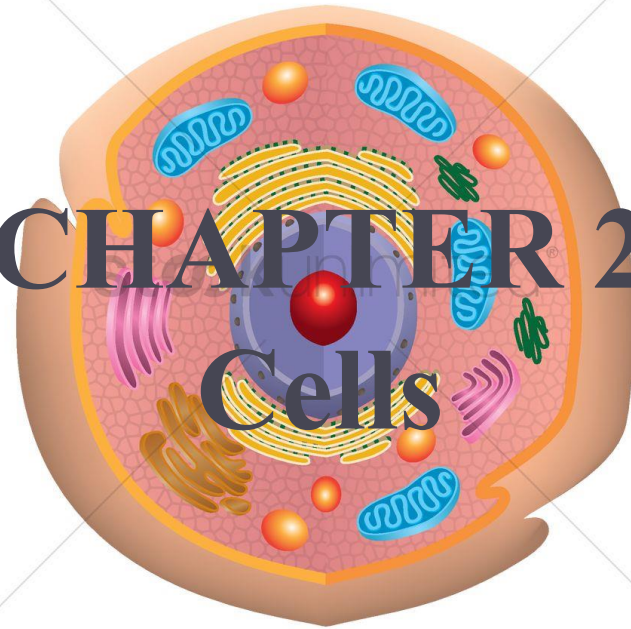


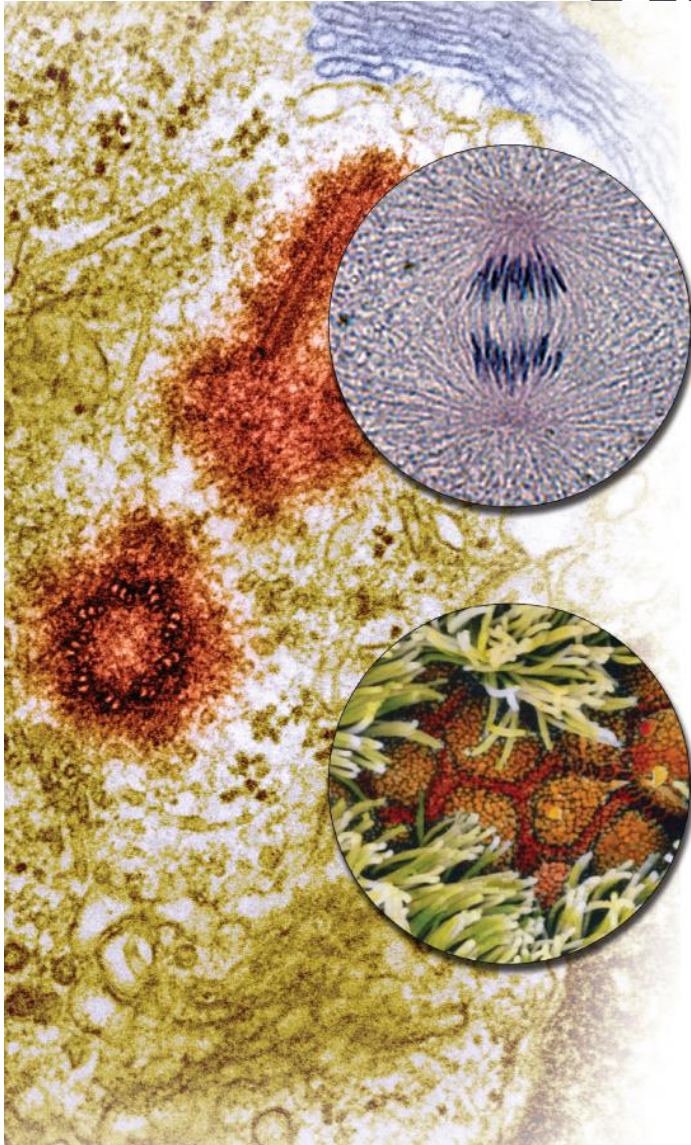
HUMAN CELL

CHAPTER 2

Cells



Cells - 2.1 Generalized Cell

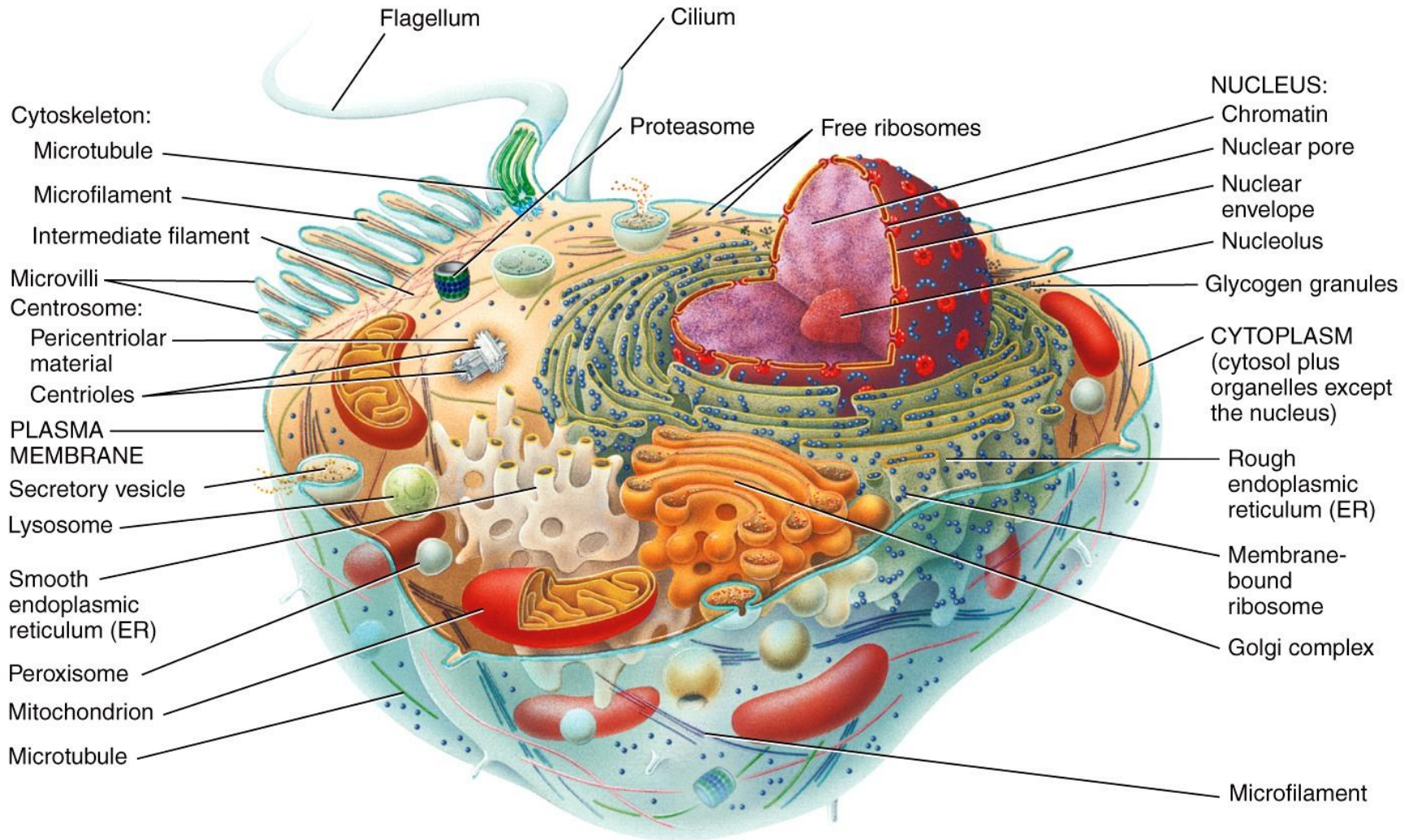


- ▶ Cells are the basic, living, structural and functional units of the body
- ▶ Cell biology or cytology
- ▶ Cells perform chemical reactions to create life processes
- ▶ Compartmentalization

Cells - 2.1 Generalized Cell

- ▶ **Cells** can survive independently for long periods of time if supplied with nutrients.
- ▶ The body consists of more than **100 trillion cells** classified into about **200 different types**.
- ▶ Cells of a particular cell type are composed of **characteristic parts**; their coordinated functioning enables them to fulfill a unique biochemical or structural role.
- ▶ **Cell biology**, or **cytology**, is the study of cellular structure and function which are interdependent and inseparable.
- ▶ **Compartmentalization is one way of isolating the** specific kinds of chemical reactions within specialized membrane-enclosed structures inside the cell.
- ▶ Although isolated, the chemical reactions are coordinated to maintain life in a cell, tissue, organ, system, and organism.

The Cell



Sectional view

A Generalized Cell - Three Principal Parts

- ▶ **Plasma membrane:** Flexible yet sturdy barrier separating intracellular and extracellular environments.
 - selective barrier regulates the flow of materials into and out of a cell, helping to establish and maintain the appropriate environment for normal cellular activities.
 - plays a key role in communication among cells and between cells and their external environment.
 - The structure–function relationships of the cell membrane are responsible for many of the functions of the human body
- ▶ **Cytoplasm:** all of the cellular contents between the plasma membrane and
 - ▶ the nucleus. 2 components:
 - ▶ a) Cytosol - fluid portion of cytoplasm, contains water, dissolved solutes, and suspended particles.
 - ▶ b) Organelles - Within the cytosol, several different types of organelles. Each organelle has a characteristic shape and specific functions. Examples include ribosomes, endoplasmic reticulum, Golgi complex, lysosomes, peroxisomes, and mitochondria.

A Generalized Cell - Three Principal Parts

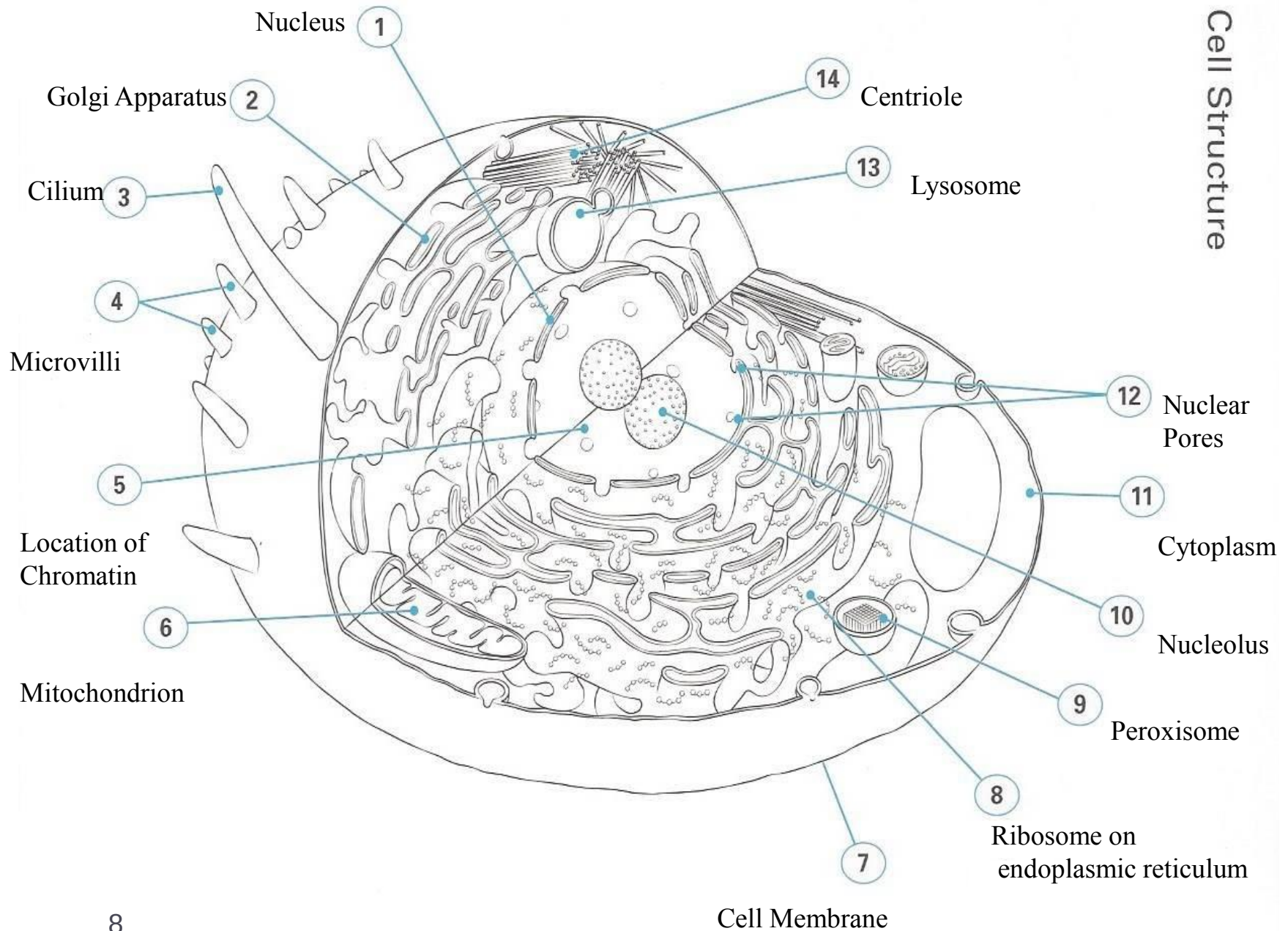
- ▶ **Nucleus:** large organelle that houses most of a cell's DNA. Within the nucleus, each **chromosome** (single molecule of DNA associated with several proteins) contains thousands of hereditary units called genes that control most aspects of cellular structure and function.

Anatomy Overview:

