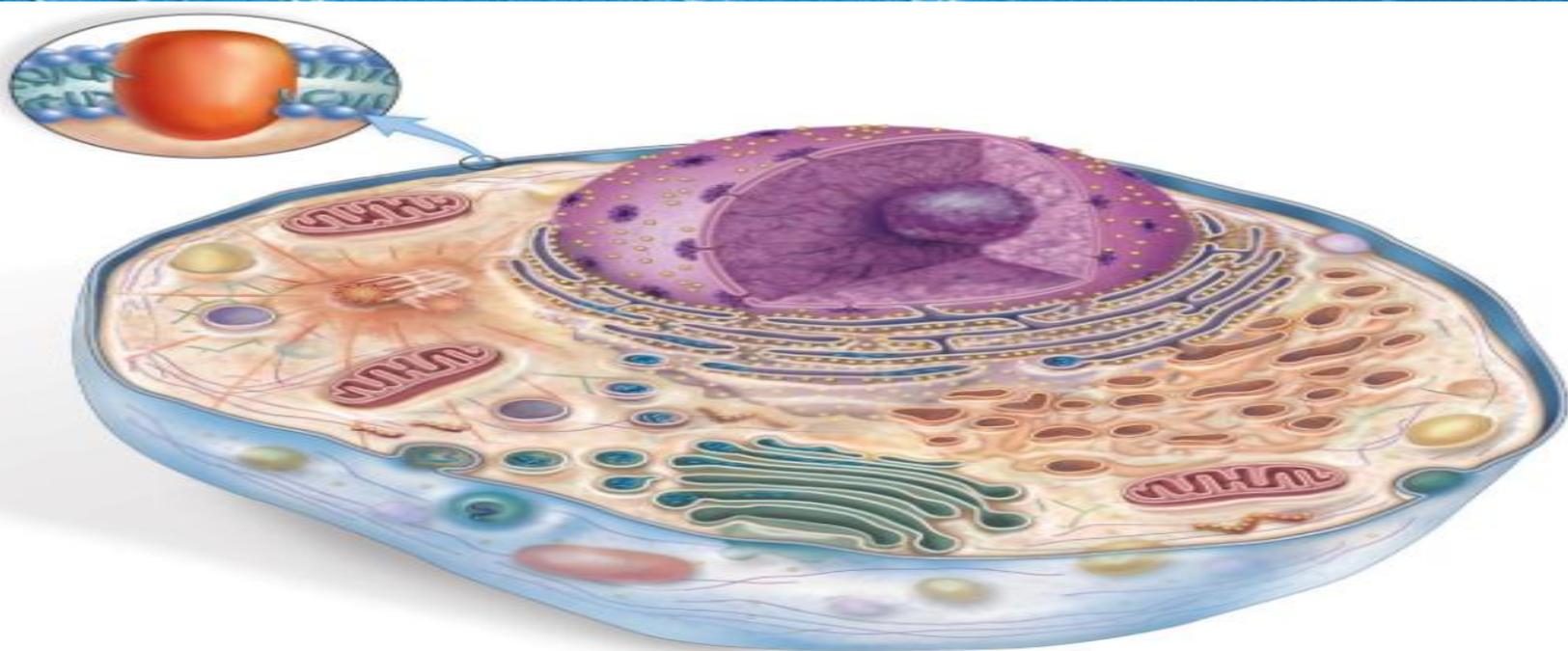
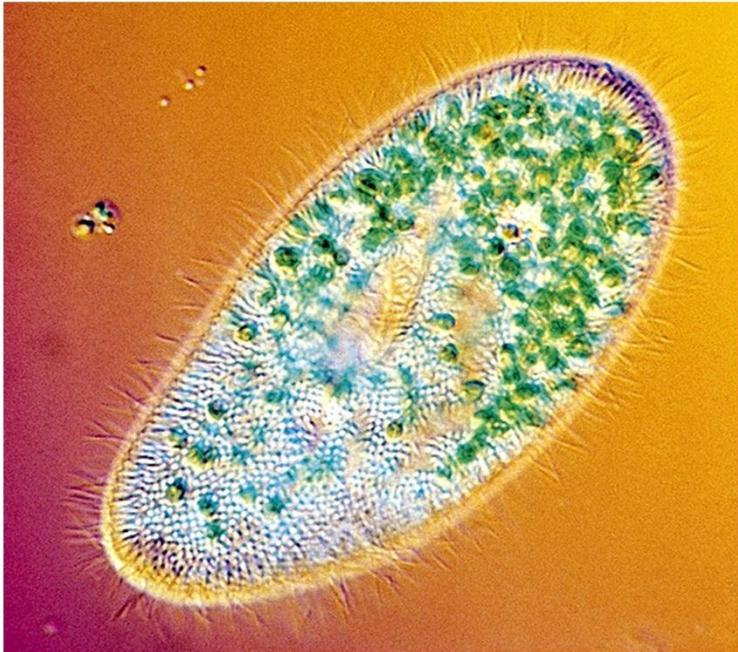


Cell Structure and Function
Lecture – 4
Zoology / 1st class – Biology
By
Prof. Dr. Mohammed Qais
College of Science - U of A



Cells

- Smallest living unit
- Most are microscopic



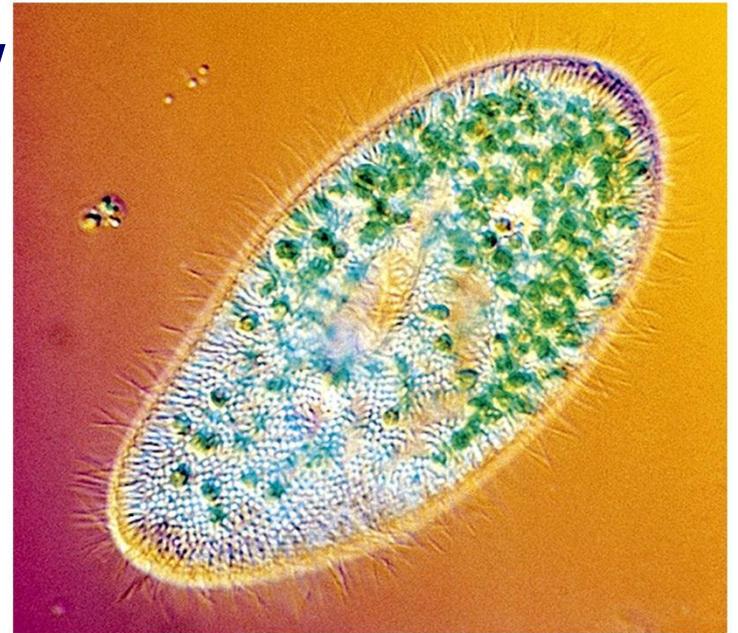
Discovery of Cells

- Robert Hooke (mid-1600s)
 - Observed sliver of cork
 - Saw “row of empty boxes”
 - Coined the term cell



Cell theory

- (1839)Theodor Schwann & Matthias Schleiden
“ all living things are made of cells”
- (50 yrs. later) Rudolf Virchow
“all cells come from cells”



Principles of Cell Theory

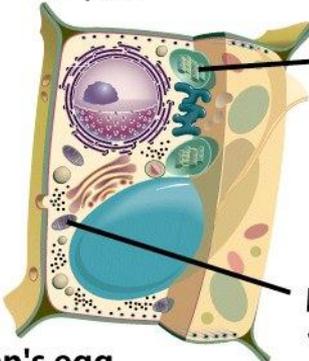
- All living things are made of cells
- Smallest living unit of structure and function of all organisms is the cell
- All cells arise from preexisting cells
(this principle discarded the idea of spontaneous generation)

Cell Theory

- Detailed study of the cell began in the 1830s
- A unifying concept in biology
- Originated from the work of biologists Schleiden and Schwann in 1838-9
- States that:
 - All organisms are composed of cells
 - German botanist Matthias Schleiden in 1838
 - German zoologist Theodor Schwann in 1839
 - All cells come only from preexisting cells
 - German physician Rudolph Virchow in 1850's
 - Cells are the smallest structural and functional unit of organisms

Cell Size

Typical plant cell
10–100 μm



Chloroplast
2–10 μm

Mitochondrion
1–5 μm

Trypanosoma (protozoan)
25 μm long



Chlamydomonas (green alga)
5–6 μm



HIV (AIDS virus)
100 nm

Poliovirus
30 nm



DNA molecule
2 nm diameter



Hen's egg
65 mm



Human red blood cell
7–8 μm diameter

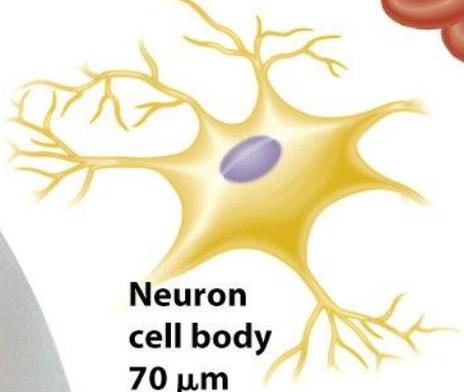


T4 bacteriophage
225 nm long

Tobacco mosaic virus
300 nm long



Escherichia coli (bacterium)
1–5 μm long



Neuron cell body
70 μm

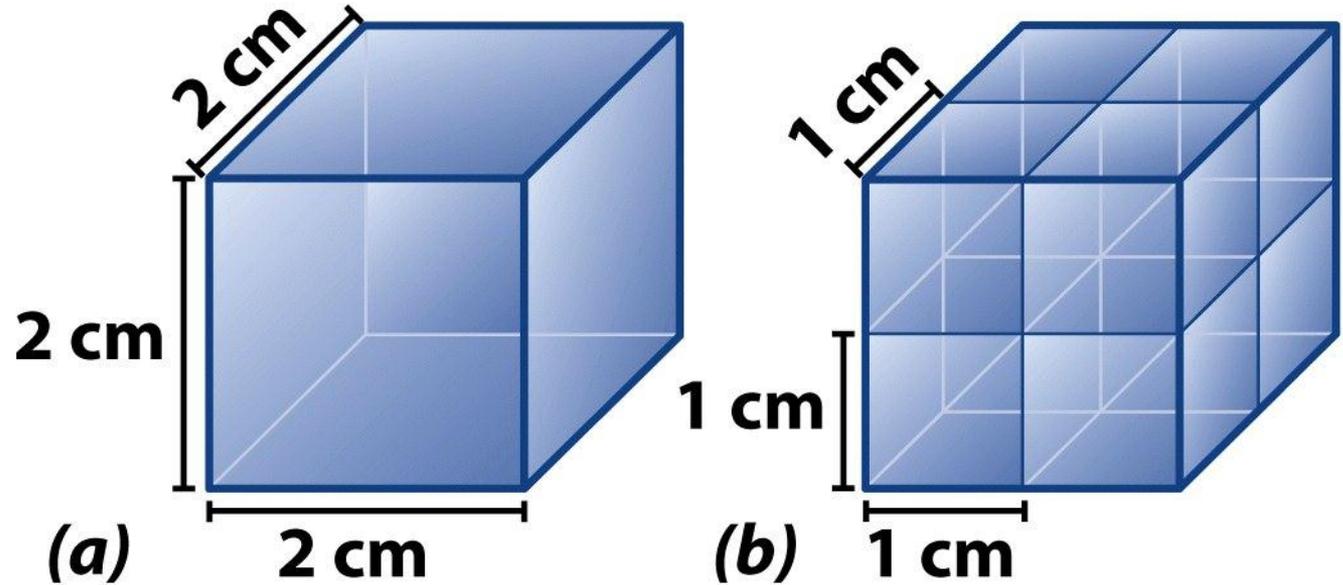
Unaided vision

Light microscopes (down to 200 nm)

Electron microscopes (down to 0.5 nm)

1 mm 100 μm 10 μm 1 μm 100 nm 10 nm 1 nm 0.5 nm

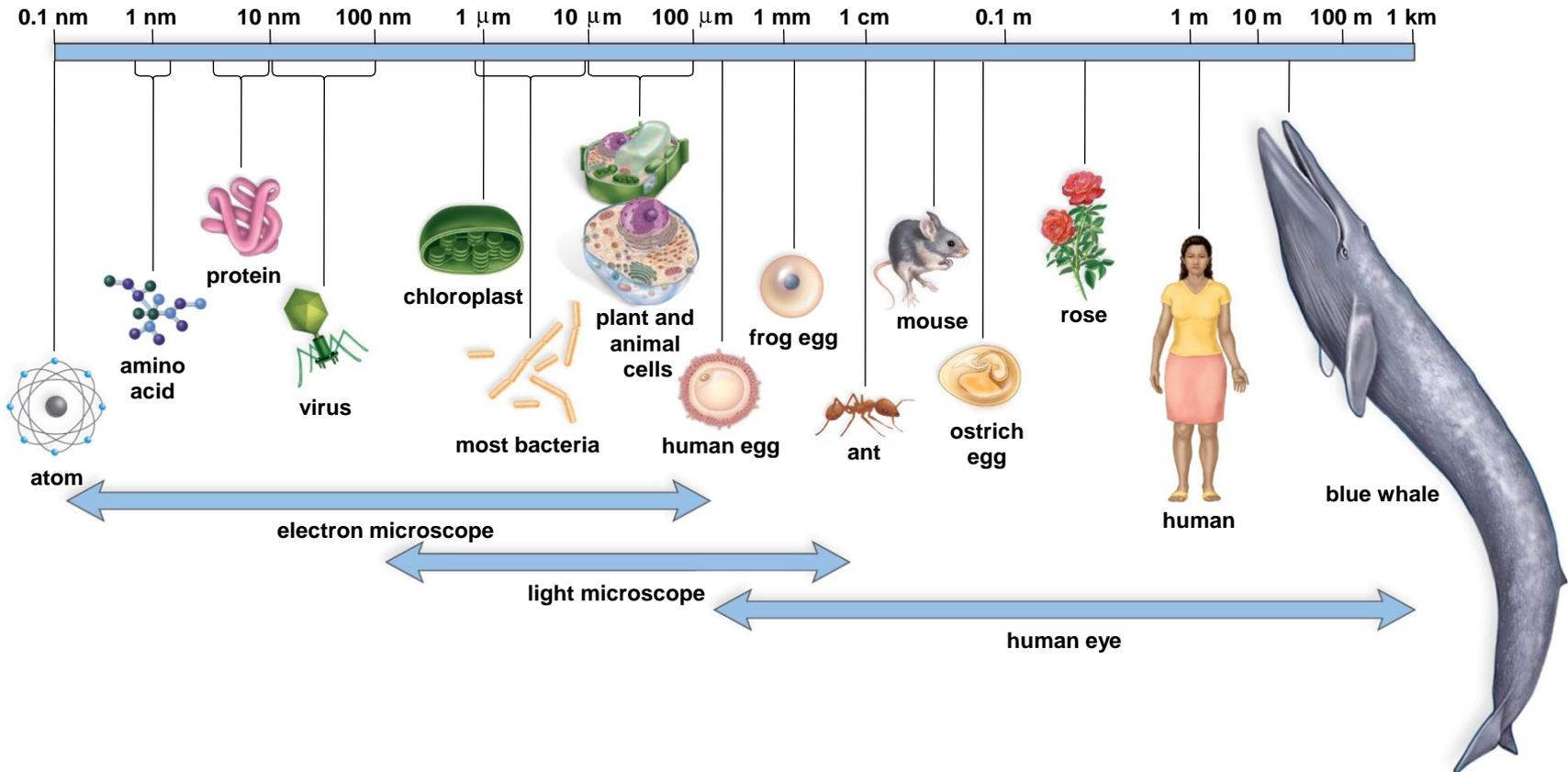
Cells Have Large Surface Area-to-Volume Ratio



Number of cells	1	8
Total surface area	24 cm ²	48 cm ²
Total volume	8 cm ³	8 cm ³
Surface area/volume	24/8 = 3:1	48/8 = 6:1

Sizes of Living Things

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

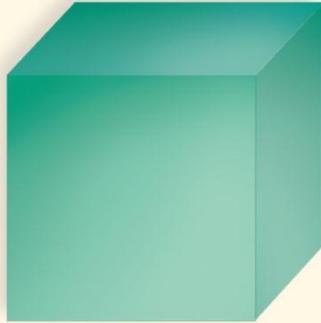


Cell Size

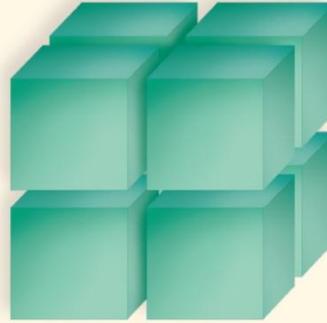
- Cells range in size from one millimeter down to one micrometer
- Cells need a large surface area of plasma membrane to adequately exchange materials.
- The **surface-area-to-volume ratio** requires that cells be small
 - Large cells - surface area relative to volume decreases
 - Volume is living cytoplasm, which demands nutrients and produces wastes
 - Cells specialized in absorption utilize membrane modifications such as microvilli to greatly increase surface area per unit volume

Surface to Volume Ratio

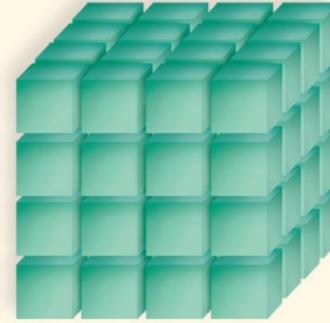
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



One 4-cm cube



Eight 2-cm cubes



Sixty-four 1-cm cubes

Total surface area (height × width × number of sides × number of cubes)

96 cm²

192 cm²

384 cm²

Total volume (height × width × length × number of cubes)

64 cm³

64 cm³

64 cm³

Surface area: Volume per cube (surface area ÷ volume)

1.5:1

3:1

6:1

Microscopy Today: Compound Light Microscope

- Light passed through specimen
- Focused by glass lenses
- Image formed on human retina
- Max magnification about 1000X
- Resolves objects separated by $0.2 \mu\text{m}$, 500X better than human eye

Microscopy Today: Transmission Electron Microscope

- Abbreviated T.E.M.
- Electrons passed through specimen
- Focused by magnetic lenses
- Image formed on fluorescent screen
 - Similar to TV screen
 - Image is then photographed
- Max magnification 1000,000sX
- Resolves objects separated by 0.00002 μm , 100,000X better than human eye

Microscopy Today: Scanning Electron Microscope

- Abbreviated S.E.M.
- Specimen sprayed with thin coat of metal
 - Electron beam scanned across surface of specimen
 - Metal emits secondary electrons
- Emitted electrons focused by magnetic lenses
- Image formed on fluorescent screen
 - Similar to TV screen
 - Image is then photographed

Microscopy Today:

Immunofluorescence Light Microscope

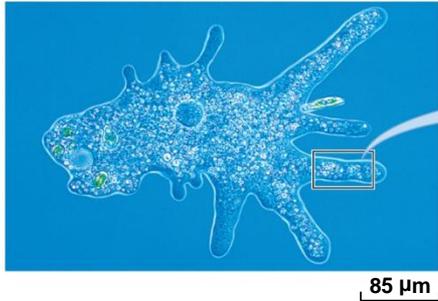
- Antibodies developed against a specific protein
 - Fluorescent dye molecule attached to antibody molecules
 - Specimen exposed to fluorescent antibodies
- Ultra-violet light (black light) passed through specimen
 - Fluorescent dye glows in color where antigen is located
 - Emitted light is focused by glass lenses onto human retina
- Allows mapping distribution of a specific protein in cell

Microscopy Today: Confocal Microscopy

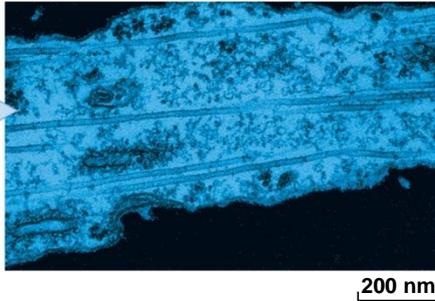
- Narrow laser beam scanned across transparent specimen
- Beam is focused at a very thin plane
- Allows microscopist to optically section a specimen
 - Sections made at different levels
 - Allows assembly of 3d image on computer screen that can be rotated

Microscopy and *Amoeba proteus*

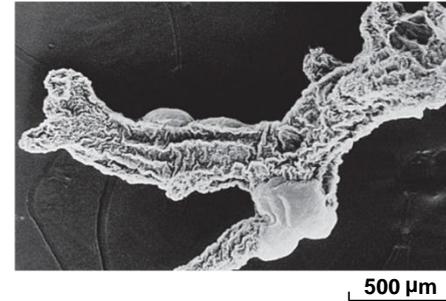
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



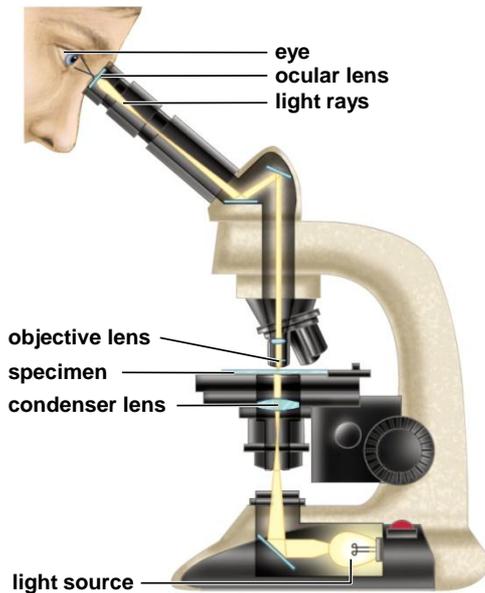
amoeba, light micrograph



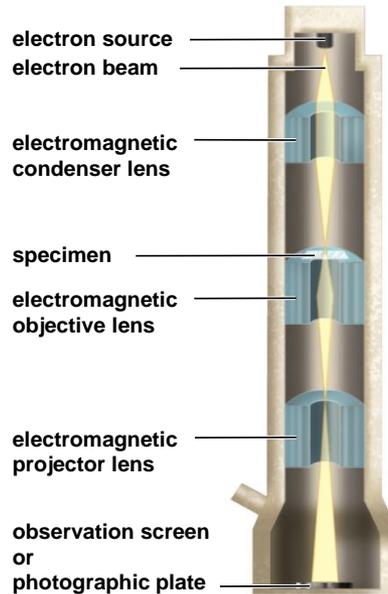
pseudopod segment, transmission electron micrograph



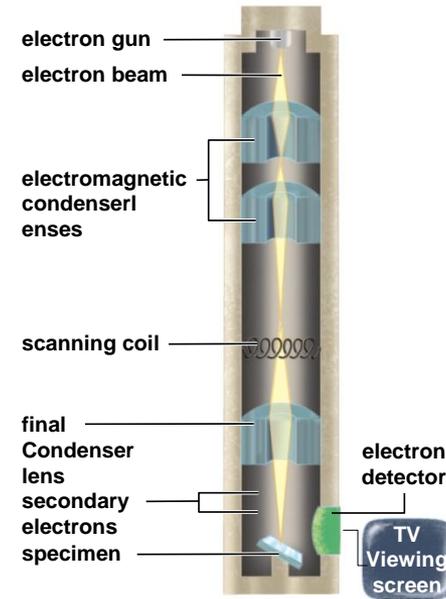
amoeba, scanning electron micrograph



a. Compound light microscope



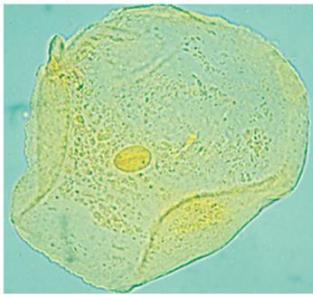
b. Transmission electron microscope



c. Scanning electron microscope

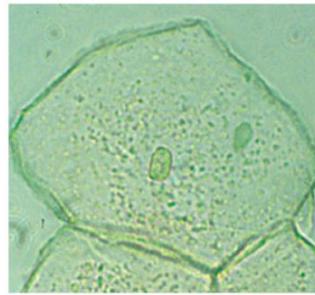
Microscopy and Cheek Cells

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



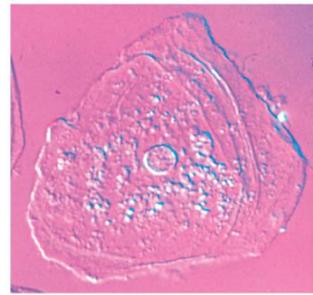
30 μm

Bright-field. Light passing through the specimen is brought directly into focus. Usually, the low level of contrast within the specimen interferes with viewing all but its largest components.



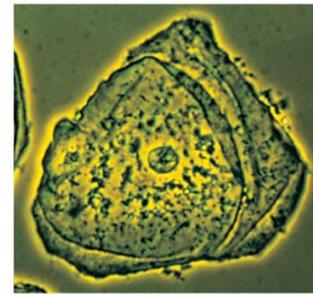
30 μm

Bright-field (stained). Dyes are used to stain the specimen. Certain components take up the dye more than other components, and therefore contrast is enhanced.



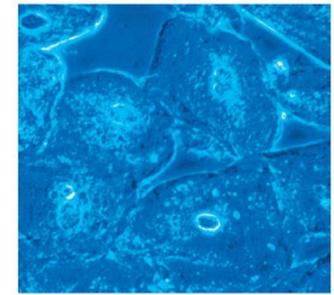
25 μm

Differential interference contrast. Optical methods are used to enhance density differences within the specimen so that certain regions appear brighter than others. This technique is used to view living cells, chromosomes, and organelle masses.



25 μm

Phase contrast. Density differences in the specimen cause light rays to come out of “phase.” The microscope enhances these phase differences so that some regions of the specimen appear brighter or darker than others. The technique is widely used to observe living cells and organelles.



25 μm

Dark-field. Light is passed through the specimen at an oblique angle so that the objective lens receives only light diffracted and scattered by the object. This technique is used to view organelles, which appear quite bright against a dark field.

