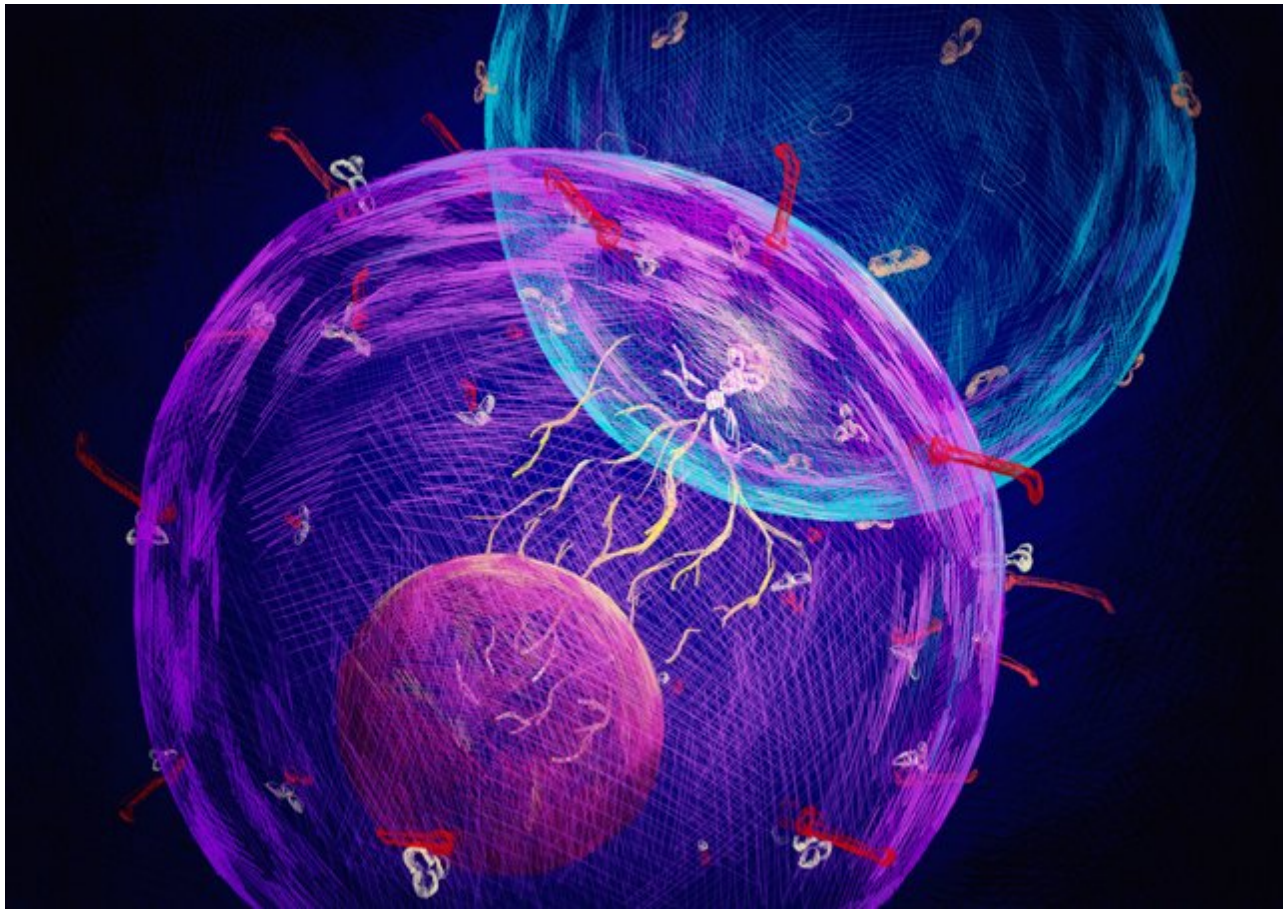
NEPHAR116: HISTOLOGY

The cell and its Organelles



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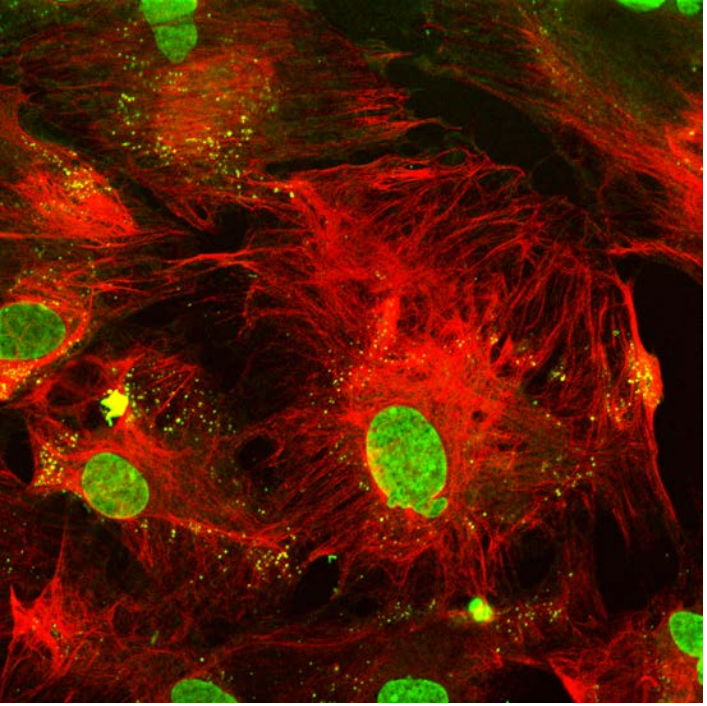
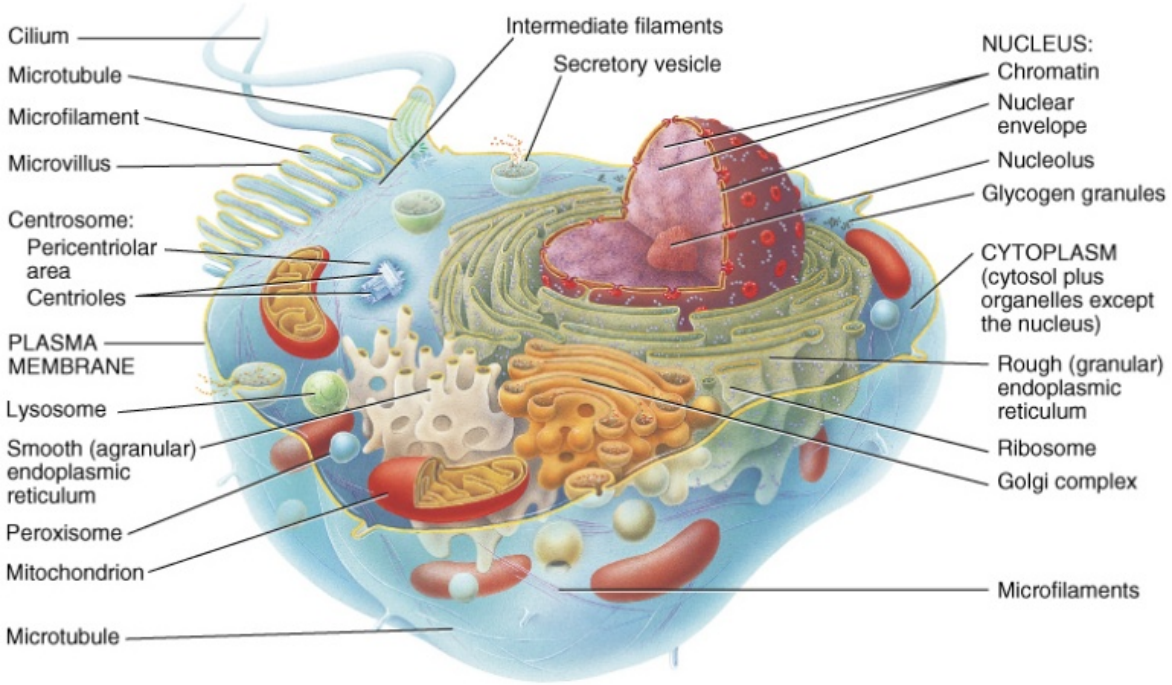