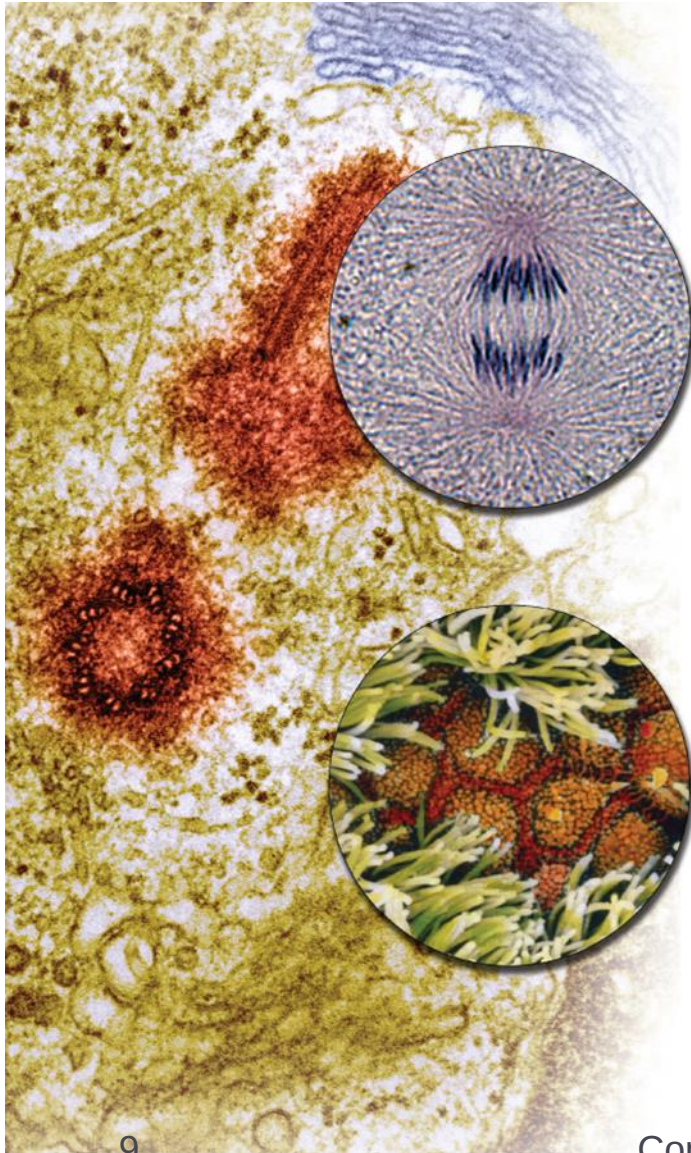
- Cell Structure and Function

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Cell Structure



Cells - 2.2 Plasma Membrane

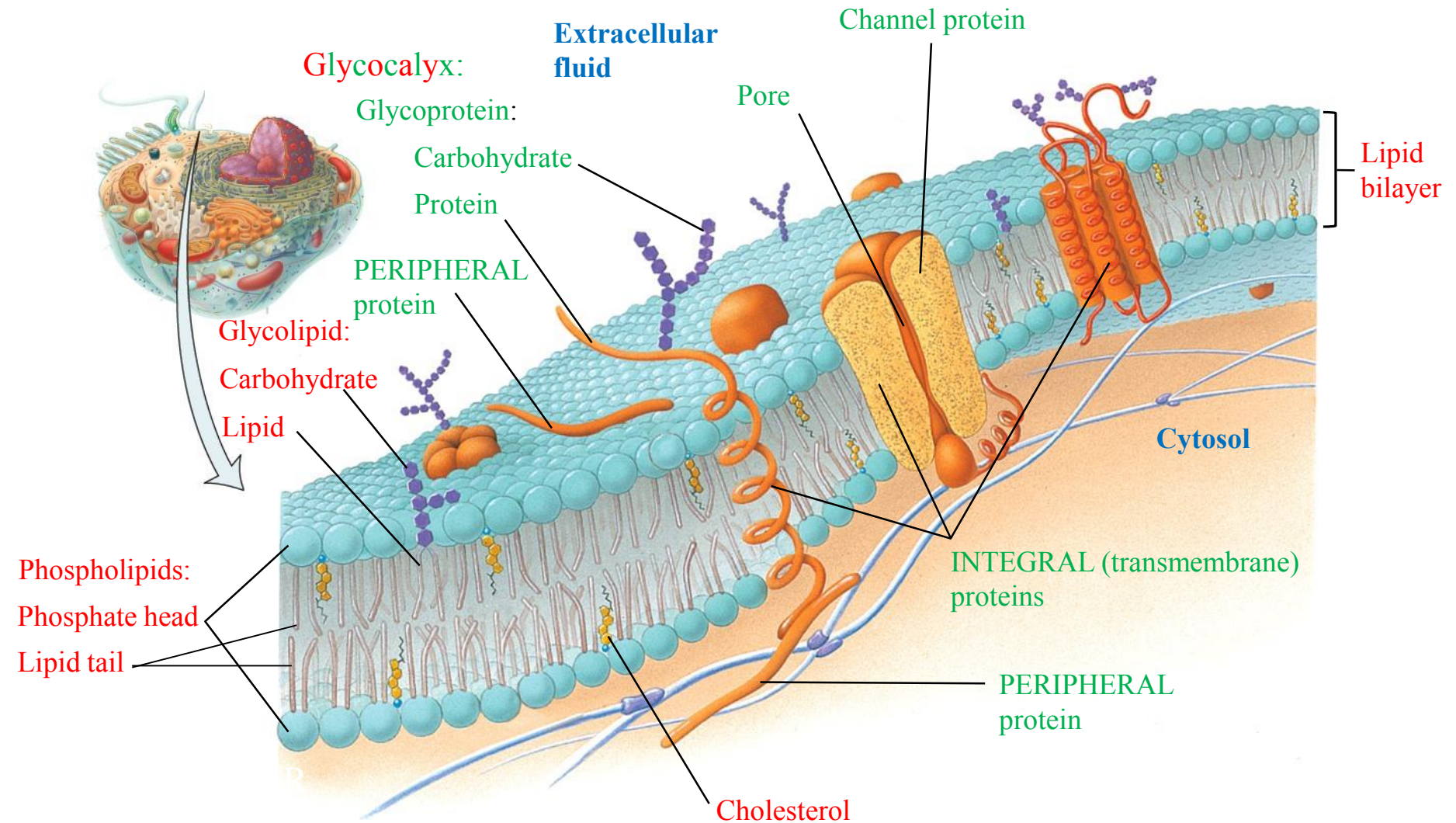


- ▶ Flexible yet sturdy barrier separating intracellular and extracellular environments
- ▶ Fluid mosaic model - the arrangement of molecules within the membrane resembles a sea of lipids containing many types of proteins
- ▶ Lipids act as a barrier to certain substances
- ▶ Proteins act as “gatekeepers” to certain molecules and ions

Anatomy Overview:

Plasma Membrane Structure

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LIPID BILAYER

phospholipids 75%

cholesterol 20%

glycolipids 5%

Structure of a Membrane

- ▶ Consists of a lipid bilayer
- ▶ Proteins (2 main groups)
 - ▶ Integral proteins-glycoproteins
 - ▶ Glyocalyx
 - ▶ Transmembrane proteins
 - ▶ Peripheral proteins

*Generally, **lipids** only vary slightly from one type of cellular membrane to another, while **proteins** vary immensely. It is ultimately the membrane's protein composition that determines the membrane's functions.*

Structure of a Membrane

1. Integral proteins

- firmly embedded into the membrane
 - extend into the lipid bilayer
 - most are **trans-membrane proteins** (span entire bilayer & protrude into either the extracellular or intracellular fluids)
 - Many integral membrane proteins are **glycoproteins** (proteins with carbohydrate groups attached to the ends that protrude into the ECF)
 - **Glycocalyx**: An extensive sugary coat made up of the carbohydrate portions of **glycolipids & glycoproteins**
- Functions:
- Enables cells to recognize one another due to the unique composition of the glycocalyx - acts like a molecular “signature” (WBC’s ability to detect foreign glycocalyxes)
 - Enables cells to adhere to one another in some tissues.
 - Enables cells to be moist and slippery in other tissues because it attracts a film of fluid to the surface. (RBC’s, lining of airways and GI tract)
 - Protects cells from being digested by enzymes in the ECF

► 2. Peripheral proteins

- not as firmly embedded into the membrane
- attach to membrane lipids or integral proteins at the inner or outer surface of the membrane

Functions of Membrane Proteins

- ▶ Proteins form ion channels, pores or holes through which specific ions, such as **K⁺ ions** can flow through to gain entry or leave the cell.
- ▶ Act as **carriers or transporters**, **selectively moving a polar substance** (one having two opposite poles) or ion from one side of the membrane to the other.
- ▶ Integral proteins called receptors serve as cellular recognition sites. Each type of receptor recognizes and **binds a specific type of molecule**. For instance, insulin receptors bind the **hormone insulin**.
- ▶ **Ligand** (LI--gand; liga-tied) specific molecule that binds to a receptor
- ▶ **Enzymes** catalyze specific chemical reactions at the inside or outside surface of the cell.
- ▶ **Linkers** anchor the plasma membranes of neighboring cells to one another or to protein filaments inside and outside the cell. Cell **Identity markers** - glycoproteins and glycolipids enable a cell to
 - ▶ (1) recognize other cells of the same kind during tissue formation or
 - ▶ (2) recognize and respond to potentially dangerous foreign cells.
- ▶ The ABO blood type markers are one example of cell identity markers. When you receive a blood transfusion, the blood type must be compatible with your own, or red blood cells may clump together.

Cell Membrane Functions

Interactions Animations:

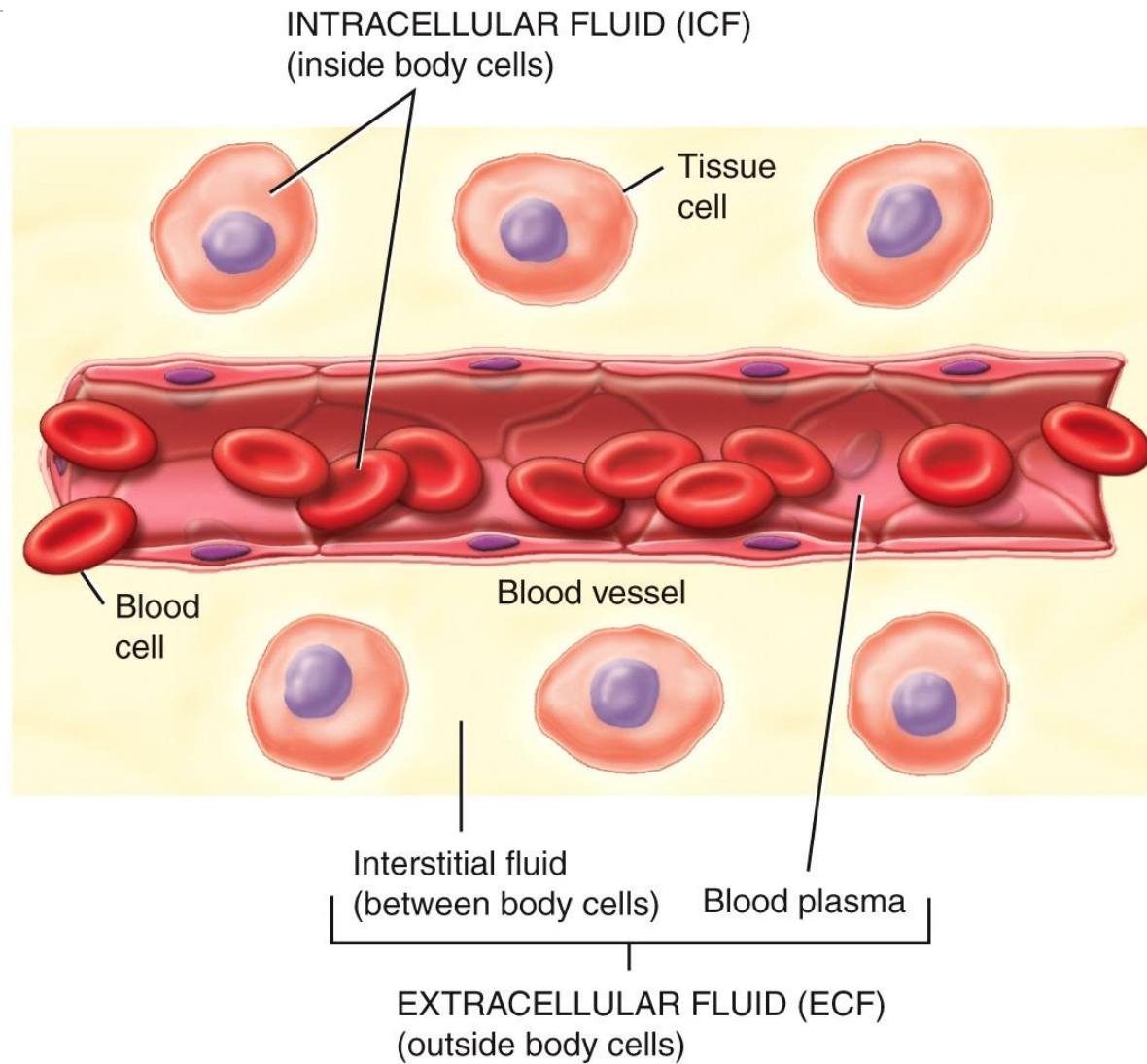
- Membrane Functions

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1.1 Membrane functions

- 2.1 Transport – selective permeability
- 2.2 Transport – phospholipid bilayer
- 2.3 Transport – membrane protein pores and pumps
- 2.4 Transport – membrane transporter proteins
- 2.5 Transport – transport vesicles
- 3.1 Communication
- 4.1 Enzymatic reactions
- 5.1 Cell Identification
- 6.1 Cell junction formation

Body Fluids



Body fluids

Intracellular fluid (ICF) or cytosol is the fluid within cells.
Extracellular fluid (ECF) is found outside cells:
 in blood vessels as **plasma**,
 in lymphatic vessels as **lymph**
 between tissue cells as **interstitial fluid**.

Membrane Permeability

Permeable: a structure permits the passage of substances through it

Impermeable: a structure does not permit the passage of substances through it

Cell membranes have **selective permeability**

- ▶ *permeable to:* molecules such as oxygen, carbon dioxide, water and steroids
- ▶ *impermeable to:* ions and molecules such as glucose

Transport Across the Plasma Membrane

- ▶ Intracellular fluid (ICF)
- ▶ Extracellular fluid (ECF)
 - ▶ Interstitial fluid
 - ▶ Plasma
 - ▶ Lymph
- ▶ All body cells are surrounded by the same fluid environment.
- ▶ The movement of substances across a plasma membrane and across membranes within cells is essential to the life of the cell and the organism

Transport Across the Plasma Membrane

- ▶ ECF substances: gas molecules, nutrient molecules, and ions—all needed for the maintenance of life.
- ▶ ECF is in constant motion throughout the body. It circulates through the blood vessels (circulatory vessels), returns through lymphatic vessels (accessory drainage vessels), and moves into and out of the spaces between the tissue cells and capillaries of these two categories of vessels.
- ▶ Certain substances—oxygen, for example—must move into the cell to support life, and waste materials or harmful substances must be moved out. Plasma membranes regulate the movements of such materials.

Transport

Interactions Animations

- ▶ Transport Across the Plasma Membrane

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You must be connected to the internet to run this animation.

Passive vs. Active Processes

- ▶ Passive processes: no energy consumption
- ▶ Active processes : with energy consumption
- ▶ 1.1 Role of transport in a cell
- ▶ 2.1 Types of transport – passive and active processes
- ▶ 3.1 Diffusion – gases and non polar compounds transport
- ▶ 3.2 Diffusion – ion transport
- ▶ 4.1 Facilitated diffusion – glucose transport
- ▶ 5.1 Osmosis – water transport
- ▶ 5.2 Osmosis – isotonic solutions
- ▶ 5.3 Osmosis – hypertonic solutions
- ▶ 5.4 Osmosis – hypertonic solutions
- ▶ 6.1 Primary active transport – support for electrochemical gradient
- ▶ 6.2 Primary active transport – ion transport/water movement
- ▶ 7.1 Secondary active transport
- ▶ 8.1 Endocytosis – types
- ▶ 8.2 Endocytosis – phagocytosis
- ▶ 8.3 Endocytosis – pinocytosis
- ▶ 8.4 Endocytosis – receptor mediated
- ▶ 8.5 Endocytosis – transcytosis
- ▶ 9.1 Exocytosis - secretion

Transport Across Plasma Membranes

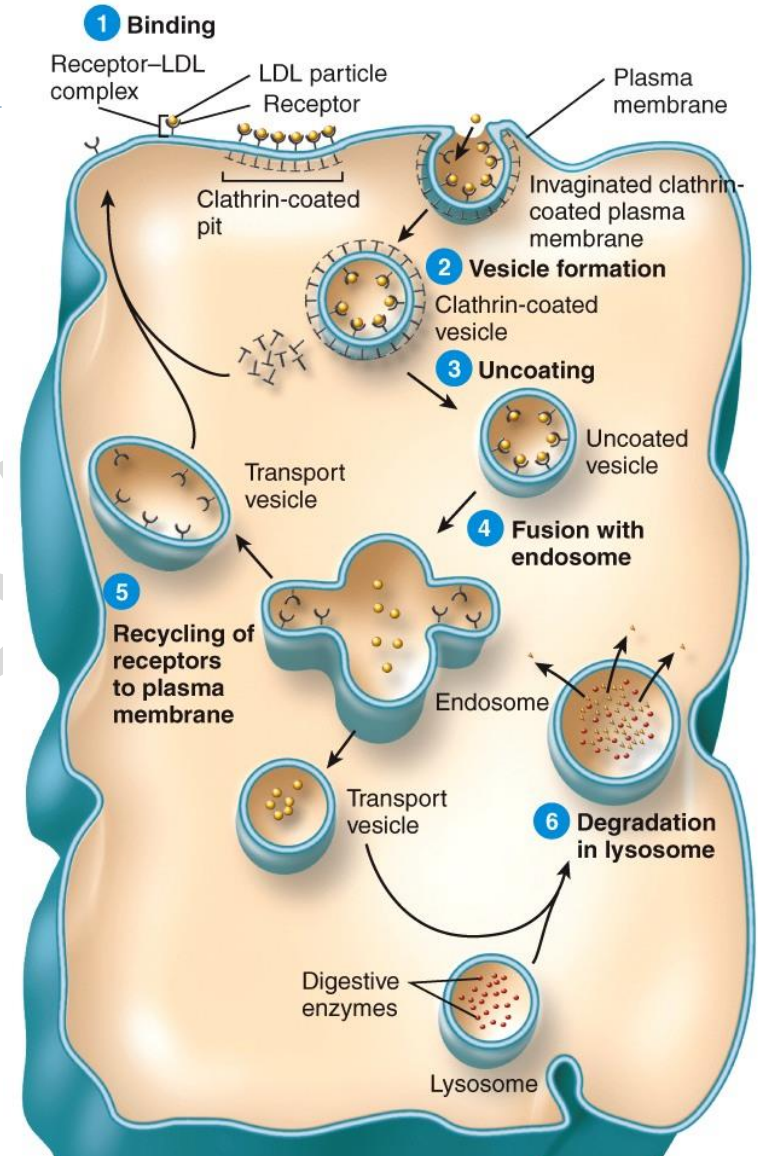
► Kinetic energy transport

- **Diffusion**: is the movement of a substance from an area of high concentration to an area of low concentration. **Diffusion** happens in liquids and gases because their particles move randomly from place to place. **Diffusion** is an important process for living things; it is how substances move in and out of cells.
- **Osmosis**: a process by which molecules of a solvent tend to pass through a semipermeable membrane from a less concentrated solution into a more concentrated one, thus equalizing the concentrations on each side of the membrane.
- **Facilitated Diffusion**: (also known as **facilitated** transport or passive-mediated transport) is the process of spontaneous passive transport (as opposed to active transport) of molecules or ions across a biological membrane via specific transmembrane integral proteins

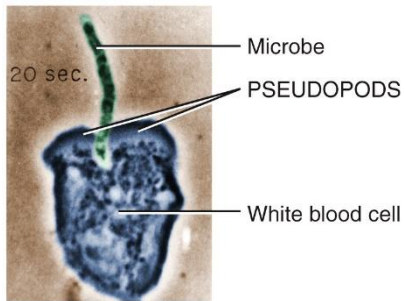
Transport in Vesicles

- ▶ **Vesicle**
- ▶ **Endocytosis:** A process in which cell takes in materials from the outside by engulfing and fusing them with its plasma membrane - three types
 - ▶ Receptor-mediated endocytosis
 - ▶ Phagocytosis
 - ▶ Bulk-phase endocytosis (pinocytosis)
- ▶ **Exocytosis:** membrane-bound vesicles containing cellular molecules are transported to the cell membrane
- ▶ **Transcytosis:** (also known as cytopempsis) is a type of transcellular transport in which various macromolecules are transported across the interior of a cell. Macromolecules are captured in vesicles on one side of the cell, drawn across the cell, and ejected on the other side