(Bright field): © Ed Reschke; (Bright field stained): © Biophoto Associates/Photo Researchers, Inc.;
(Differential, Phase contrast, Dark field): © David M. Phillips/Visuals Unlimited

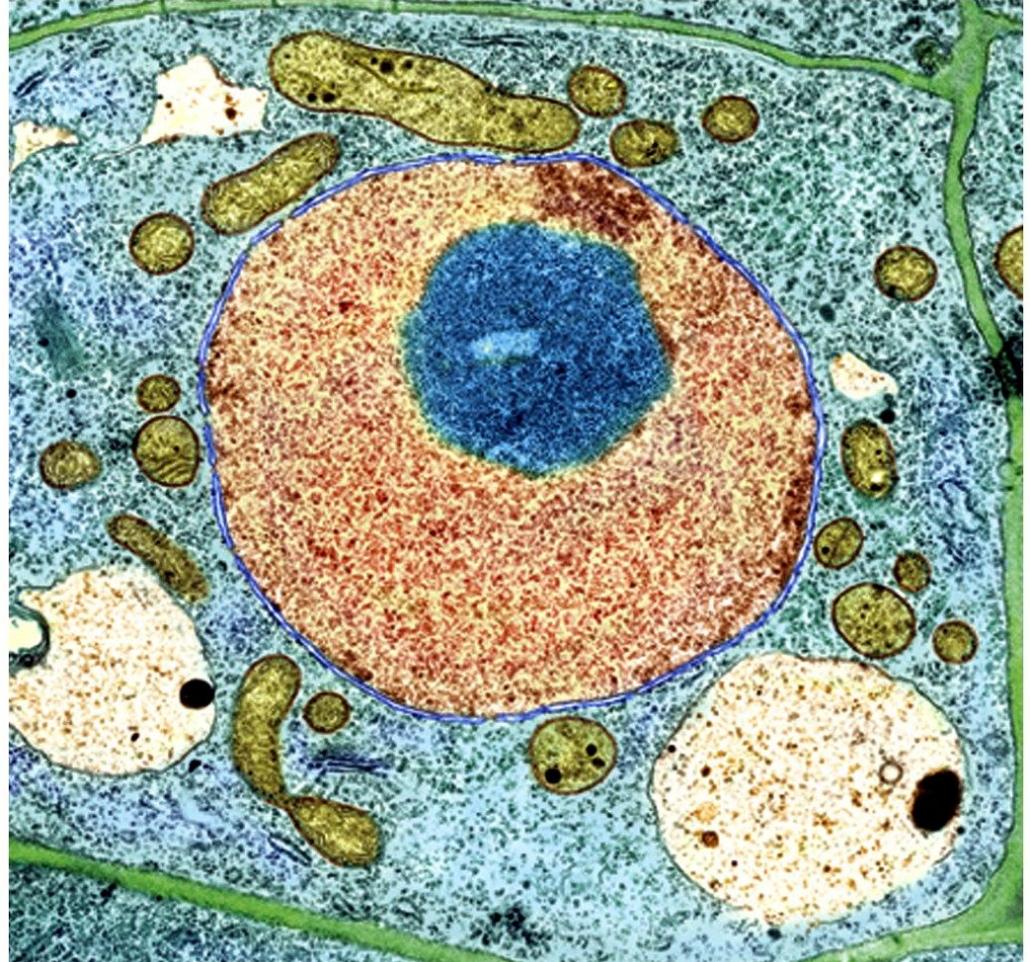
Characteristics of All Cells

- A surrounding membrane
- Protoplasm – cell contents in thick fluid
- Organelles – structures for cell function
- Control center with DNA



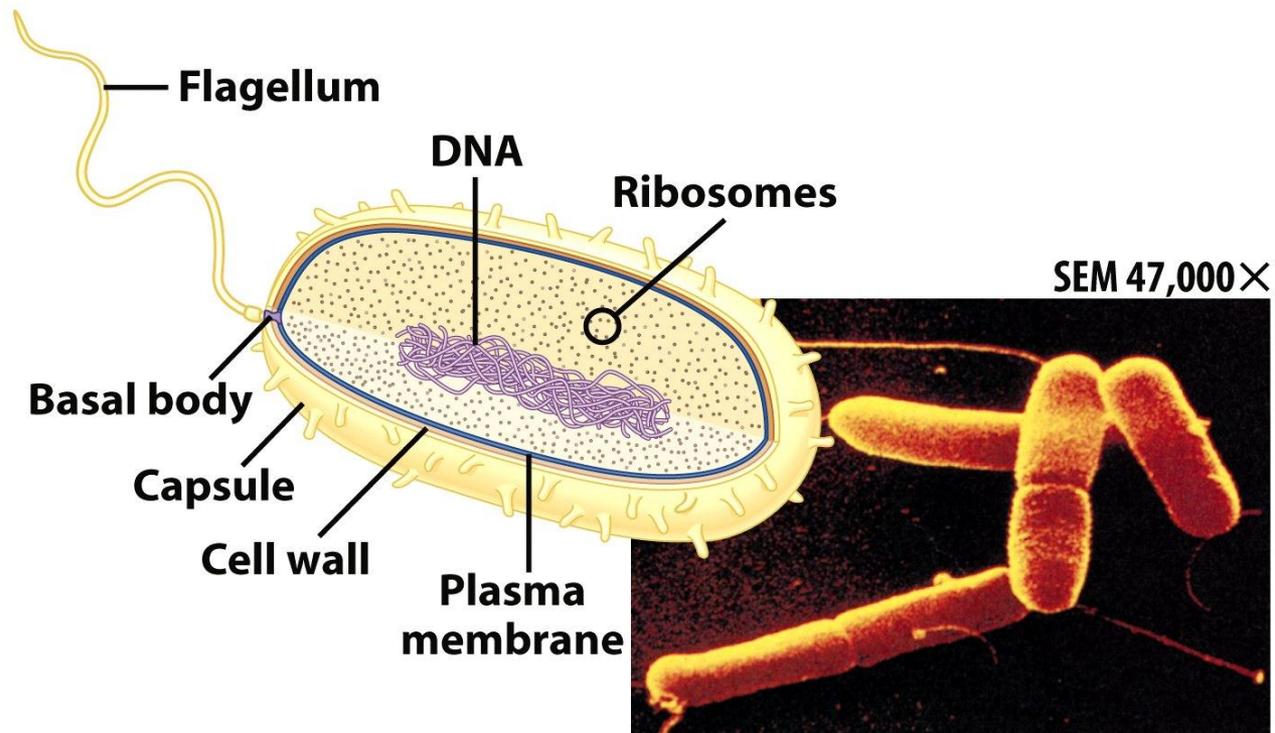
Cell Types

- Prokaryotic
- Eukaryotic



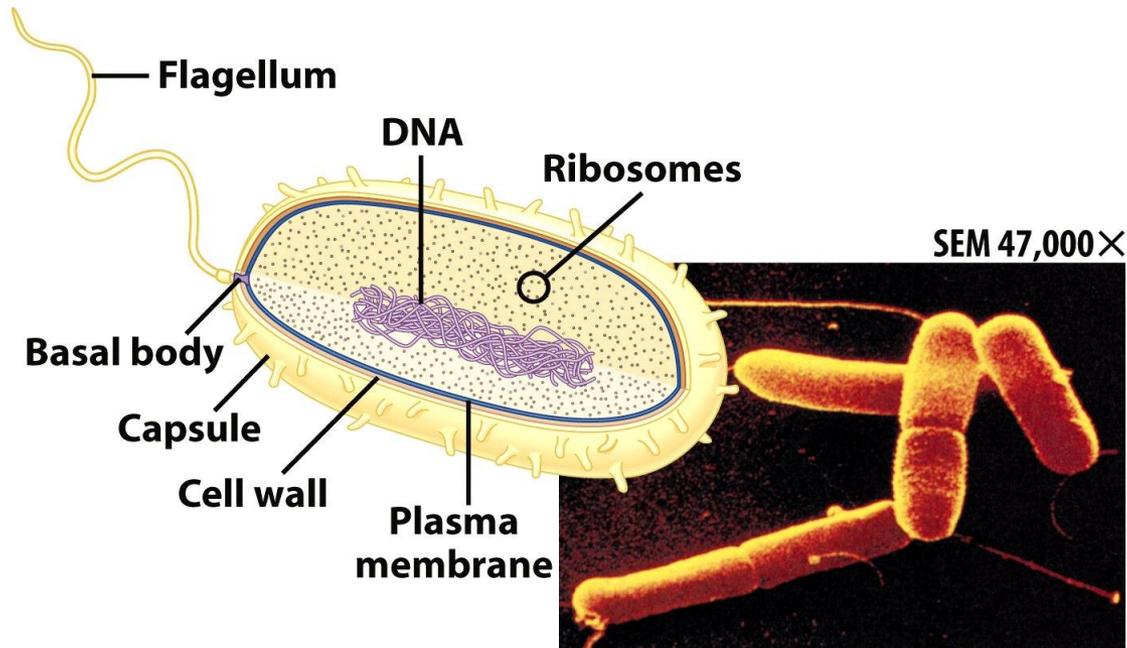
Prokaryotic Cells

- First cell type on earth
- Cell type of Bacteria and Archaea



Prokaryotic Cells

- No membrane bound nucleus
- Nucleoid = region of DNA concentration
- Organelles not bound by membranes



Prokaryotic Cells

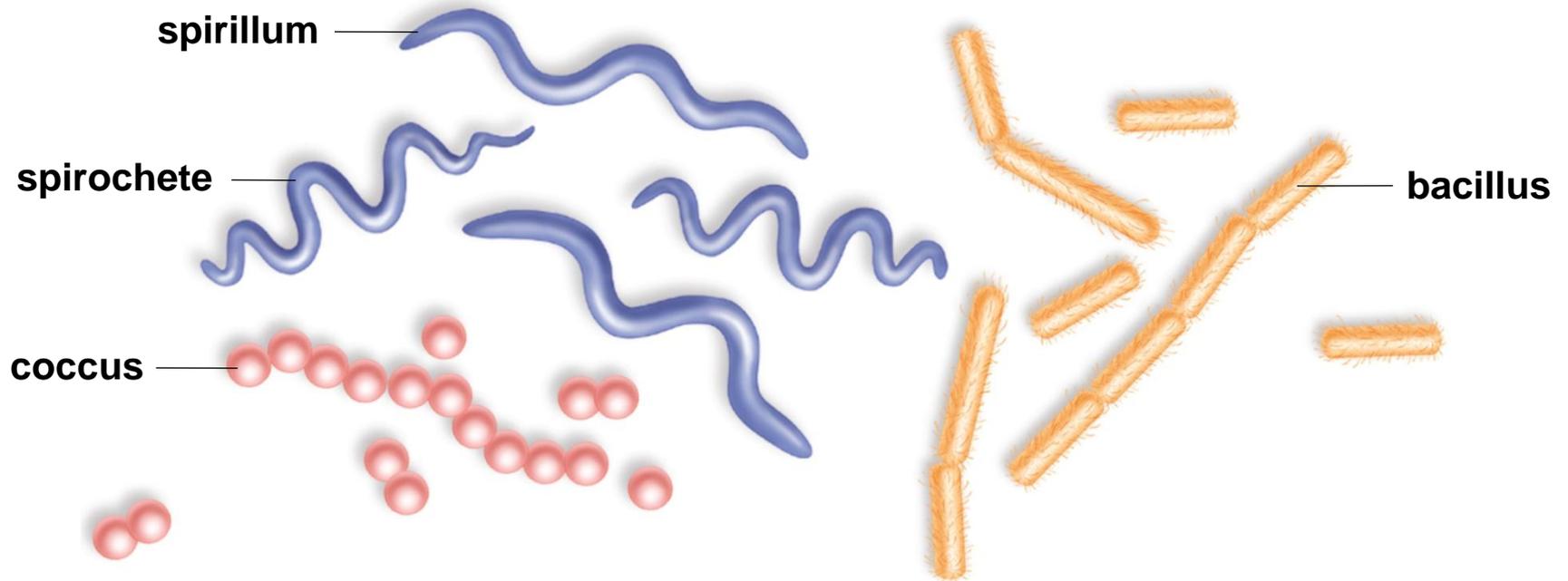
- Lack a membrane-bound nucleus
- Structurally smaller and simpler than eukaryotic cells (which have a nucleus).
- Prokaryotic cells are placed in two taxonomic domains:
 - Bacteria
 - Archaea
 - Live in extreme habitats
 - Domains are structurally similar but biochemically different

The Structure of Bacteria

- Extremely small - 1–1.5 μm wide and 2–6 μm long
- Occur in three basic shapes:
 - Spherical **coccus**,
 - Rod-shaped **bacillus**,
 - Spiral **spirillum** (if rigid) or **spirochete** (if flexible).
- Cell Envelope includes:
 - Plasma membrane - lipid bilayer with imbedded and peripheral protein
 - Form internal pouches (mesosomes)
 - Cell wall - maintains the shape of the cell and is strengthened by **peptidoglycan**
 - Glycocalyx - layer of polysaccharides on the outside of the cell wall
 - Well organized and resistant to removal (capsule)

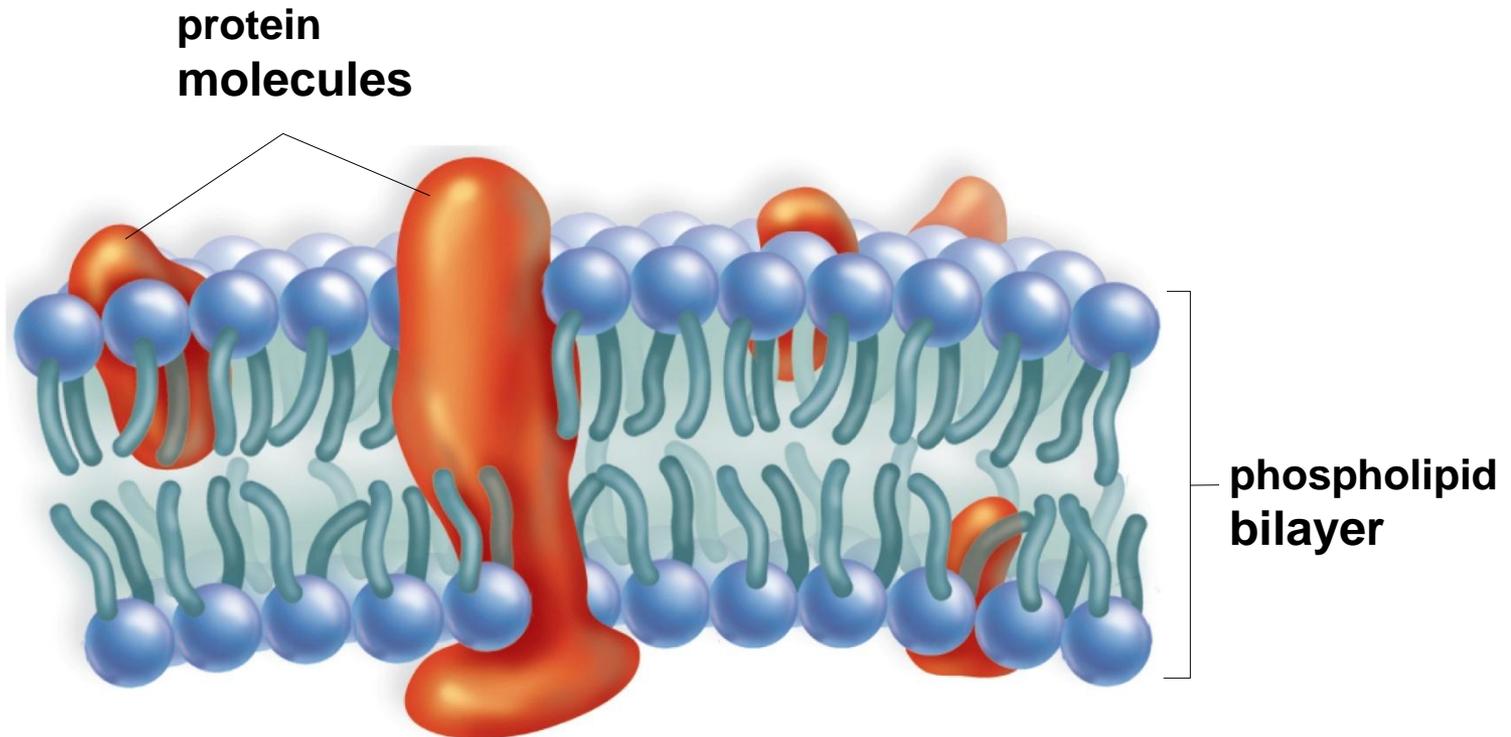
The Structure of Bacteria

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



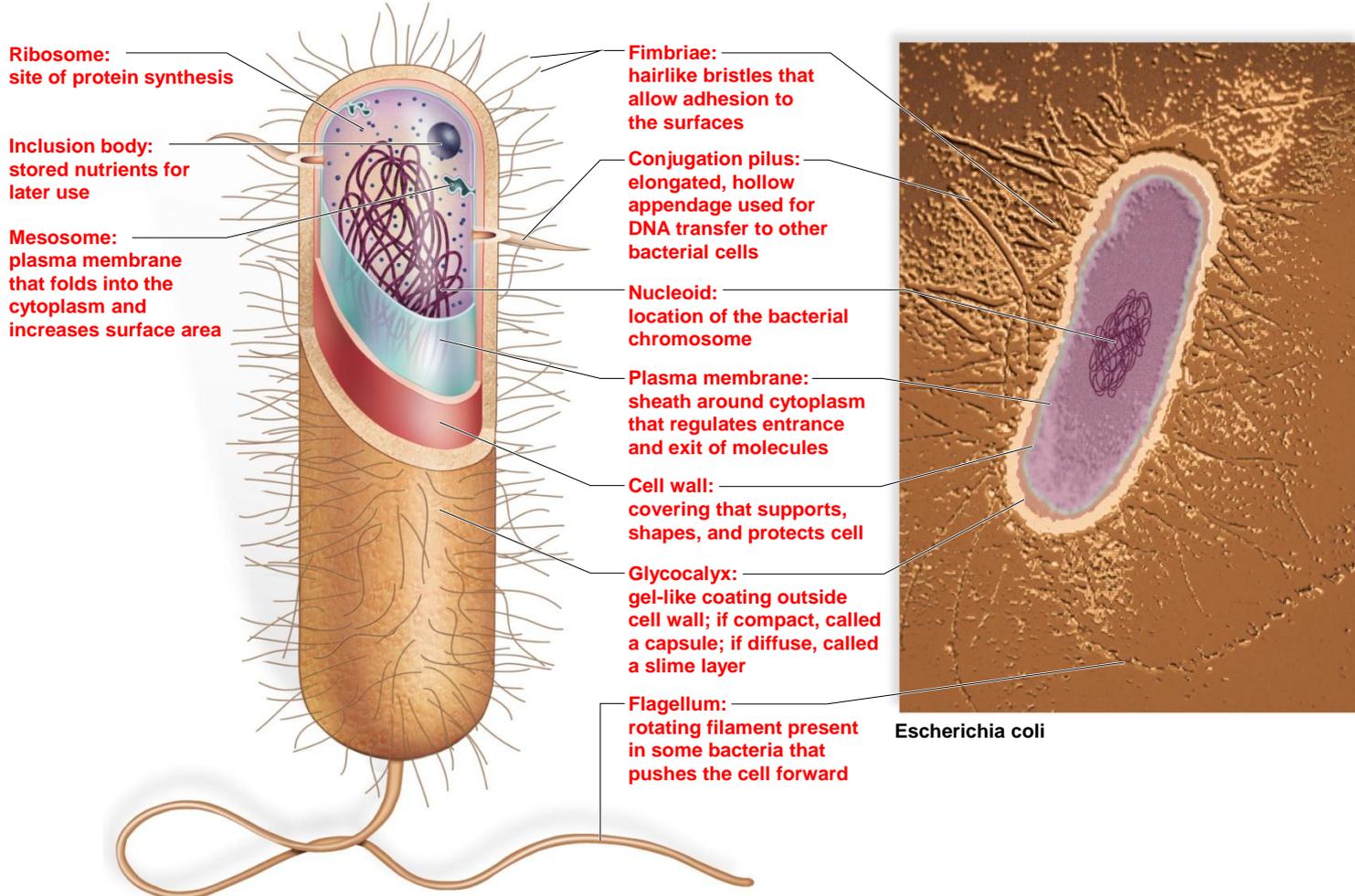
The Structure of Bacteria

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



The Structure of Bacteria

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



The Structure of Bacteria Cytoplasm & Appendages

- Cytoplasm
 - Semifluid solution
 - Bounded by plasma membrane
 - Contains water, inorganic and organic molecules, and enzymes.
 - **Nucleoid** is a region that contains the single, circular DNA molecule.
 - **Plasmids** are small accessory (extrachromosomal) rings of DNA
- Appendages
 - Flagella – Provide motility
 - Fimbriae – small, bristle-like fibers that sprout from the cell surface
 - Sex pili – rigid tubular structures used to pass DNA from cell to cell

Eukaryotic Cells

- Nucleus bound by membrane
- Include fungi, protists, plant, and animal cells
- Possess many organelles



Protozoan

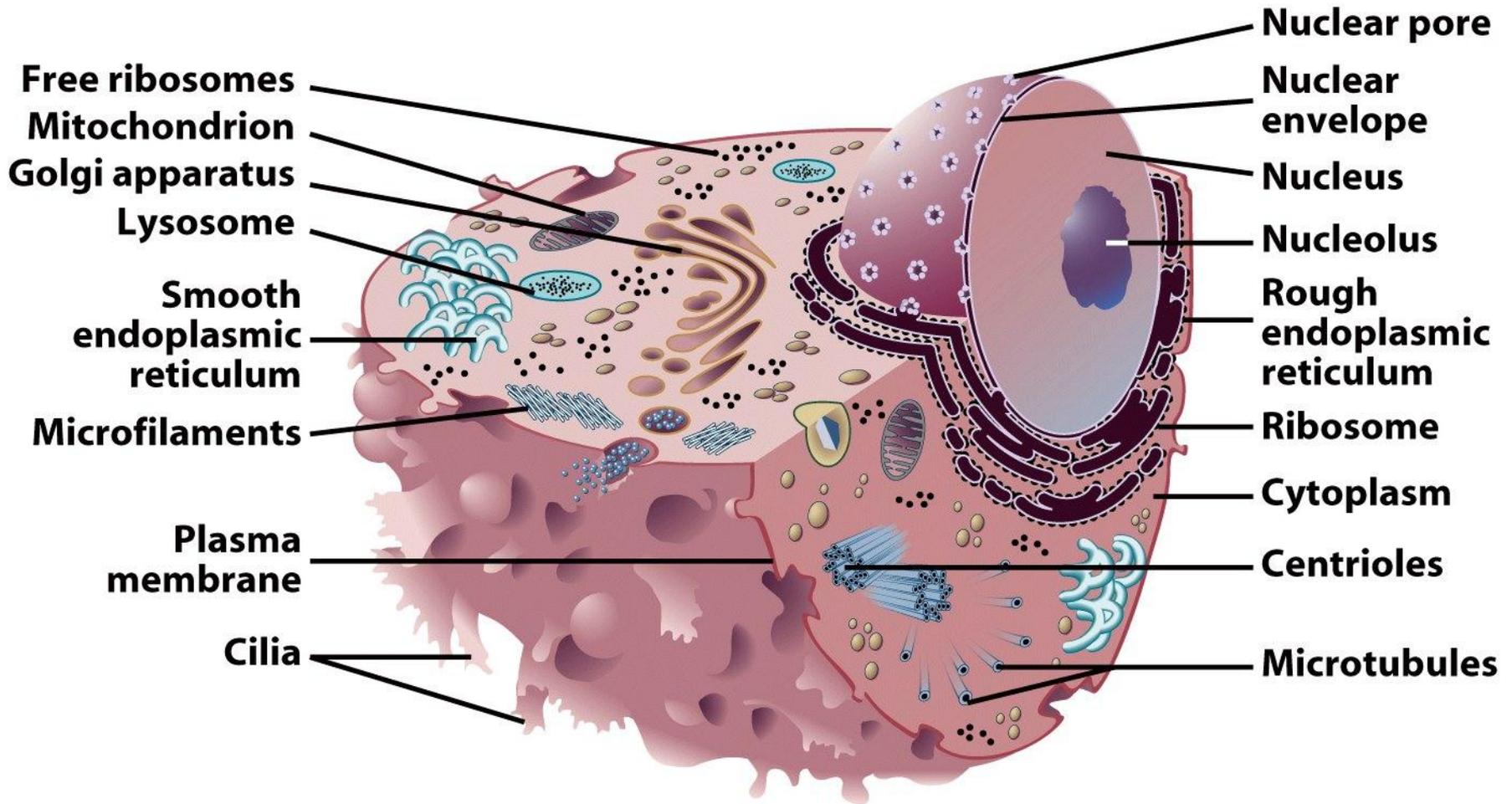
Eukaryotic Cells

- Domain Eukarya includes:
 - Protists
 - Fungi
 - Plants
 - Animals
- Cells contain:
 - Membrane-bound nucleus that houses DNA
 - Specialized organelles
 - Plasma membrane
 - Much larger than prokaryotic cells
 - Some cells (e.g., plant cells) have a **cell wall**