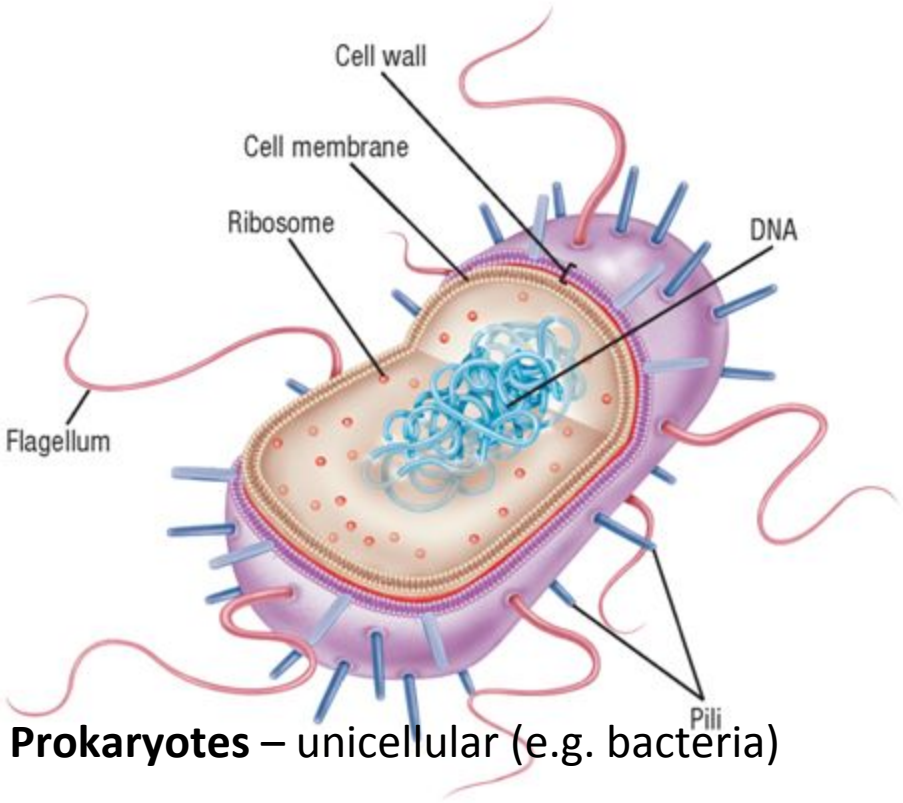
Balcı D, 2009

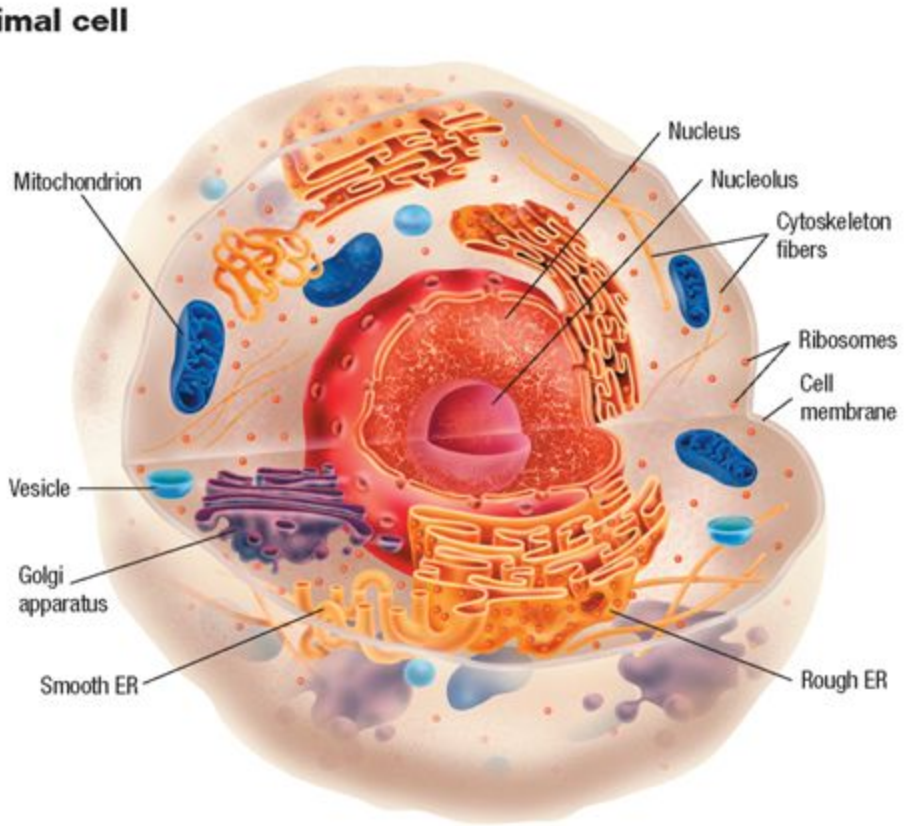
The CELL

Cells are the basic structural and functional units of all multicellular organisms.(with the possible exceptions of viruses and prions).