Receptor-Mediated Endocytosis

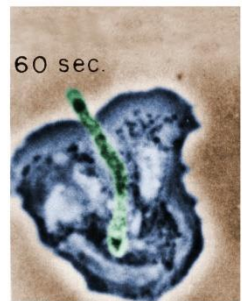


Phagocytosis



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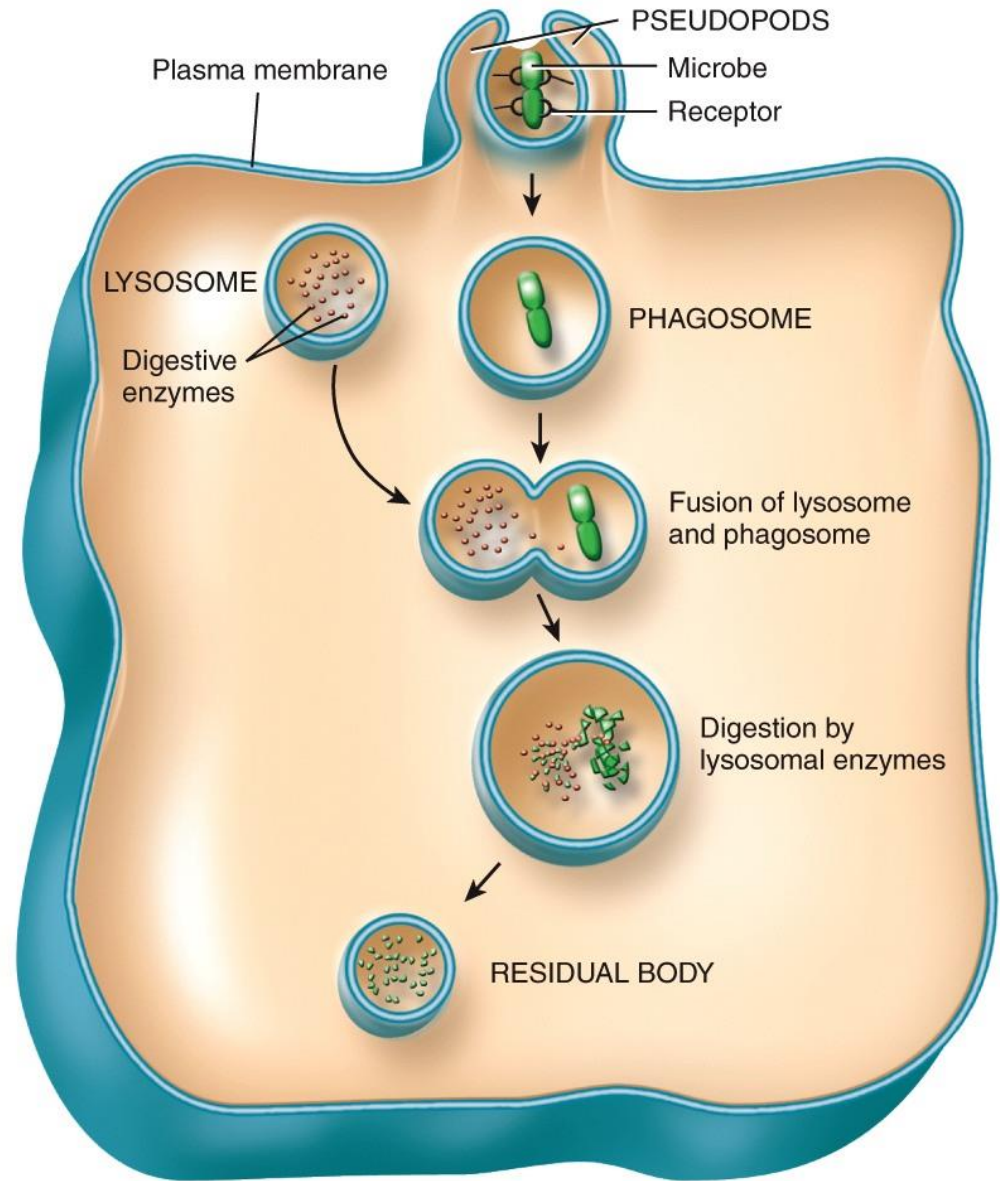
(b) White blood cell engulfs microbe



LM 450x

(c) White blood cell destroys microbe

Omikron/Photo Researchers, Inc.



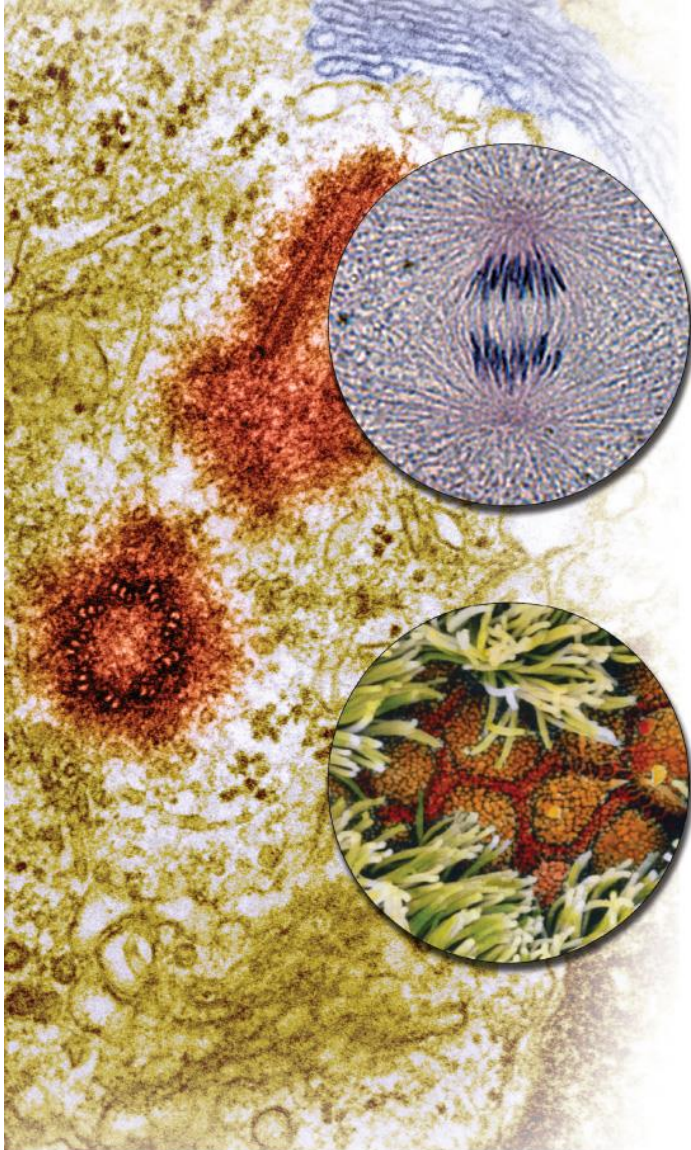
(a) Diagram of the process

Clinical Connection

- ▶ Viruses and Receptor-mediated Endocytosis
- ▶ Phagocytosis
- ▶ Pus

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2.3 Cytoplasm – Two Components



► Cytosol – the fluid portion of the cytoplasm that surrounds organelles

► Cytoskeleton

► Microfilaments,

► Intermediate Filaments

► Microtubules

► Organelles – specialized structures within the cell have specific shape and functions

2.3 Cytoplasm – Two Components

▶ Cytosol

- constitutes about 55 percent of total cell volume
- varies in composition & consistency in different parts of cell
- 75–90 percent water plus various dissolved and suspended components (ions, glucose, amino acids, fatty acids, proteins, lipids, ATP, waste products and various organic molecules that aggregate into masses for storage (*glycogen granules, lipid droplets*))

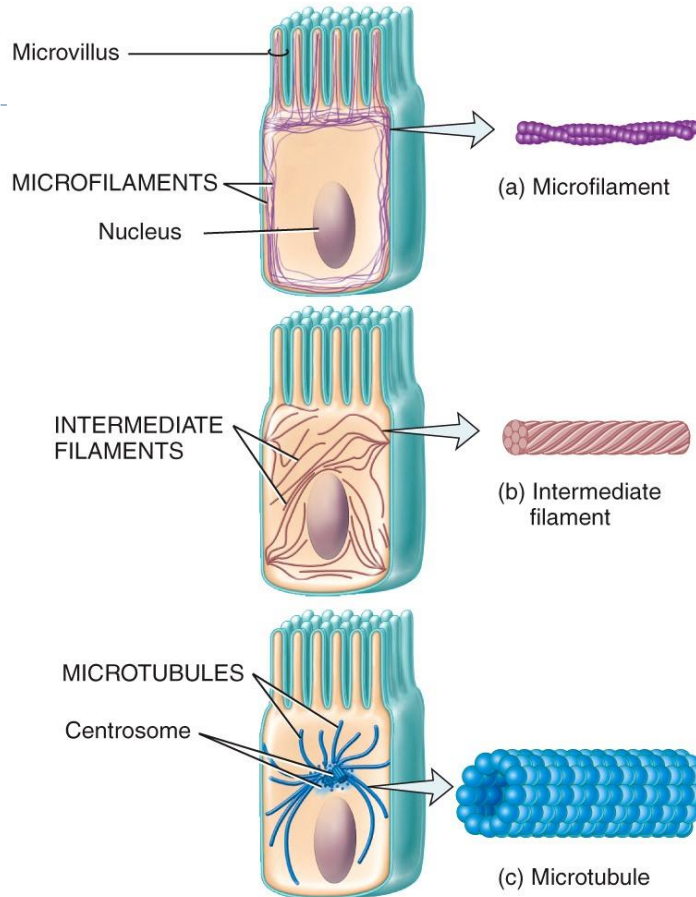
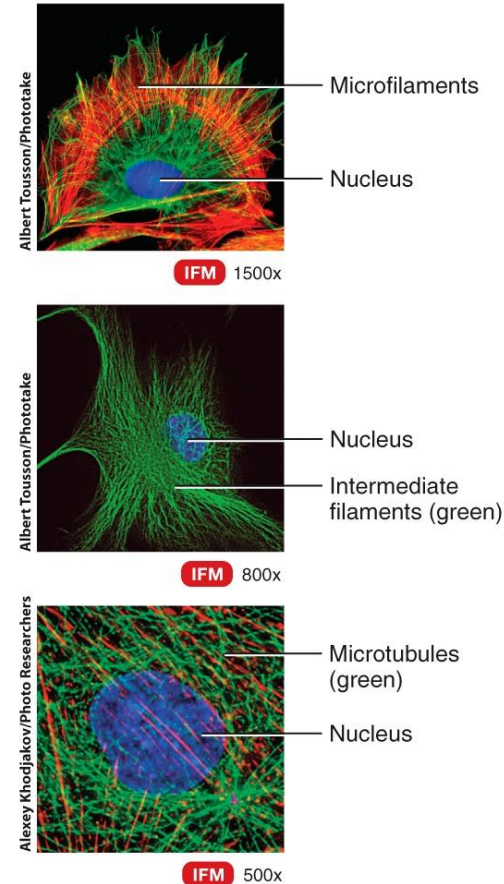
FUNCTION:

- site of many chemical reactions required for a cell's existence. (enzymes in cytosol catalyze numerous chemical reactions that release and capture energy to drive cellular activities; some of these reactions provide the building blocks for maintaining cell structure, function, and growth.)

▶ Organelles

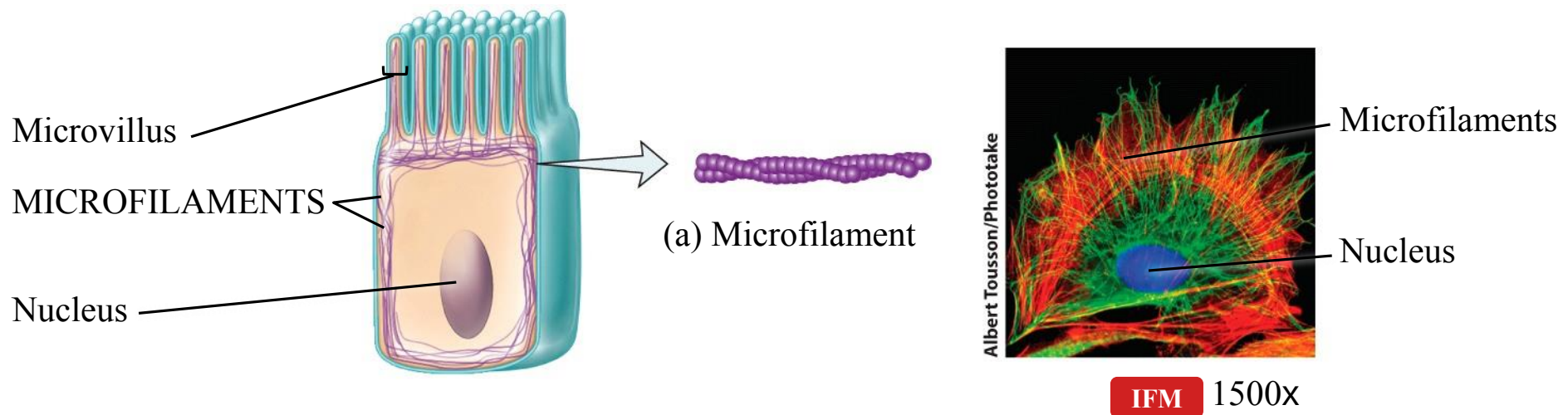
- The multitude of cellular reactions going on do not interfere because they are confined to different organelles.
- Each type of organelle has its own set of enzymes that carry out specific reactions, and serves as a functional compartment for specific biochemical processes. The numbers and types of organelles vary in different cells, depending on the cell's function.

Cytoskeleton



Cytoskeleton: is a network of protein filaments that extends throughout the cytosol. Three types of filamentous proteins contribute to the structure of the cytoskeleton and other organelles. In the order of their increasing diameter, these structures are microfilaments, intermediate filaments, and microtubules.

Cytoskeleton - Microfilaments



FUNCTIONS OF THE CYTOSKELETON

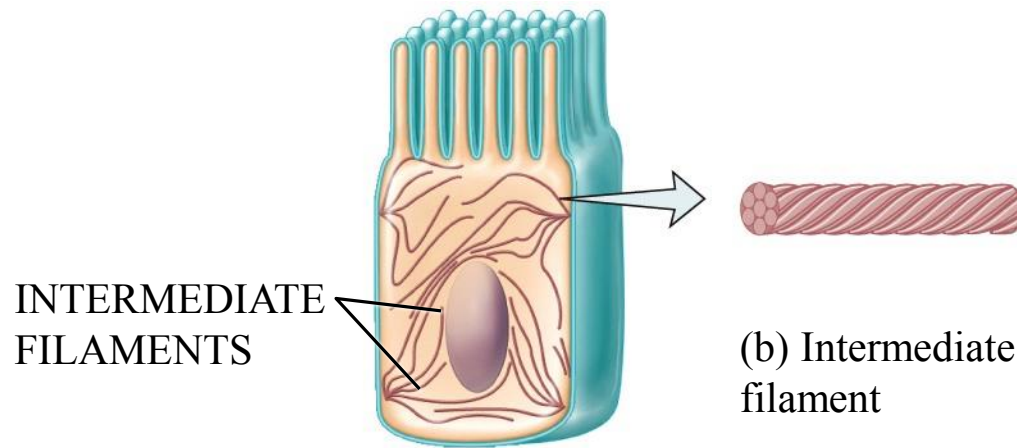
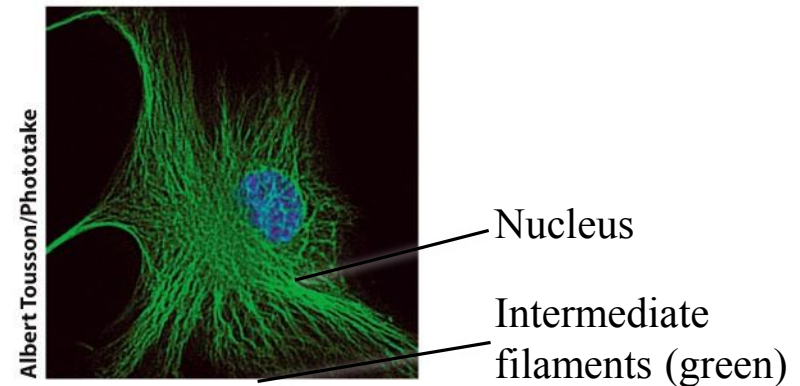
1. Aids movement of organelles within the cell, of chromosomes during cell division, and of whole cells such as phagocytes.
2. Serves as a scaffold that helps to determine a cell's shape and to organize the cellular contents.