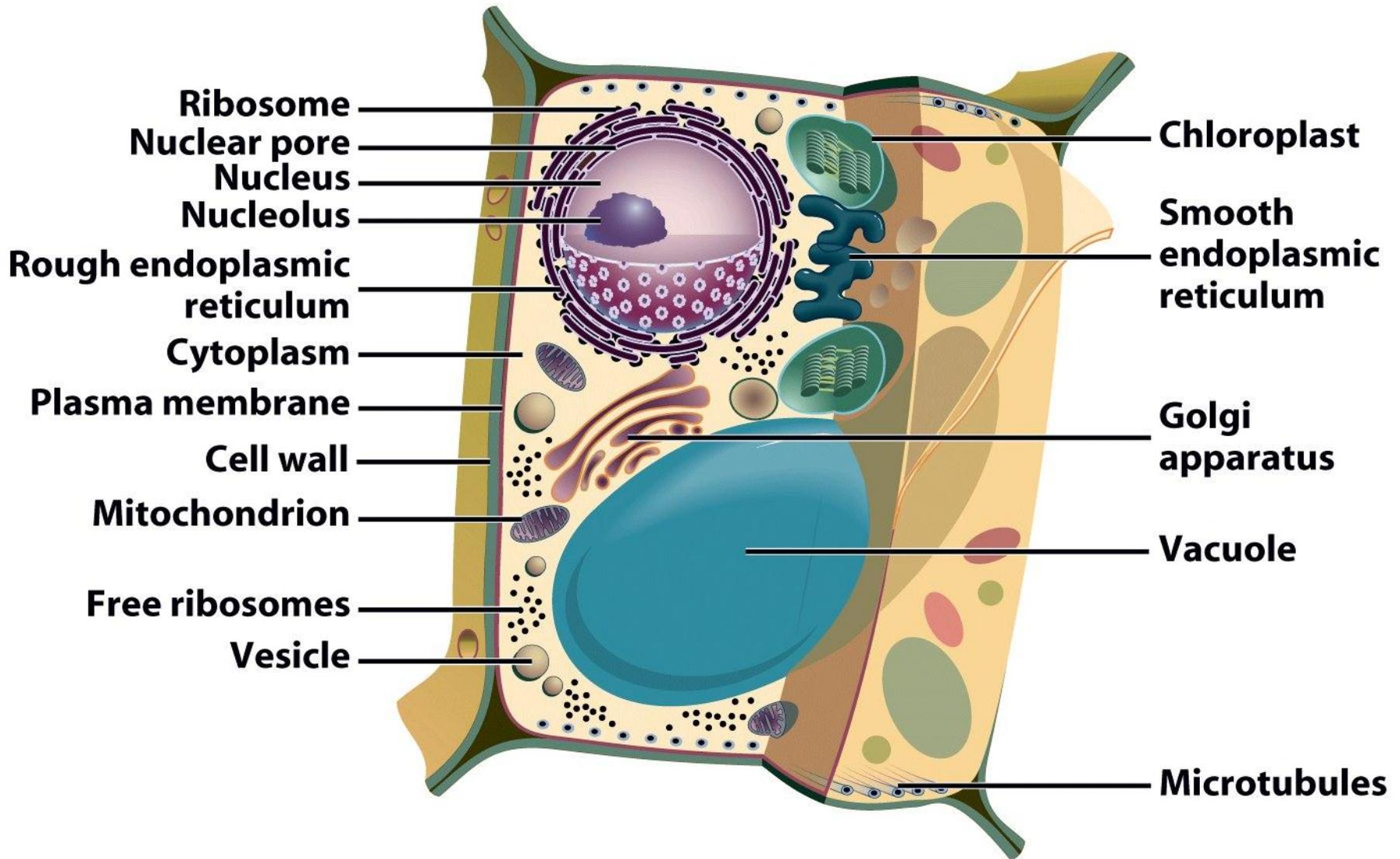
H.W

- Explain the Origin of Eukaryotic Cells

Representative Animal Cell



Representative Plant Cell

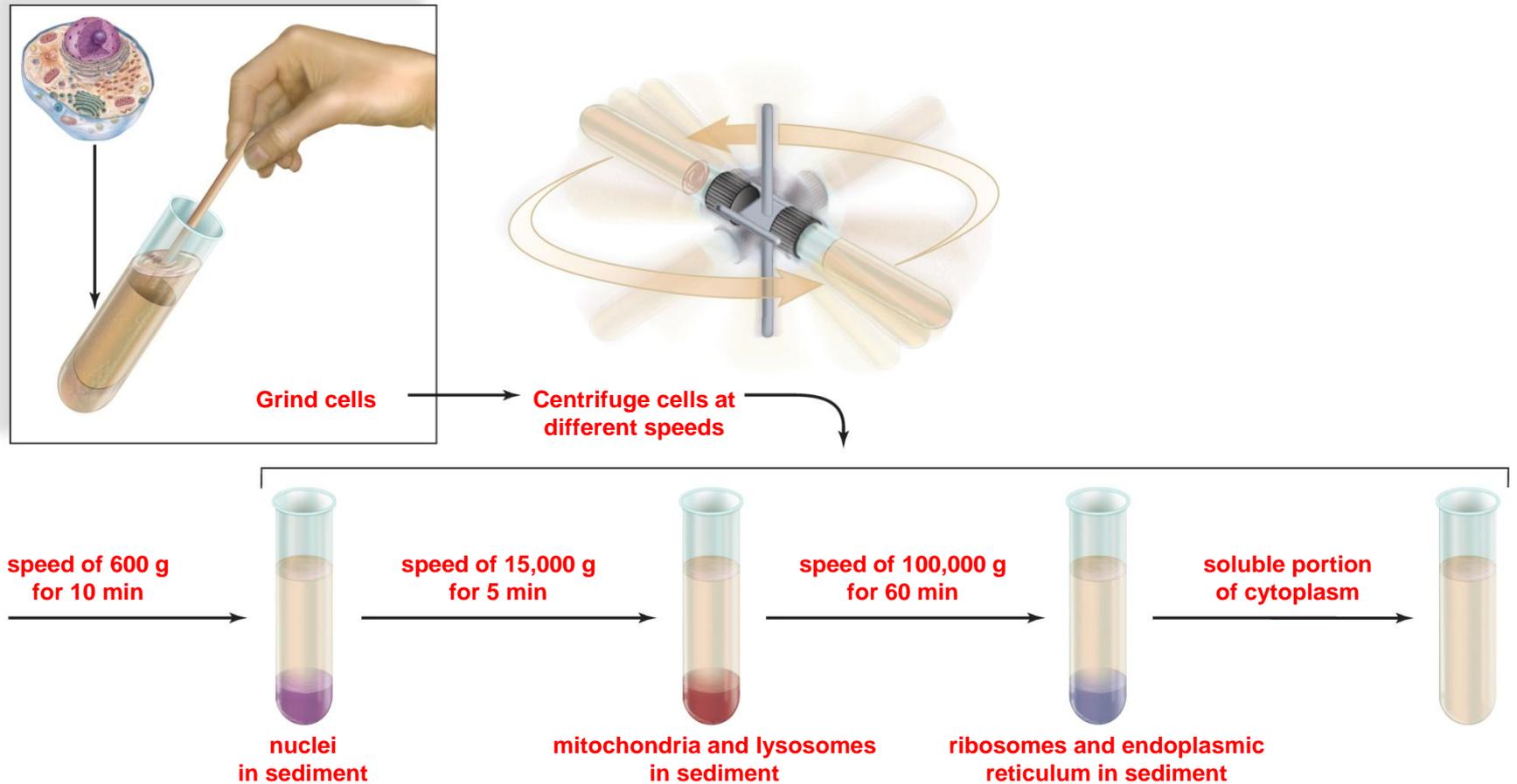


Cell Fractionation and Differential Centrifugation

- Cell fractionation is the breaking apart of cellular components
- Differential centrifugation:
 - Allows separation of cell parts
 - Separated out by size & density
- Works like spin cycle of washer
- The faster the machine spins, the smaller the parts that are settled out

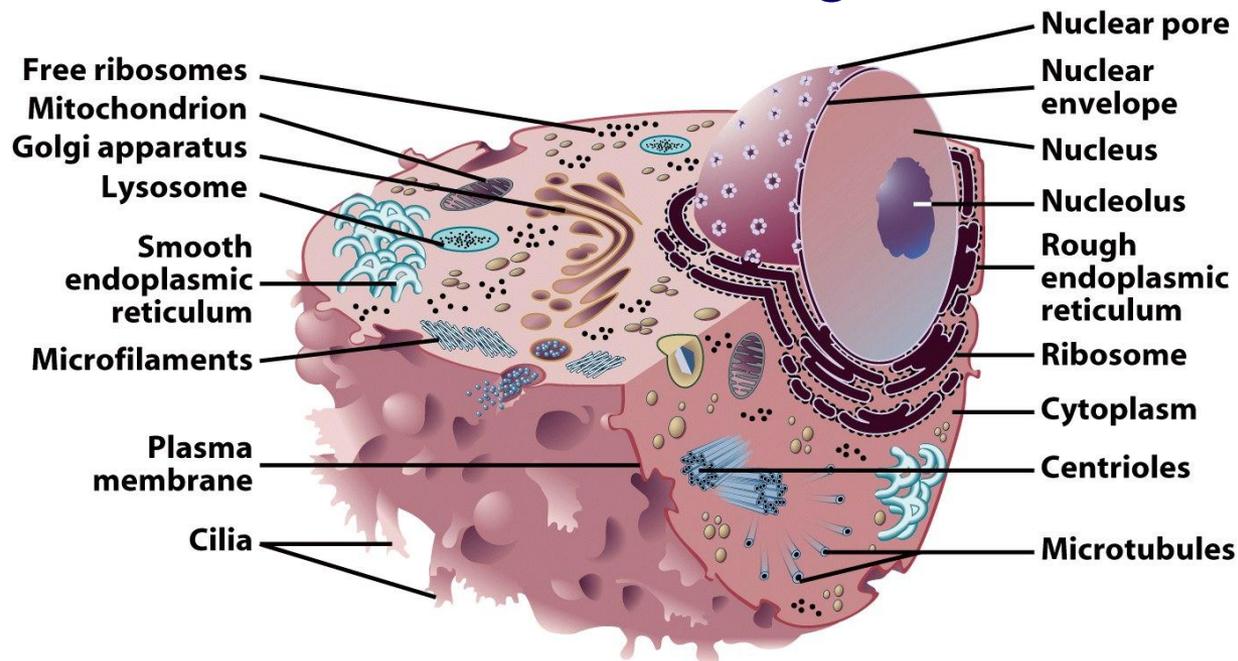
Cell Fractionation and Differential Centrifugation

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



Organelles

- Cellular machinery
- Two general kinds
 - Derived from membranes
 - Bacteria-like organelles

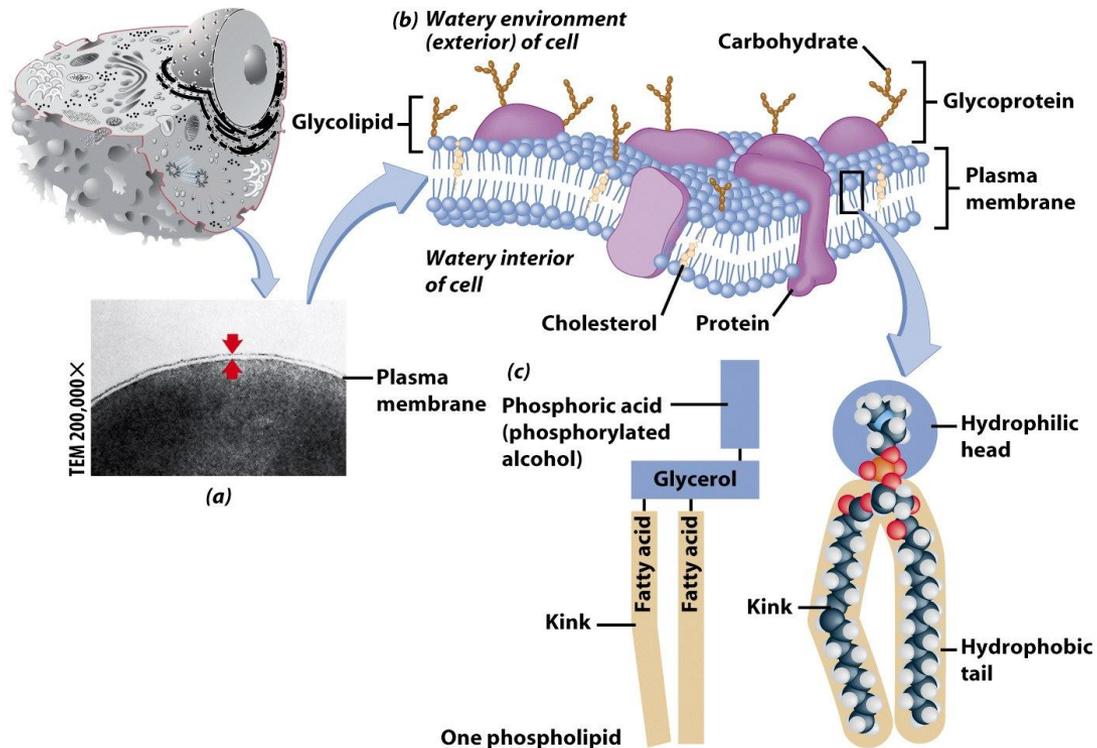


Bacteria-Like Organelles

- Derived from symbiotic bacteria
- Ancient association
- Endosymbiotic theory
 - Evolution of modern cells from cells & symbiotic bacteria

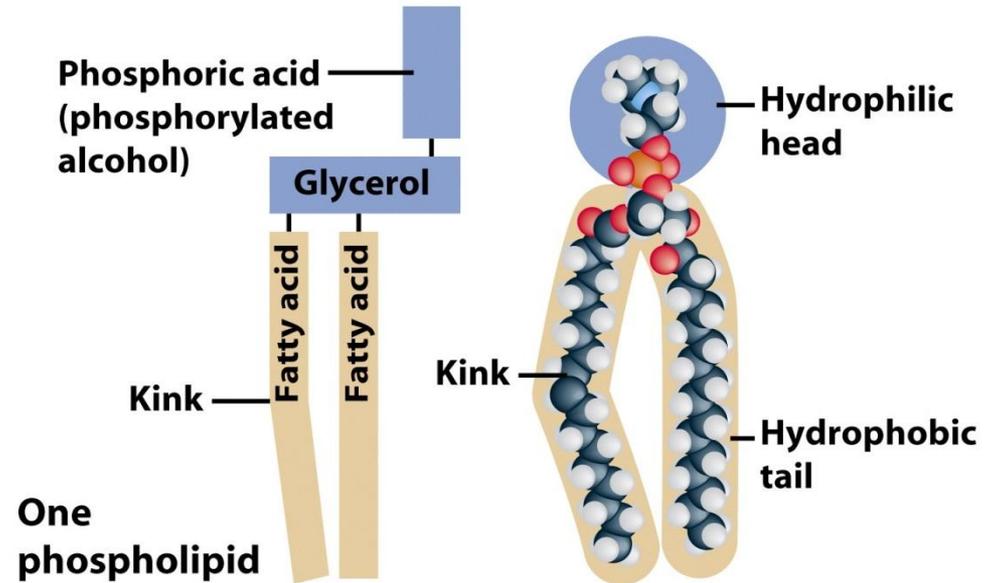
Plasma Membrane

- Contains cell contents
- Double layer of phospholipids & proteins



Phospholipids

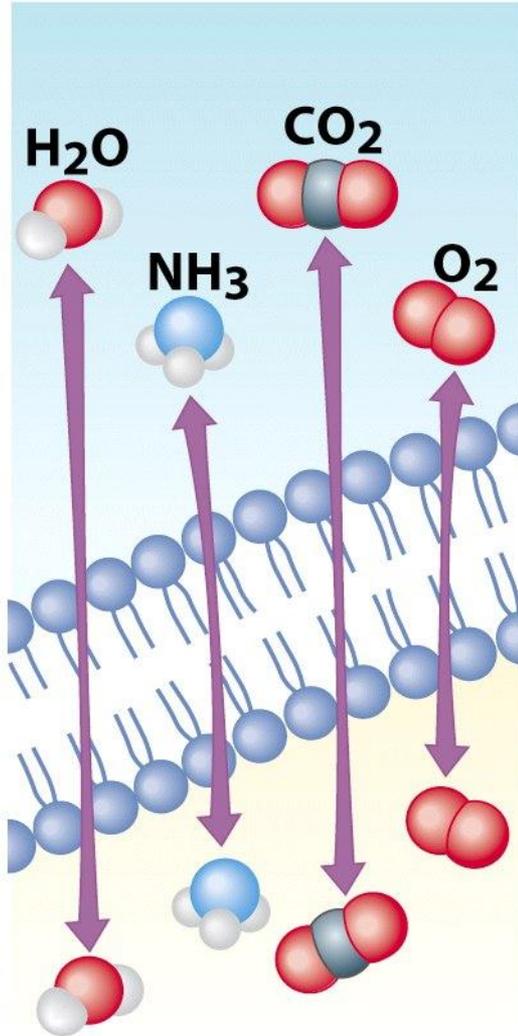
- Polar
 - Hydrophylic head
 - Hydrophobic tail
- Interacts with water



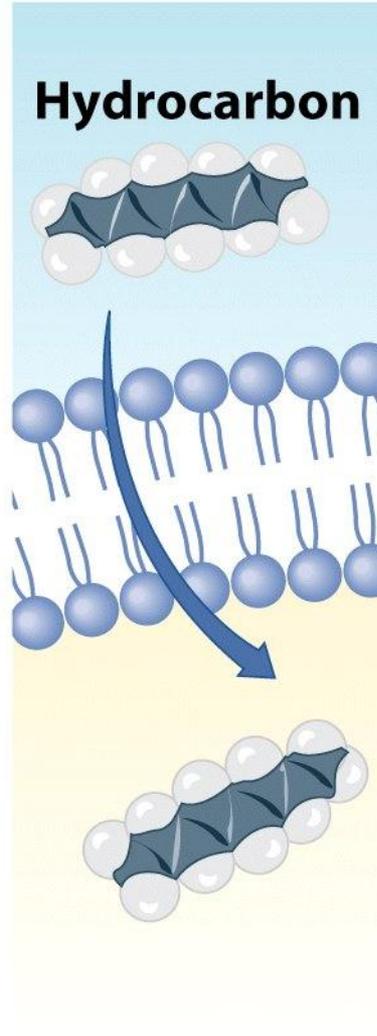
Movement Across the Plasma Membrane

- A few molecules move freely
 - Water, Carbon dioxide, Ammonia, Oxygen
- Carrier proteins transport some molecules
 - Proteins embedded in lipid bilayer
 - Fluid mosaic model – describes fluid nature of a lipid bilayer with proteins

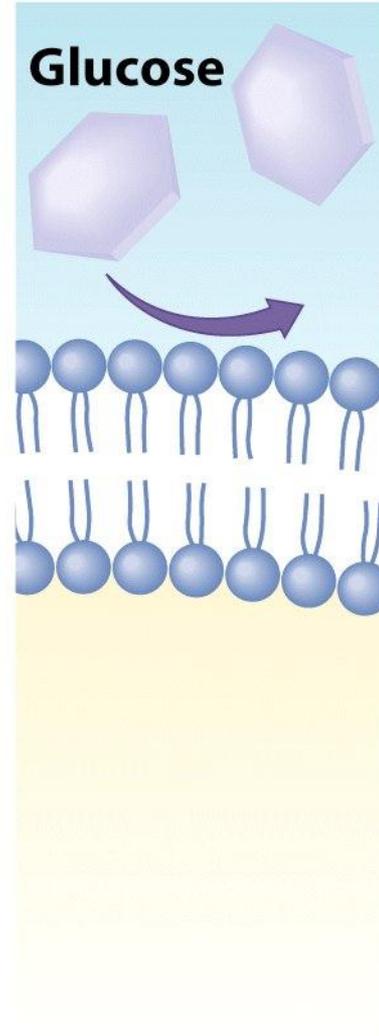
(a)
Small uncharged
molecules



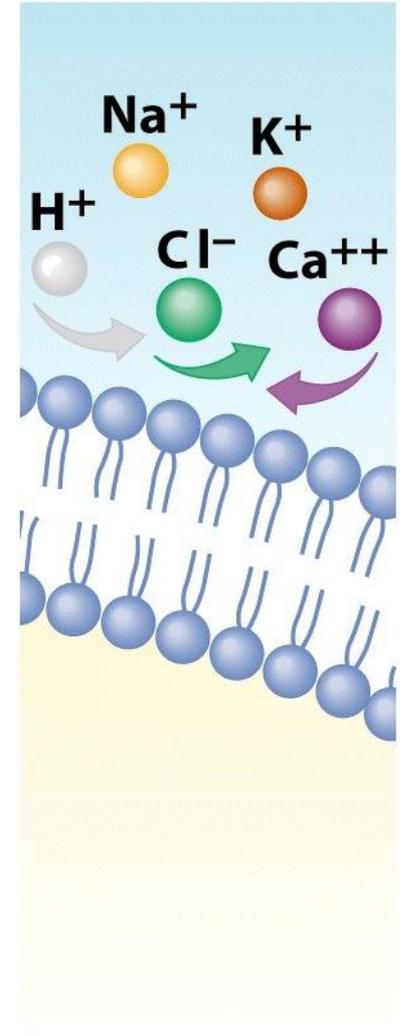
(b)
Lipid-soluble
substances



(c)
Water-soluble
substances

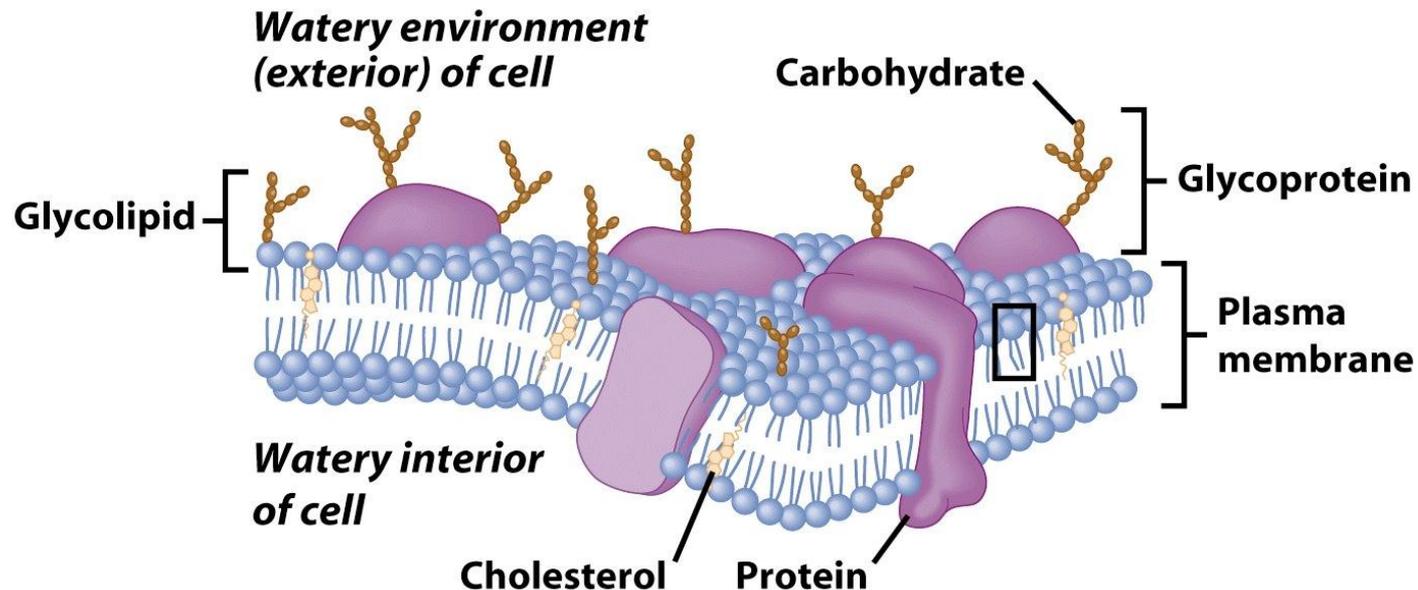


(d)
Ions



Membrane Proteins

1. Channels or transporters
 - Move molecules in one direction
2. Receptors
 - Recognize certain chemicals



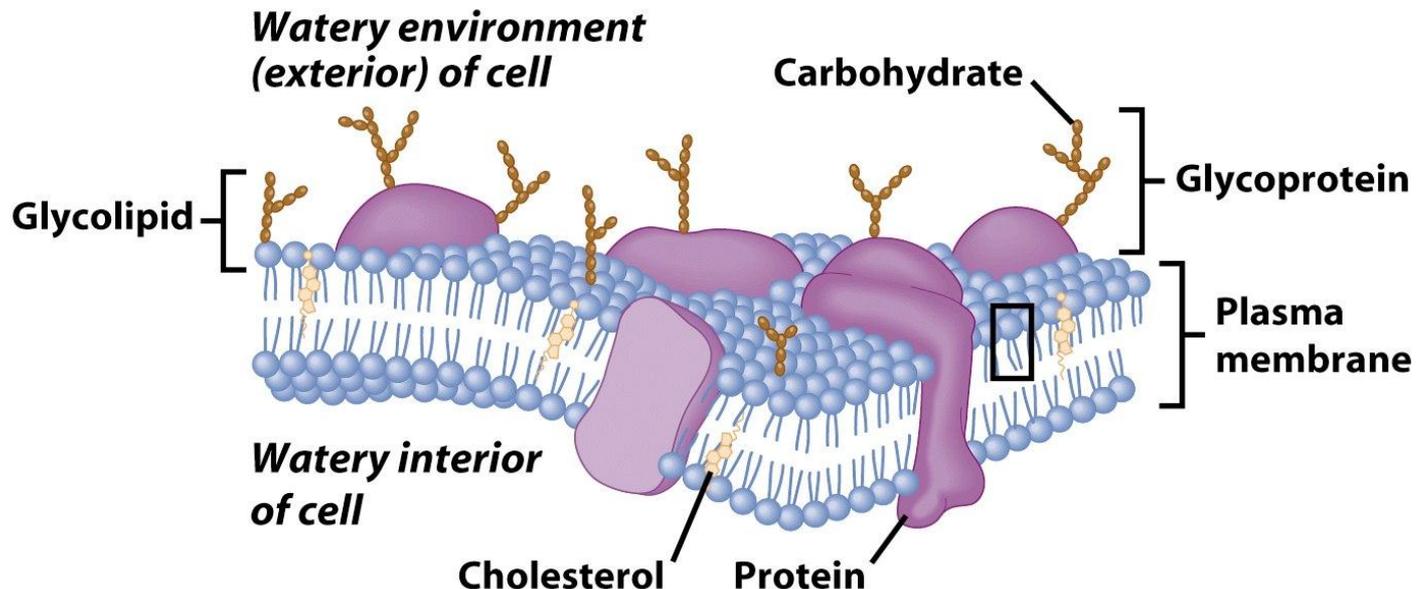
Membrane Proteins

3. Glycoproteins

- Identify cell type

4. Enzymes

- Catalyze production of substances



Cell Walls

- Found in plants, fungi, & many protists
- Surrounds plasma membrane



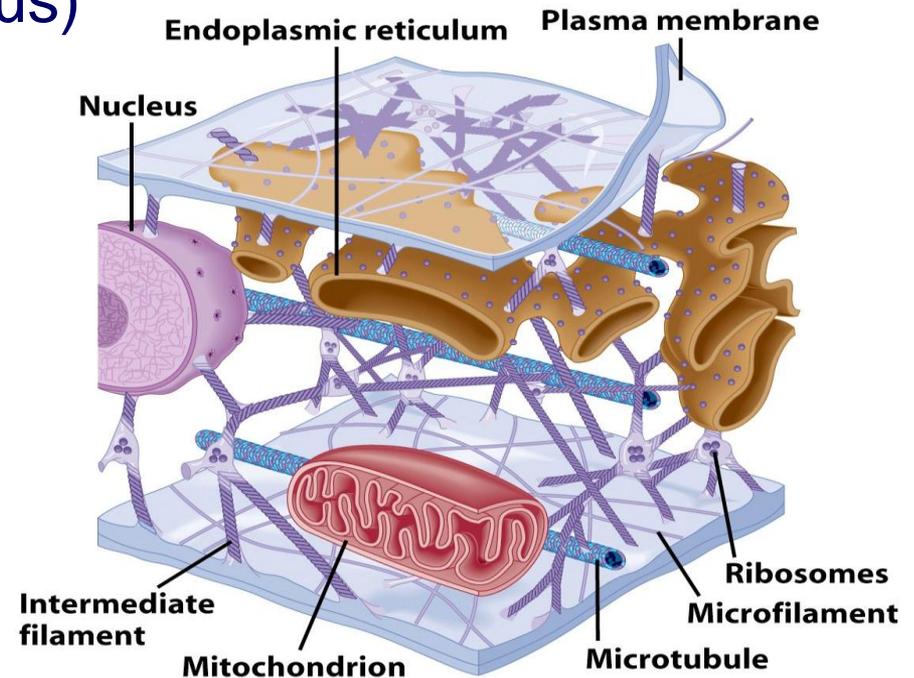
Cell Wall Differences

- Plants – mostly cellulose
- Fungi – contain chitin



Cytoplasm

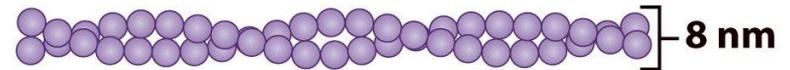
- Viscous fluid containing organelles
- components of cytoplasm
 - Interconnected filaments & fibers
 - Fluid = cytosol
 - Organelles (not nucleus)
 - storage substances