Prokaryotic and Eukaryotic cells





Prokaryotes – unicellular (e.g. bacteria)

Archaea (e.g. thermophiles)

Eukaryotes – can be unicellular or multicellular (e.g. fungi, animal, human, plants).

Prokaryotic and Eukaryotic Cell Structure

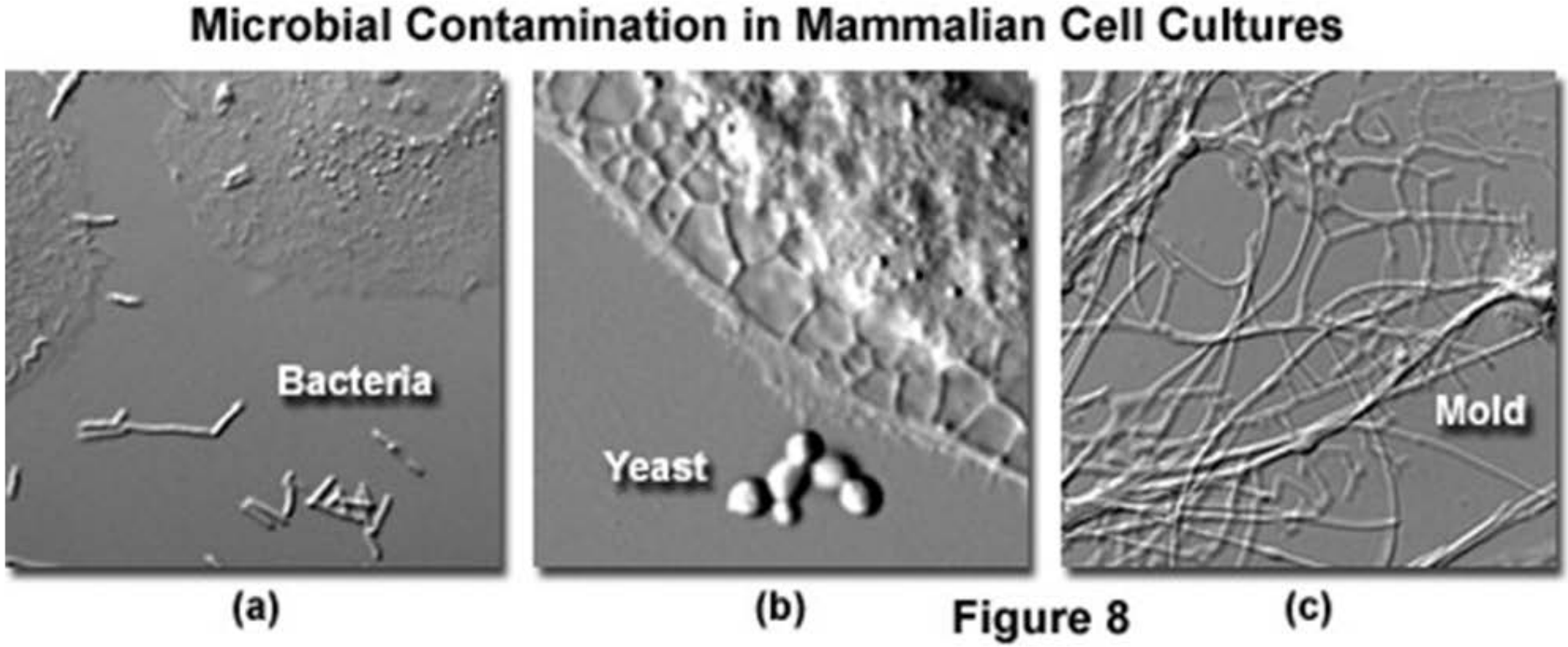


Figure 8

Differences In Cellular Organizations of Prokaryotes and Eukaryotes

	Prokaryotes	Eukaryotes
Microorganism	Mostly unicellular	Multicellular or unicellular
Nucleus	No	Yes
Membranous organelles	No	Yes (e.g. mitochondria, Golgi bodies)
DNA organisation	Circular and double stranded	Linear, enclosed in the nucleus
Size	1 µm	10 – 100 µm
Cytoskeleton	No but some of them have actin filaments	Yes (e.g. microtubules and actin filaments)
Metabolism	Anaerobic or aerobic	aerobic

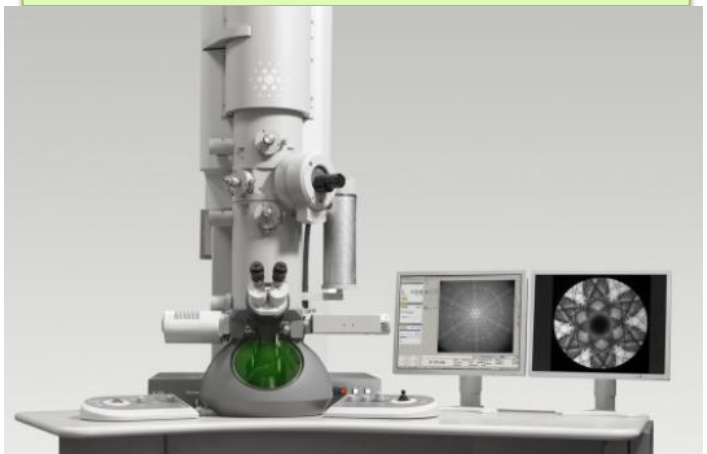
Note: In prokaryotes **ribosomes** are the only cytoplasmic organelles. They are smaller than eukaryotic ribosomes.