Cytoskeleton

Microvilli:

- nonmotile, microscopic finger like projections of the plasma membrane
- core of parallel microfilaments within a microvillus supports it and attaches it to other parts of the cytoskeleton
- increase the surface area of the plasma membrane and are abundant on the surfaces of cells involved in absorption, such as the epithelial cells that line the small intestine.
- some microfilaments extend beyond the plasma membrane and help cells attach to one another or to extracellular materials

Cytoskeleton – Intermediate Filaments



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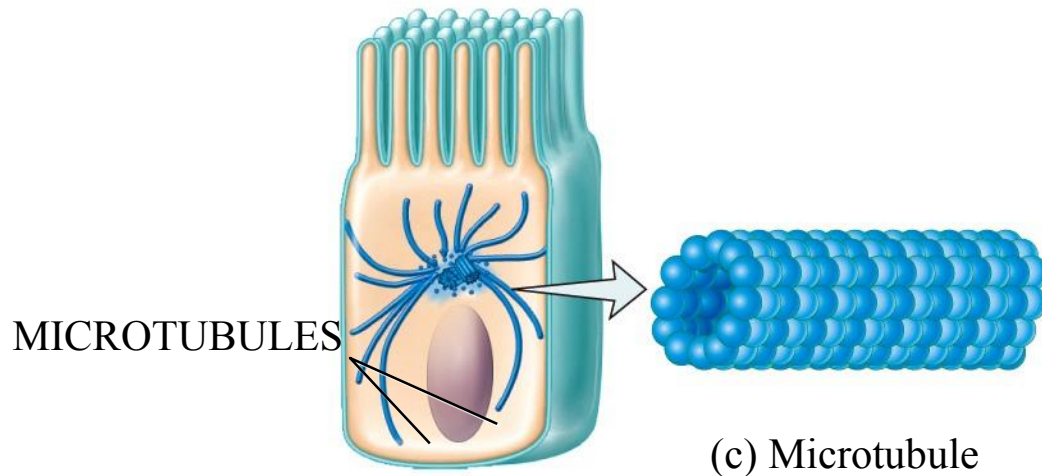
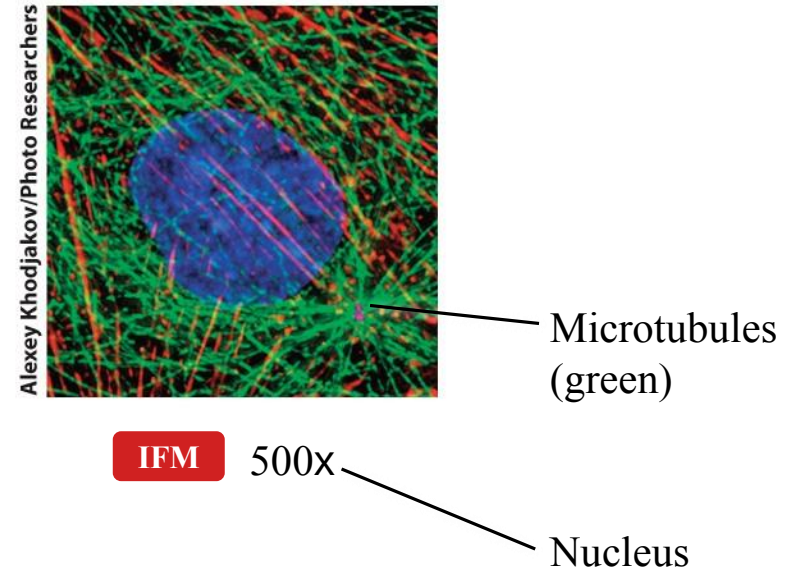
Intermediate filaments

- thicker than microfilaments but thinner than microtubules
 - composed of several different proteins which are exceptionally strong.
- found in parts of cells subject to mechanical stress

Functions:

- help anchor organelles such as the nucleus
- attach cells to one another

Cytoskeleton - Microtubules



Microtubules

- largest of the cytoskeletal components
- long, unbranched hollow tubes composed mainly of *tubulin*.

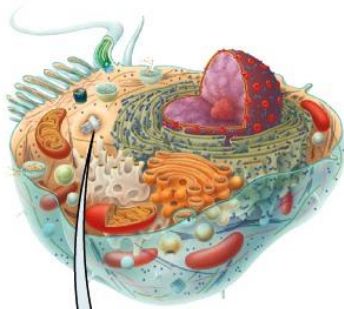
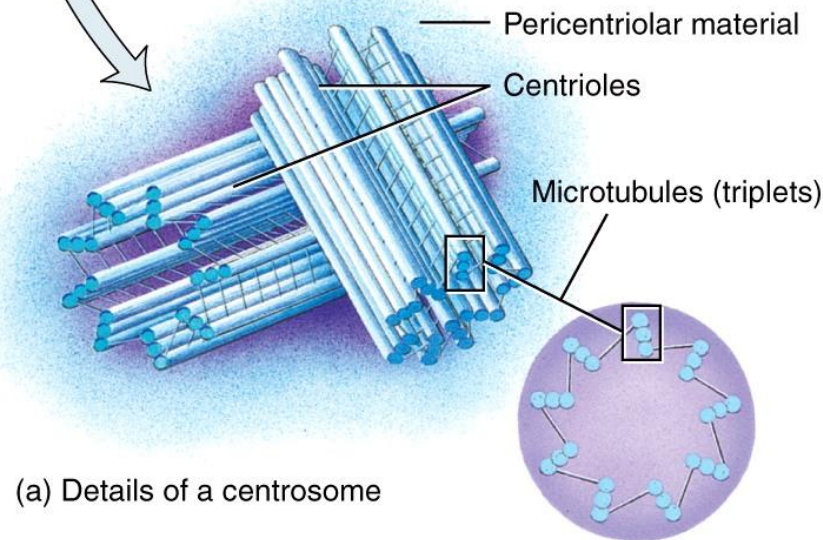
Microtubules Functions:

- help determine cell shape and function in the intracellular transport of organelles - secretory vesicles; migration of chromosomes during cell division
- participate in the movement of specialized cell projections such as cilia and flagella.

Centrosome

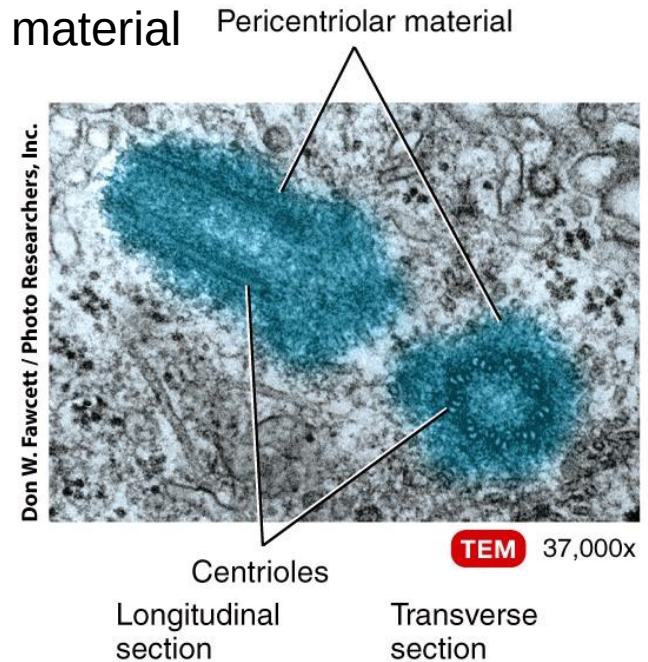
- **Centrosome**

- is the initiation site for the assembly of microtubules. The microtubules grow outward from the centrosome toward the periphery of the cells
- located near the nucleus
- consists of a pair of centrioles and pericentriolar material



(a) Details of a centrosome

(b) Arrangement of microtubules in centrosome



(c) Centrioles

Centrosome

Centrosome:

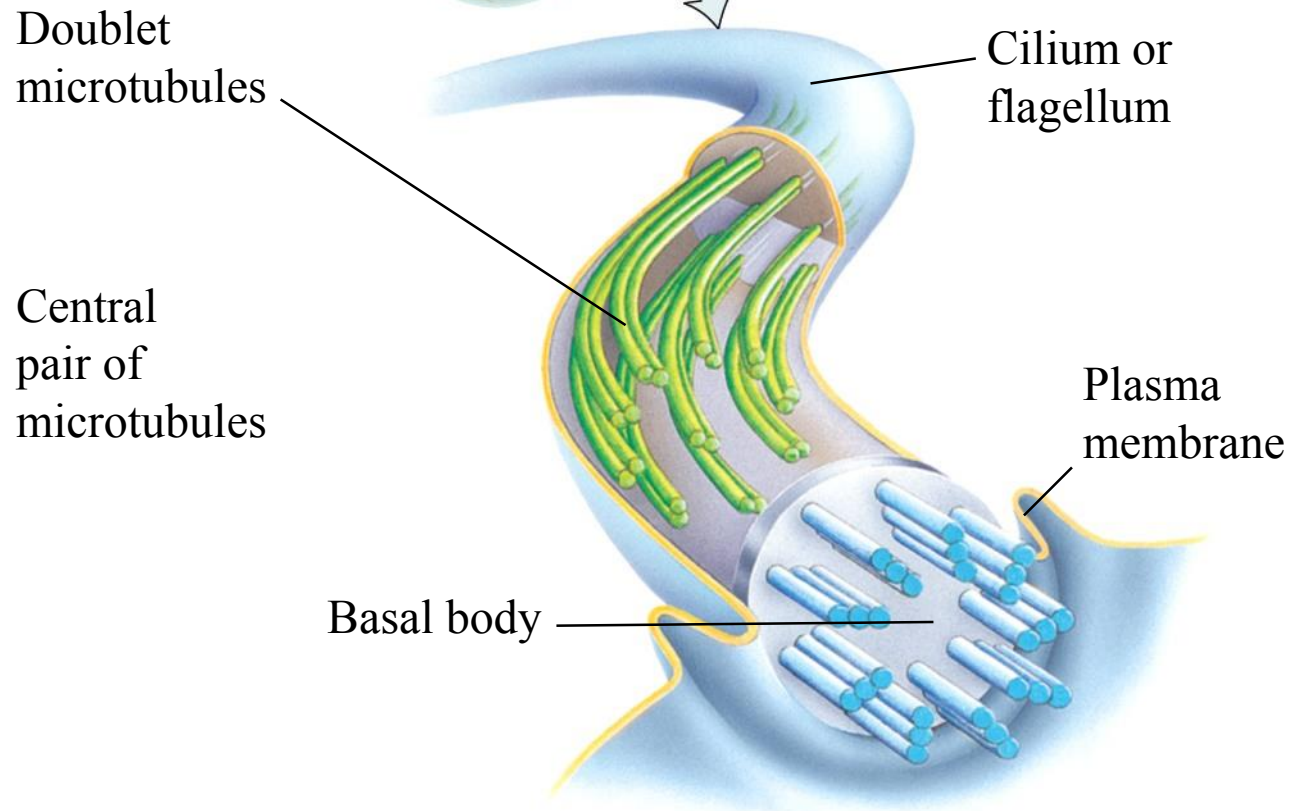
- is the initiation site for the assembly of microtubules
- located near the nucleus
- consists of two components:
 - **a pair of centrioles**
 - cylindrical structures, each composed of nine clusters of three **microtubules** (triplets) arranged in a circular pattern
 - The long axis of one centriole is at a right angle to the long axis of the other
 - **pericentriolar material**
 - contains hundreds of ring-shaped complexes composed of the protein **tubulin**.
 - **tubulin complexes** -organizing centers for growth of the *mitotic spindle*
 - critical role in cell division
 - microtubule formation in nondividing cells.

CENTROSOME FUNCTIONS:

1. The pericentriolar material of the centrosome contains tubulins that build microtubules in non-dividing cells.
2. The pericentriolar material forms the mitotic spindle during cell division

During cell division, centrosomes replicate so that succeeding generations of cells have the capacity for cell division.

Cilia and Flagella



(a) Arrangement of microtubules in a cilium or flagellum

(b) Cilia lining the trachea

Cilia

- numerous, short, hair like projections that extend from the surface of the cell
- Each contains a core of 20 microtubules surrounded by plasma membrane arranged with one pair in the center surrounded by nine clusters of two fused microtubules (doublets).

Each cilium is anchored to a **basal body** just below the surface of the plasma membrane. A basal body is similar in structure to a centriole and functions in initiating the assembly of cilia and flagella.



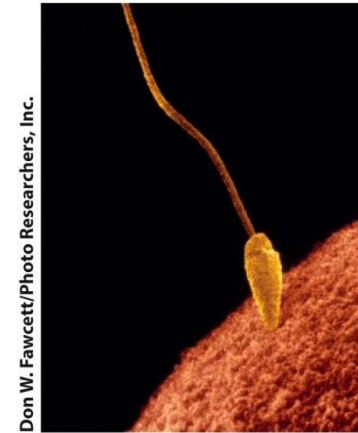
P. Motta/Photo Researchers Inc

SEM 3,000x

(c) Flagellum of a sperm cell

Flagella

- similar in structure to cilia but are typically much longer
- Only example: a sperm cell's tail, which propels the sperm toward the oocyte in the uterine tube.



Flagellum

SEM 4,000x

FUNCTIONS OF CILIA and FLAGELLA

1. **Cilia** move fluids along a cell's surface.
2. **A flagellum** moves an entire cell.

Microtubules are the dominant components of cilia and flagella, which are motile projections of the cell surface.

Many cells of the respiratory tract, for example, have hundreds of cilia that help sweep foreign particles trapped in mucus away from the lungs. The extremely thick mucus secretions that are produced in people who suffer from cystic fibrosis interfere with ciliary action and the normal functions of the respiratory tract.

Clinical Connection

Cilia and smoking

The movement of Cilia is paralyzed by nicotine in cigarette smoke

Smokers cough

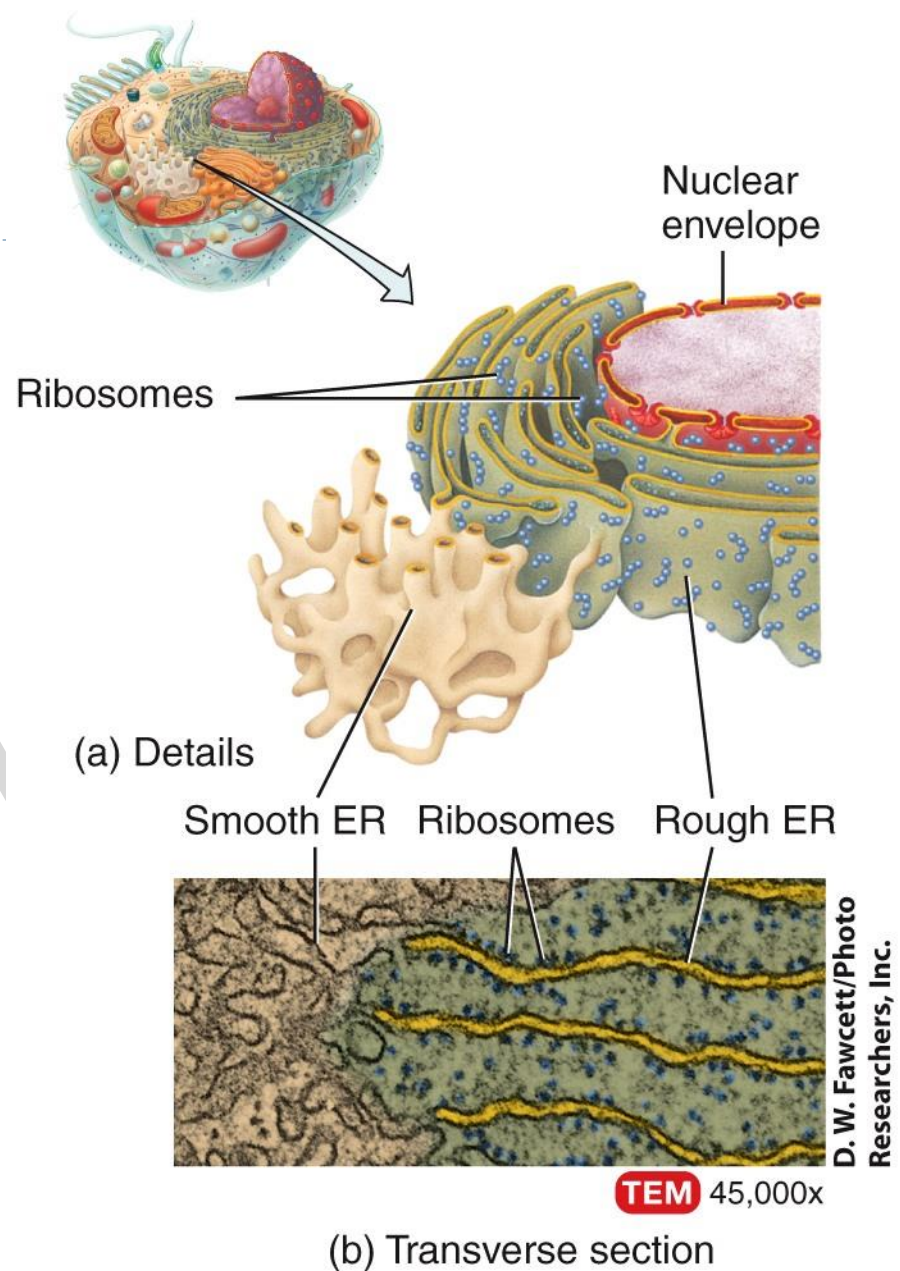
Infertility

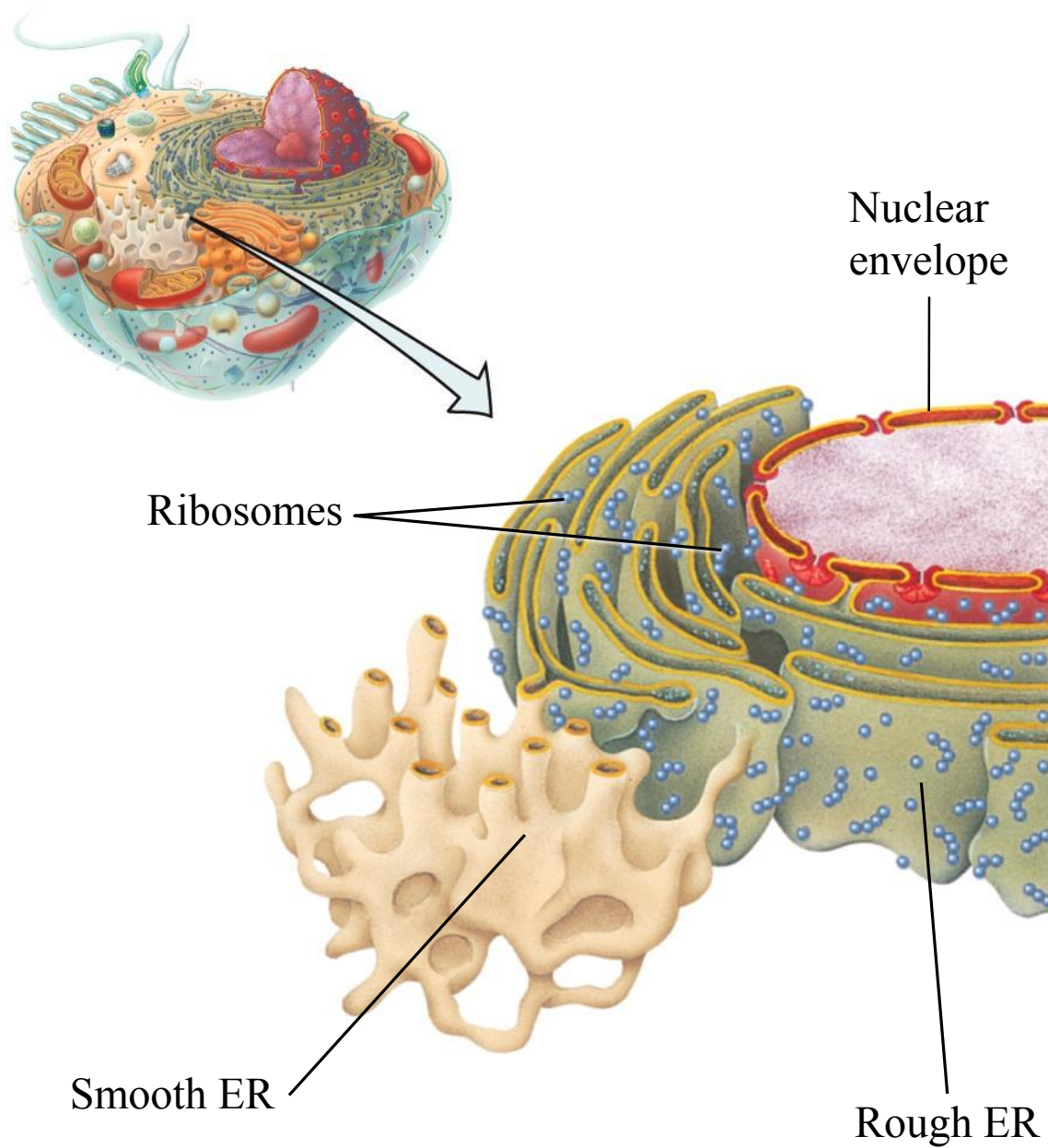
Cilia and Smoking

The movement of cilia is also paralyzed by nicotine in cigarette smoke. For this reason, smokers cough often to remove foreign particles from their airways. Because cells that line the uterine (fallopian) tubes also have cilia that sweep oocytes (egg cells) toward the uterus, females who smoke have an increased risk of ectopic (outside the uterus) pregnancy.

