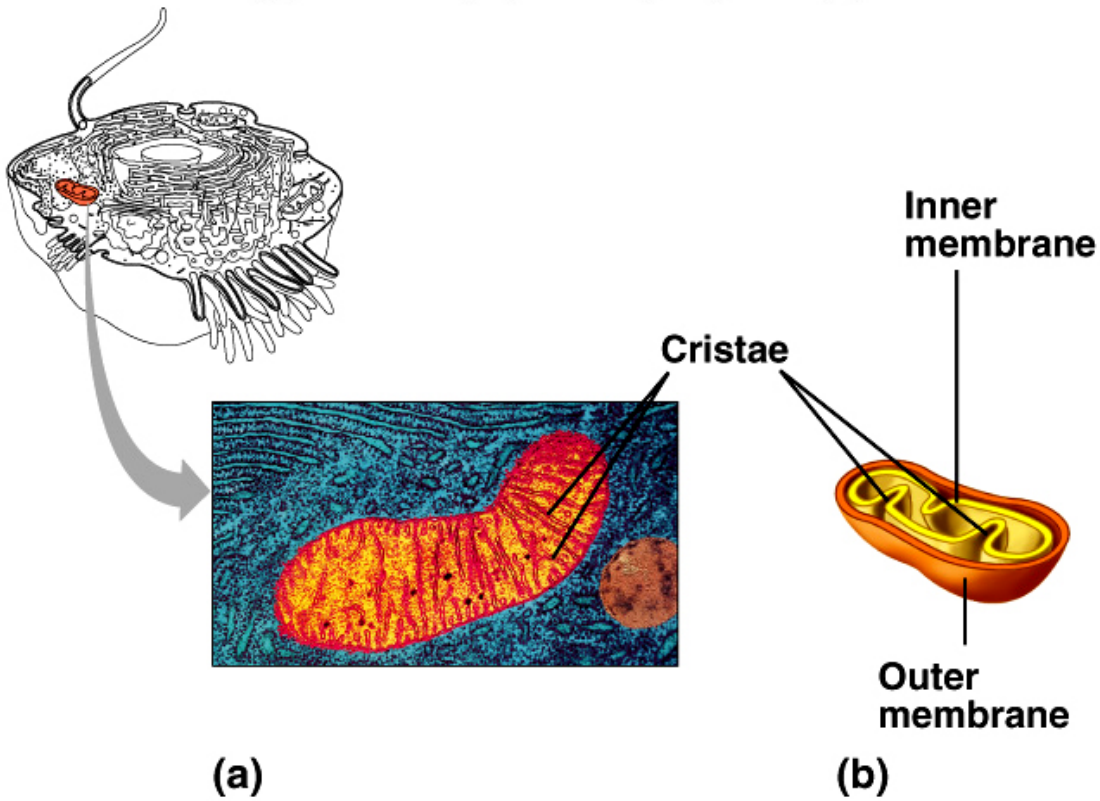
- stack of flattened, membranous sacs
- modifies, packages and delivers proteins

Vesicles

- membranous sacs
- store substances

Mitochondria

- membranous sacs with inner partitions
- generate energy



Cytoplasmic Organelles

Lysosomes

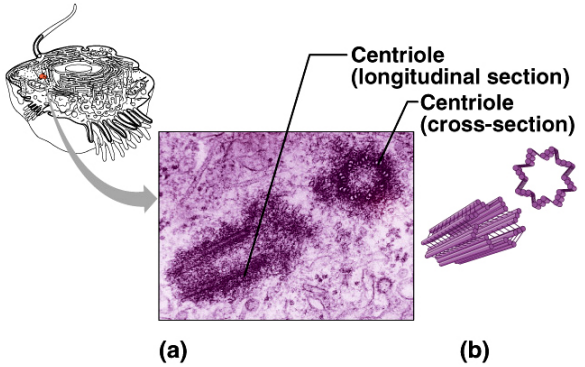
- enzyme-containing sacs
- digest worn out cell parts or unwanted substances

Peroxisomes

- enzyme-containing sacs
- break down organic molecules

Centrosome

- two rod-like centrioles
- used to produce cilia and flagella
- distributes chromosomes during cell division