ORGANELLES

Light microscope a maximum of 2000x magnification

→ Walls, vacuoles, cytoplasm, chloroplasts, nucleus and cell membrane

Electron microscope up to 2 million times



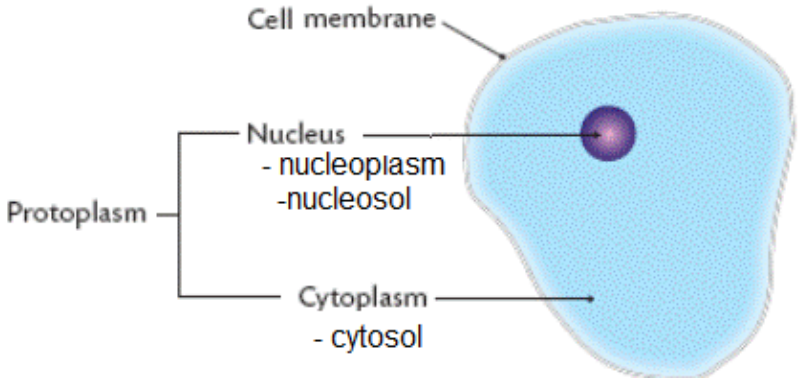
→ Ribosomes, endoplasmic reticulum, lysosomes, centrioles, golgi bodies

Components of a Cell:

The cell is a mass of **Protoplasm** separated from the external environment by a **Plasma Membrane**.

The Protoplasm is made up of two components:

1. **Cytoplasm:** that contains



- ➢ <u>numerous organelles:</u>
  - Mitochondria
  - Endoplasmic Reticulum
  - Golgi Apparatus
  - Ribosomes
  - Lysosomes
  - Peroxisomes
  - The cytoskeleton of the Cell: (a) Microfilaments
    (b) Intermediate filaments
    (c) Microtubules
  - Centrosome and centrioles
  - ➢ <u>Cytoplasmic Inclusions</u>

In cytoplasmic matrix

2. Nucleus: that houses the genome of the cell.

Organelles are described as membranous (membrane- limited) or nonmembranous

- perform the metabolic, synthetic, energy-requiring, and energy-generating functions of the cell

- All cells have the same basic set of intracellular organelles, which can be classified into two groups:

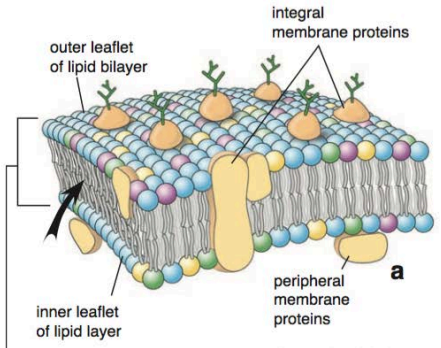
①membranous organelles

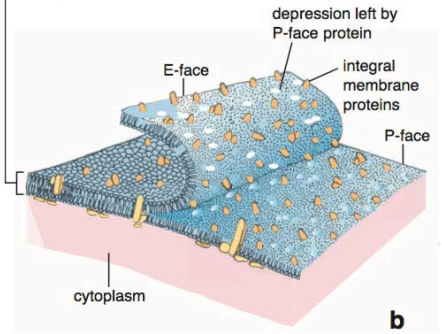
②nonmembranous organelles-

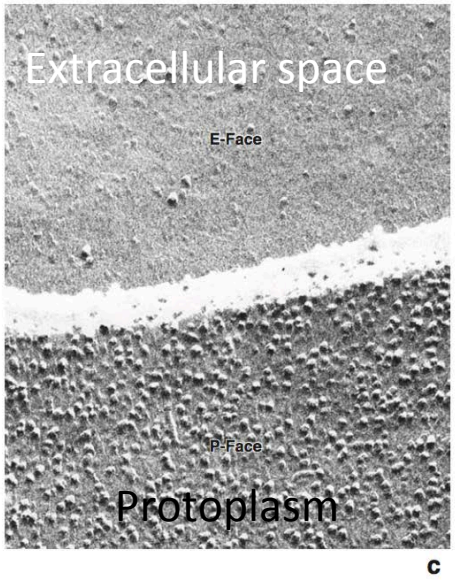
cytoskeleton, centrioles, ribosomes

Plasma Membrane (Plasmalemma)

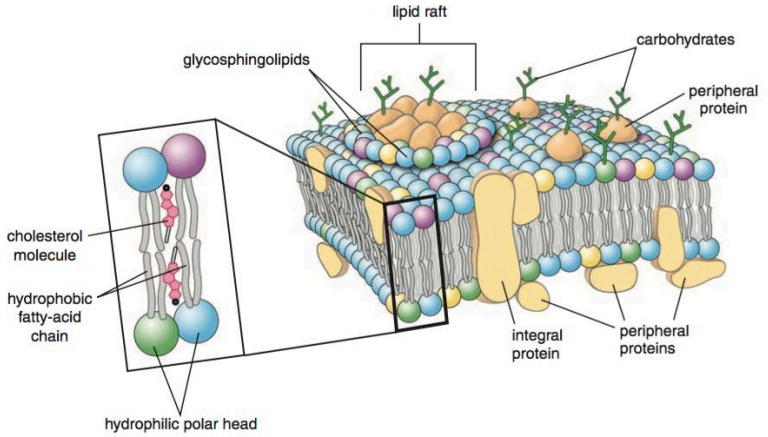
- Lipid bilayer (2 layers).
- 8 to 10 nm
- Primarily consists of phospholipid, cholesterol, and protein molecules.