Organelles

- ▶ Ribosomes
- ▶ Endoplasmic reticulum
 - ▶ Rough ER
 - ▶ Smooth ER



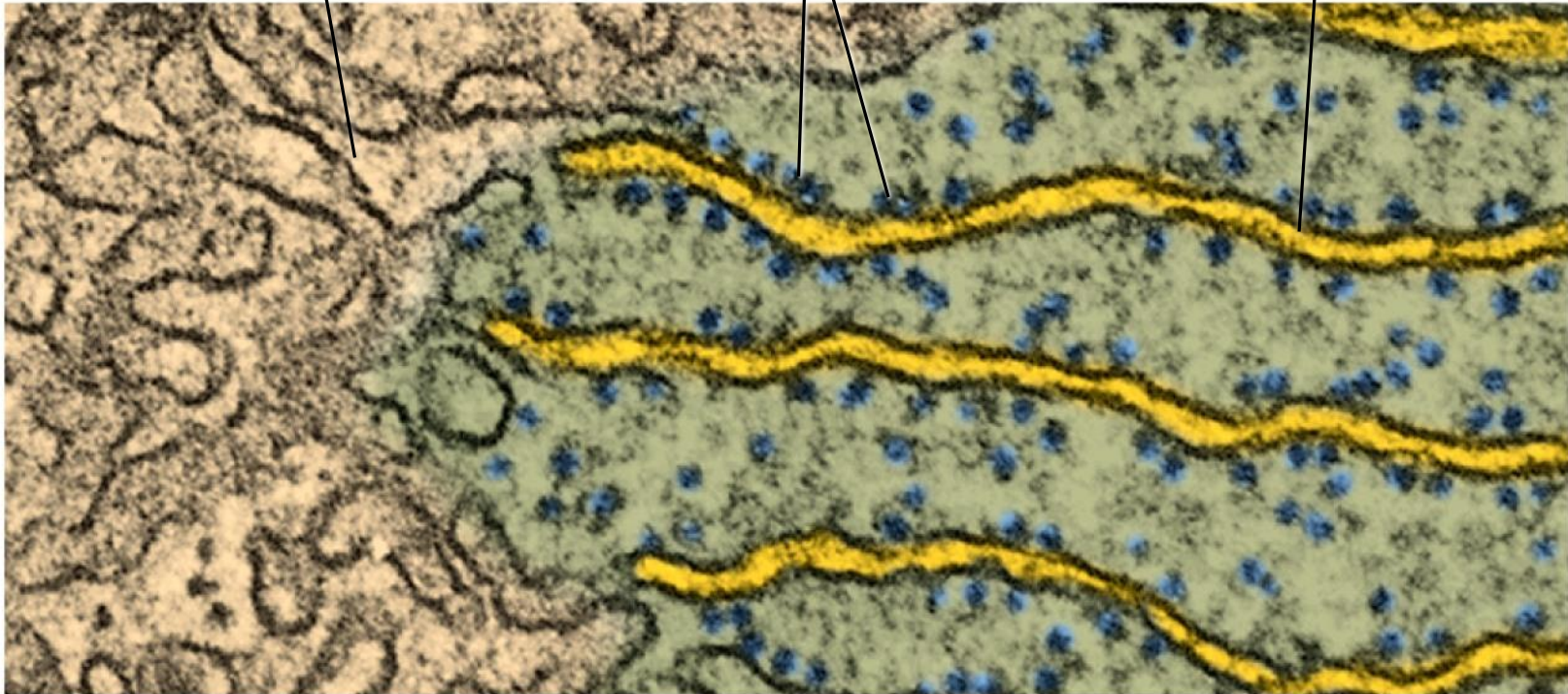


(a) Details

Smooth ER

Ribosomes

Rough ER



TEM 45,000x

D. W. Fawcett/Photo
Researchers, Inc.

(b) Transverse section

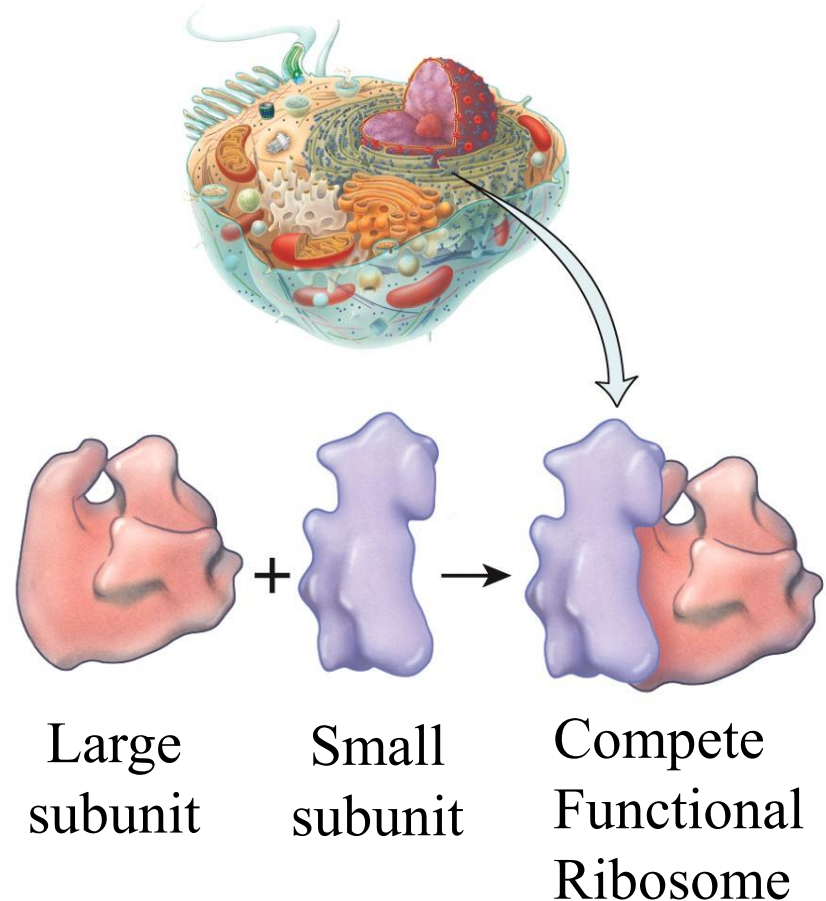
Ribosomes

- packages of **ribosomal RNA**
- **(rRNA)** and many ribosomal
- proteins
- sites of protein synthesis
- consists of two subunits
- free & membrane-bound

Ribosomes are so named because of their high content of *ribonucleic acid*.

consists of two subunits, one about half the size of the other

Large and small ribosomal subunits are synthesized in the nucleolus of the nucleus and assembled in the cytoplasm



Ribosomes

TYPES:

free ribosomes

unattached to any structure in the cytoplasm

membrane-bound ribosomes

attached to the nuclear membrane

attached to an extensively folded membrane called the endoplasmic reticulum

located within mitochondria, where they synthesize mitochondrial proteins

Functions:

- Free ribosomes synthesize proteins used in the cytosol.
- Ribosomes associated with endoplasmic reticulum synthesize proteins destined for insertion in the plasma membrane or secretion from the cell.

Endoplasmic Reticulum

-----A network of membrane-enclosed sacs or tubules that extend throughout the cytoplasm and connect to the nuclear envelope.

- Rough ER
- Smooth ER

The ER is so extensive that it constitutes more than half of the membranous surfaces within the cytoplasm of most cells

Rough ER has attached ribosomes; **smooth ER** does not.

The outer surface of rough ER is studded with ribosomes

Rough ER synthesizes proteins that will be exported from the cell;

Smooth ER is associated with lipid synthesis and other metabolic reactions.

*contains **unique enzymes** that make it functionally more diverse than rough ER.*

Endoplasmic reticulum

FUNCTIONS:

Rough ER

- ▶ synthesizes glycoproteins and phospholipids that are transferred into cellular organelles, inserted into the plasma membrane, or secreted during exocytosis.

Smooth ER

- ▶ synthesizes fatty acids and steroids, such as estrogens and testosterone;
- ▶ inactivates or detoxifies drugs and other potentially harmful substances;
- ▶ removes the phosphate group from glucose-6-phosphate; and stores and releases calcium ions that trigger contraction in muscle cells.

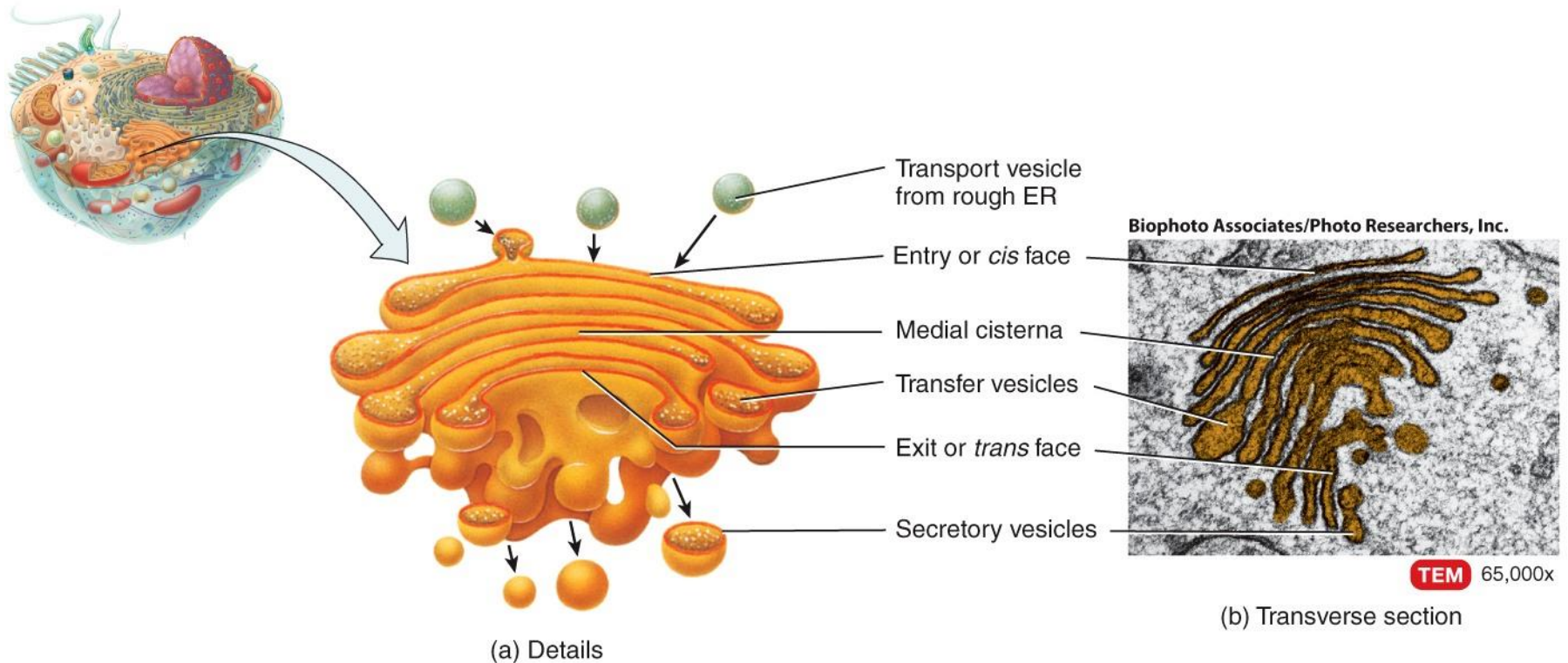
Endoplasmic reticulum

- ▶ **Rough ER synthesizes proteins that will be exported from the cell;**
- ▶ *Proteins synthesized by ribosomes attached to the rough ER enter spaces within the ER for processing and sorting.*
- ▶ *Enzymes attach the proteins to carbohydrates to form glycoproteins. In other cases, enzymes attach the proteins to phospholipids, also synthesized by rough ER. These molecules (glycoproteins and phospholipids) may be incorporated into the membranes of organelles, inserted into the plasma membrane, or secreted via exocytosis.*
- ▶ *Thus rough ER produces secretory proteins, membrane proteins, and many organellar proteins.*
- ▶ **Smooth ER is associated with lipid synthesis and other metabolic reactions.**
- ▶ *contains **unique enzymes** that make it functionally more diverse than rough ER.*
- *synthesize fatty acids and steroids, such as estrogens and testosterone.*
- ***In liver cells**, enzymes of the smooth ER help release glucose into the bloodstream and inactivate or detoxify lipid-soluble drugs or potentially harmful substances, such as alcohol, pesticides, and carcinogens (cancer-causing agents).*
- ***In liver, kidney, and intestinal cells** a smooth ER enzyme removes the phosphate group from glucose-6-phosphate, which allows the “free” glucose to enter the bloodstream.*
- ***In muscle cells**, the calcium ions (Ca^{2+}) that trigger contraction are released from the sarcoplasmic reticulum, a form of smooth ER.*

Organelles

- ▶ **Golgi complex**
- ▶ Most of the proteins synthesized by ribosomes attached to rough ER are ultimately transported to other regions of the cell. The first step in the transport pathway is through an organelle called the **Golgi complex**
- ▶ **Lysosomes**(LĪ-sō-sōms; *lyso-* = dissolving; *-somes* = bodies) are membrane-enclosed vesicles that form from the Golgi complex

Golgi Complex



Consists of 3 to 20 **cisternae** (small, flattened membranous sacs with bulging edges that resemble a stack of pita bread).

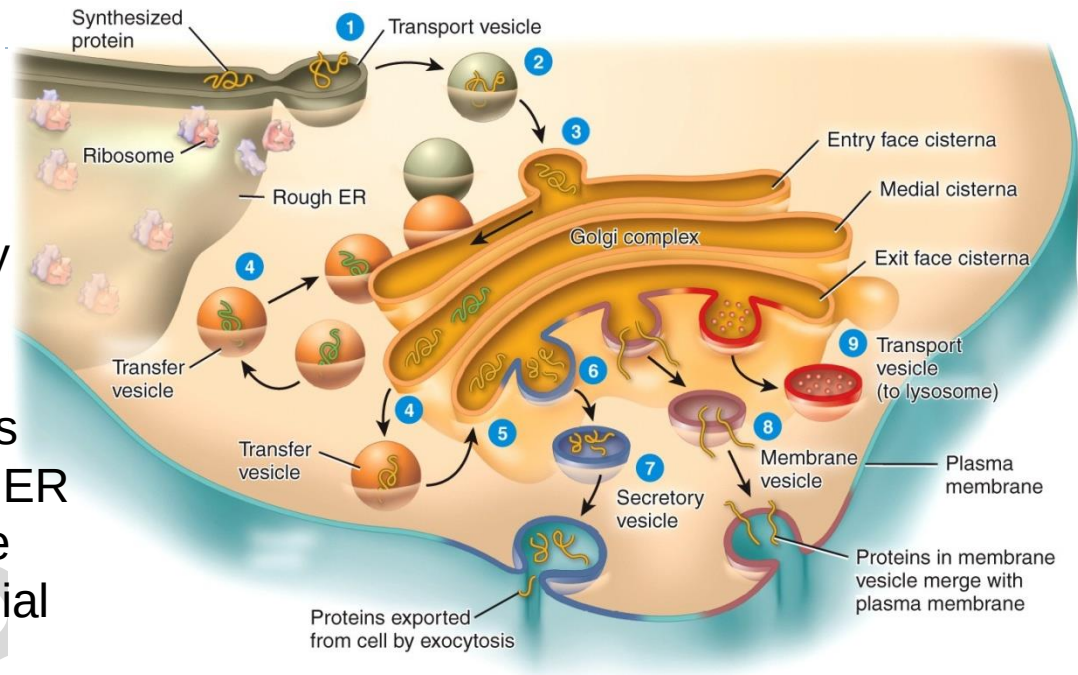
The cisternae are often curved, giving the Golgi complex a cuplike shape.