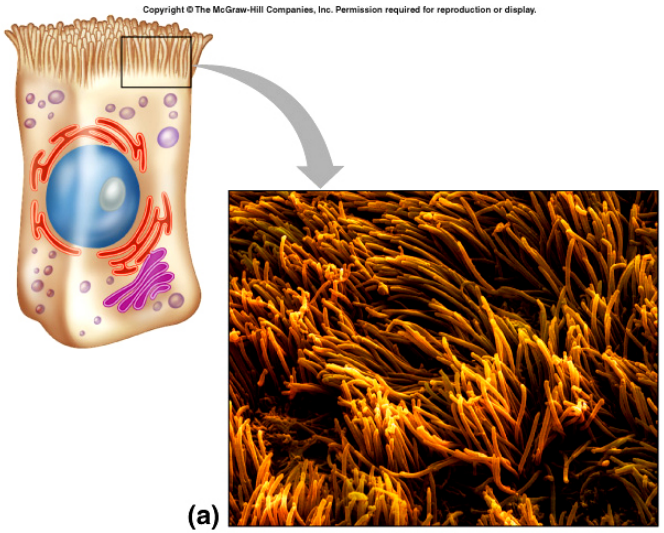
Cytoplasmic Organelles

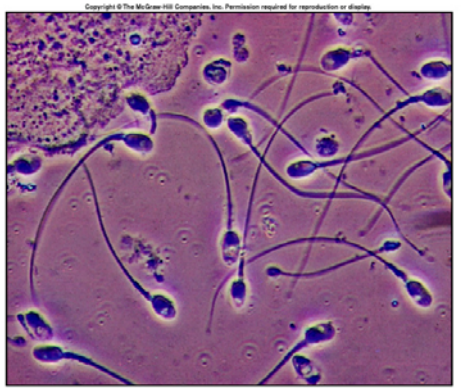
Cilia

- short hair-like projections
- propel substances on cell surface

Flagellum

- long tail-like projection
- provides motility to sperm

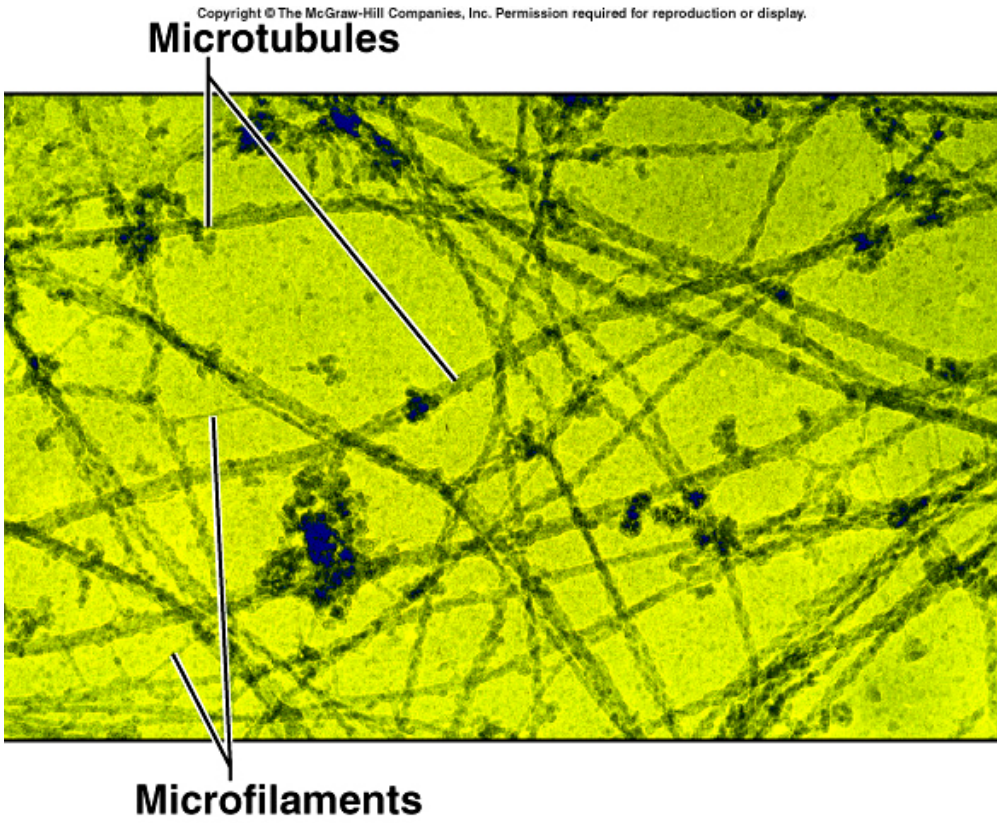




Cytoplasmic Organelles

Microfilaments and microtubules

- thin rods and tubules
- support cytoplasm
- allows for movement of organelles

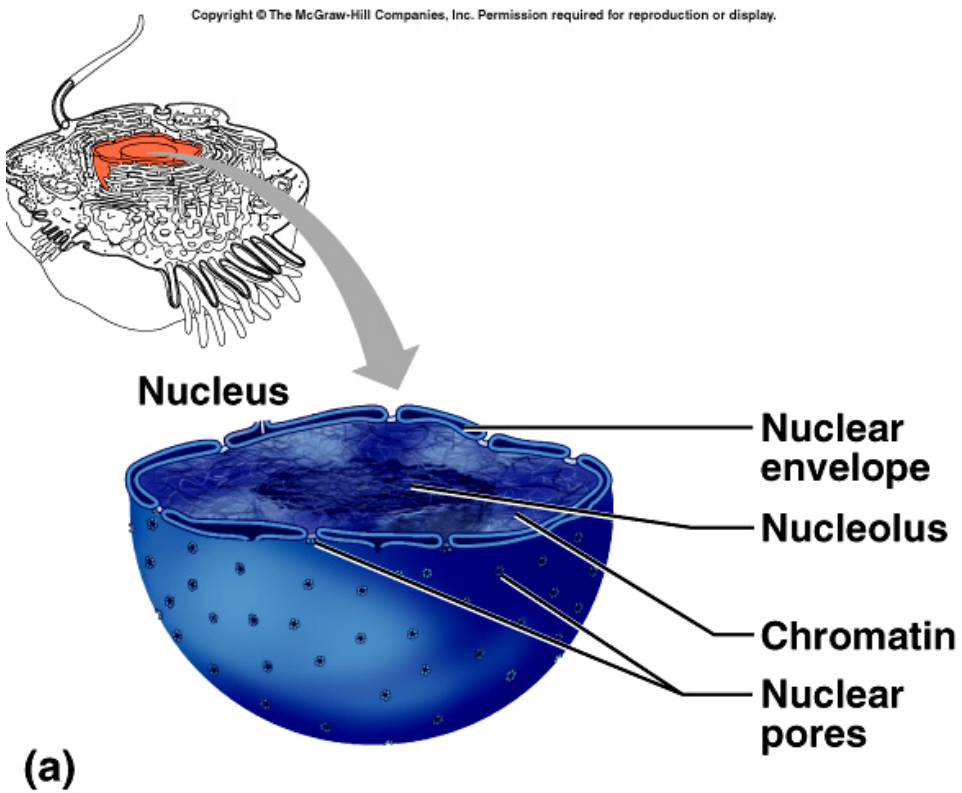


Inclusions

- temporary nutrients and pigments

Cell Nucleus

- control center of cell
- nuclear envelope
  - porous double membrane
  - separates nucleoplasm from cytoplasm
- nucleolus
  - dense collection of RNA and proteins
  - site of ribosome production
- chromatin
  - fibers of DNA and proteins
  - stores information for synthesis of proteins