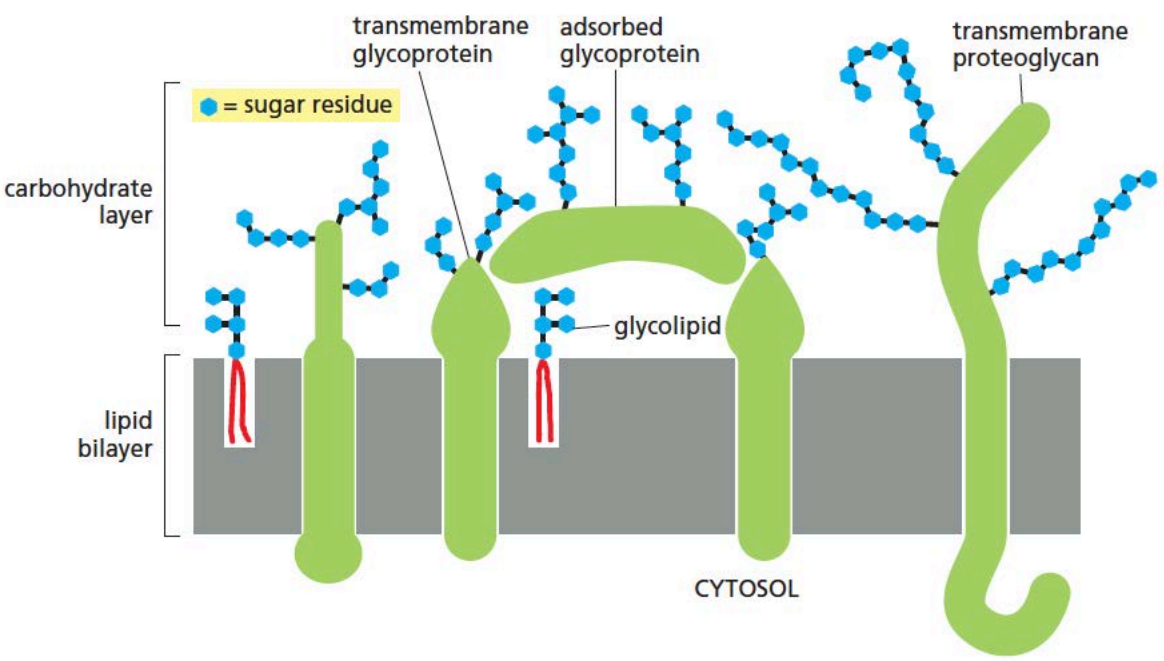


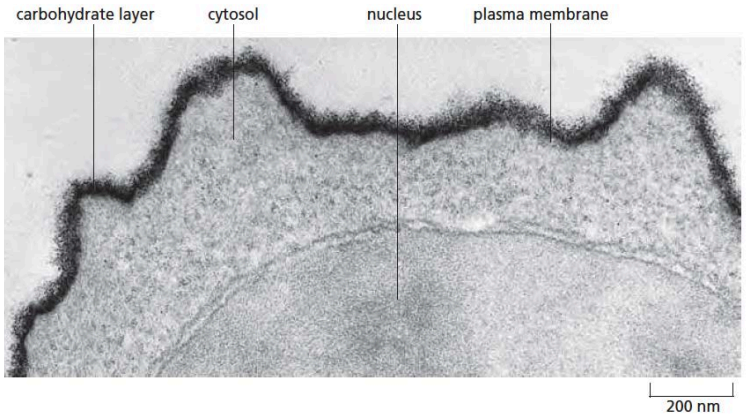




- Cell membranes are involved in a variety of cellular processes such as ion and nutrient transport, recognition of environment signal (receptor), adhesion.
- Cell injury often manifests as morphologic changes in the cell's plasma membrane **(Blebbing).**







Surface molecules constitute a layer at the surface of the cell called **cell coat or glycocalyx.**

Made inside the cell and secreted

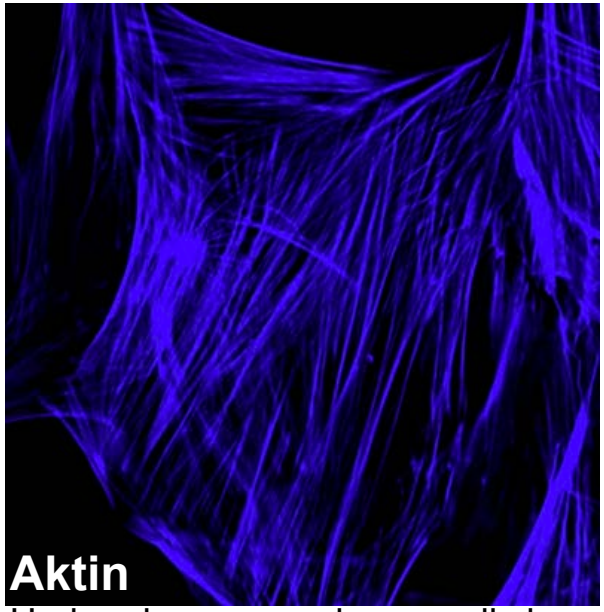
Functions

- Protection, Metabolism, Cell recognition, Cell association
- Serve as receptor sites for hormones
- Cell identity (organ transplantation)

Cytoskeleton

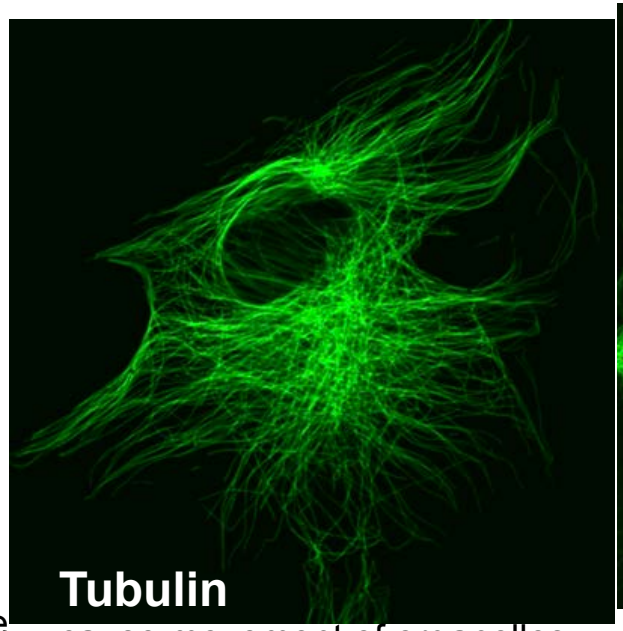
- Maintains cell shape
- Facilitates cell mobility
- Anchors the various organelles
- Phagocytosis
- Cytokinesis
- Cell-cell and cell–ECM adherence