Most cells have several Golgi complexes (more extensive in protein-secreting cells)

Processing and Packaging by Golgi Complex

The opposite faces of a Golgi complex differ in size, shape, content, and enzymatic activity

The entry (convex or cis) face receives and modifies proteins from rough ER. Faces rough ER
Medial cisternae - between the entry and exit faces. The medial cisternae add carbohydrates to proteins to form glycoproteins, and add lipids to proteins to form lipoproteins.
The exit (concave or trans) face modifies, sorts, packages, and transports molecules to other destinations. Faces Plasma Membrane

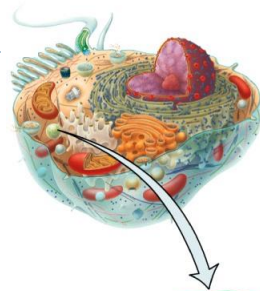
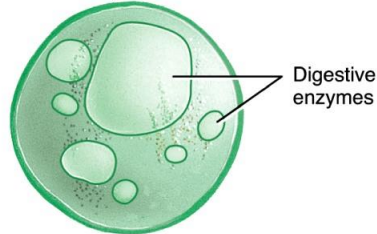


Golgi Complex

FUNCTIONS:

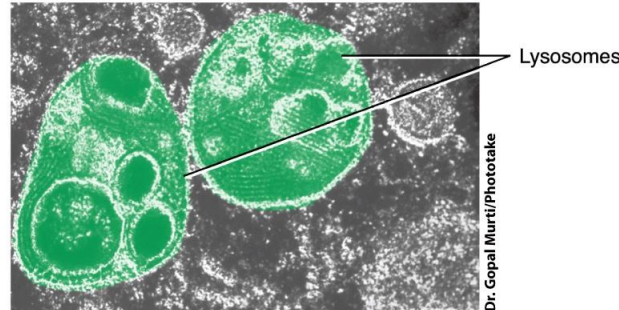
- Modifies, sorts, packages, and transports proteins received from the rough ER.
- Forms secretory vesicles that discharge processed proteins via exocytosis into extracellular fluid.
- Forms membrane vesicles that ferry new molecules to the plasma membrane.
- Forms transport vesicles that carry molecules to other organelles, such as **lysosomes**

Lysosomes



(a) Lysosome

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TEM 12,500x

(b) Several lysosomes

After lysosomes fuse with vesicles formed during endocytosis, the lysosomal enzymes break down the contents of the vesicles.

Proteins in the lysosomal membrane allow the final products of digestion, such as sugars, fatty acids, and amino acids, to be transported into the cytosol for use by the cell.

Lysosomes

FUNCTIONS:

- Digest substances that enter a cell via endocytosis and transport final products of digestion into cytosol.
- Carry out autophagy, the digestion of worn-out organelles.
- Implement autolysis, the digestion of the entire cell.
- Accomplish extracellular digestion.

Clinical Connection

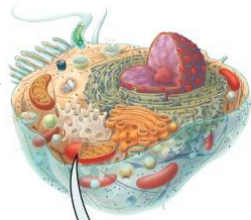
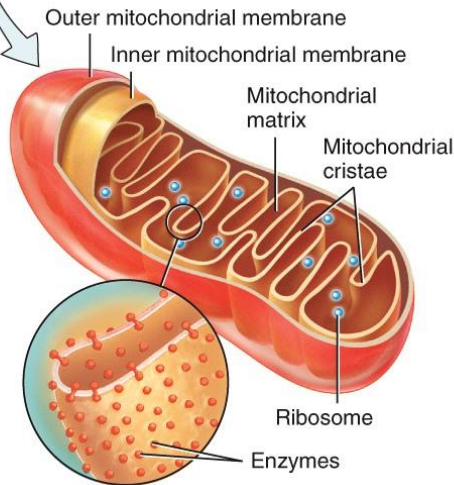
- ▶ Tay-Sachs : Caused by faulty or absent lysosomal enzymes --- **absence of a single lysosomal enzyme called Hex A**: normally breaks down a membrane glycolipid called ganglioside GM2 that is especially prevalent in nerve cells. As the excess ganglioside GM2 accumulates, the nerve cells function less efficiently.
- ▶ inherited condition - most often affects children of Ashkenazi (eastern European Jewish) descent
- ▶ seizures and muscle rigidity – leading to gradual blindness, dementia, poor motor coordination and death by age 5.
- ▶ Tests can now reveal whether an adult is a carrier of the defective gene.



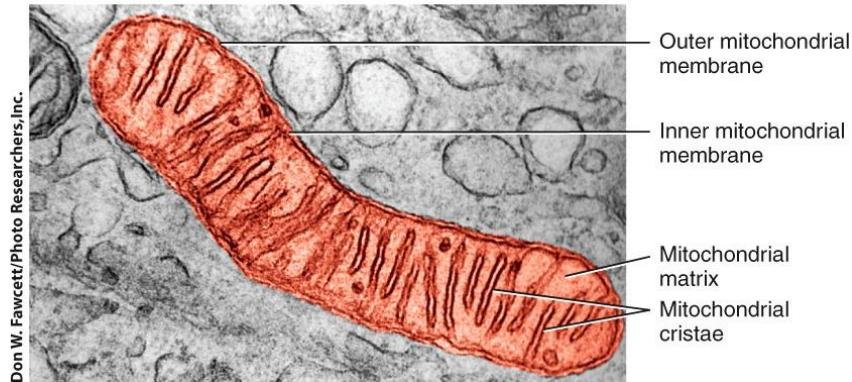
Organelles

- ▶ **Peroxisomes (peroxide “H₂O₂”)**
- ▶ contain several *oxidases*, enzymes that can oxidize (remove hydrogen atoms from) various organic substances.
- ▶ For instance, amino acids and fatty acids are oxidized in peroxisomes as part of normal metabolism. In addition, enzymes in peroxisomes oxidize toxic substances, such as alcohol.
- ▶ Thus, peroxisomes are very abundant in the liver, where detoxification of alcohol and other damaging substances occurs.
- ▶ Peroxisomes can self-replicate. New peroxisomes may form from preexisting ones by enlarging and dividing. They may also form by a process in which components accumulate at a given site in the cell and then assemble into a peroxisome.
- ▶ **Proteasomes**
 - ▶ Parkinson's disease and Alzheimer's disease.
 - ▶ contain myriad *proteases* - continual destruction of unneeded, damaged, or faulty proteins
 - ▶ very small (discovered only recently)

Organelles - Mitochondria



(a) Details



TEM 80,000x

(b) Transverse section

Several thousand in a cell muscles, liver, and kidneys, have a large number of mitochondria

Regular exercise can lead to an increase of mitochondria in muscle cells usually located where oxygen enters the cell or where the ATP is used, for example, among the contractile proteins in muscle cells.

Mitochondria

▶STRUCTURE: Cristae

- ▶ Matrix
- ▶ Self-replicate during times of increased cellular demand or before cell division

consists of an **outer mitochondrial membrane** and an **inner mitochondrial membrane** with a small fluid-filled space between them

Both membranes are similar in structure to the plasma membrane.

mitochondrial cristae The inner mitochondrial membrane contains a series of folds

mitochondrial matrix The central fluid-filled cavity of a mitochondrion, enclosed by the inner mitochondrial membrane:

- own ribosomes, own DNA, in the form of multiple copies of a circular DNA molecule that contains 37 genes. **mitochondrial genes are inherited only from your mother.**

This is due to the fact that all mitochondria in a cell are **descendants of those that were present in the oocyte during the fertilization process.** The head of a sperm (the part that penetrates and fertilizes an oocyte) normally lacks most organelles, such as mitochondria, ribosomes, endoplasmic reticulum, and the Golgi complex, and any sperm mitochondria that do enter the oocyte are soon destroyed.

Mitochondria

FUNCTIONS:

- ▶ Generate ATP through reactions of aerobic cellular respiration.
- ▶ Play an important early role in **apoptosis**: the orderly, genetically programmed death of a cell

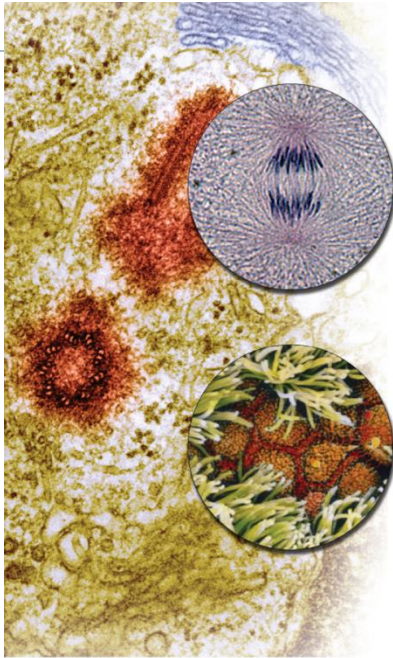
The elaborate folds of the **cristae** provide an enormous surface area for the chemical reactions that are part of the aerobic phase of *cellular respiration*, the reactions that produce most of a cell's ATP. The enzymes that catalyze these reactions are located on the cristae and in the matrix of the mitochondria.

Animation:

- Cell Respiration

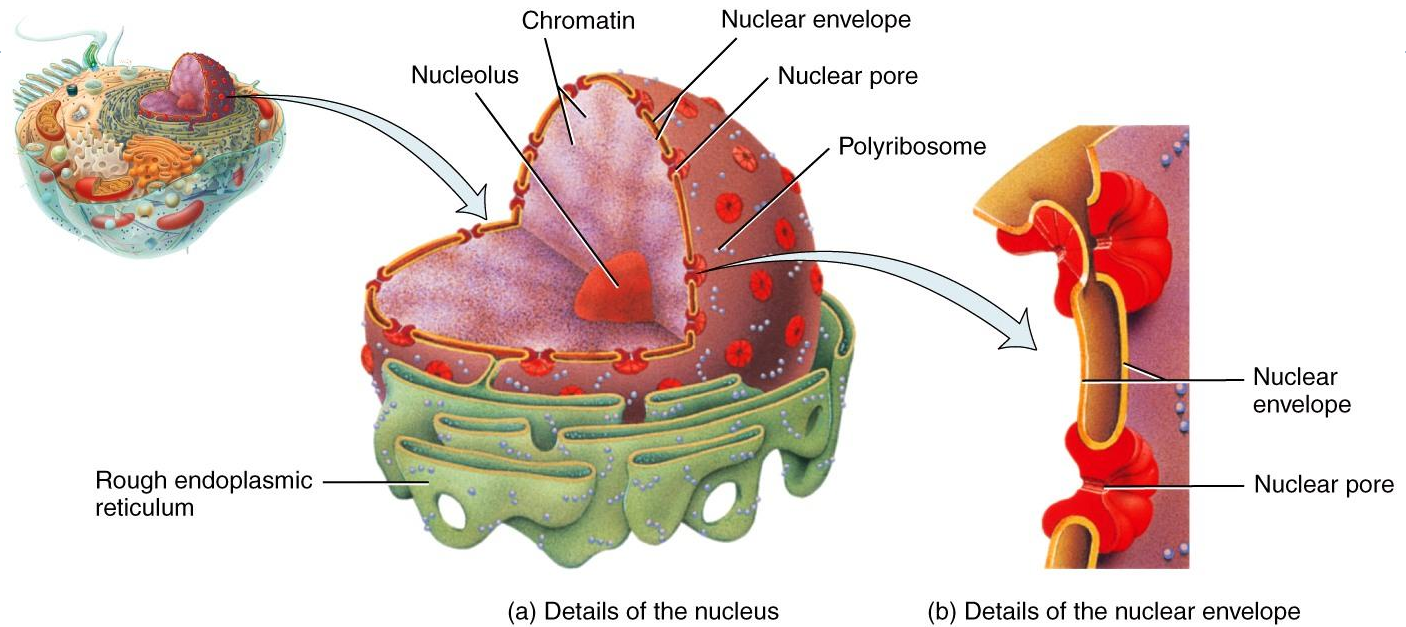
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Cells - 2.4 Nucleus



- ▶ Spherical or oval shaped structure
 - ▶ Usually most prominent feature of a cell
 - ▶ Nuclear envelope
 - ▶ Nuclear pores
 - ▶ Nucleolus
 - ▶ Genes
 - ▶ Chromosomes
- organelle - directing the life of a cell
 - The nucleus contains most of a cell's genes, which are located on chromosomes.
 - Most cells have a single nucleus, although some, such as mature red blood cells, have none. In contrast, skeletal muscle cells and a few other types of cells have multiple nuclei.

Nucleus



- **Nuclear envelope** - double membrane separates the nucleus from the cytoplasm. Both layers of the nuclear envelope are lipid bilayers similar to the plasma membrane. The outer membrane of the nuclear envelope is continuous with rough ER and resembles it in structure.

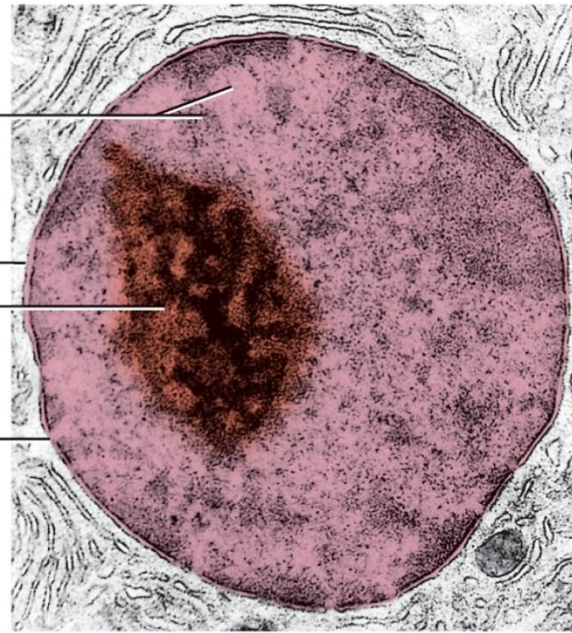
Nucleus

Chromatin

Nuclear envelope

Nucleolus

Nuclear pore



about 10,000x **TEM**

(c) Transverse section of the nucleus

- **Nucleoli: spherical body inside the nucleus** that function in producing **ribosomes**.
 - a cluster of protein, DNA, and RNA that is not enclosed by a membrane.
 - sites of rRNA synthesis and the assembly of rRNA and proteins into ribosomal subunits.
 - quite prominent in cells that synthesize large amounts of protein, such as muscle and liver cells.
 - disperse and disappear during cell division and reorganize once new cells are formed.

Nuclear pore

- **Nuclear pore:** openings in nuclear envelope. Each nuclear pore consists of a circular arrangement of proteins surrounding a large central opening that is about 10 times wider than the pore of a channel protein in the plasma membrane.
 - control the movement of substances between the nucleus and the cytoplasm
 - Small molecules and ions move through the pores passively by diffusion
 - Most large molecules, such as RNAs and proteins, cannot pass through the nuclear pores by diffusion. Instead, their passage involves an active transport process in which the molecules are recognized and selectively transported through the nuclear pore into or out of the nucleus. For example, proteins needed for nuclear functions move from the cytosol into the nucleus; newly formed RNA molecules move from the nucleus into the cytosol in this manner.