Movements Into and Out of the Cell

Passive (Physical) Processes

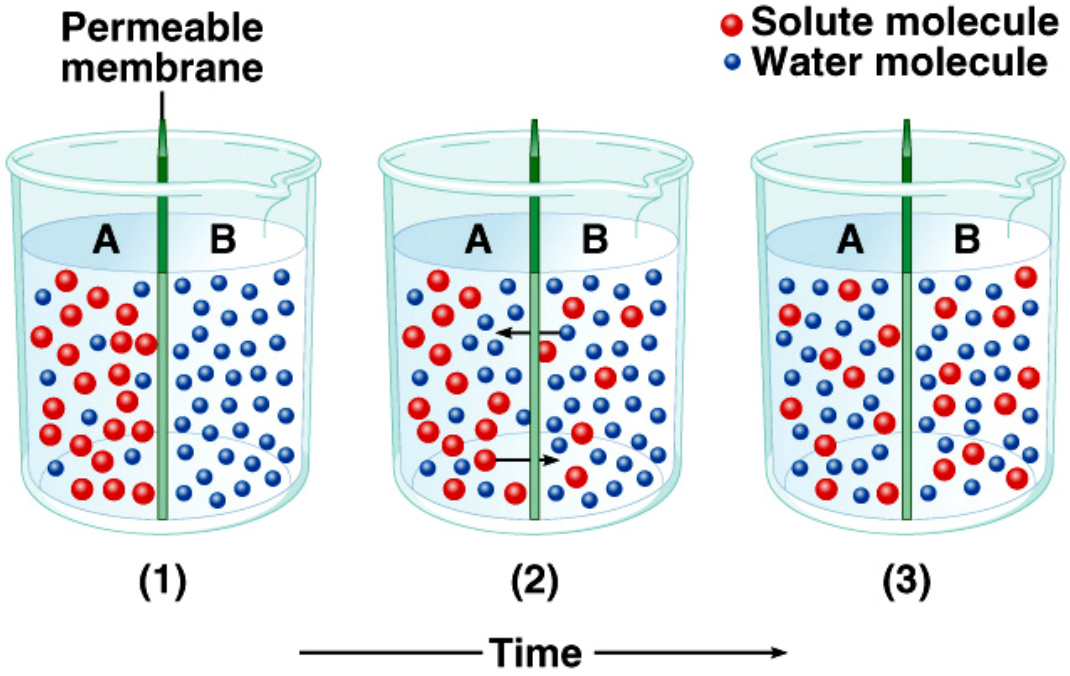
- require no cellular energy
- simple diffusion
- facilitated diffusion
- osmosis
- filtration

Active (Physiological) Processes

- require cellular energy
- active transport
- endocytosis
- exocytosis
- transcytosis

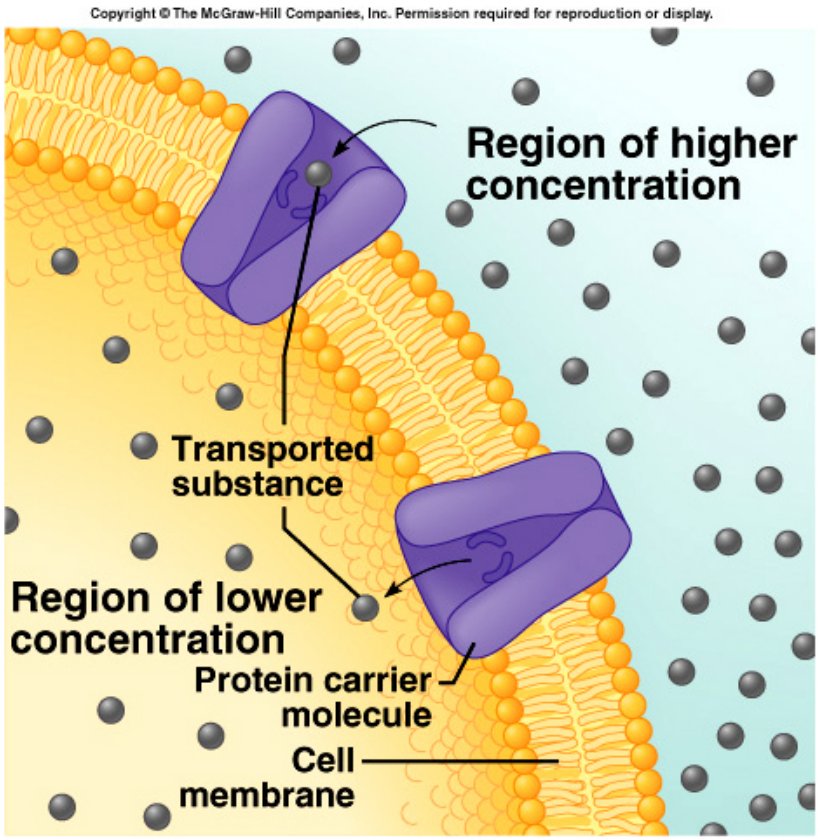
Simple Diffusion

- movement of substances from regions of higher concentration to regions of lower concentration
- oxygen, carbon dioxide and lipid-soluble substances