Microfilaments 7nm



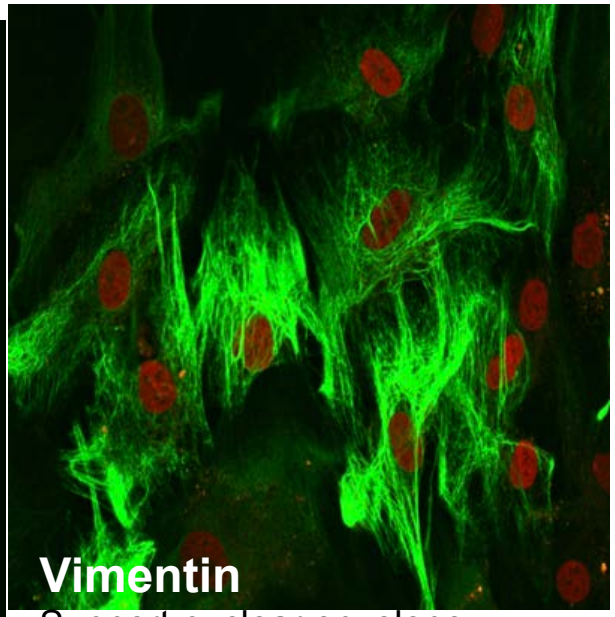
Under plasma membrane cell shape,
Support for microvilli in intestinal cell

Microtubules 25 nm



cause movement of organelles

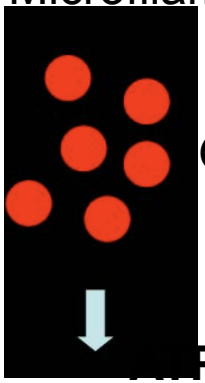
Intermediate filaments 10 nm



Support nuclear envelope ,
holding skin cells tightly together

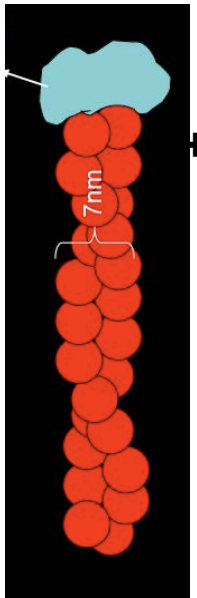
Assembly of Cytoskeleton

Microfilament



G-actin, globular

ATP-dependent



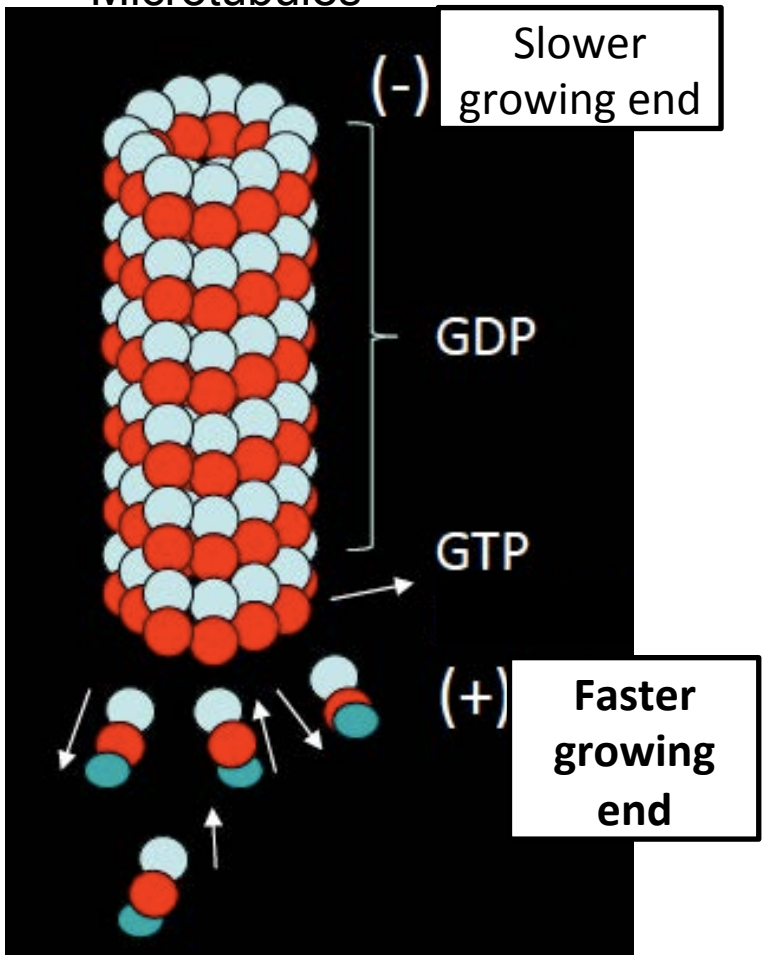
Gelsolin(capping)