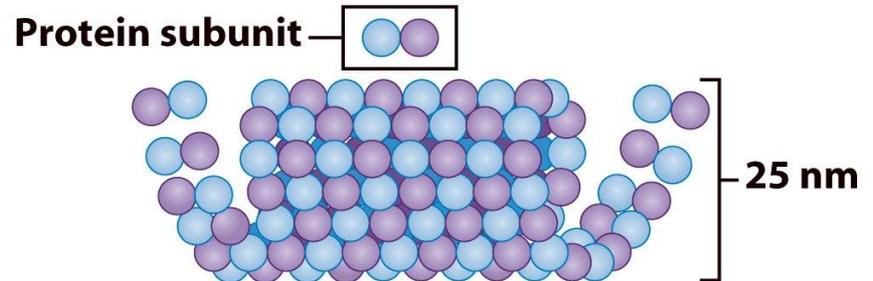
Cytoskeleton

- Filaments & fibers
- Made of 3 fiber types
 - Microfilaments
 - Microtubules
 - Intermediate filaments
- 3 functions:
 - mechanical support
 - anchor organelles
 - help move substances

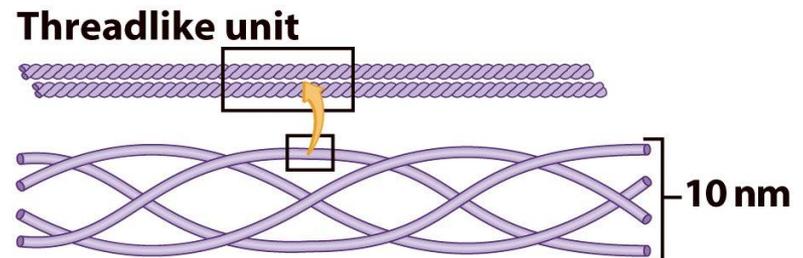
(a) Microfilament

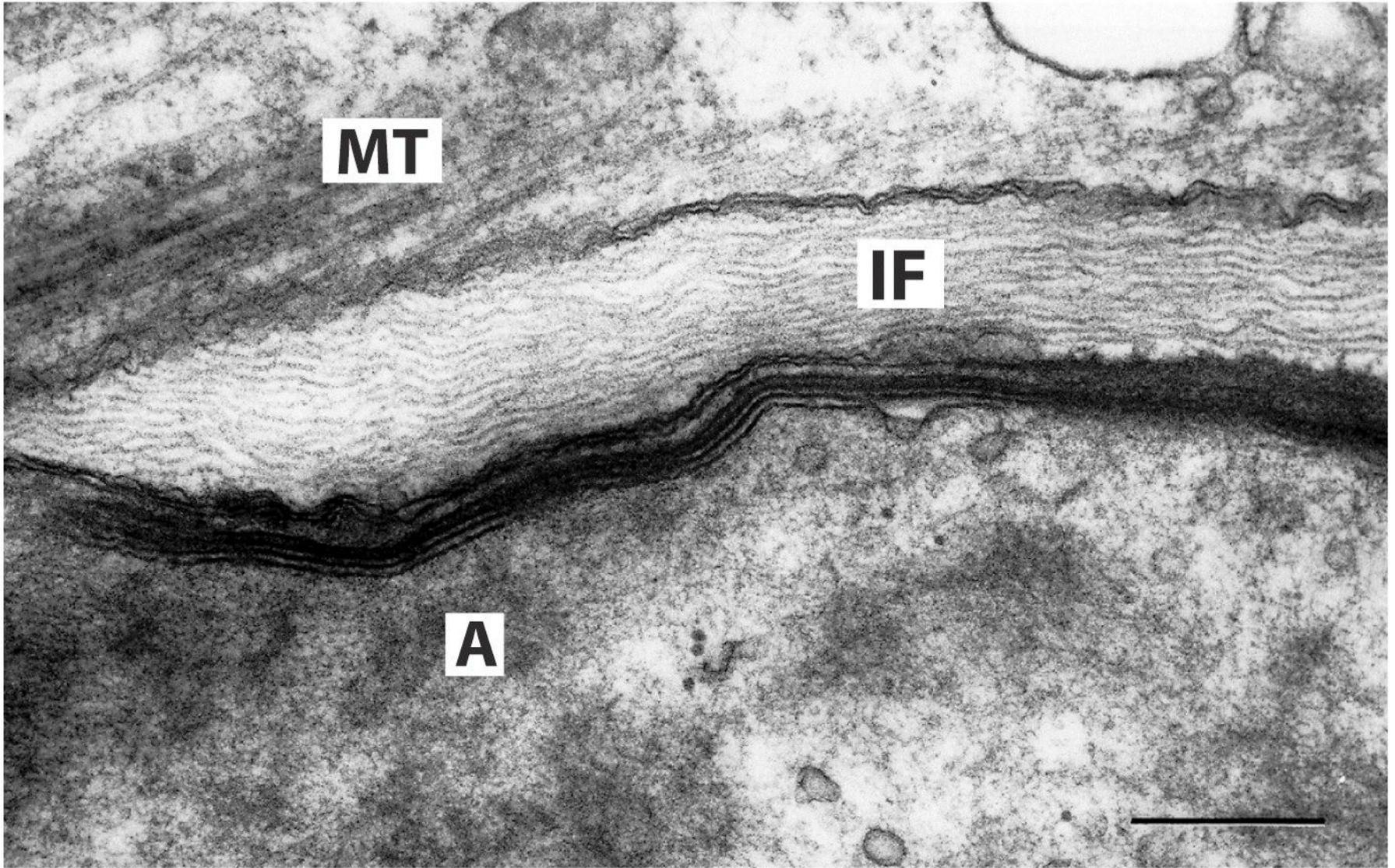


(b) Microtubule



(c) Intermediate filament





A = actin, IF = intermediate filament, MT = microtubule

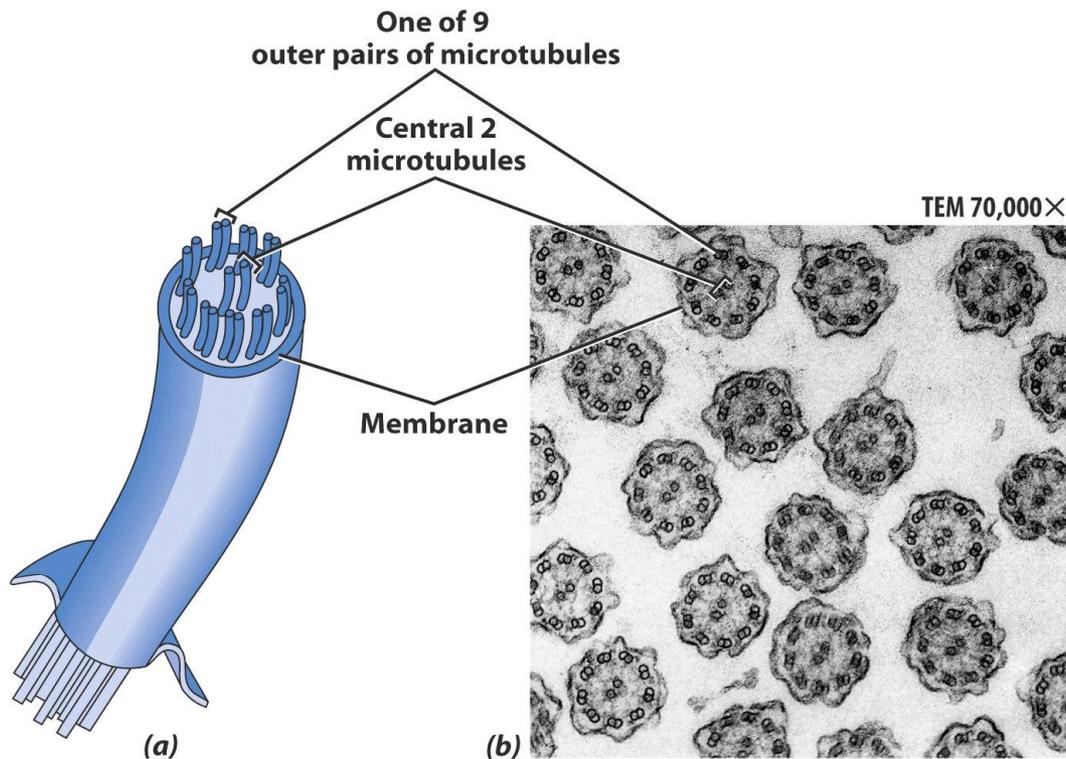
Cilia & Flagella

- Provide motility
- Cilia
 - Short
 - Used to move substances outside human cells
- Flagella
 - Whip-like extensions
 - Found on sperm cells
- Basal bodies like centrioles



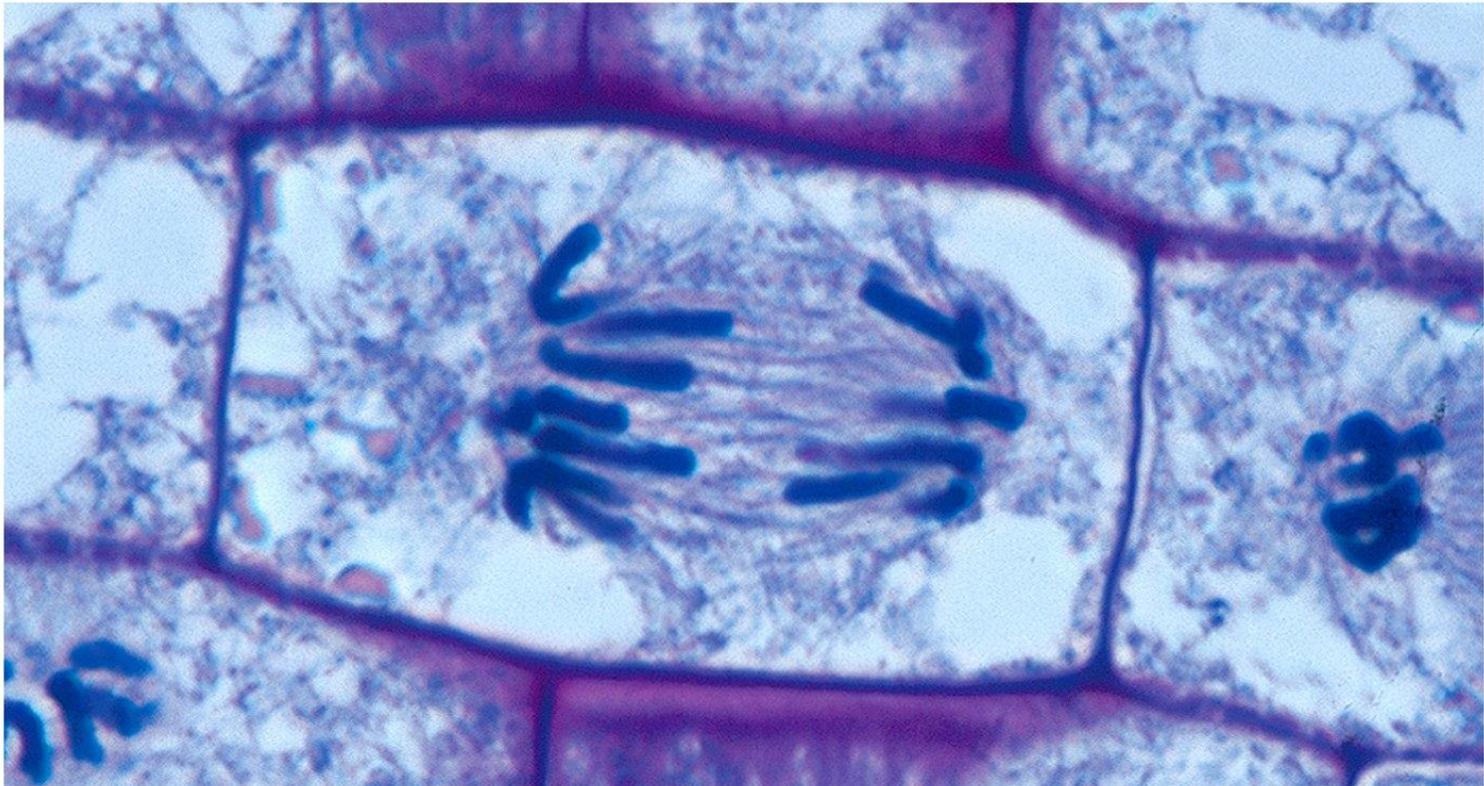
Cilia & Flagella Structure

- Bundles of microtubules
- With plasma membrane



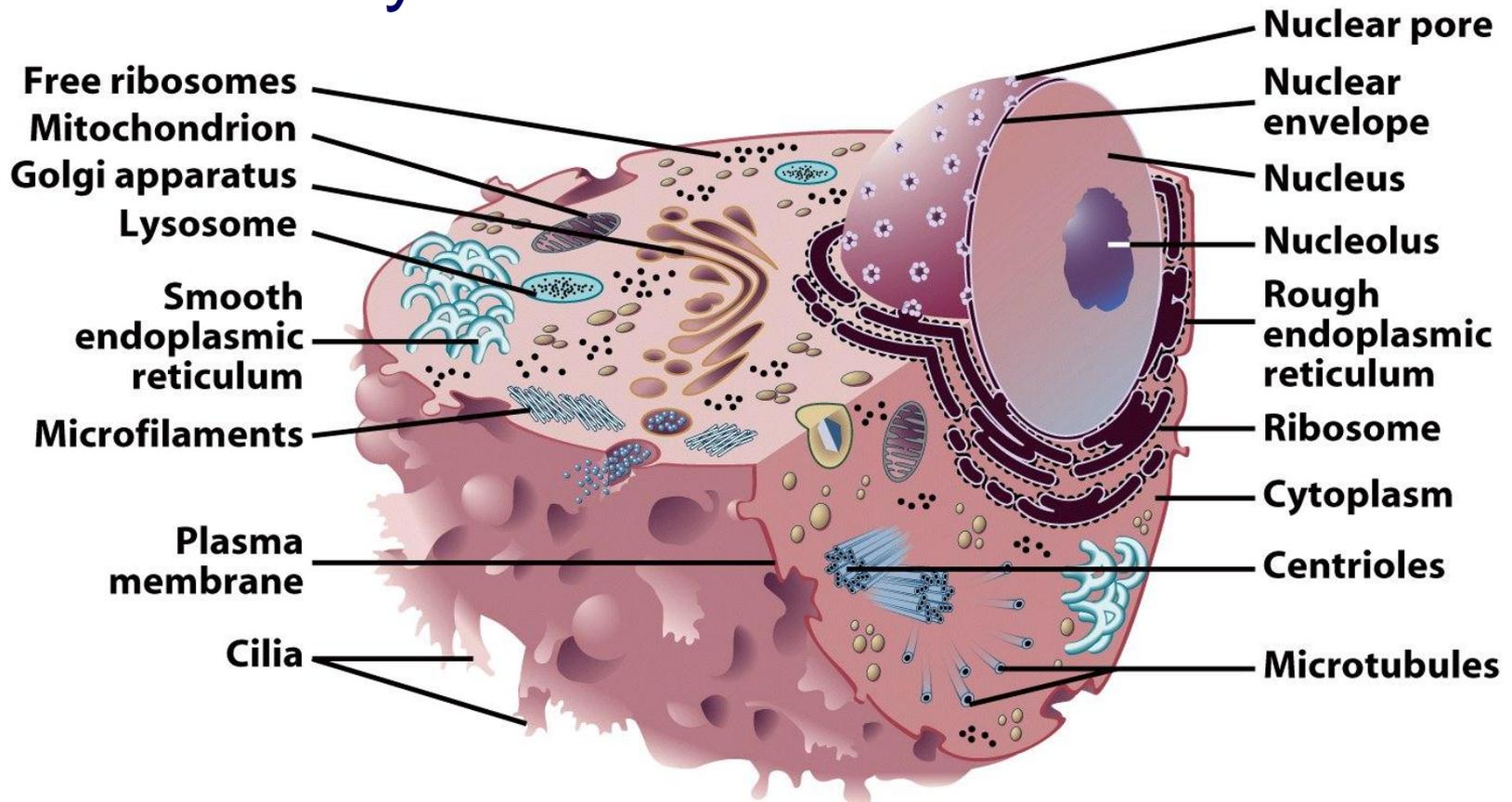
Centrioles

- Pairs of microtubular structures
- Play a role in cell division



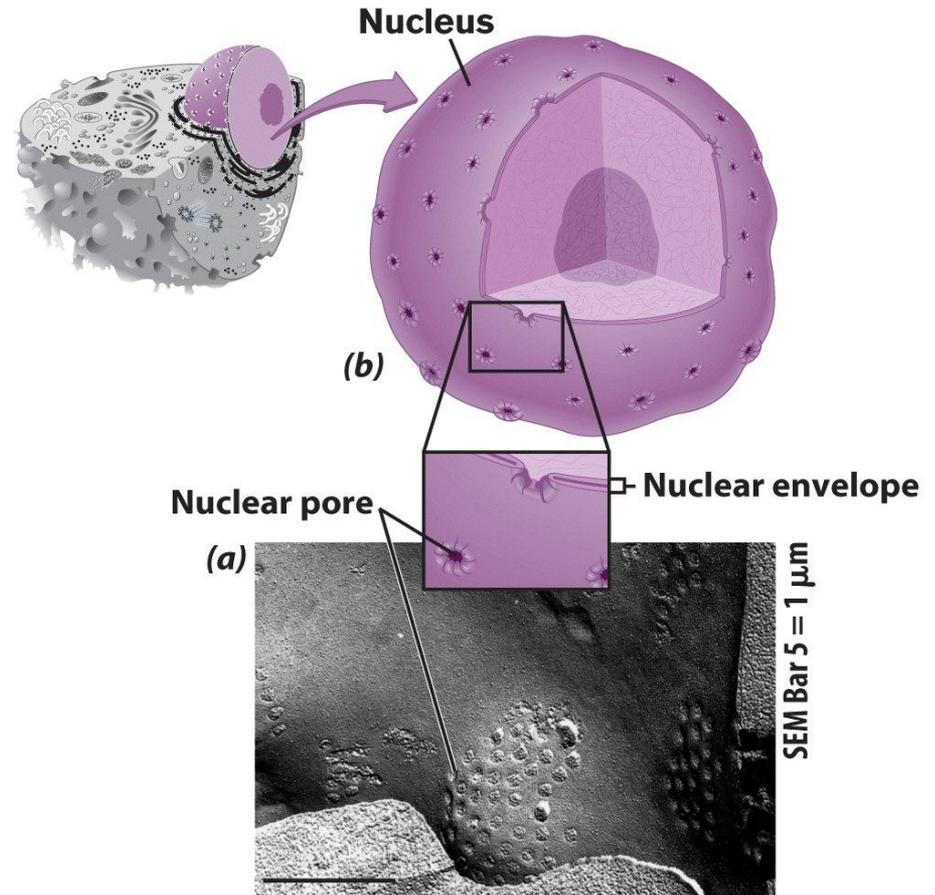
Membranous Organelles

- Functional components within cytoplasm
- Bound by membranes



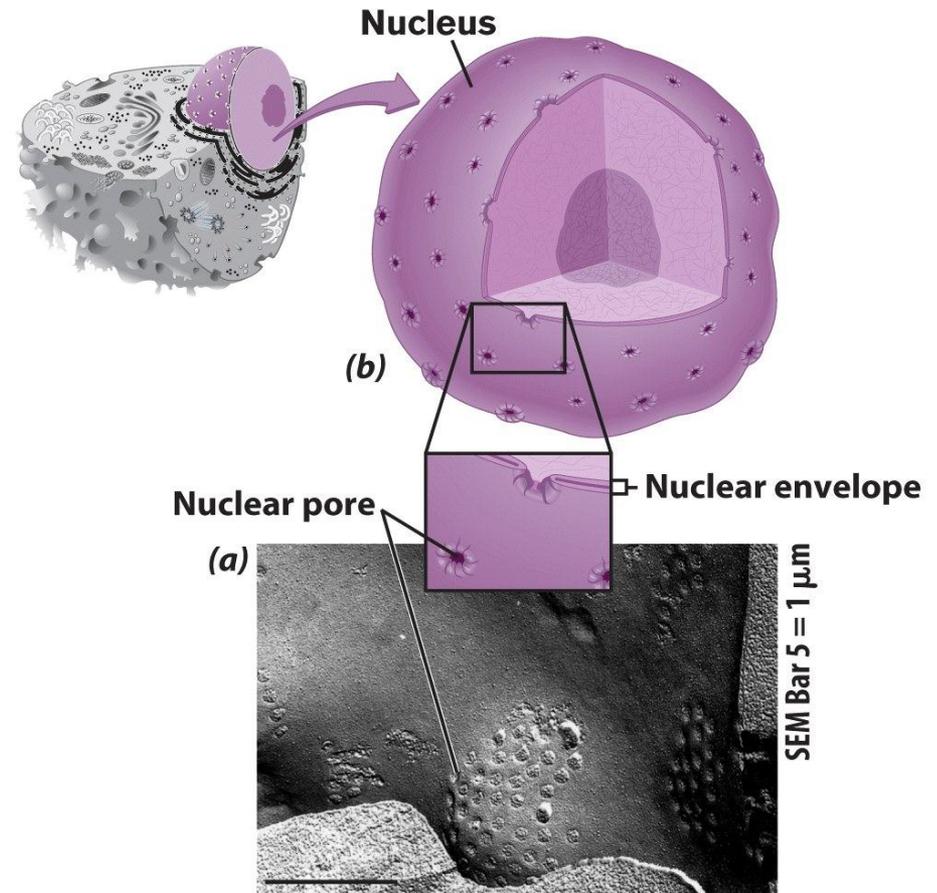
Nucleus

- Control center of cell
- Double membrane
- Contains
 - Chromosomes
 - Nucleolus



Nuclear Envelope

- Separates nucleus from rest of cell
- Double membrane
- Has pores



DNA

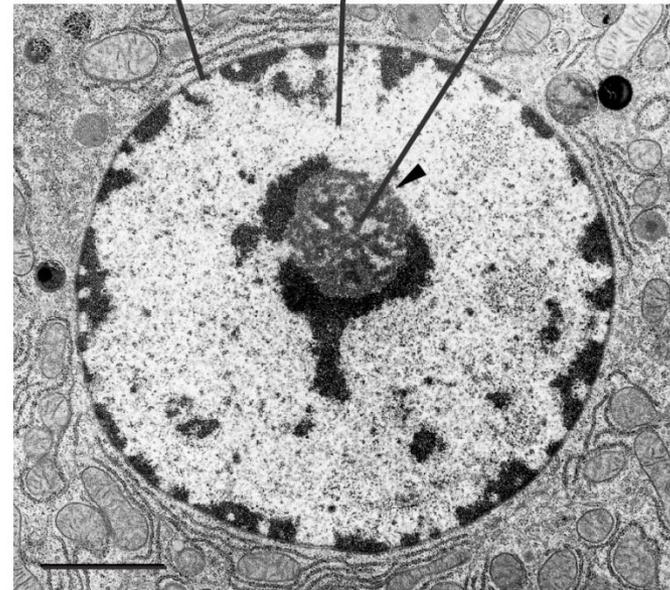
- Hereditary material
- Chromosomes
 - DNA
 - Proteins
 - Form for cell division
- Chromatin