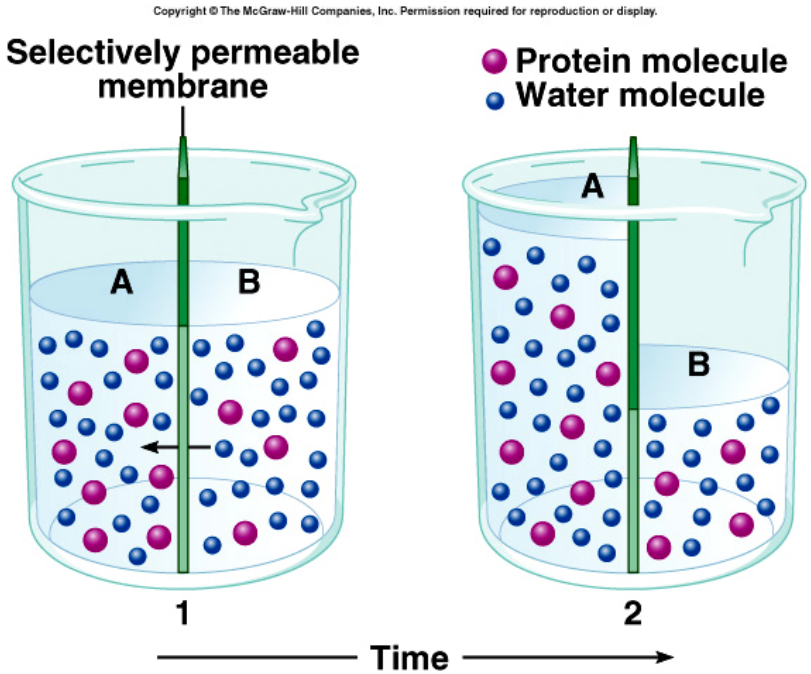
Facilitated Diffusion

- **diffusion across a membrane with the help of a channel or carrier molecule**
- **glucose and amino acids**



Osmosis

- movement of water through a selectively permeable membrane from regions of higher concentration to regions of lower concentration
- water moves toward a higher concentration of solutes

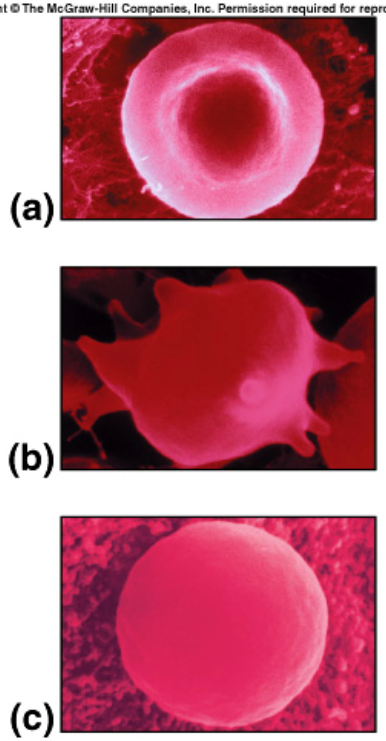


Osmosis

Osmotic Pressure – ability of osmosis to generate enough pressure to move a volume of water

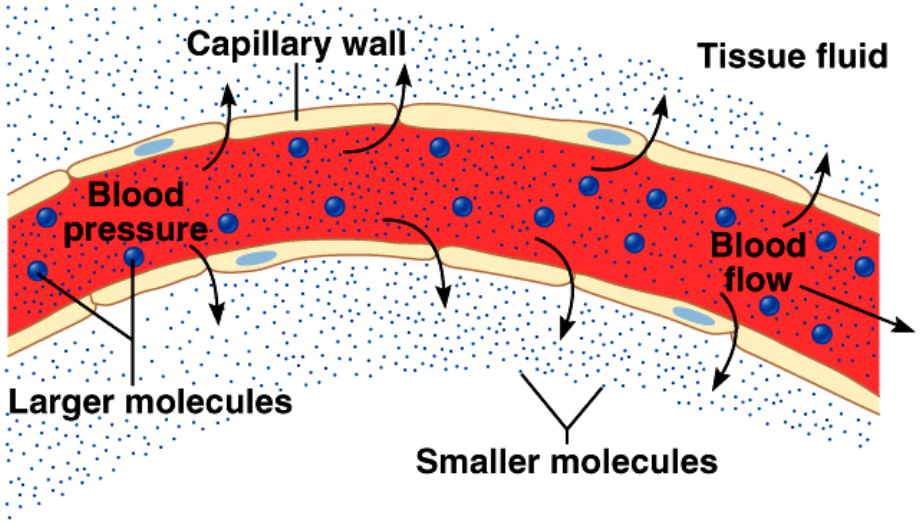
Osmotic pressure increases as the concentration of nonpermeable solutes increases

- **hypertonic – higher osmotic pressure**
- **hypotonic – lower osmotic pressure**
- **isotonic – same osmotic pressure**



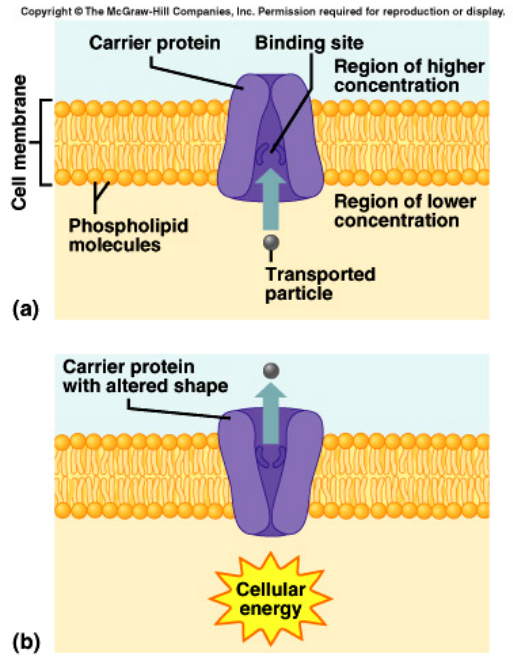
Filtration

- smaller molecules are forced through porous membranes
- hydrostatic pressure important in the body
- molecules leaving blood capillaries