+ Barbed end Polymerization

F- actin; filamentous

- Pointed end Depolymerization

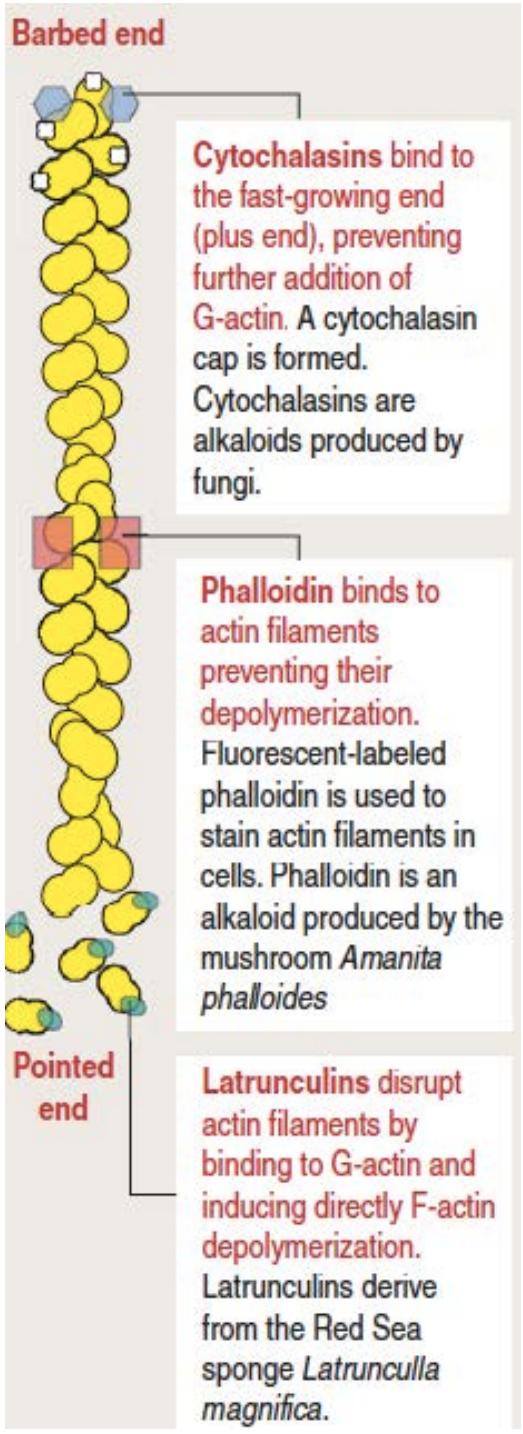
Microtubules

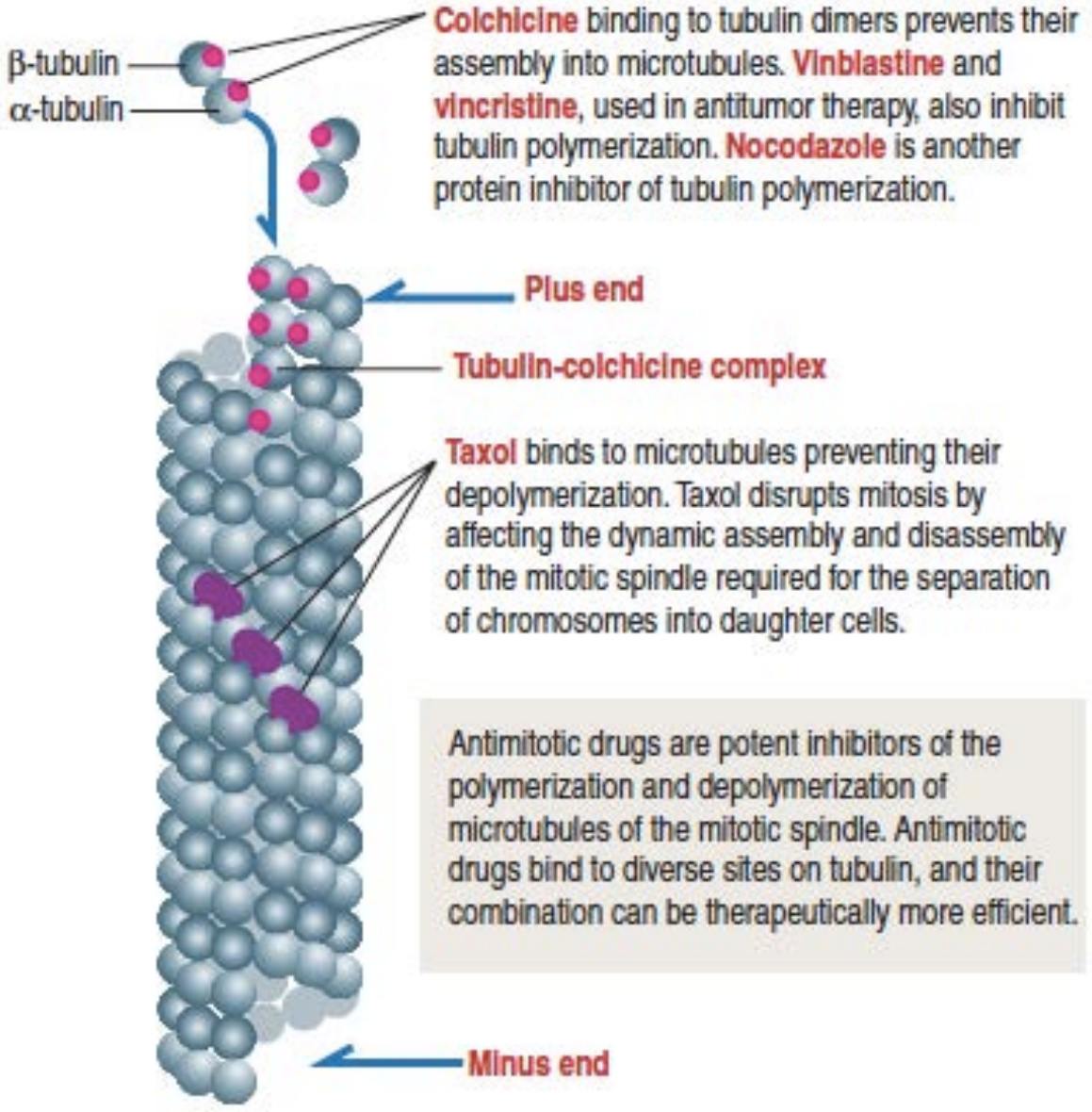


Cytoskeletal Drugs

Drug Name	Target cytoskeletal component	Effect	Clinical applications
Colchicine[2]	microtubules	prevents polymerization	Used to treat gout
Cytochalasins[3]	actin	prevents polymerization	none
Demecolcine[4]	microtubules	depolymerizes	chemotherapy
Latrunculin[5]	actin	prevent polymerization, enhance depolymerisation	none
Jasplakinolide[6][7]	actin	enhances polymerization	none
Nocodazole[8]	microtubules	prevents polymerization	none
Paclitaxel (taxol)[9]	microtubules	stabilizes microtubules and therefore prevents mitosis	chemotherarpy
Phalloidin[10]	actin	stabilizes filaments	none
Swinholide[11]	actin	sequesters actin dimers	none
Vinblastine[1]	microtubules	prevents polymerization	chemotherapy

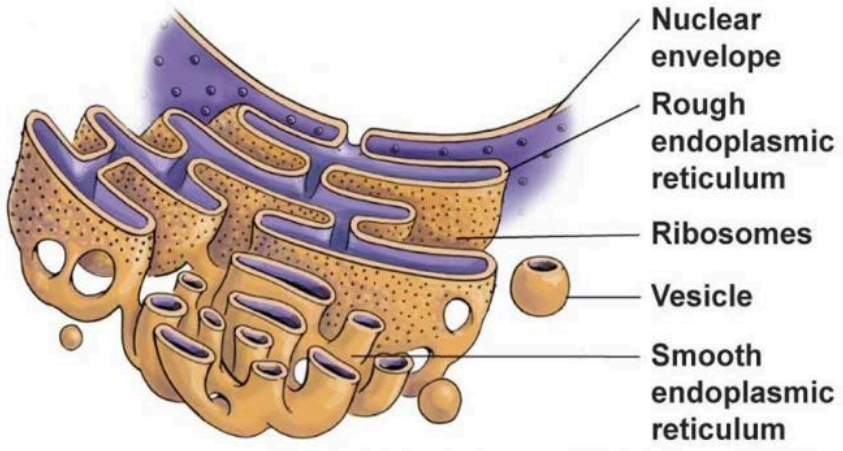
Agents that prevent cytoskeletal functions