Nucleolus

- Most cells have 2 or more
- Directs synthesis of RNA
- Forms ribosomes

Nuclear membrane Nucleus Nucleolus

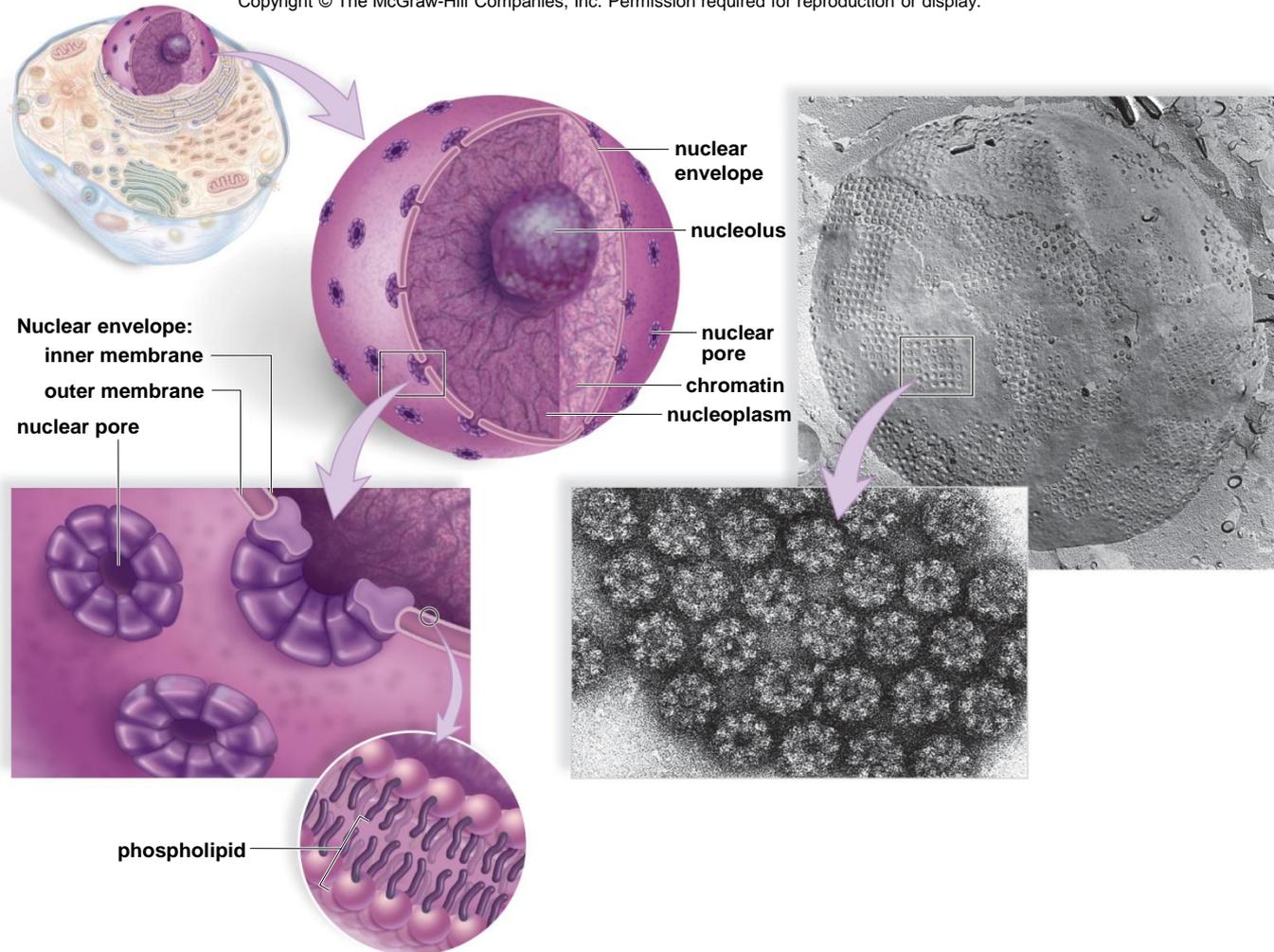


Nucleus

- Command center of cell, usually near center
- Separated from cytoplasm by nuclear envelope
 - Consists of double layer of membrane
 - Nuclear pores permit exchange between nucleoplasm & cytoplasm
- Contains chromatin in semifluid nucleoplasm
 - Chromatin contains DNA of genes, and proteins
 - Condenses to form chromosomes
 - Chromosomes are formed during cell division
- Dark nucleolus composed of rRNA
 - Produces subunits of ribosomes

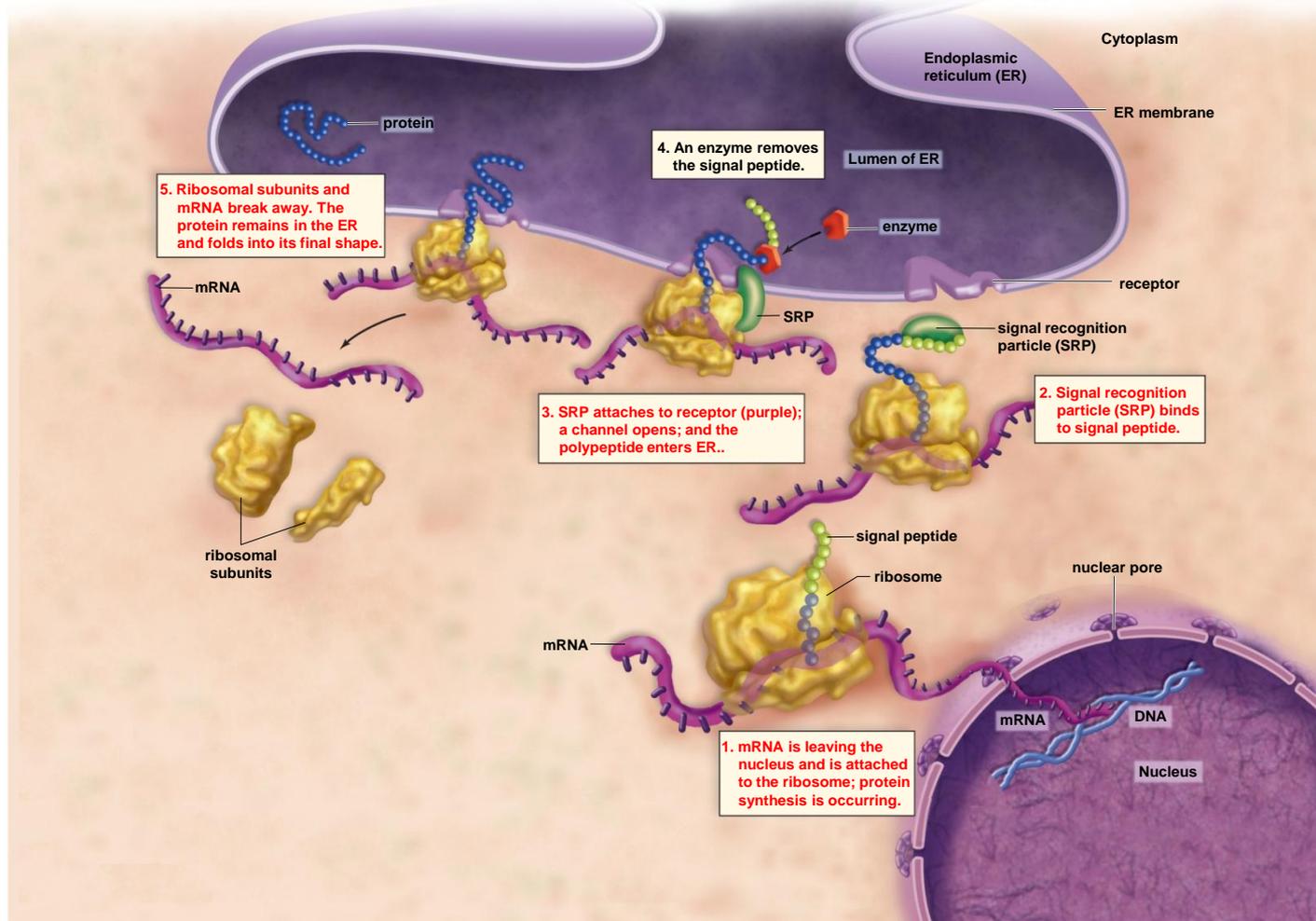
Anatomy of the Nucleus

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



Nucleus, Ribosomes, & ER

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



Endomembrane System

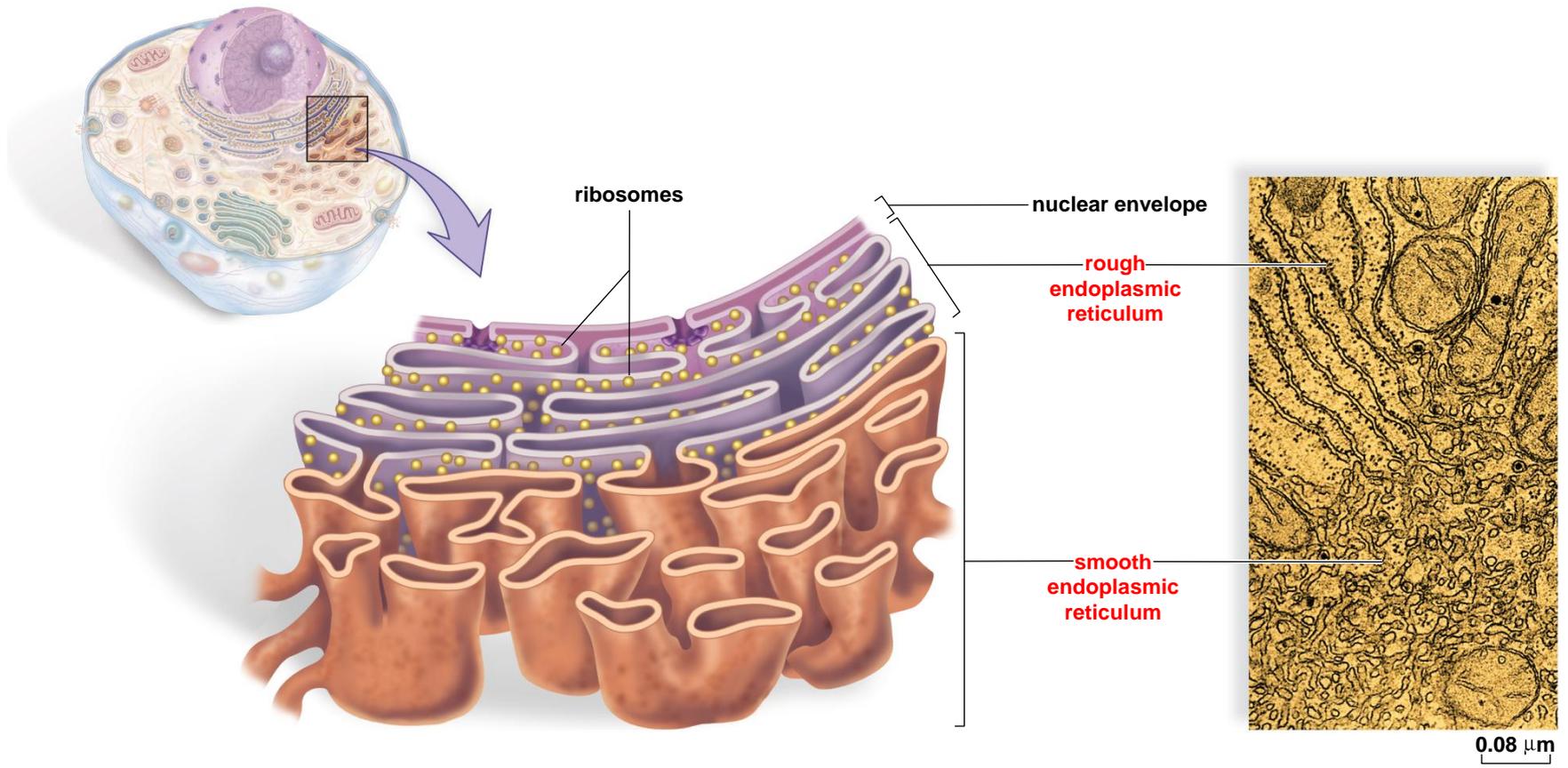
- Series of intracellular membranes that compartmentalize the cell
- Restrict enzymatic reactions to specific compartments within cell
- Consists of:
 - Nuclear envelope
 - Membranes of endoplasmic reticulum
 - Golgi apparatus
 - Vesicles
 - Several types
 - Transport materials between organelles of system

Endomembrane System: The Endoplasmic Reticulum

- A system of membrane channels and saccules (flattened vesicles) continuous with the outer membrane of the nuclear envelope
- Rough ER
 - Studded with ribosomes on cytoplasmic side
 - Protein anabolism
 - Synthesizes proteins
 - Modifies and processes proteins
 - Adds sugar to protein
 - Results in glycoproteins
- Smooth ER
 - No ribosomes
 - Synthesis of lipids
 - Site of various synthetic processes, detoxification, and storage
 - Forms **transport vesicles**

Endoplasmic Reticulum

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



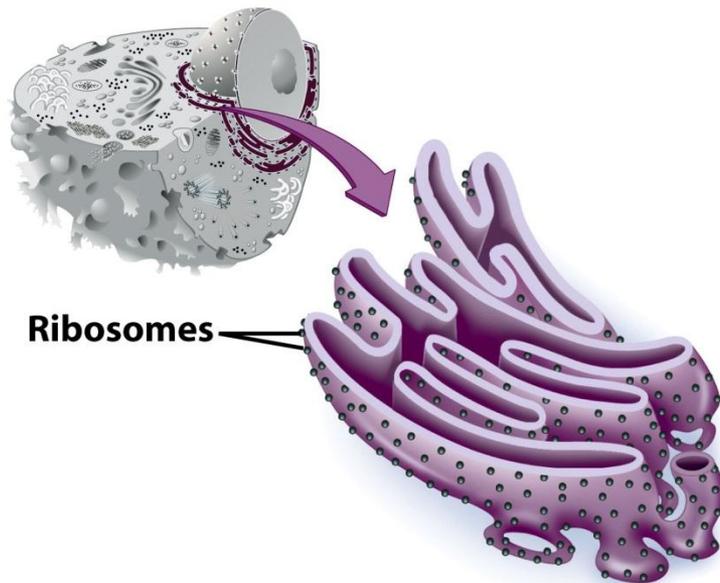
© R. Bolender & D. Fawcett/Visuals Unlimited

Endoplasmic Reticulum

- Helps move substances within cells
- Network of interconnected membranes
- Two types
 - Rough endoplasmic reticulum
 - Smooth endoplasmic reticulum

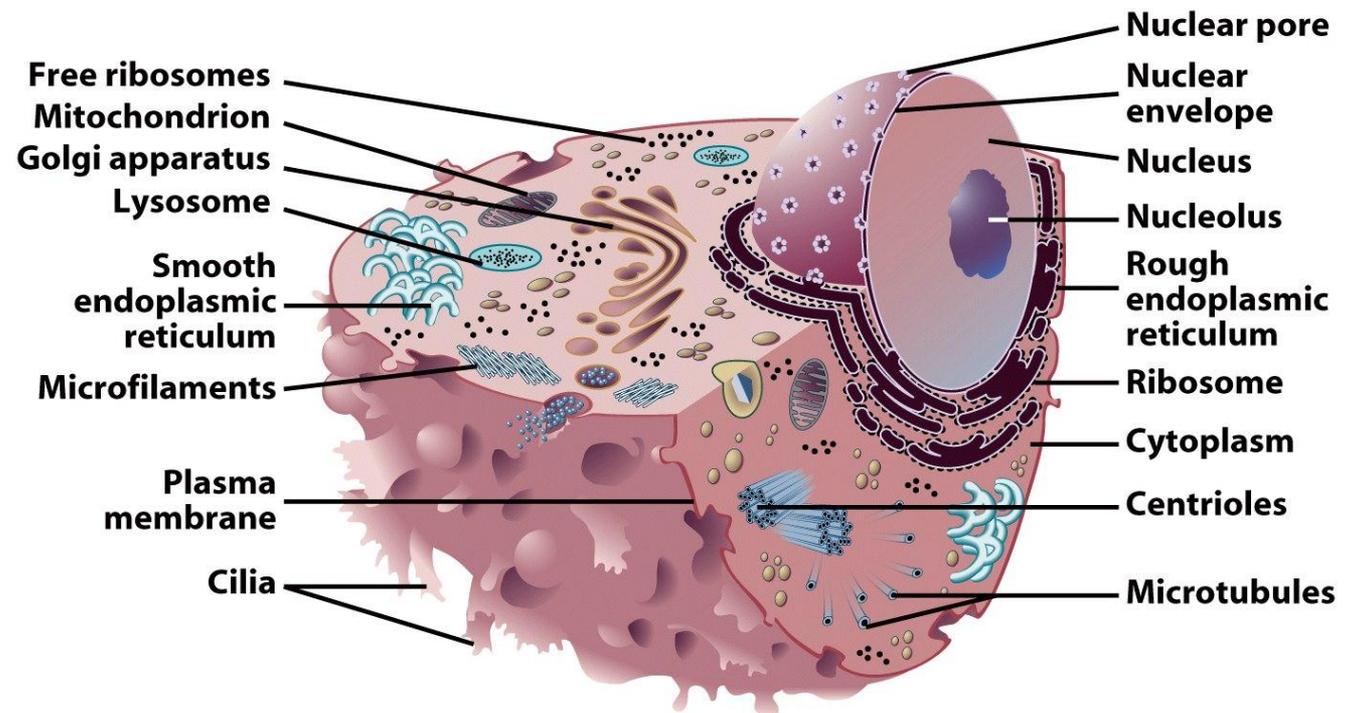
Rough Endoplasmic Reticulum

- Ribosomes attached to surface
 - Manufacture proteins
 - Not all ribosomes attached to rough ER
- May modify proteins from ribosomes



Smooth Endoplasmic Reticulum

- No attached ribosomes
- Has enzymes that help build molecules
 - Carbohydrates
 - Lipids



Endomembrane System: The Golgi Apparatus

- Golgi Apparatus
 - Consists of 3-20 flattened, curved saccules
 - Resembles stack of hollow pancakes
 - Modifies proteins and lipids
 - Receives vesicles from ER on cis (or inner face)
 - Packages them in vesicles
 - Prepares for “shipment” in v Packages them in vesicles from trans (or outer face)
 - Within cell
 - Export from cell (secretion, exocytosis)

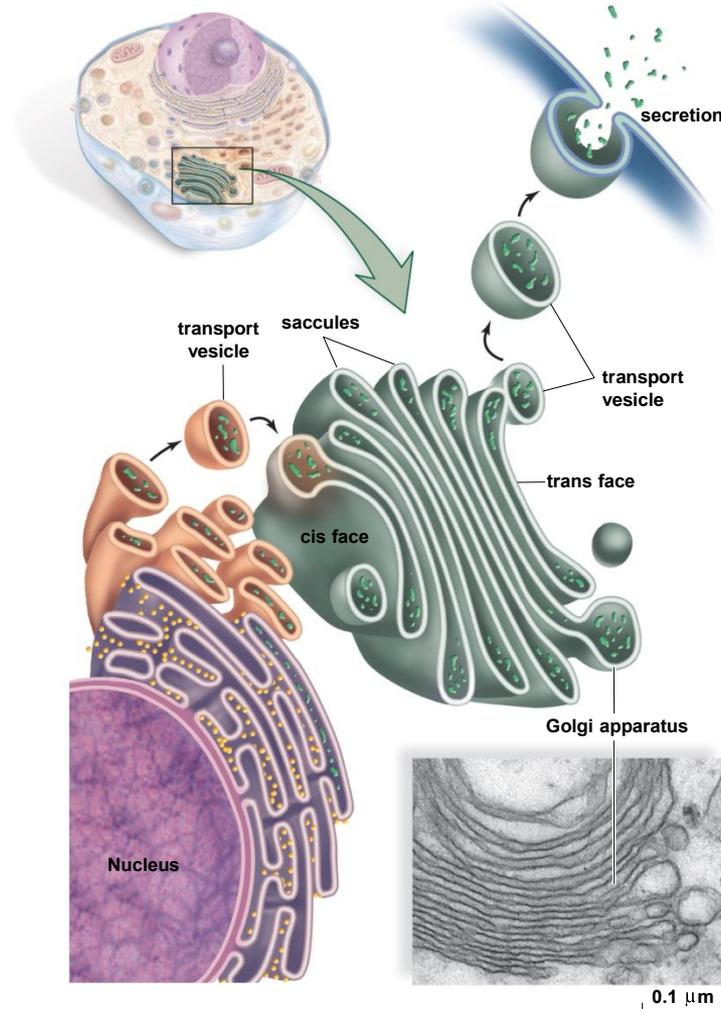
The rest in the next lecture

Dr. Mohammed Qais



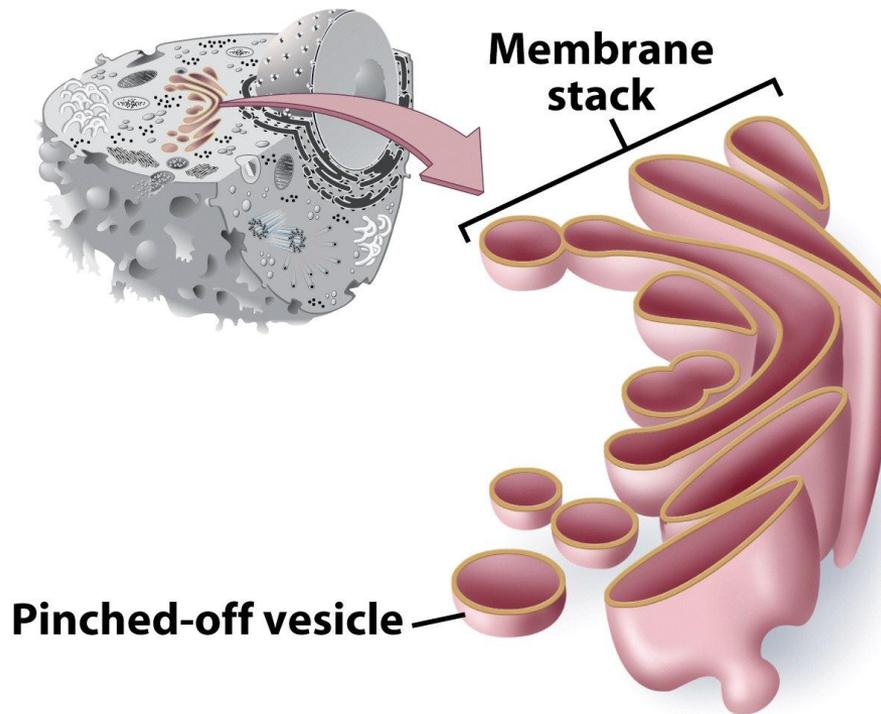
Golgi Apparatus

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



Golgi Apparatus

- Involved in synthesis of plant cell wall
- Packaging & shipping station of cell

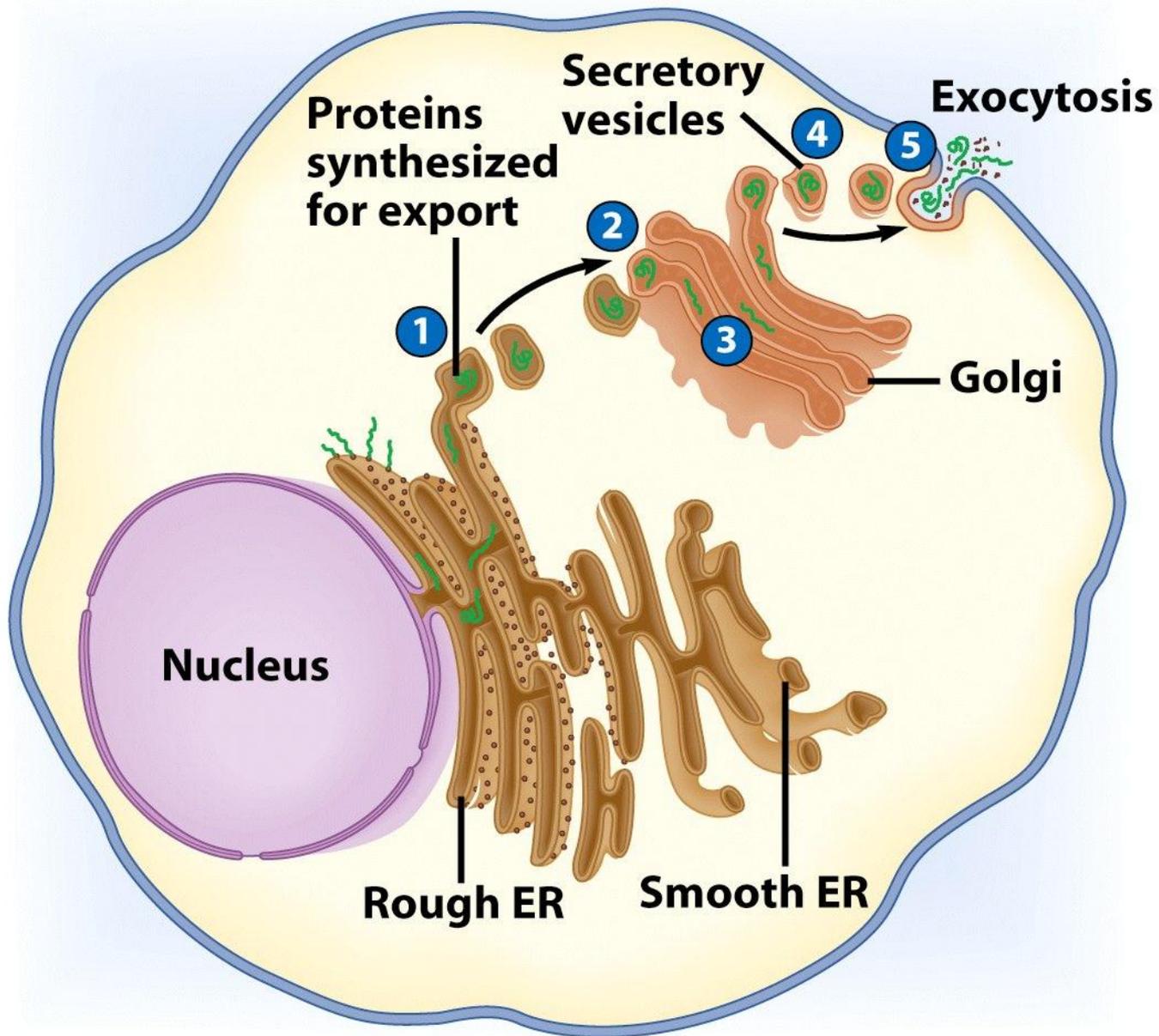


Golgi Apparatus Function

1. Molecules come in vesicles
2. Vesicles fuse with Golgi membrane
3. Molecules may be modified by Golgi

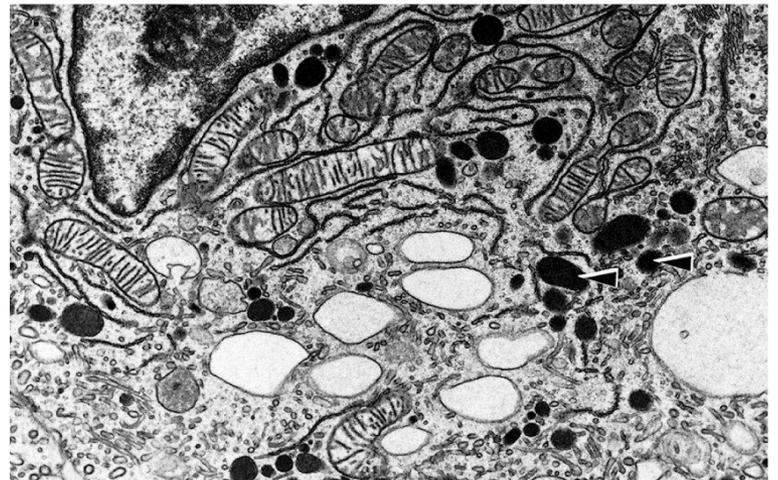
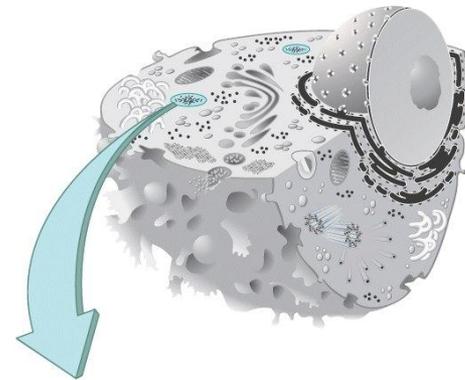
Golgi Apparatus Function (Continued)