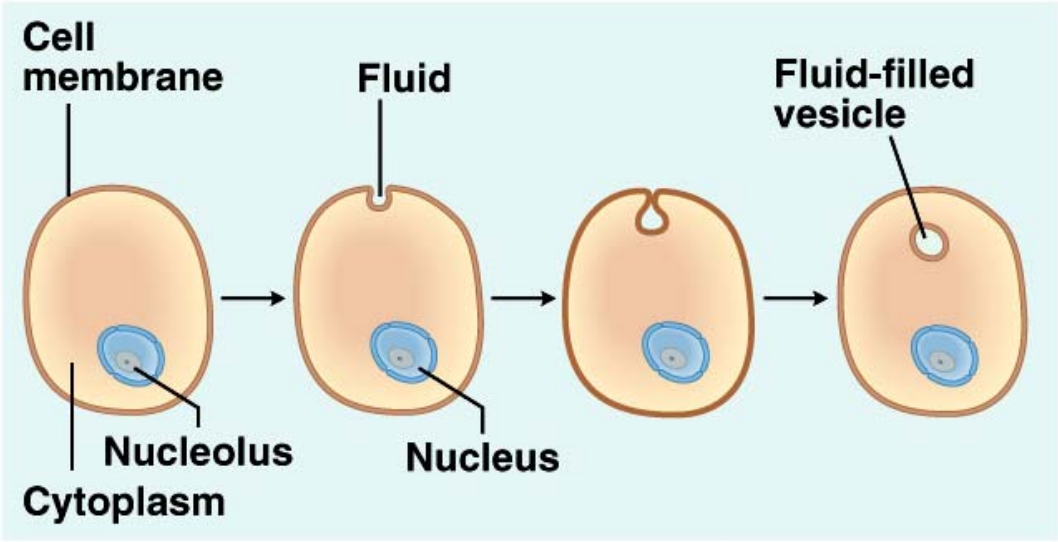
Active Transport

- carrier molecules transport substances across a membrane from regions of lower concentration to regions of higher concentration
- sugars, amino acids, sodium ions, potassium ions, etc.

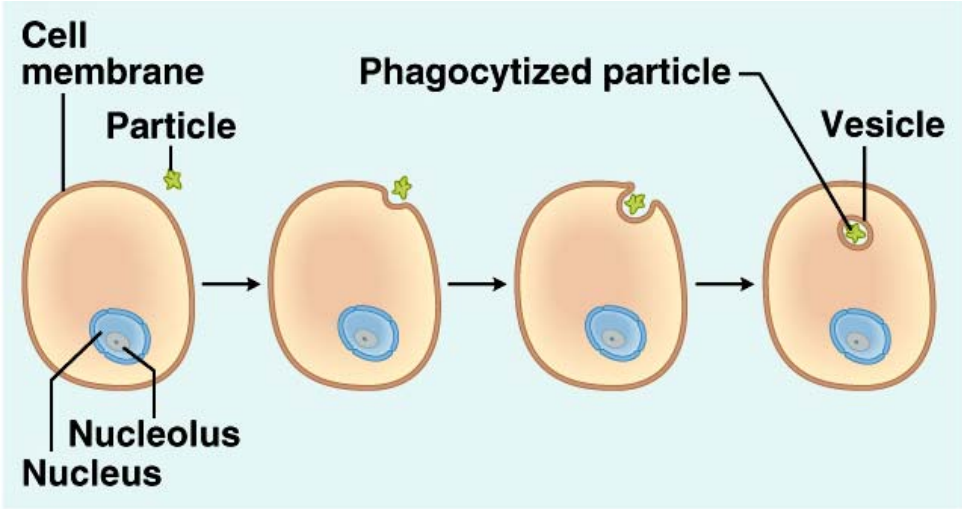


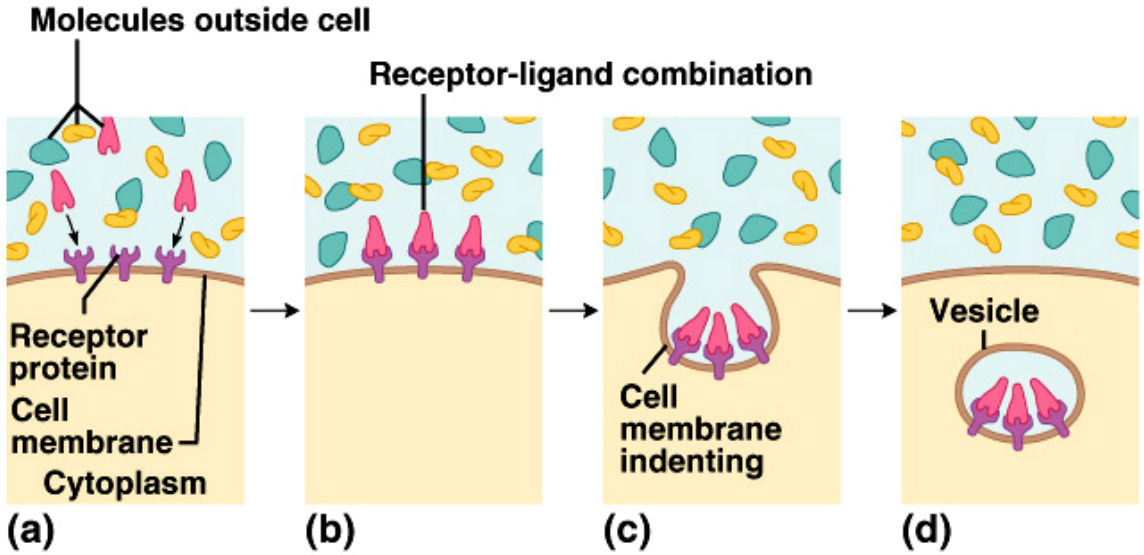
Endocytosis

- cell engulfs a substance by forming a vesicle around the substance
- three types
  - pinocytosis – substance is mostly water
  - phagocytosis – substance is a solid
  - receptor-mediated endocytosis – requires the substance to bind to a membrane-bound receptor