Genomics

- ▶ Genome
- ▶ There are approximately 30,000 genes in the human genome

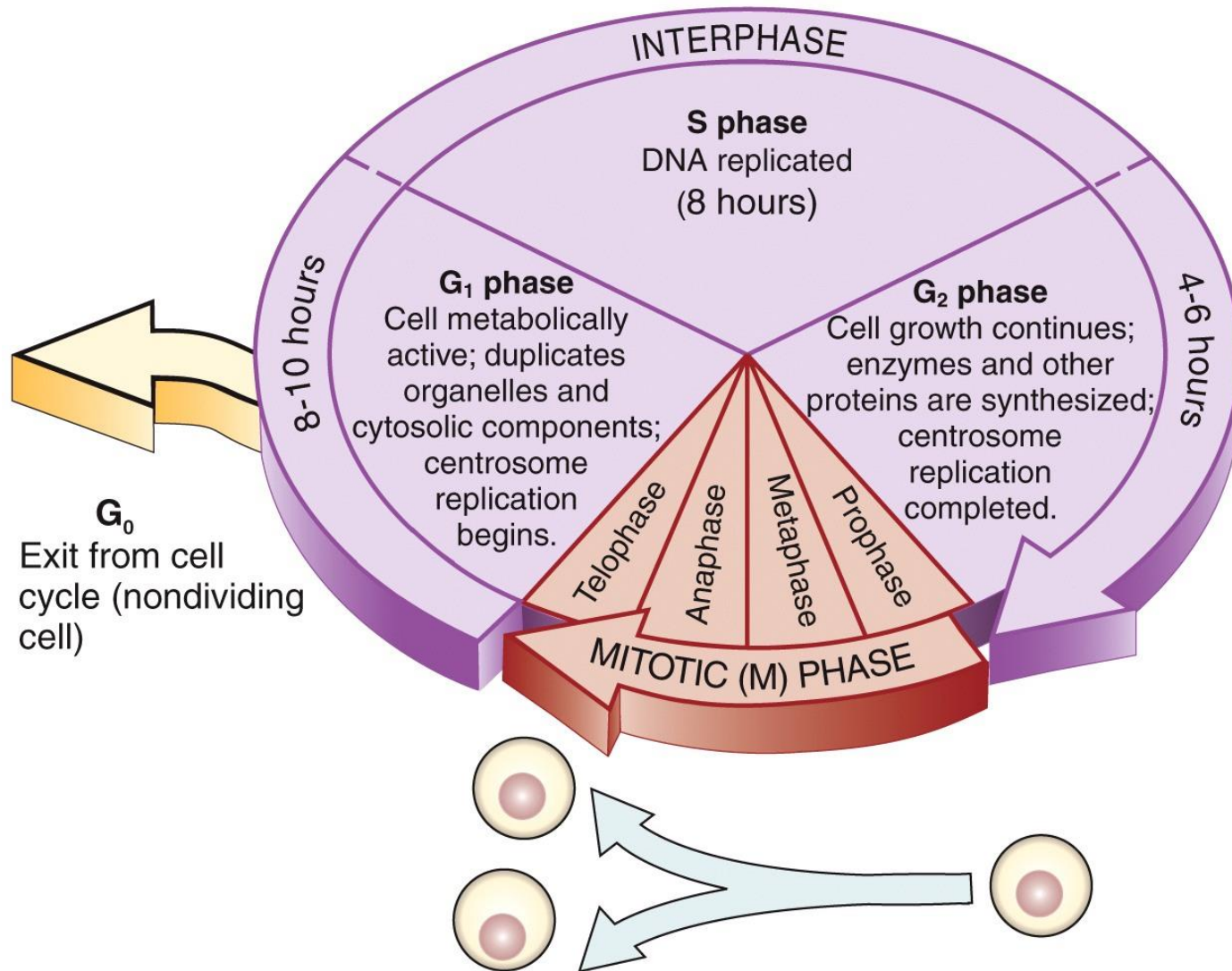
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Cell Division

- ▶ **Somatic cell division: Mitosis:**
 - ▶ Interphase
 - ▶ Mitotic Phase

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The Cell Cycle



Cell Division

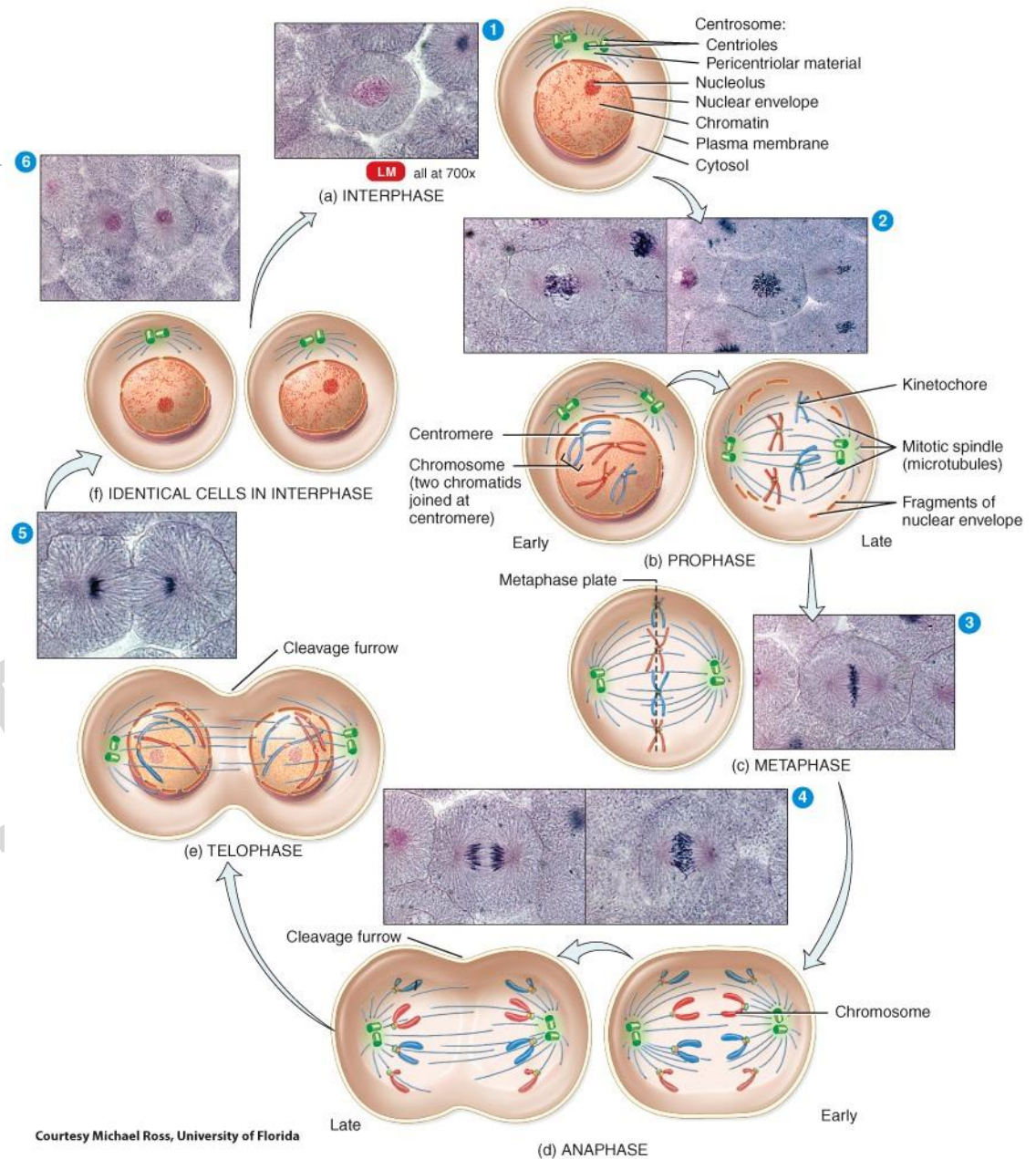
Interactions Animation

▶ Gametogenesis

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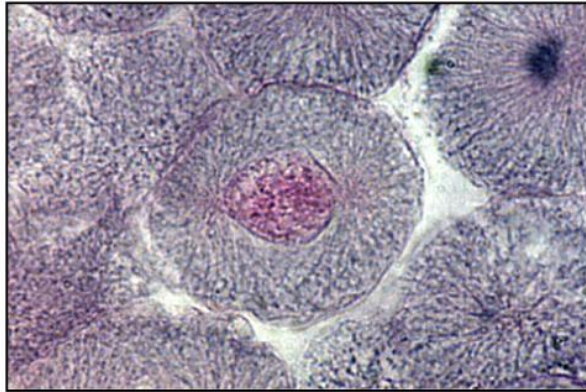
You must be connected to the internet to run this animation.

Cell Division: Mitosis and Cytokinesis



Cell Division: Mitosis and Cytokinesis

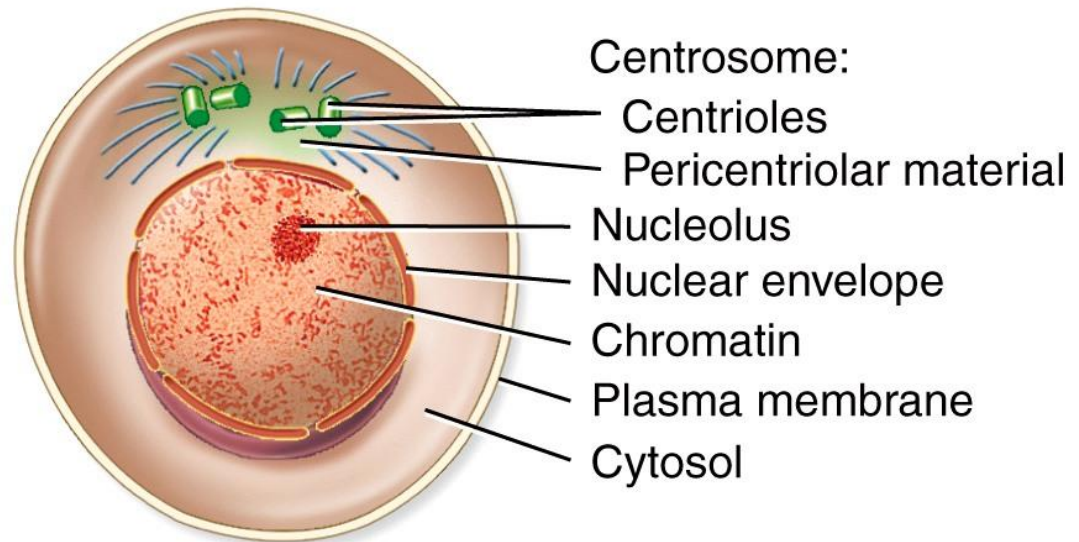
Courtesy Michael Ross, University of Florida



LM

all at 700x

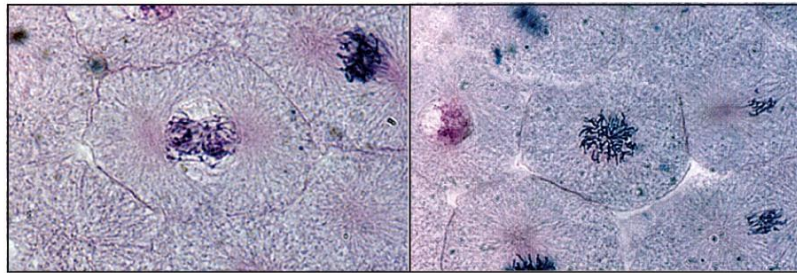
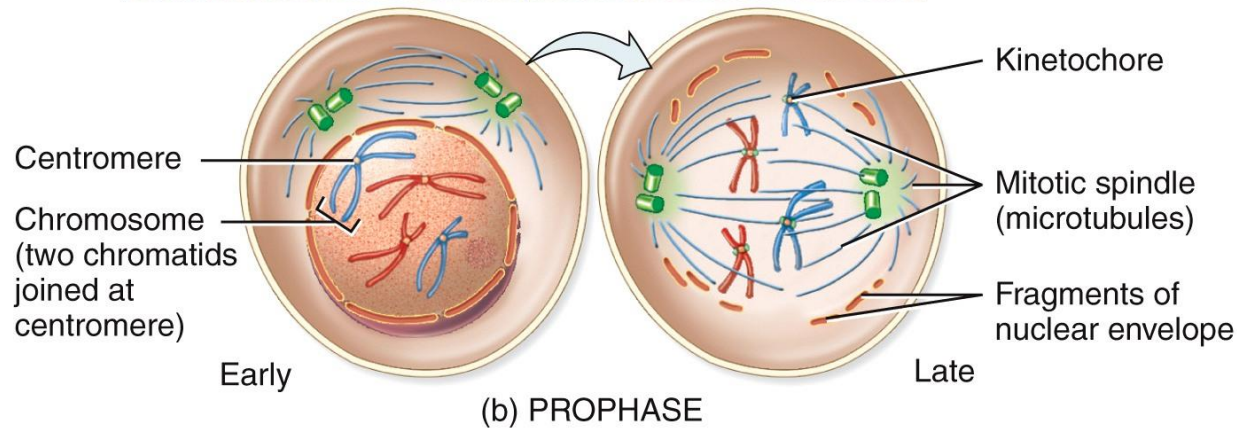
(a) INTERPHASE



Interphase is the 'daily living' or metabolic phase of the cell, in which the cell obtains nutrients and metabolizes them, grows, reads its DNA, and conducts other "normal" cell functions. This phase was formerly called the resting phase

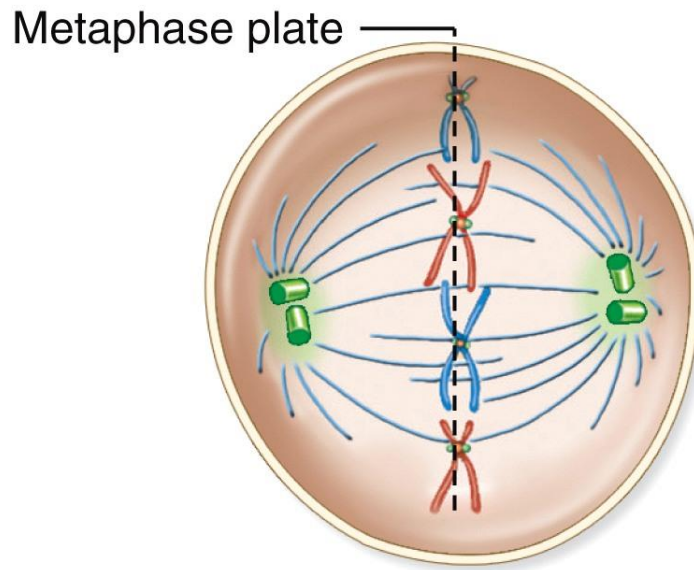
Cell Division: Mitosis and Cytokinesis

Courtesy Michael Ross, University of Florida

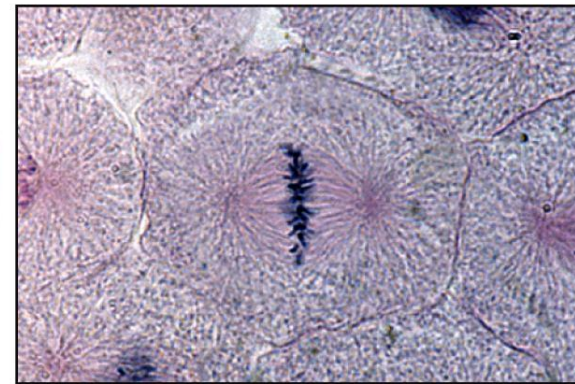


Prophase is the first phase of mitosis, the process that separates the duplicated genetic material carried in the nucleus of a parent cell into two identical daughter cells. During **prophase**, the complex of DNA and proteins contained in the nucleus, known as chromatin, condenses

Cell Division: Mitosis and Cytokinesis



Courtesy Michael Ross, University of Florida

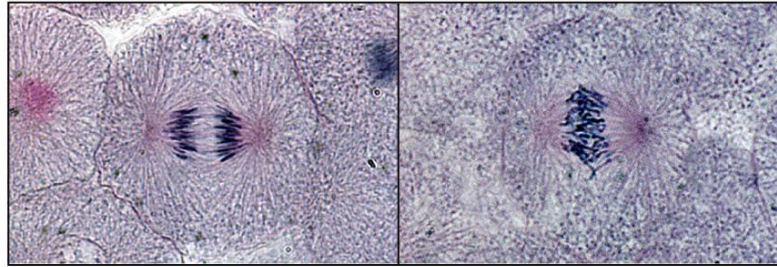
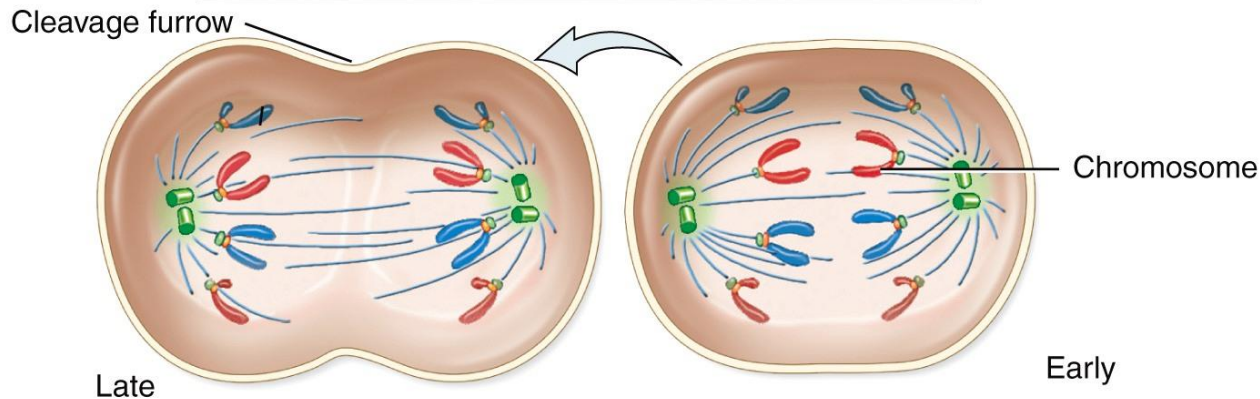


(c) METAPHASE

Metaphase is a stage of mitosis in the eukaryotic cell cycle in which chromosomes are at their second-most condensed and coiled stage (they are at their most condensed in anaphase).

Cell Division: Mitosis and Cytokinesis

Courtesy Michael Ross, University of Florida

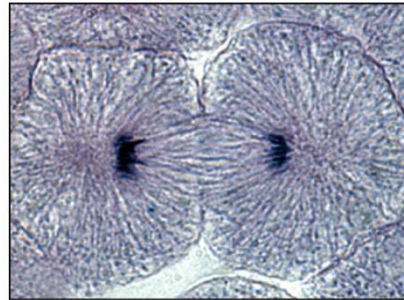
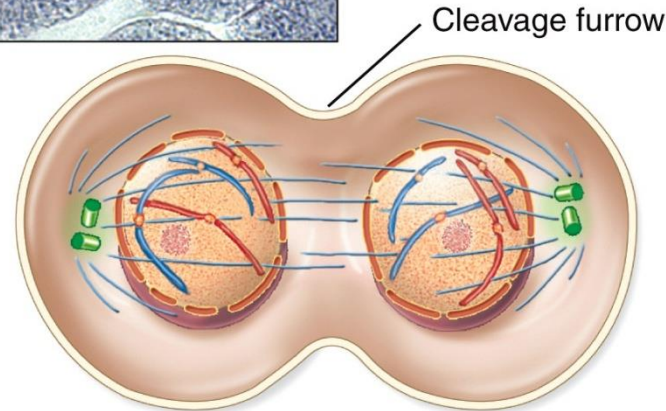


(d) ANAPHASE

Anaphase is the stage of mitosis after the process of metaphase, when replicated chromosomes are split and the newly-copied chromosomes (daughter chromatids) are moved to opposite poles of the cell.