4. Molecules pinched-off in separate vesicle
5. Vesicle leaves Golgi apparatus
6. Vesicles may combine with plasma membrane to secrete contents



Lysosomes

- Contain digestive enzymes
- Functions
 - Aid in cell renewal
 - Break down old cell parts
 - Digests invaders



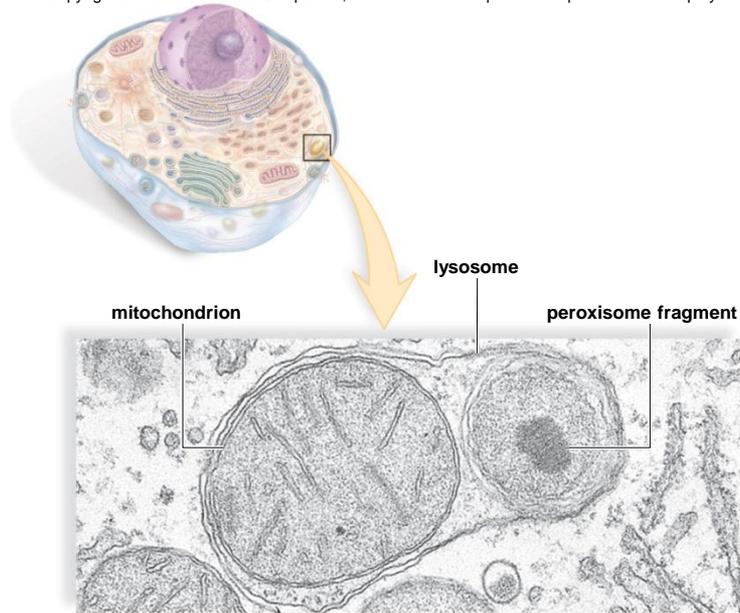
Endomembrane System:

Lysosomes

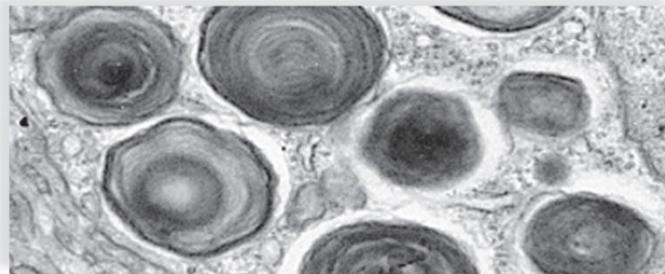
- Membrane-bound vesicles (not in plants)
 - Produced by the Golgi apparatus
 - Contain powerful digestive enzymes and are highly acidic
 - Digestion of large molecules
 - Recycling of cellular resources
 - Apoptosis (programmed cell death, like tadpole losing tail)
- Some genetic diseases
 - Caused by defect in lysosomal enzyme
 - Lysosomal storage diseases (Tay-Sachs)

Lysosomes

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



a. Mitochondrion and a peroxisome in a lysosome



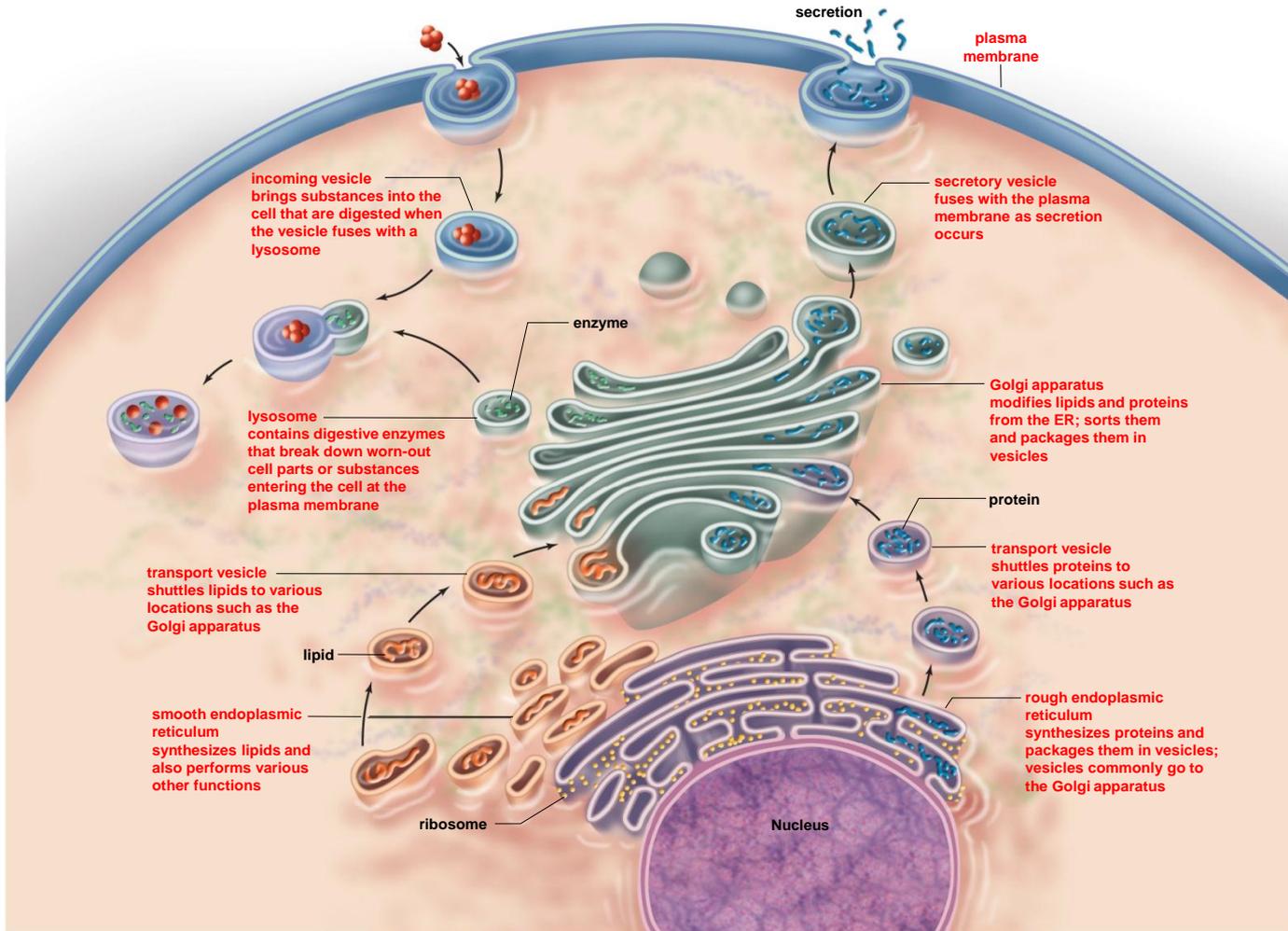
b. Storage bodies in a cell with defective lysosomes

Endomembrane System: Summary

- Proteins produced in rough ER and lipids from smooth ER are carried in vesicles to the Golgi apparatus.
- The Golgi apparatus modifies these products and then sorts and packages them into vesicles that go to various cell destinations.
- Secretory vesicles carry products to the membrane where exocytosis produces secretions.
- Lysosomes fuse with incoming vesicles and digest macromolecules.

Endomembrane System: A Visual Summary

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

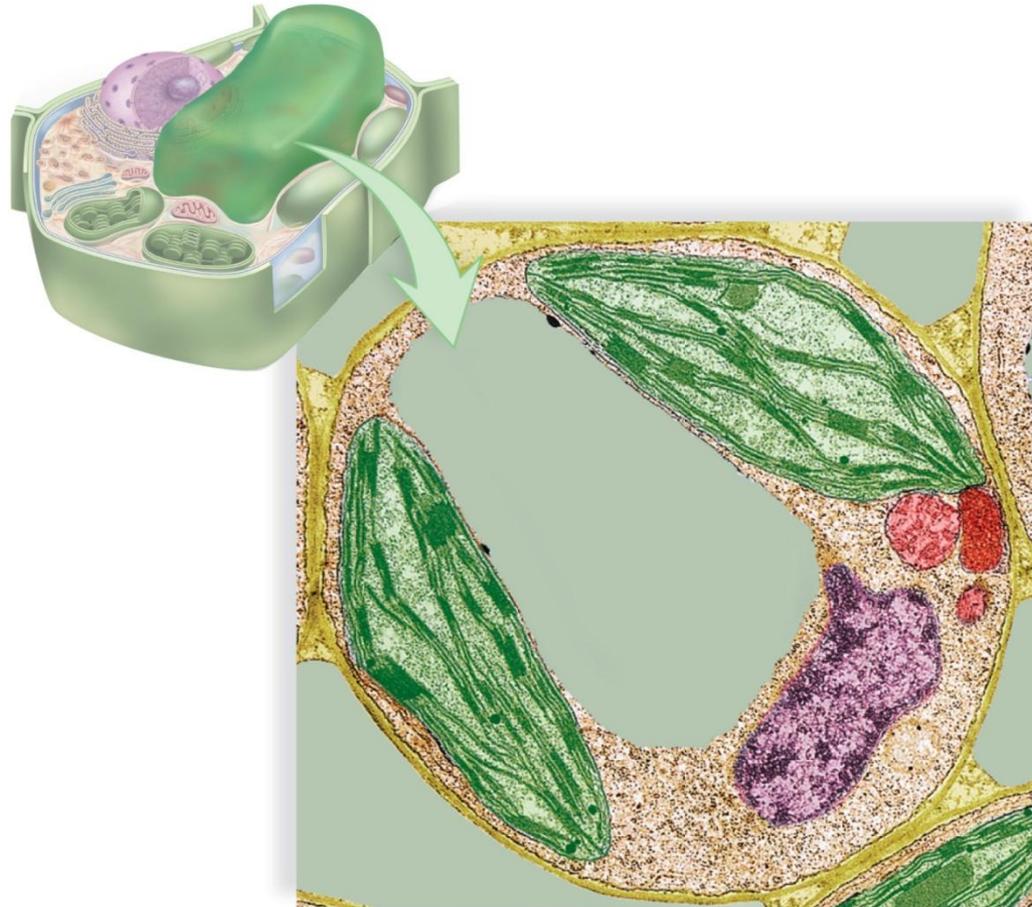


Vacuoles

- Membranous sacs that are larger than vesicles
 - Store materials that occur in excess
 - Others very specialized (contractile vacuole)
- Plants cells typically have a central vacuole
 - Up to 90% volume of some cells
 - Functions in:
 - Storage of water, nutrients, pigments, and waste products
 - Development of turgor pressure
 - Some functions performed by lysosomes in other eukaryotes

Vacuoles

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

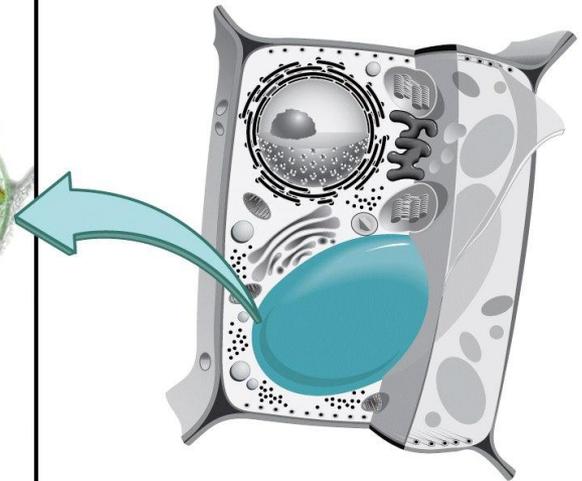
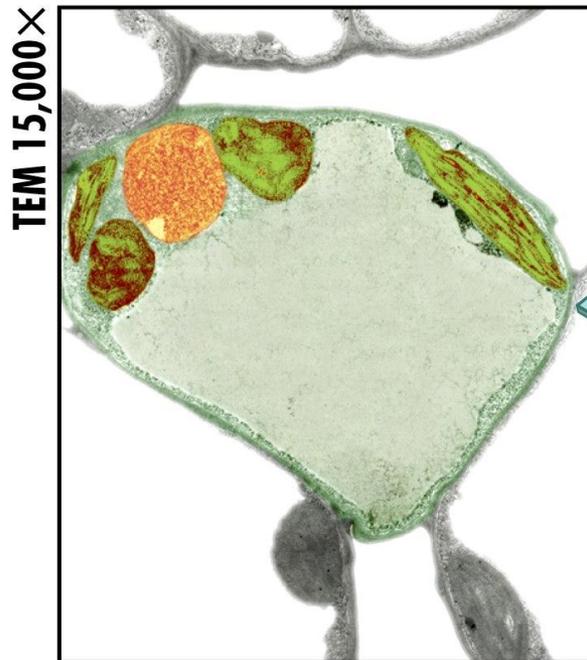


100 nm

© Newcomb/Wergin/Biological Photo Service

Vacuoles

- Membrane bound storage sacs
- More common in plants than animals
- Contents
 - Water
 - Food
 - wastes

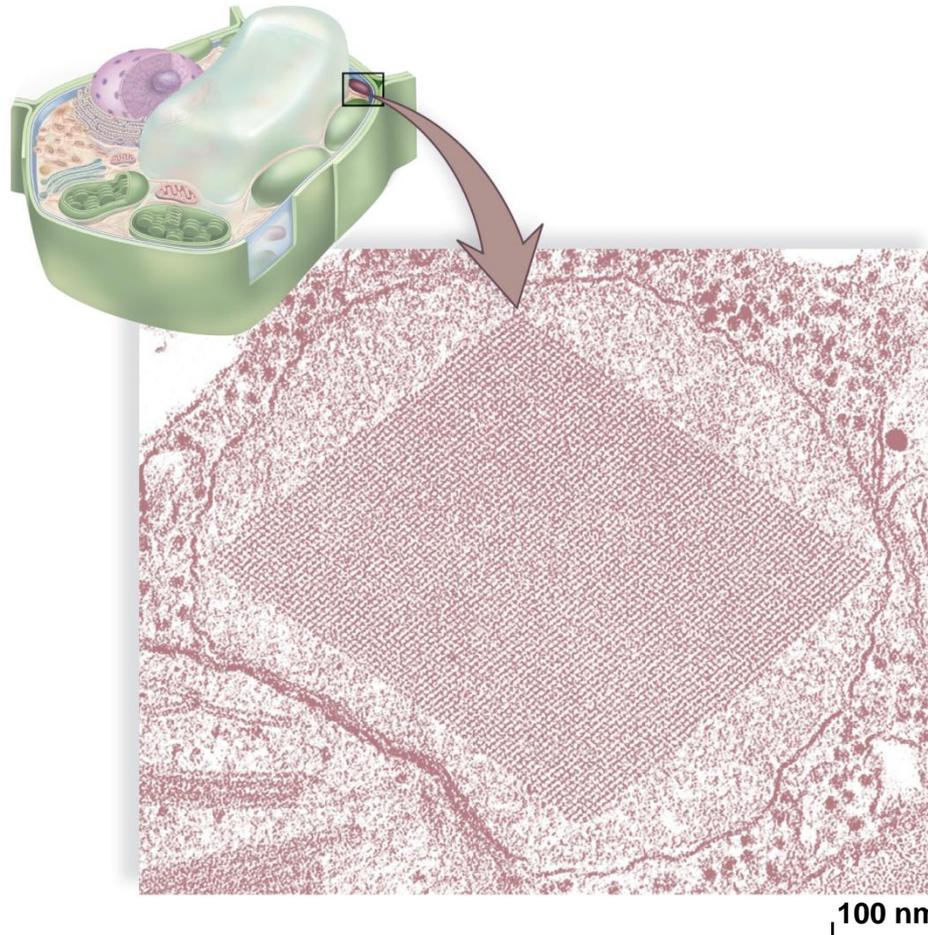


Peroxisomes

- Similar to lysosomes
 - Membrane-bounded vesicles
 - Enclose enzymes
- However
 - Enzymes synthesized by free ribosomes in cytoplasm (instead of ER)
 - Active in lipid metabolism
 - Catalyze reactions that produce hydrogen peroxide H_2O_2
 - Toxic
 - Broken down to water & O_2 by catalase

Peroxisomes

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



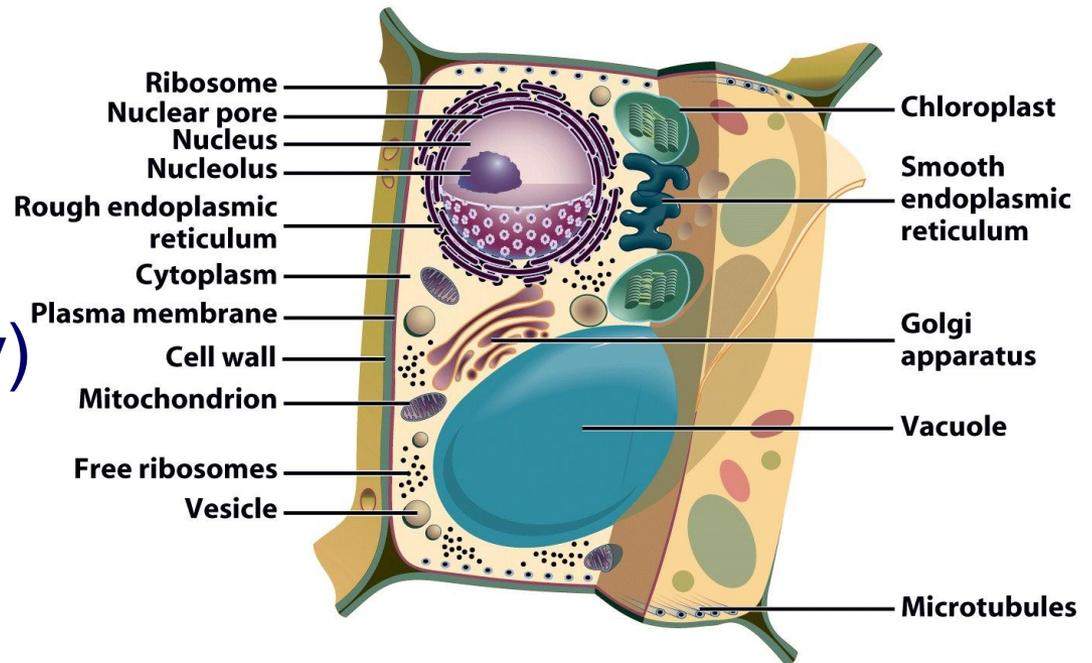
© S.E. Frederick & E.H. Newcomb/Biological Photo Service

Bacteria-Like Organelles

- Release & store energy

- Types

- Mitochondria
(release energy)
- Chloroplasts
(store energy)



Energy-Related Organelles: Chloroplast Structure

- Bounded by double membrane
- Inner membrane infolded
 - Forms disc-like thylakoids, which are stacked to form grana
 - Suspended in semi-fluid stroma
- Green due to chlorophyll
 - Green photosynthetic pigment
 - Found ONLY in inner membranes of chloroplast

Energy-Related Organelles: Chloroplasts

- Membranous organelles (a type of **plastid**) that serve as the site of photosynthesis
- Captures light energy to drive cellular machinery
- Photosynthesis
 - Synthesizes carbohydrates from CO_2 & H_2O
 - Makes own food using CO_2 as only carbon source
 - Energy-poor compounds converted to energy-rich compounds

solar energy + carbon dioxide + water → carbohydrate + oxygen

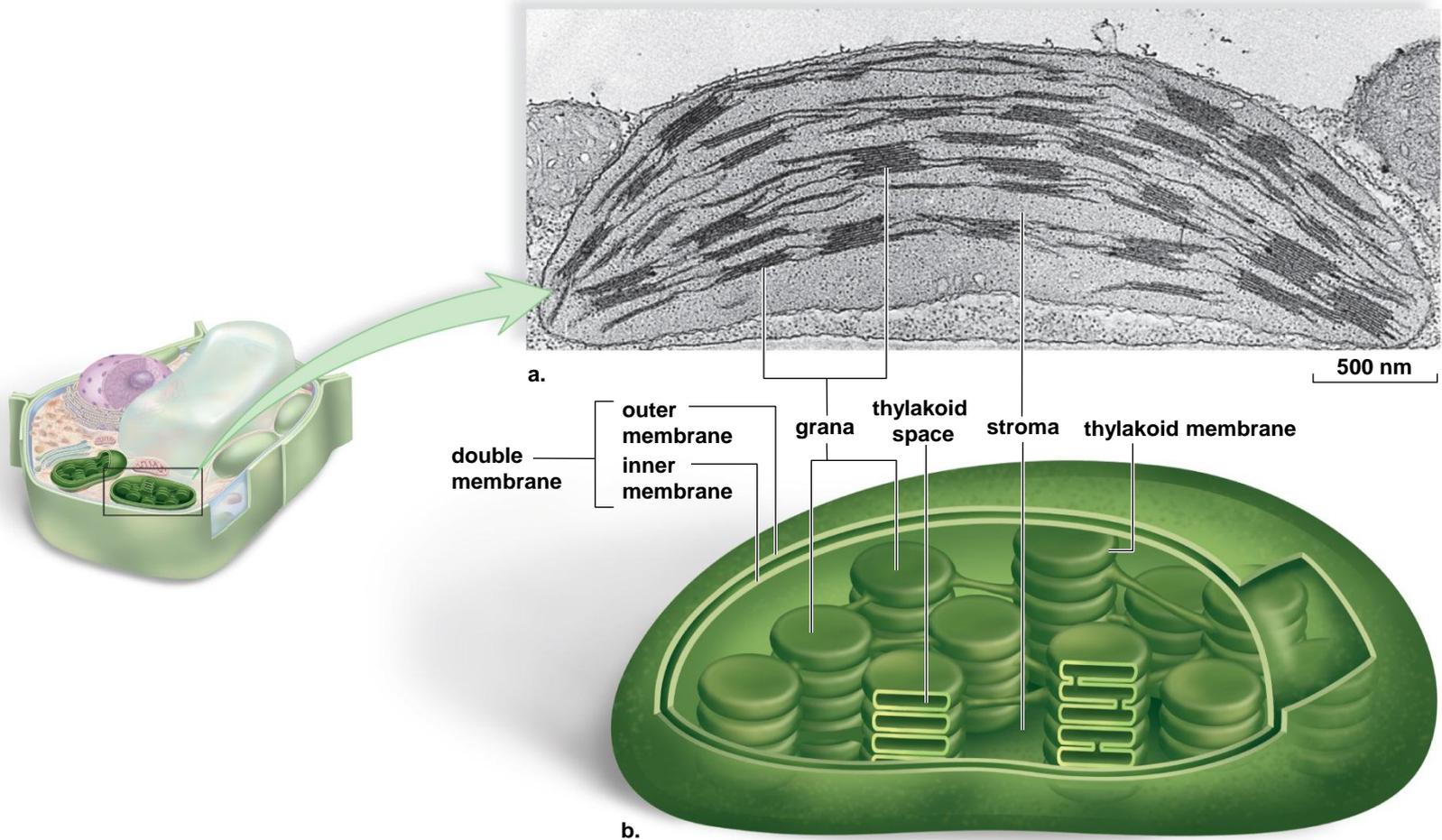
 - Only plants, algae, and certain bacteria are capable of conducting photosynthesis

Energy-Related Organelles: Chloroplasts

- Bound by a double membrane organized into flattened disc-like sacs called **thylakoids**
- Chlorophyll and other pigments capture solar energy
- Enzymes synthesize carbohydrates