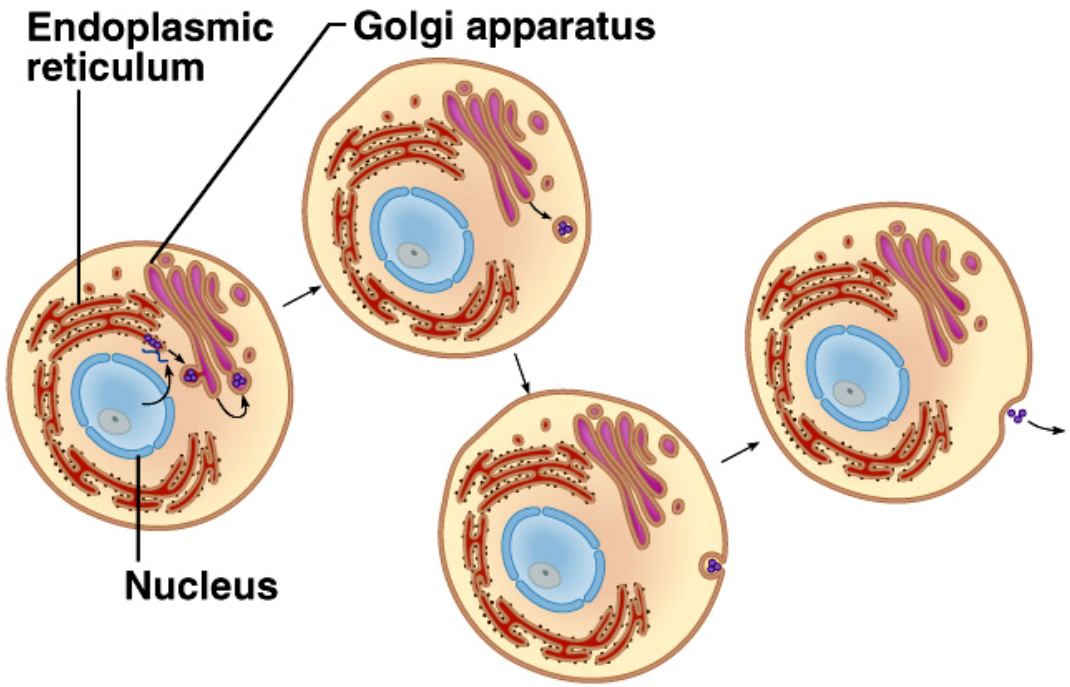
Endocytosis





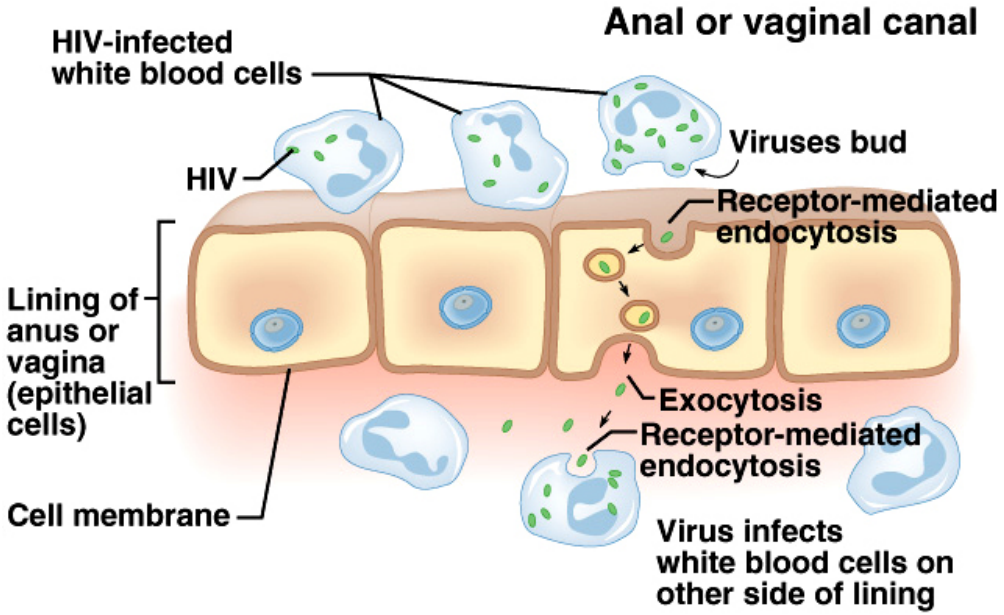
Exocytosis

- reverse of endocytosis
- substances in a vesicle fuse with cell membrane
- contents released outside the cell
- release of neurotransmitters from nerve cells



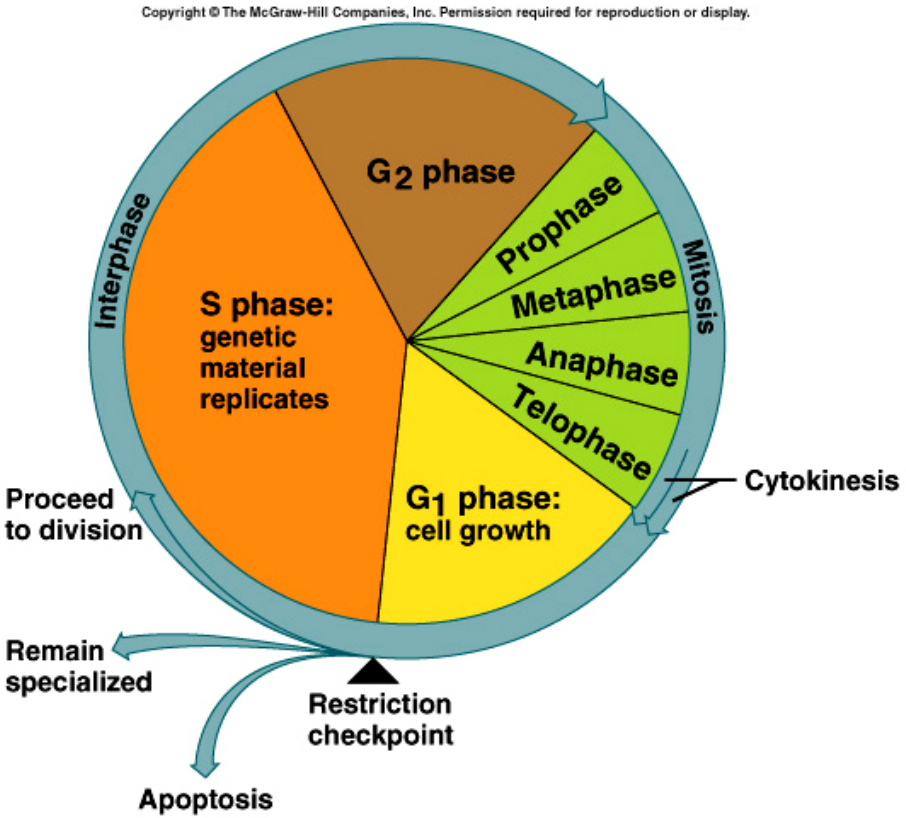
Transcytosis

- endocytosis followed by exocytosis
- transports a substance rapidly through a cell
- HIV crossing a cell layer