Cell Division: Mitosis and Cytokinesis

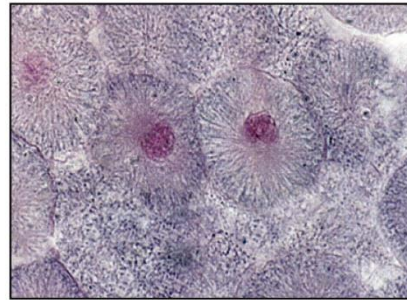
Courtesy Michael Ross, University of Florida



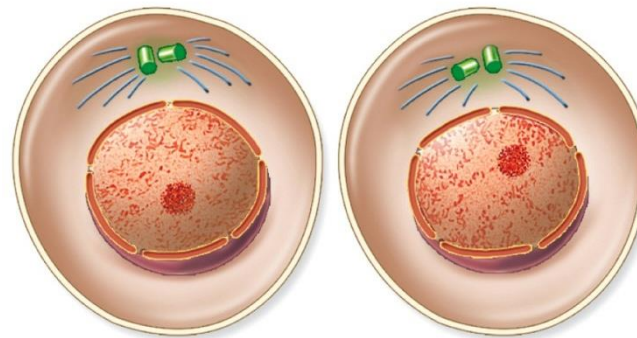
(e) TELOPHASE

The final phase of cell division, between anaphase and interphase, in which the chromatids or chromosomes move to opposite ends of the cell and two nuclei are formed.

Cell Division: Mitosis and Cytokinesis



Courtesy Michael Ross,
University of Florida



(f) IDENTICAL CELLS IN INTERPHASE

Interphase is the 'daily living' or metabolic phase of the cell, in which the cell obtains nutrients and metabolizes them, grows, reads its DNA, and conducts other "normal" cell functions. This phase was formerly called the resting phase

Reproductive Cell Division

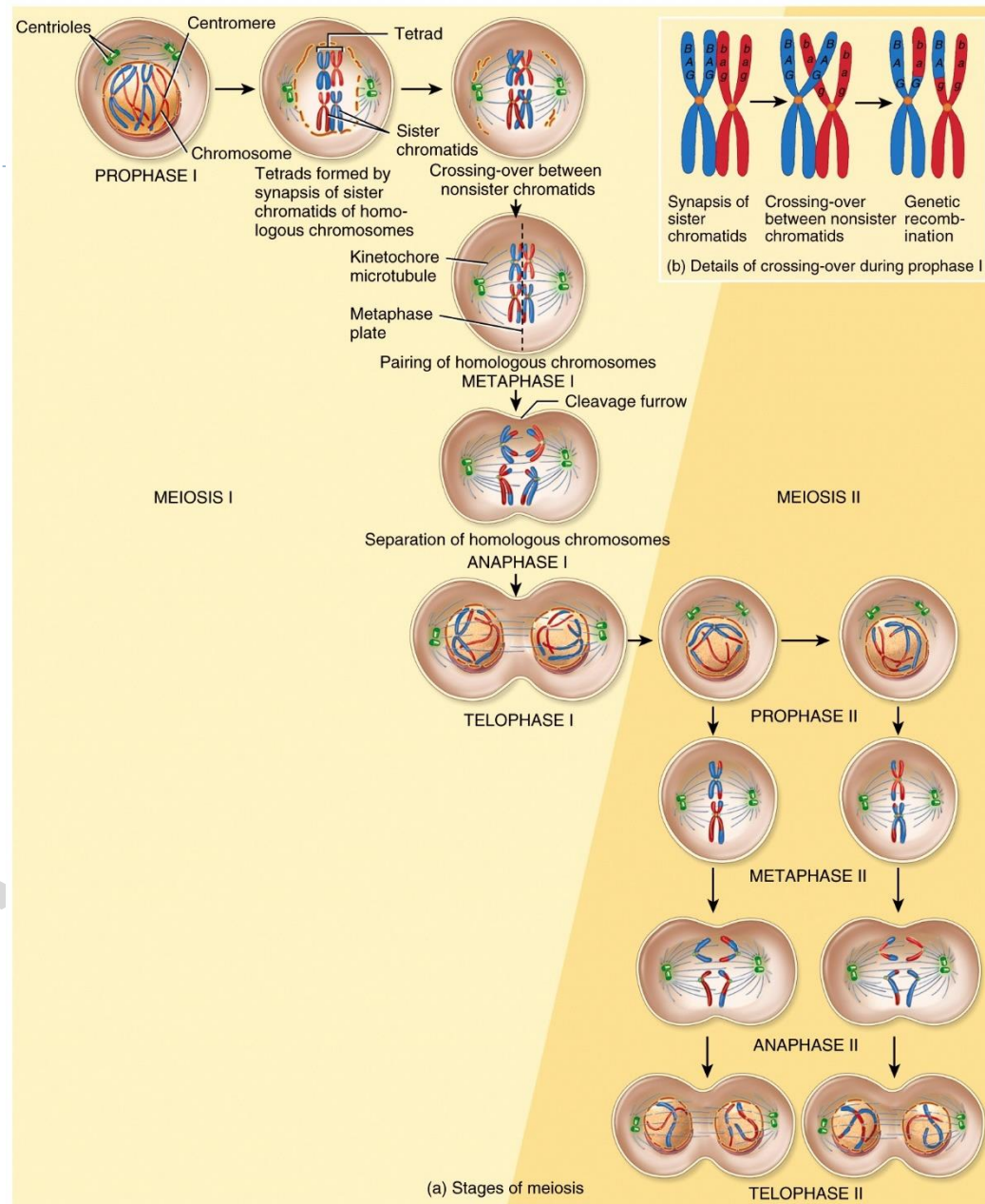
- ▶ Meiosis: for gamete cells: are sperm and ova
- ▶ A type of cell division that results in four daughter cells each with half the number of chromosomes of the parent cell, as in the production of gametes and plant spores

Meiosis

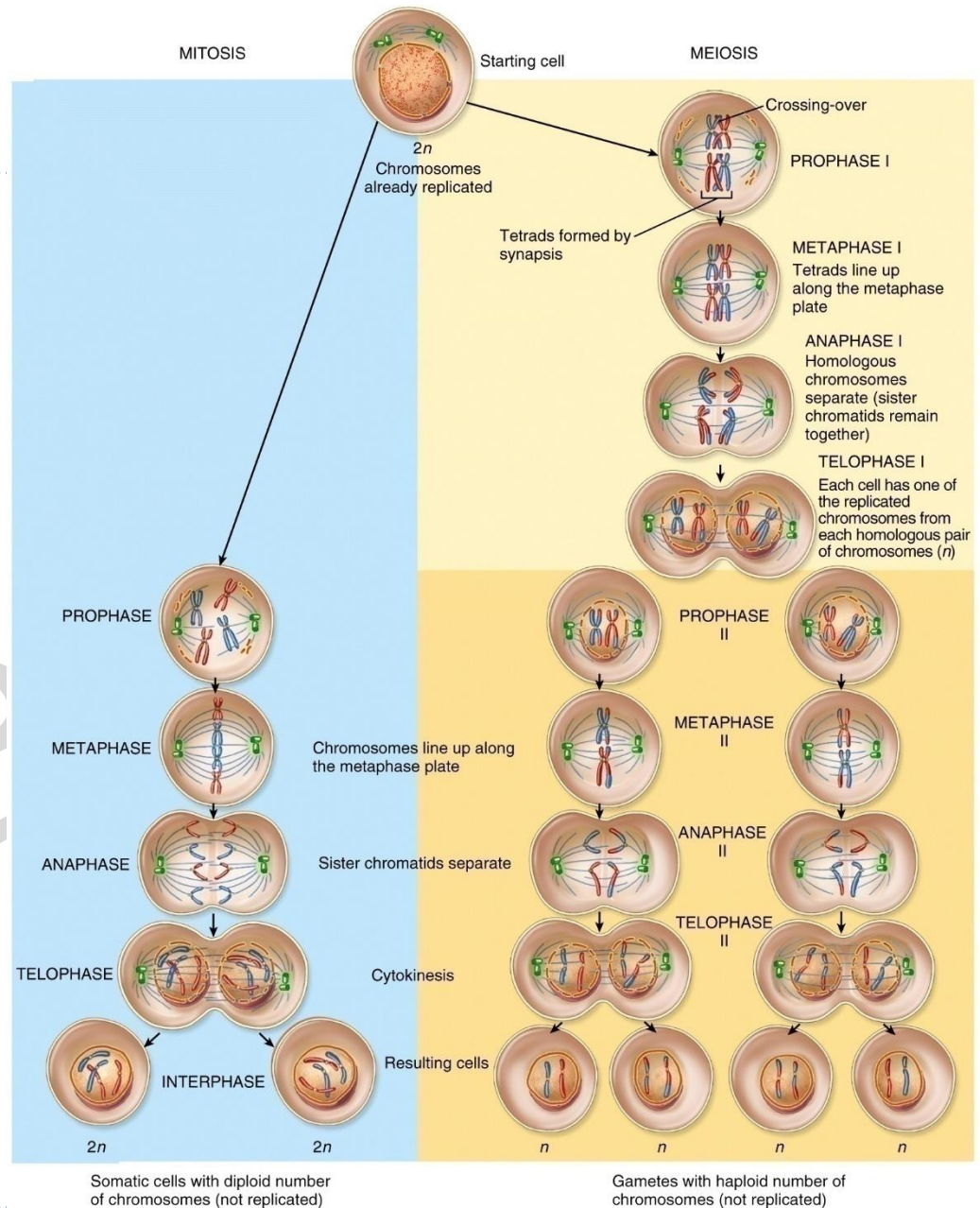
Meiosis is a process where a single cell divides twice to produce four cells containing half the original amount of genetic information.

These cells are our sex cells – sperm in males, ovae in females.

During **meiosis** one cell divides twice to form four daughter cells



Mitosis and Meiosis



Cellular Diversity

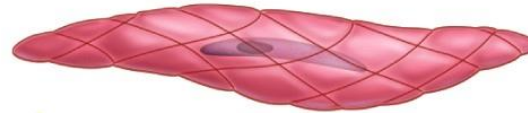
- ▶ Considerable variation in shapes and sizes of human cells

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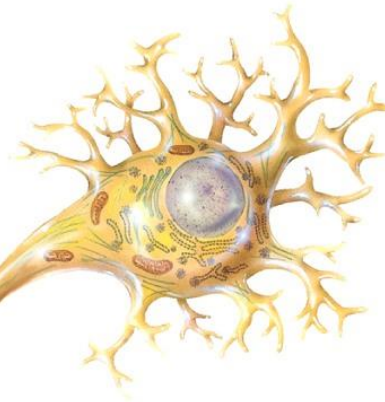
Cell Diversity



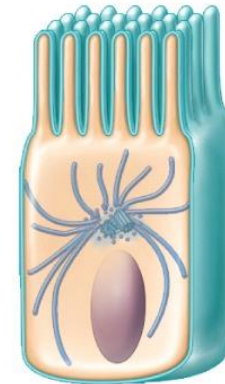
Sperm cell



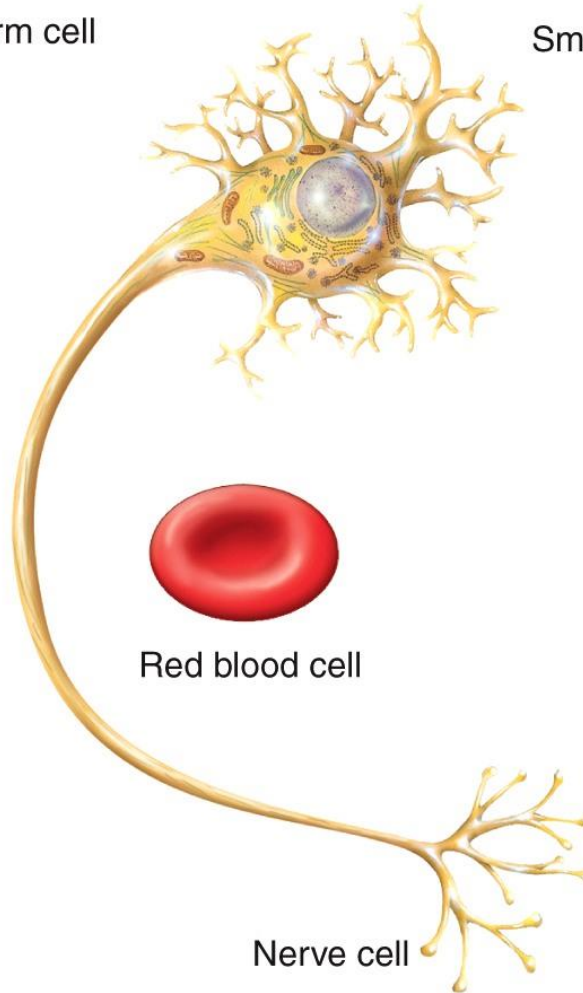
Smooth muscle cell



Red blood cell



Epithelial cell



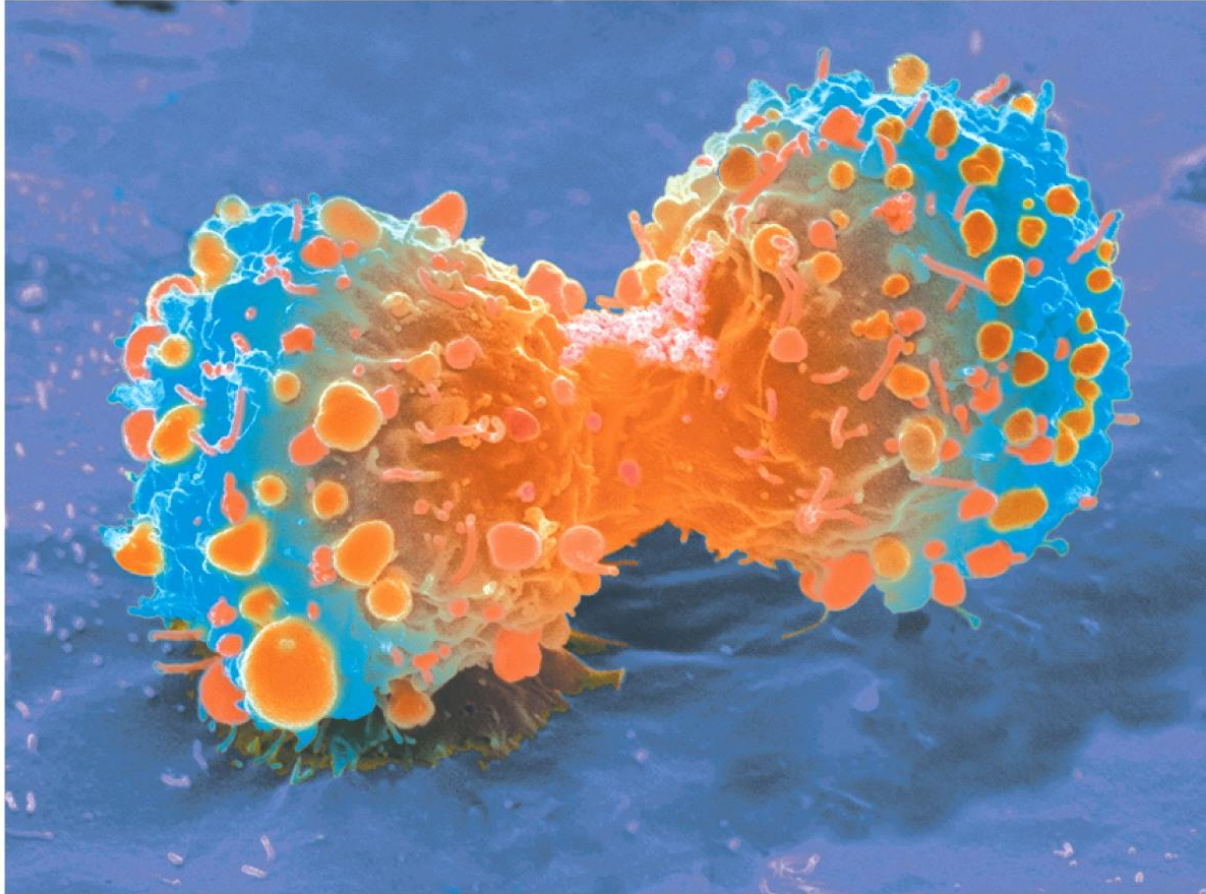
Nerve cell

Clinical Connection

- ▶ Cancer: is a group of diseases involving abnormal cell growth with the potential to invade or spread to other parts of the body. These contrast with benign tumors, which do not spread

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Lung Cancer Cell Dividing



Steve Gschmeissner/Science Photo Library

Lung cancer cell dividing

SEM

Aging and Cells

- ▶ **Geriatrics:** the branch of medicine or social science dealing with the health and care of old people.
- ▶ **Gerontology:** is the study of the social, cultural, psychological, cognitive, and biological aspects of ageing.
- ▶ **Telomeres:** a compound structure at the end of a chromosome