Chloroplast Structure

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

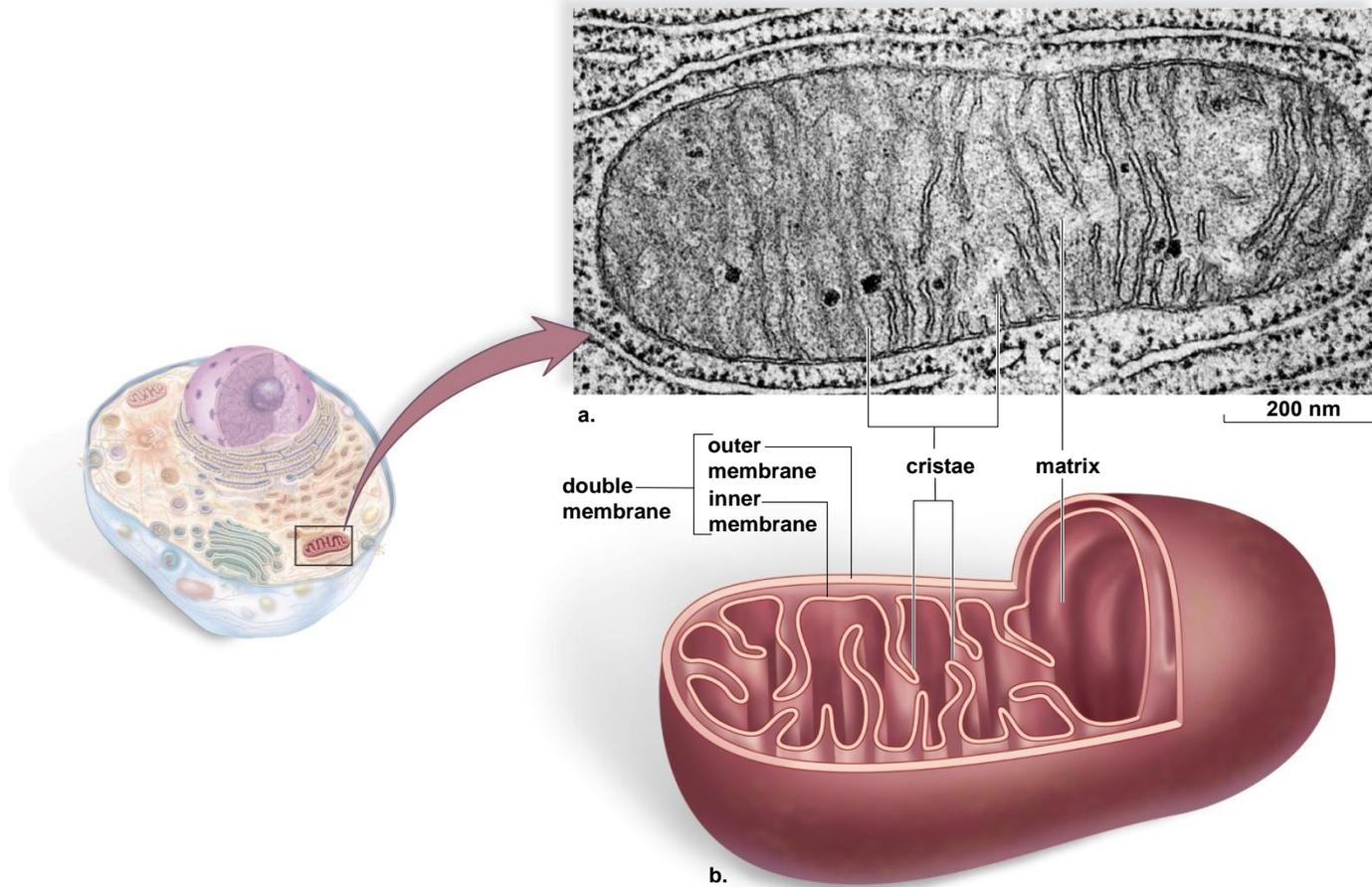


a: Courtesy Herbert W. Israel, Cornell University

- Smaller than chloroplast
- Contain ribosomes and their own DNA
- Surrounded by a double membrane
 - Inner membrane surrounds the **matrix** and is convoluted (folds) to form **cristae**.
 - Matrix – Inner semifluid containing respiratory enzymes
 - Break down carbohydrates
- Involved in cellular respiration
- Produce most of ATP utilized by the cell

Mitochondrial Structure

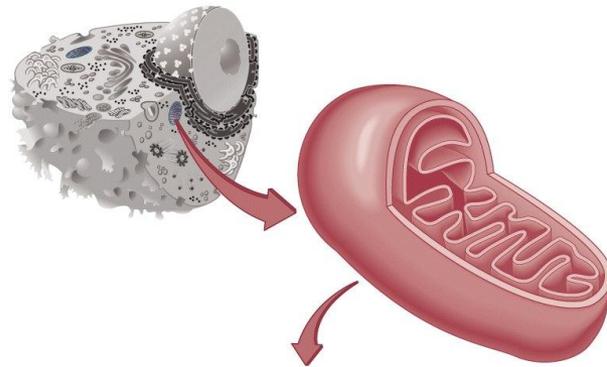
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



a: Courtesy Dr. Keith Porter

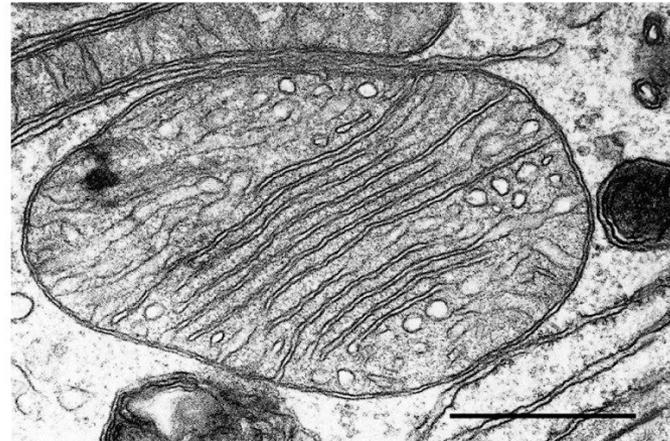
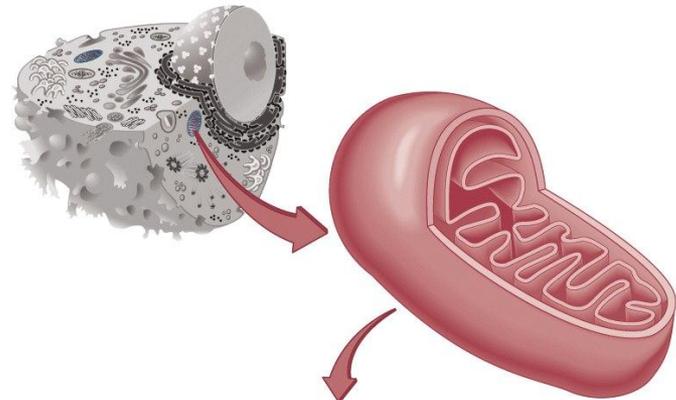
Mitochondria

- Have their own DNA
- Bound by double membrane



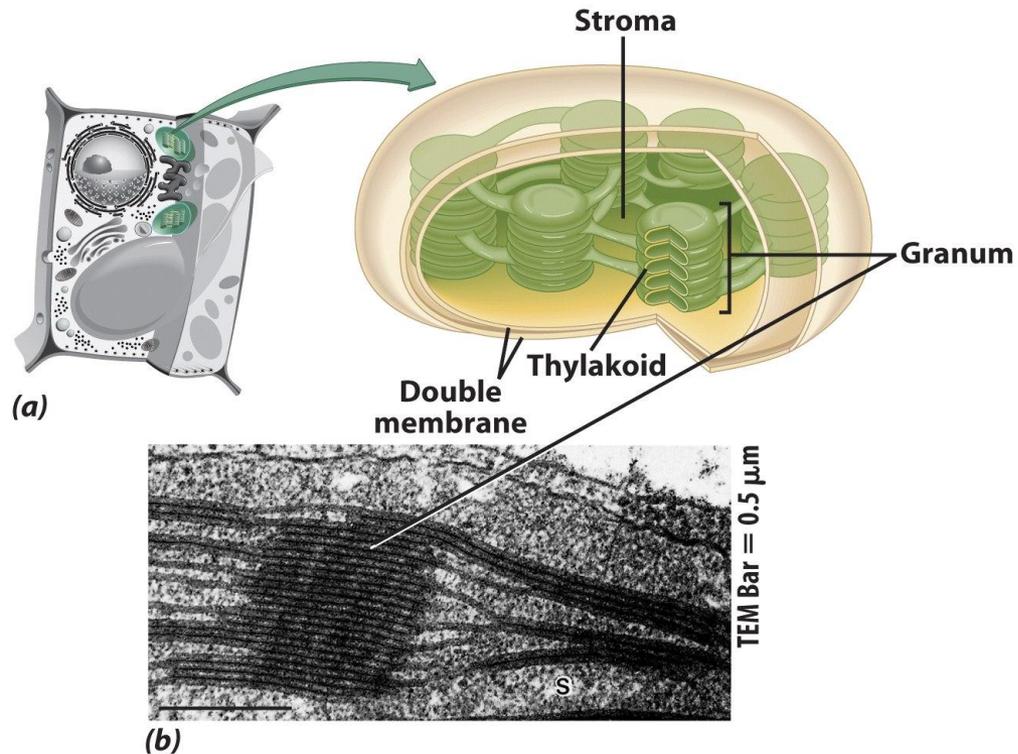
Mitochondria

- Break down fuel molecules (cellular respiration)
 - Glucose
 - Fatty acids
- Release energy
 - ATP



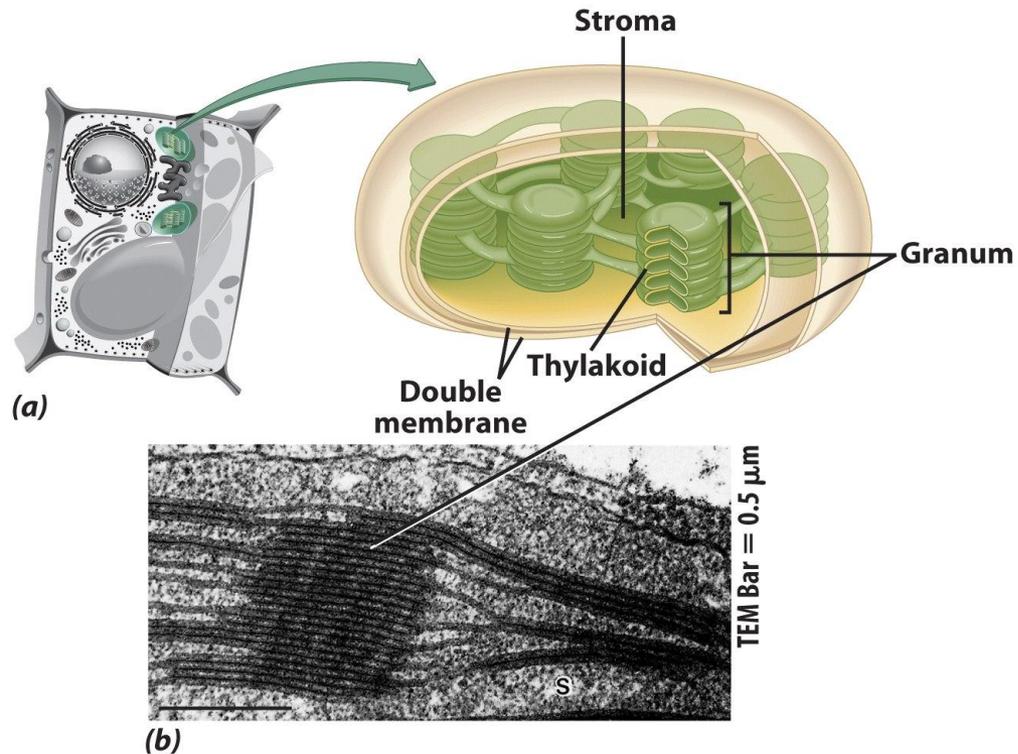
Chloroplasts

- Derived from photosynthetic bacteria
- Solar energy capturing organelle



Photosynthesis

- Takes place in the chloroplast
- Makes cellular food – glucose



Review of Eukaryotic Cells

TABLE 5.1

Eukaryotic Cell Structures and Their Functions

Structure	Description	Function
Exterior Structures		
Cell wall	Outer layer of cellulose or chitin, or absent	Protection, support
Plasma membrane	Lipid bilayer in which proteins are embedded	Regulation of what passes in and out of cell, cell-to-cell recognition
Flagella (cilia)	Cellular extensions with 9 + 2 arrangement of pairs of microtubules	Motility or moving fluids over surfaces

Review of Eukaryotic Cells

TABLE 5.1

Eukaryotic Cell Structures and Their Functions

Structure	Description	Function
Interior Structures and Organelles		
Endoplasmic reticulum (ER)	Network of internal membranes	Formation of compartments and vesicles; modification and transport of proteins; synthesis of carbohydrates and lipids
Ribosomes	Small, complex assemblies of protein and RNA, often bound to ER	Sites of protein synthesis
Nucleus	Spherical structure bounded by a double membrane, site of chromosomes	Control center of cell
Chromosomes	Long threads of DNA associated with protein	Sites of hereditary information
Nucleolus	Site within nucleus of rRNA synthesis	Synthesis and assembly of ribosomes
Golgi apparatus	Stacks of flattened vesicles	Packaging of proteins for export from cell
Lysosomes	Membranous sacs containing digestive enzymes found in animal cells	Digestion of various molecules
Cytoskeleton	Network of protein filaments, fibers, and tubules	Structural support, cell movement
Mitochondria	Bacteria like elements with inner membrane highly folded	“Power plant” of the cell
Chloroplasts	Bacterial like elements with inner membrane forming sacs containing chlorophyll, found in plant cells and algae	Site of photosynthesis

TABLE 5.2**A Comparison of Bacterial, Animal, and Plant Cells**

	Bacterium	Animal	Plant
Exterior Structures			
Cell wall	Present (protein polysaccharide)	<i>Absent</i>	Present (cellulose)
Plasma membrane	Present	Present	Present
Flagella (cilia)	Sometimes present	Sometimes present	Sperm of a few species possess flagella
Interior Structures and Organelles			
Endoplasmic reticulum	<i>Absent</i>	Usually present	Usually present
Microtubules	<i>Absent</i>	Present	Present
Centrioles	<i>Absent</i>	Present	<i>Absent</i>
Golgi apparatus	<i>Absent</i>	Present	Present
Nucleus	<i>Absent</i>	Present	Present
Mitochondria	<i>Absent</i>	Present	Present
Chloroplasts	<i>Absent</i>	<i>Absent</i>	Present
Chromosomes	A single circle of naked DNA	Multiple units, DNA associated with protein	Multiple units, DNA associated with protein
Ribosomes	Present	Present	Present
Lysosomes	<i>Absent</i>	Present	Present
Vacuoles	<i>Absent</i>	<i>Absent</i> or small	Usually a large single vacuole in mature cell

Molecule Movement & Cells

- Passive Transport
- Active Transport
- Endocytosis
(phagocytosis & pinocytosis)
- Exocytosis

Passive Transport

- No energy required
- Move due to gradient
 - differences in concentration, pressure, charge
- Move to equalize gradient
 - High moves toward low

Types of Passive Transport

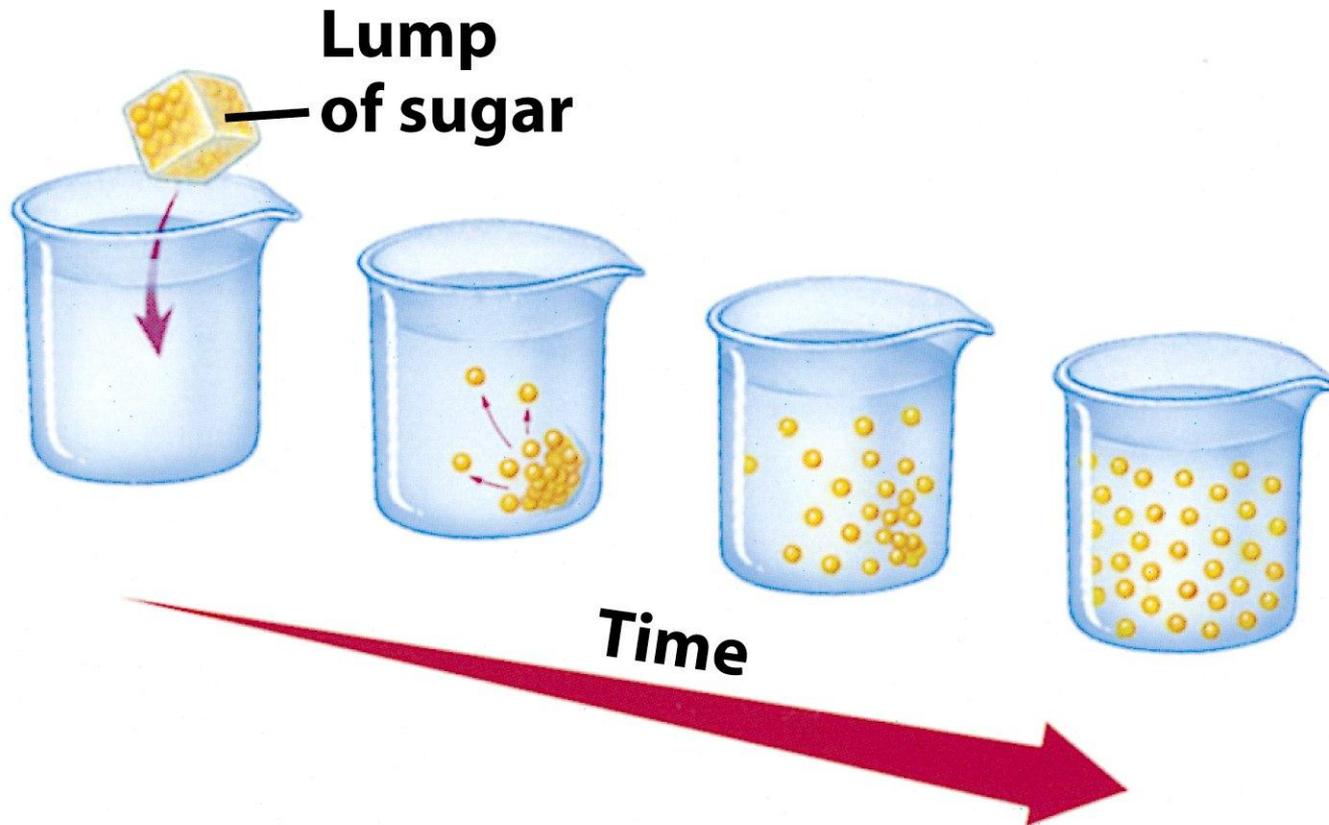
1. Diffusion

2. Osmosis

3. Facilitated diffusion

Diffusion

- Molecules move to equalize concentration

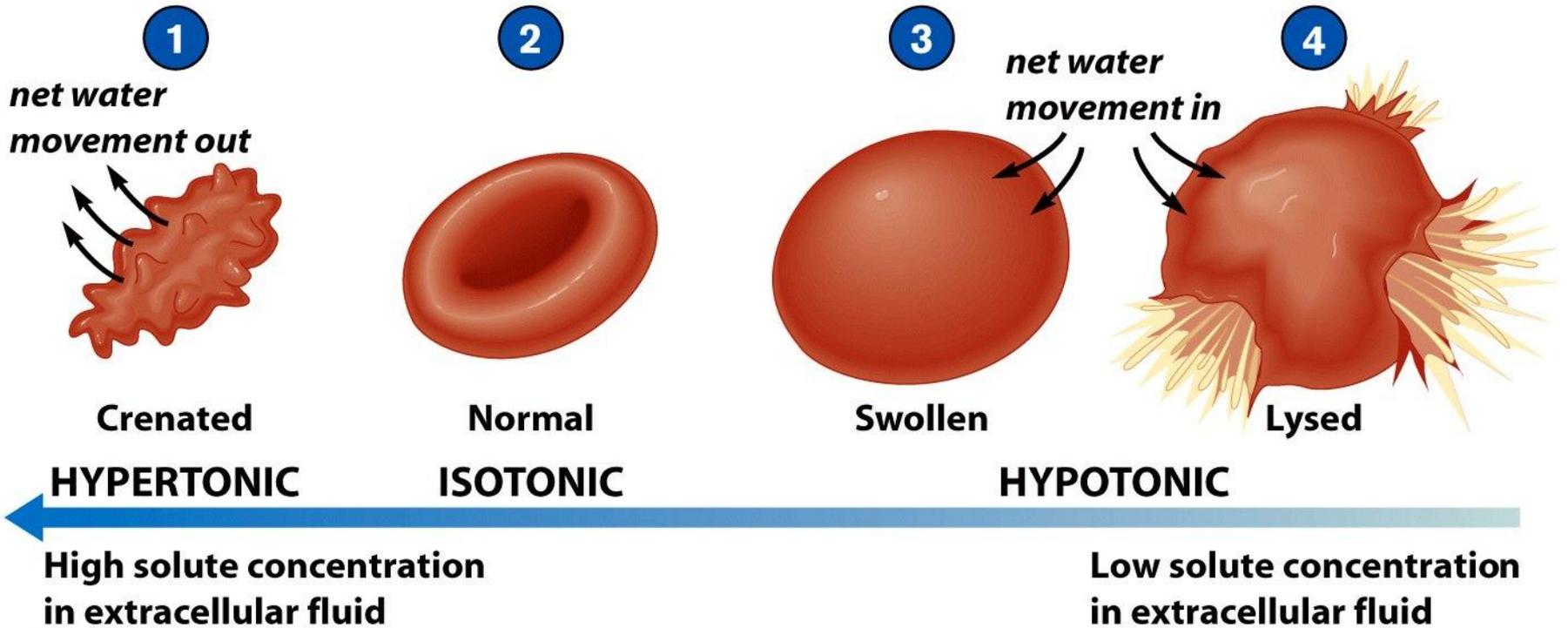


Osmosis

- Special form of diffusion
- Fluid flows from lower solute concentration
- Often involves movement of water
 - Into cell
 - Out of cell

Solution Differences & Cells

- solvent + solute = solution
- Hypotonic
 - Solutes in cell more than outside
 - Outside solvent will flow into cell
- Isotonic
 - Solutes equal inside & out of cell
- Hypertonic
 - Solutes greater outside cell
 - Fluid will flow out of cell

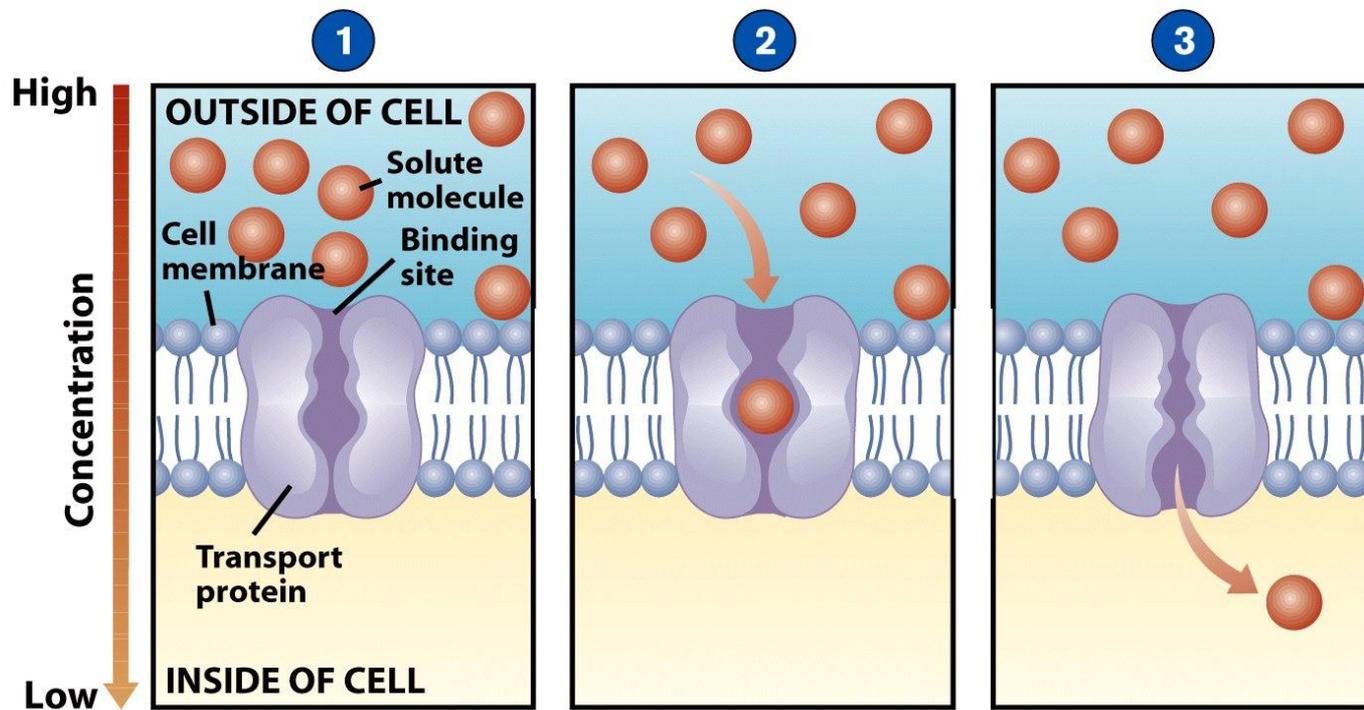


Facilitated Diffusion

- Differentially permeable membrane
- Channels (are specific) help molecule or ions enter or leave the cell
- Channels usually are transport proteins (aquaporins facilitate the movement of water)
- No energy is used