The Cell Cycle

- series of changes a cell undergoes from the time it forms until the time it divides
- stages
  - interphase
  - mitosis
  - cytoplasmic division



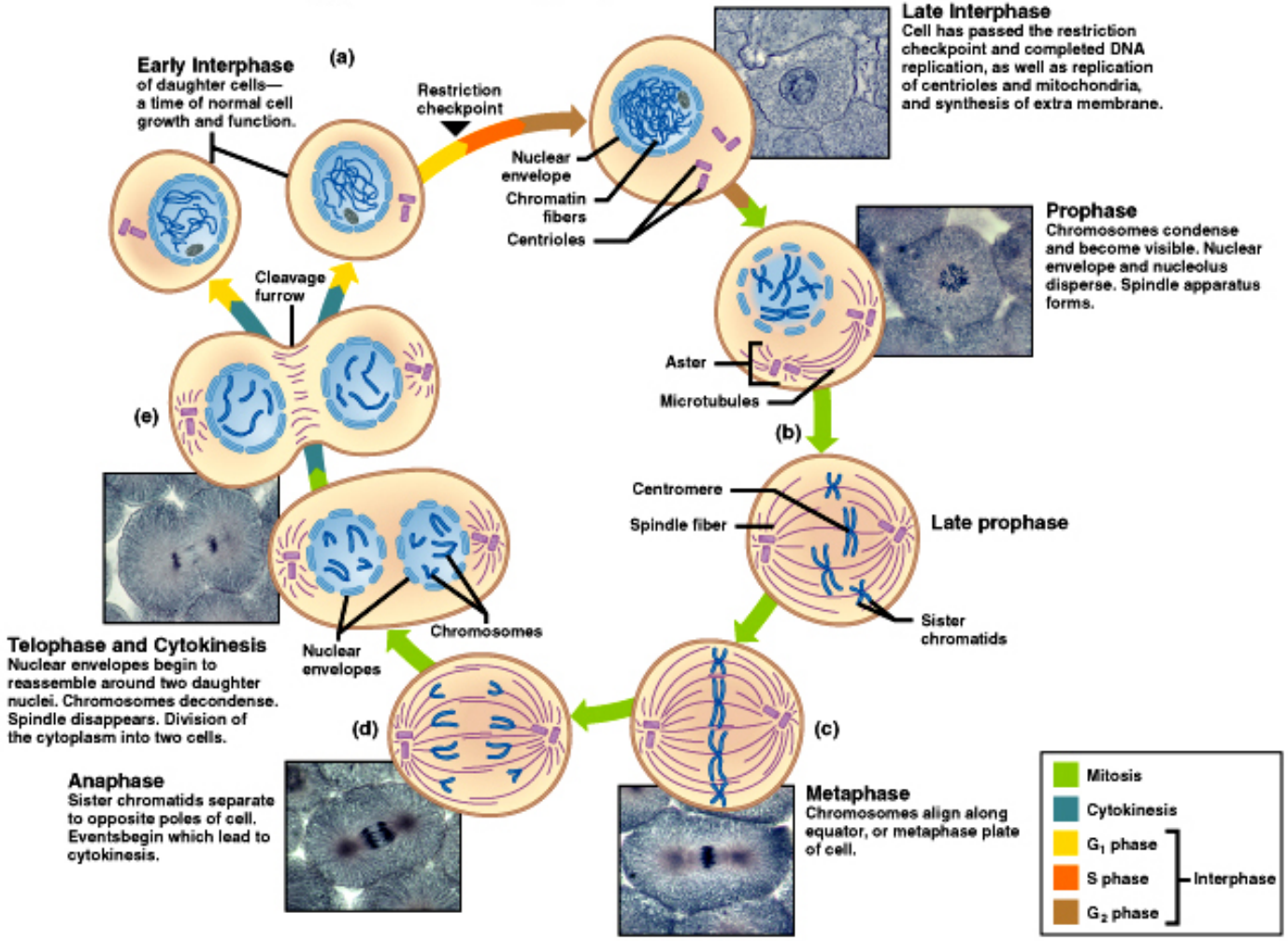
Interphase

- very active period
- cell grows
- cell maintains routine functions
- cell replicates genetic material to prepare for nuclear division
- cell synthesizes new organelles to prepare for cytoplasmic division
- phases
    - G phases – cell grows and synthesizes structures other than DNA
    - S phase – cell replicates DNA

Mitosis

- produces two daughter cells from an original somatic cell
- nucleus divides – karyokinesis
- cytoplasm divides – cytokinesis
- stages
    - prophase – chromosomes form; nuclear envelope disappears
    - metaphase – chromosomes align midway between centrioles
    - anaphase – chromosomes separate and move to centrioles
    - telophase – chromatin forms; nuclear envelope forms

Mitosis



Cytoplasmic Division

- **also known as cytokinesis**
- **begins during anaphase**
- **continues through telophase**
- **contractile ring pinches cytoplasm in half**

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**

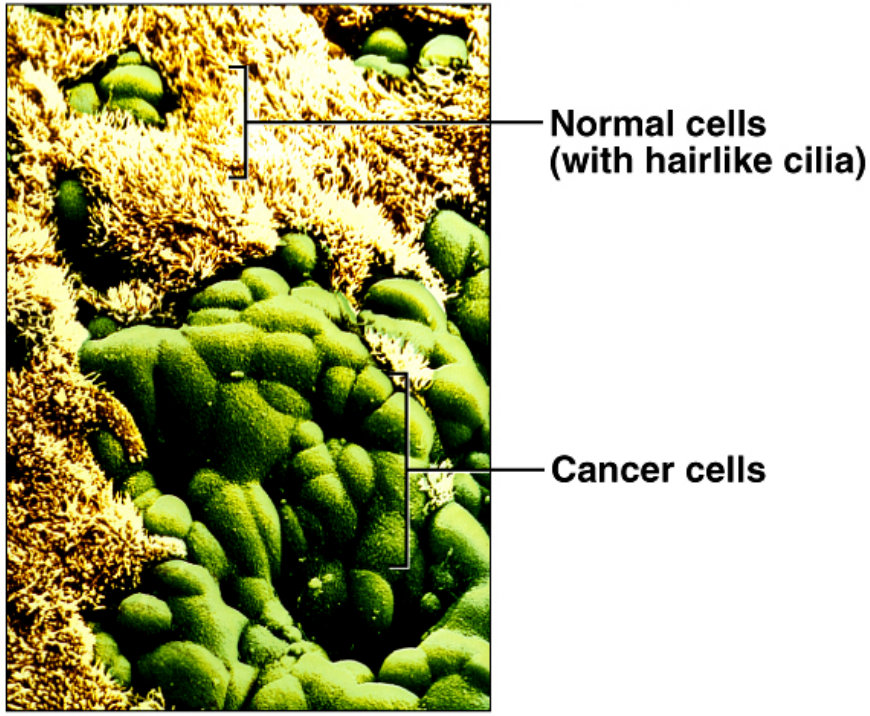
Tumors

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"



Stem and Progenitor Cells

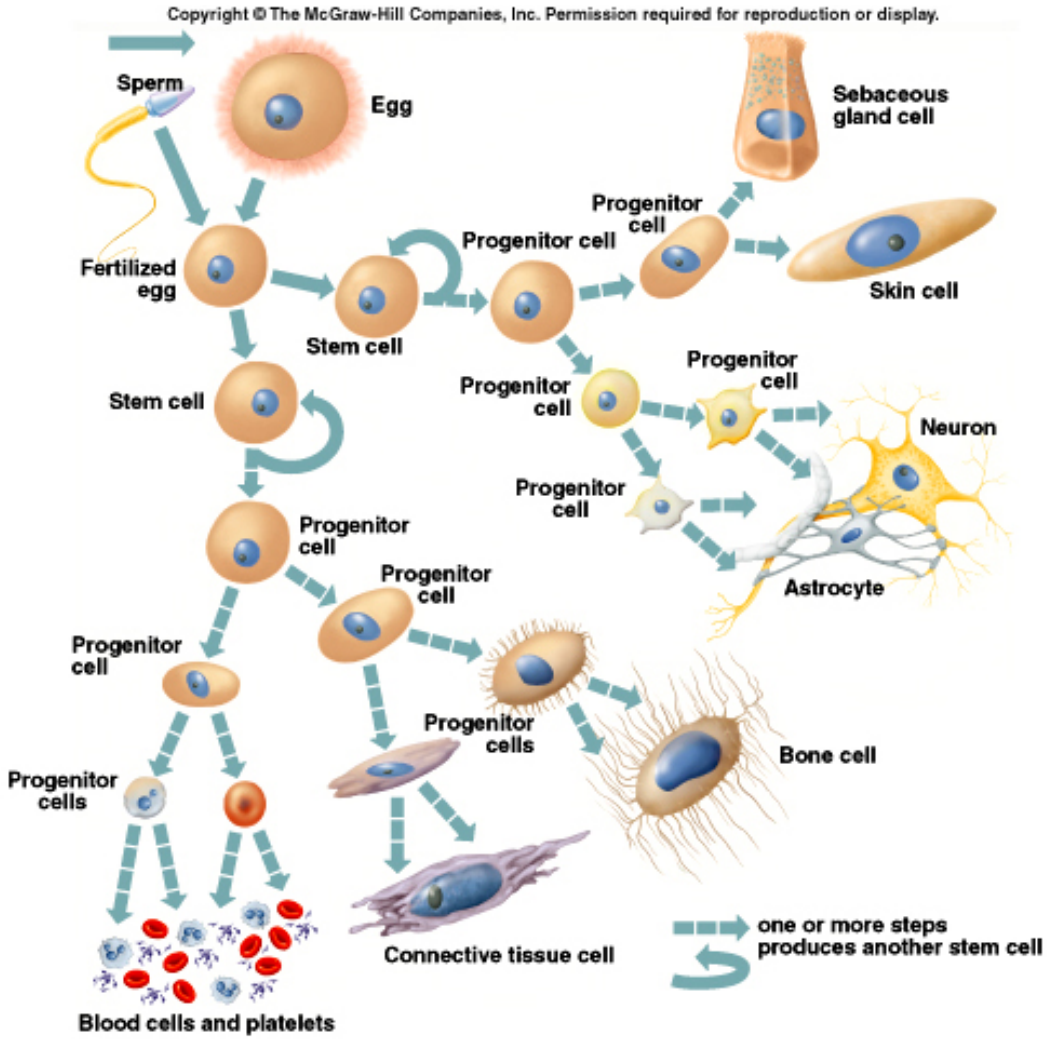
Stem cell

- **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**

Stem and Progenitor Cells



Clinical Application

Diseases at the Organelle Level

MELAS – mitochondrial encephalomyopathy, lactic acidosis, and stroke-like episodes

- **mitochondria are missing a gene necessary to carry out important energy producing reactions**
- **usually inherited by mother**
- **causes strokes, severe headaches, muscle weakness and numb hands**

ALD – adrenoleukodystrophy

- **peroxisomes are missing enzymes**
- **causes dizziness, weakness, darkening skin, and abnormal heart rhythms**

Tay-Sachs Disease

- **lysosomes are abnormally large and lack one enzyme**
- **causes nervous system failure and early death**