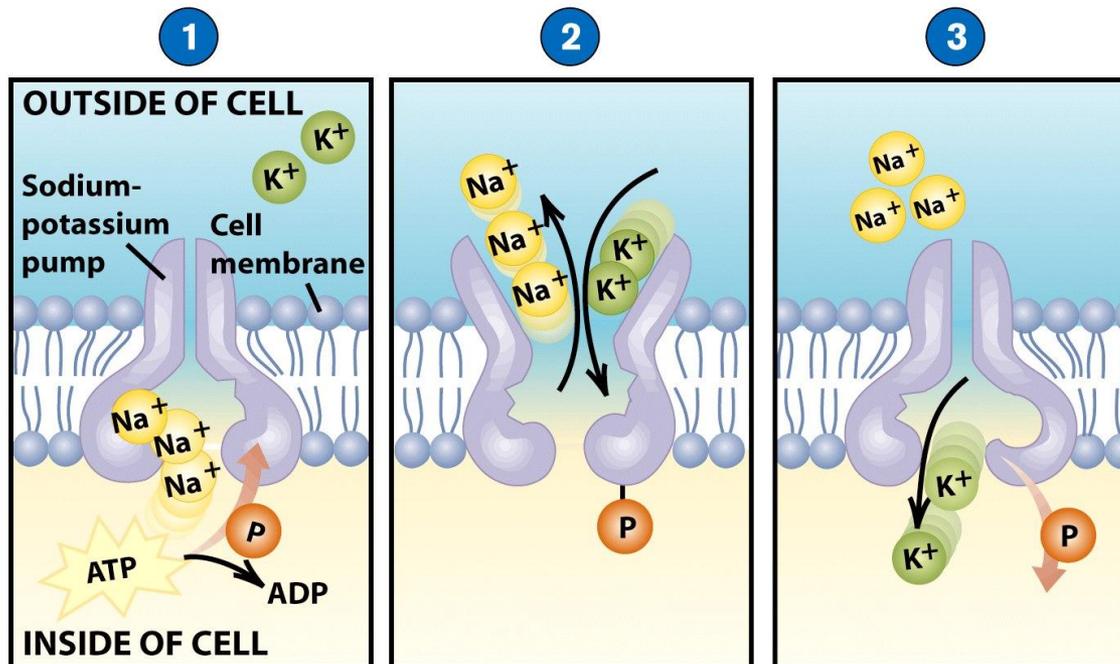
Process of Facilitated Transport

- Protein binds with molecule
- Shape of protein changes
- Molecule moves across membrane



Active Transport

- Molecular movement
- Requires energy (against gradient)
- Example is sodium-potassium pump

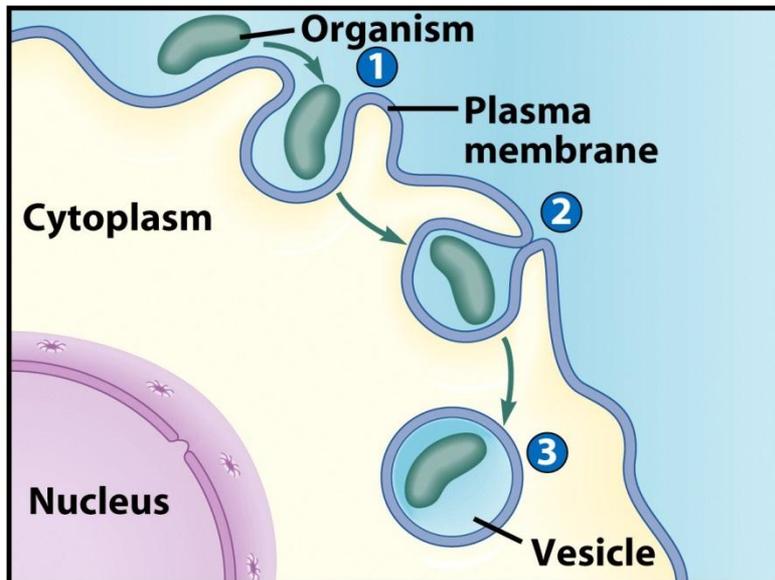


Endocytosis

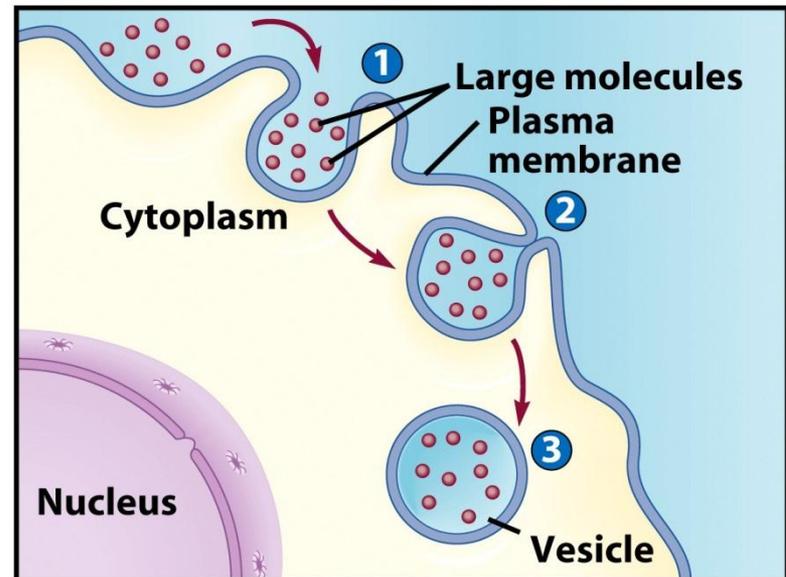
- Movement of large material
 - Particles
 - Organisms
 - Large molecules
- Movement is into cells
- Types of endocytosis
 - bulk-phase (nonspecific)
 - receptor-mediated (specific)

Process of Endocytosis

- Plasma membrane surrounds material
- Edges of membrane meet
- Membranes fuse to form vesicle



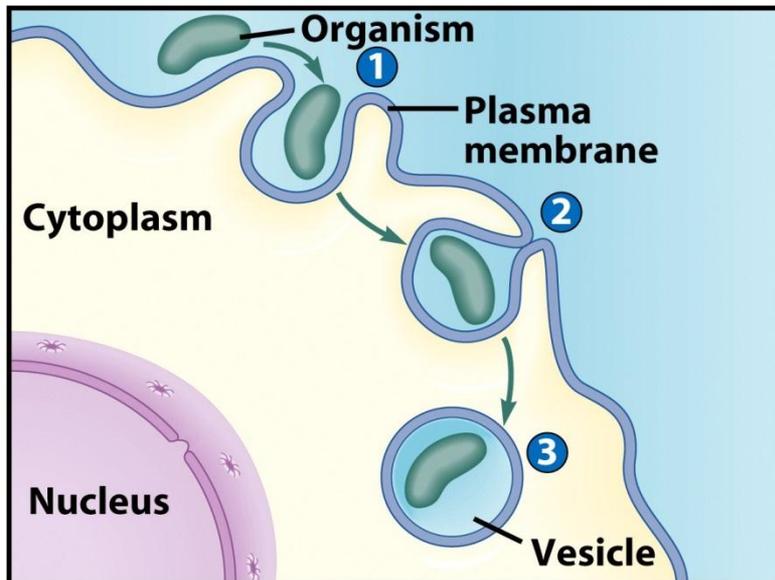
PHAGOCYTOSIS



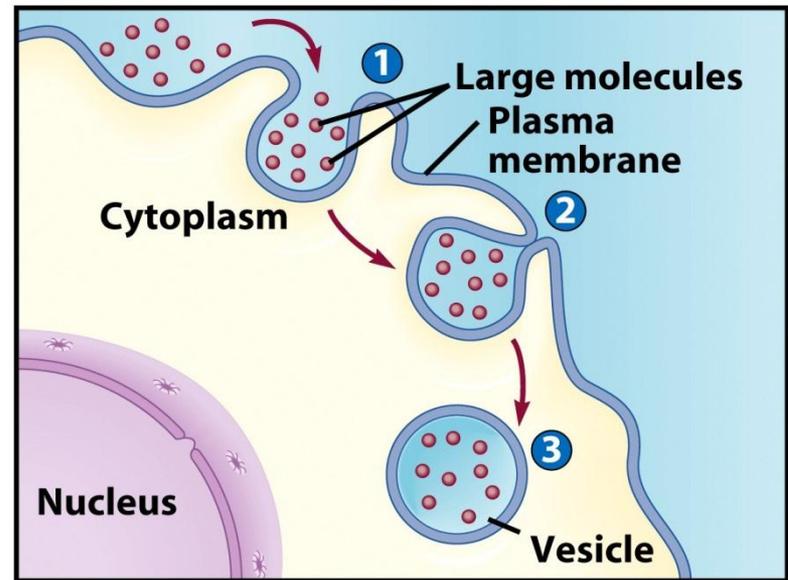
PINOCYTOSIS

Forms of Endocytosis

- Phagocytosis – cell eating
- Pinocytosis – cell drinking



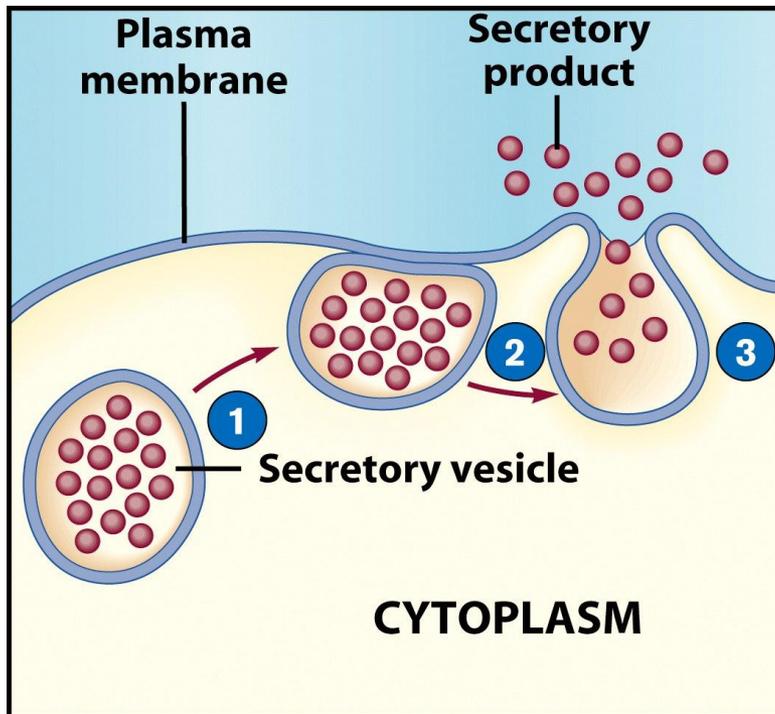
PHAGOCYTOSIS



PINOCYTOSIS

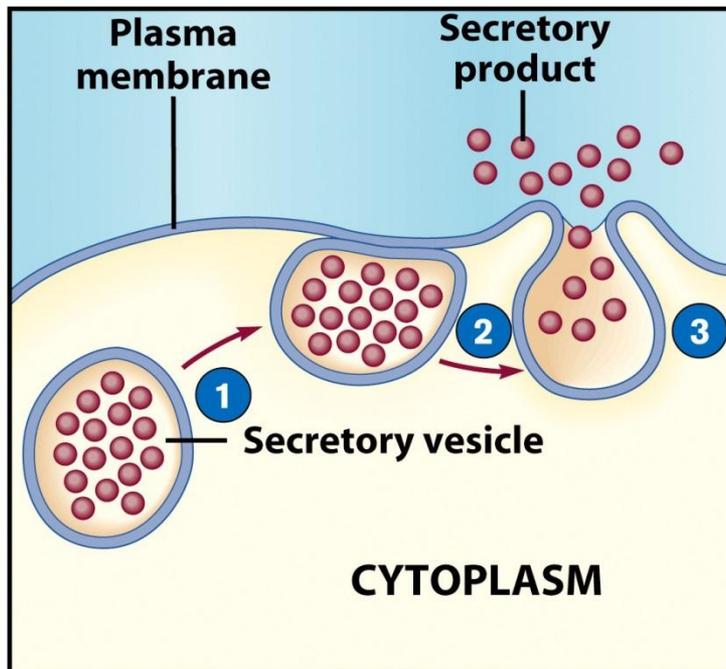
Exocytosis

- Reverse of endocytosis
- Cell discharges material



Exocytosis

- Vesicle moves to cell surface
- Membrane of vesicle fuses
- Materials expelled



The Cytoskeleton

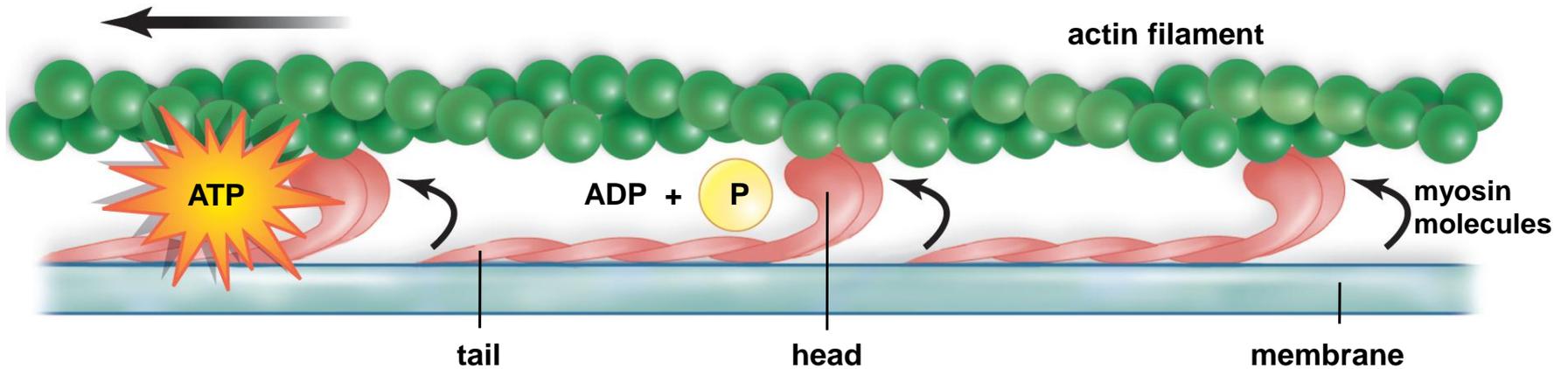
- Maintains cell shape
- Assists in movement of cell and organelles
- Three types of macromolecular fibers
 - Actin Filaments
 - Intermediate Filaments
 - Microtubules
- Assemble and disassemble as needed

The Cytoskeleton: Actin Filaments

- Extremely thin filaments like twisted pearl necklace
- Dense web just under plasma membrane maintains cell shape
- Support for microvilli in intestinal cells
- Intracellular traffic control
 - For moving stuff around within cell
 - Cytoplasmic streaming
- Function in pseudopods of amoeboid cells
- Pinch mother cell in two after animal mitosis
- Important component in muscle contraction (other is myosin)

The Cytoskeleton: Actin Filament Operation

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



The Cytoskeleton: Intermediate Filaments

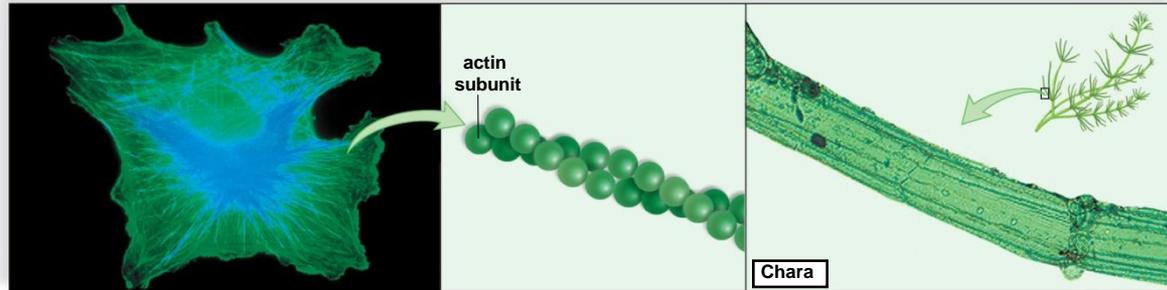
- Intermediate in size between actin filaments and microtubules
- Rope-like assembly of fibrous polypeptides
- Vary in nature
 - From tissue to tissue
 - From time to time
- Functions:
 - Support nuclear envelope
 - Cell-cell junctions, like those holding skin cells tightly together

The Cytoskeleton: Microtubules

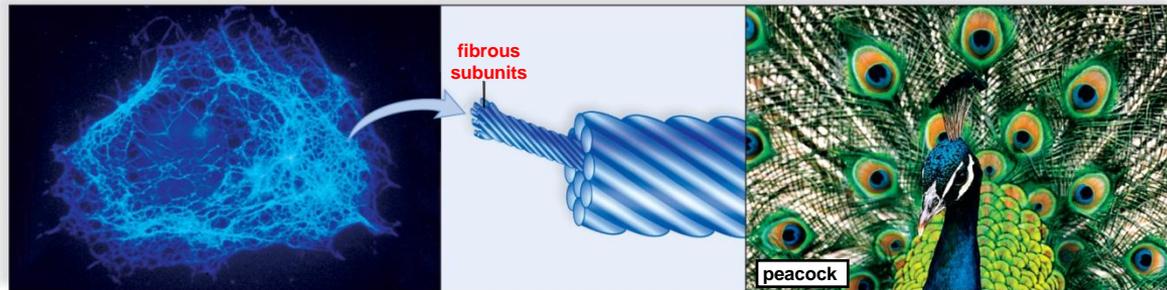
- Hollow cylinders made of two globular proteins called α and β tubulin
- Spontaneous pairing of α and β tubulin molecules form structures called dimers
- Dimers then arrange themselves into tubular spirals of 13 dimers around
- Assembly:
 - Under control of Microtubule Organizing Center (MTOC)
 - Most important MTOC is centrosome
- Interacts with proteins kinesin and dynein to cause movement of organelles

The Cytoskeleton

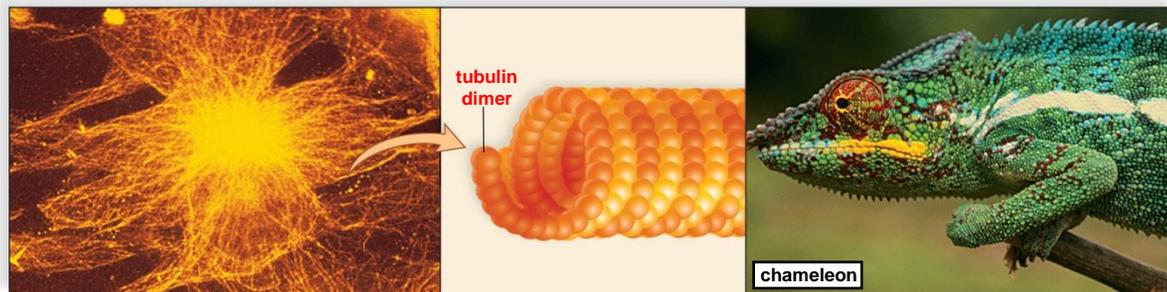
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



a. Actin filaments



b. Intermediate filaments



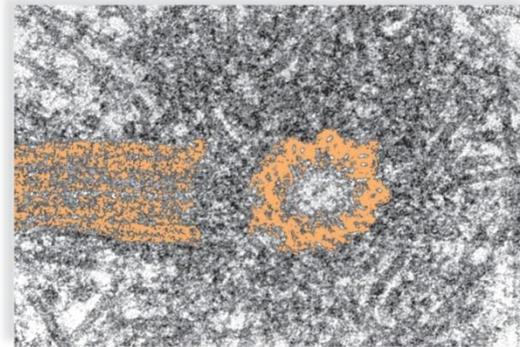
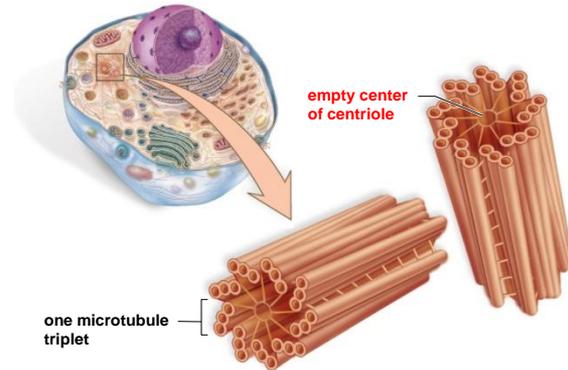
c. Microtubules

Microtubular Arrays: Centrioles

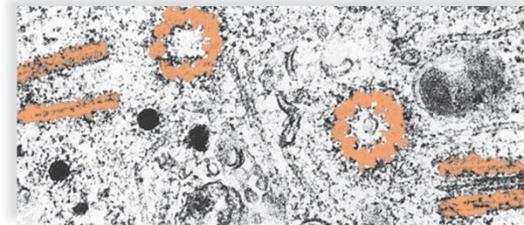
- Short, hollow cylinders
 - Composed of 27 microtubules
 - Microtubules arranged into 9 overlapping triplets
- One pair per animal cell
 - Located in centrosome of animal cells
 - Oriented at right angles to each other
 - Separate during mitosis to determine plane of division
- May give rise to basal bodies of cilia and flagella

Cytoskeleton: Centrioles

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



one centrosome: one pair of centrioles



two centrosomes: two pairs of centrioles

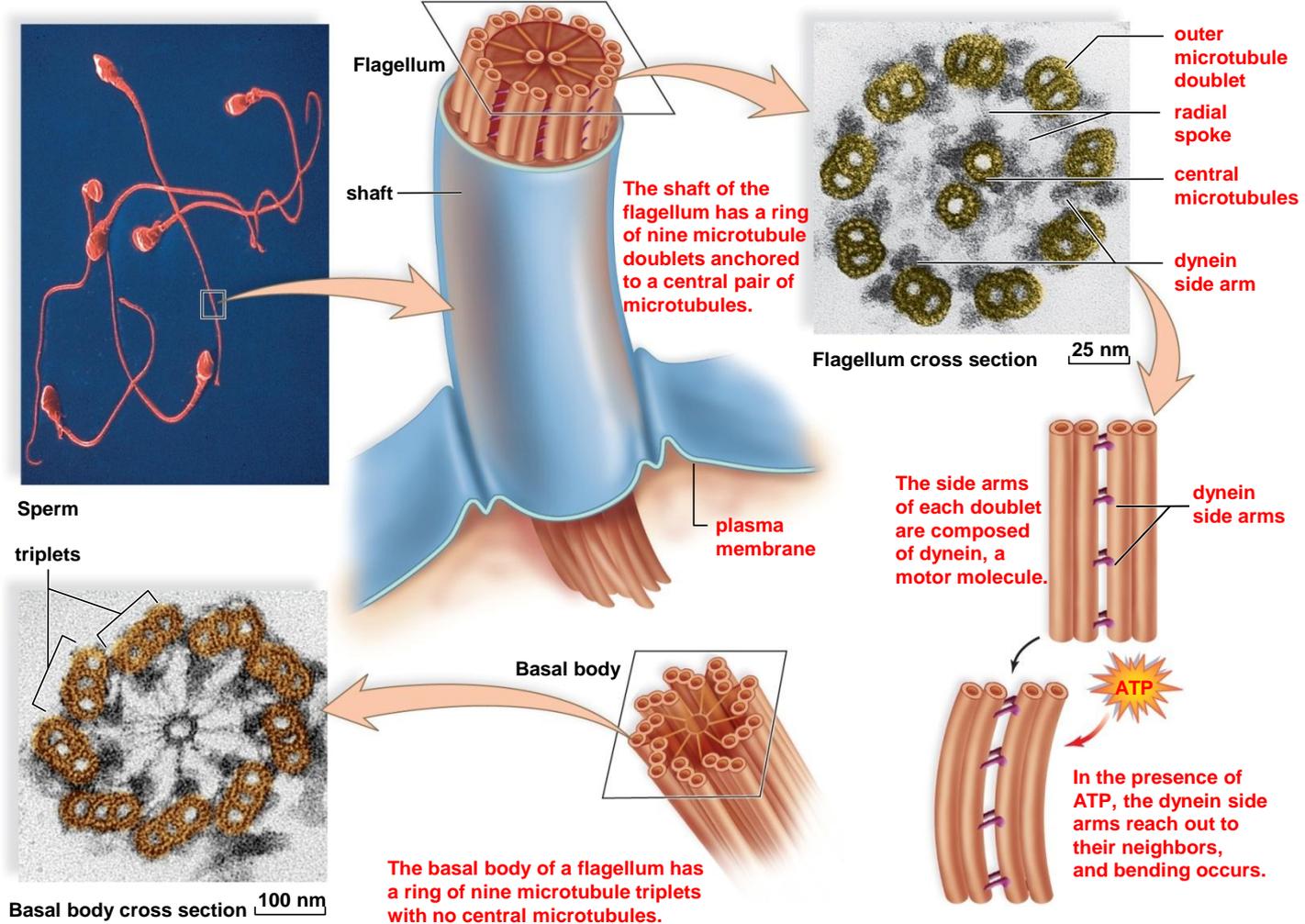
200 nm

Microtubular Arrays: Cilia and Flagella

- Hair-like projections from cell surface that aid in cell movement
- Very different from prokaryote flagella
 - Outer covering of plasma membrane
 - Inside this is a cylinder of 18 microtubules arranged in 9 pairs
 - In center are two single microtubules
 - This 9 + 2 pattern used by all cilia & flagella
- In eukaryotes, cilia are much shorter than flagella
 - Cilia move in coordinated waves like oars
 - Flagella move like a propeller or cork screw

Structure of a Flagellum

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



Comparison of Prokaryotic and Eukaryotic Cells

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

TABLE 4.1

Comparison of Prokaryotic Cells and Eukaryotic Cells

	<i>Prokaryotic Cells (1–20 μm in diameter)</i>	<i>Eukaryotic Cells (10–100 μm in diameter)</i>	
		<i>Animal</i>	<i>Plant</i>
Cell wall	Usually (peptidoglycan)	No	Yes (cellulose)
Plasma membrane	Yes	Yes	Yes
Nucleus	No	Yes	Yes
Nucleolus	No	Yes	Yes
Ribosomes	Yes (smaller)	Yes	Yes
Endoplasmic reticulum	No	Yes	Yes
Golgi apparatus	No	Yes	Yes
Lysosomes	No	Yes	No
Mitochondria	No	Yes	Yes
Chloroplasts	No	No	Yes
Peroxisomes	No	Usually	Usually
Cytoskeleton	No	Yes	Yes
Centrioles	No	Yes	No
9 + 2 cilia or flagella	No	Often	No (in flowering plants) Yes (sperm of bryophytes, ferns, and cycads)

Review

- Cellular Level of Organization
 - Cell theory
 - Cell size
- Prokaryotic Cells
- Eukaryotic Cells
 - Organelles
- Nucleus and Ribosome
- Endomembrane System
- Other Vesicles and Vacuoles
- Energy related organelles
- Cytoskeleton
 - Centrioles, Cilia, and Flagella