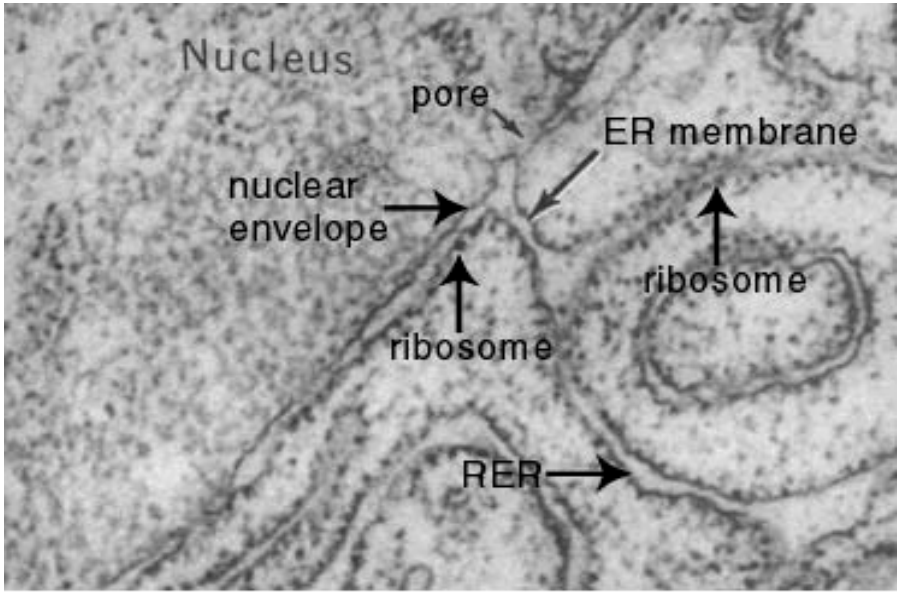


Endoplasmic Reticulum (ER)

- ✧ Both types of ER are continuous with one another.
- ✧ plays a role in **the transport of materials**



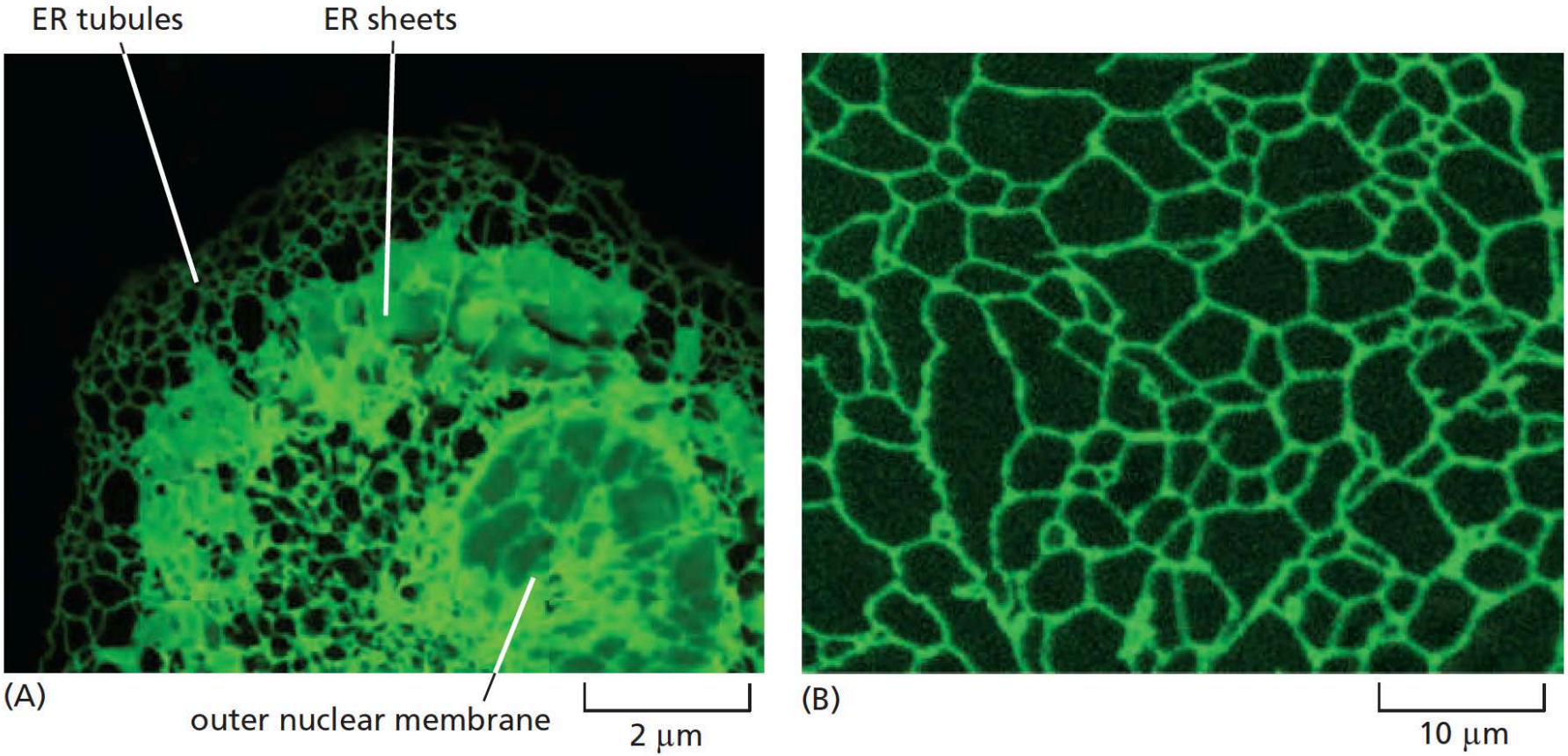
- ✧ **Rough ER-** has ribosomes
- Synthesizes and transports gene products **(exported proteins)**
- quality checkpoint in the process of protein production.



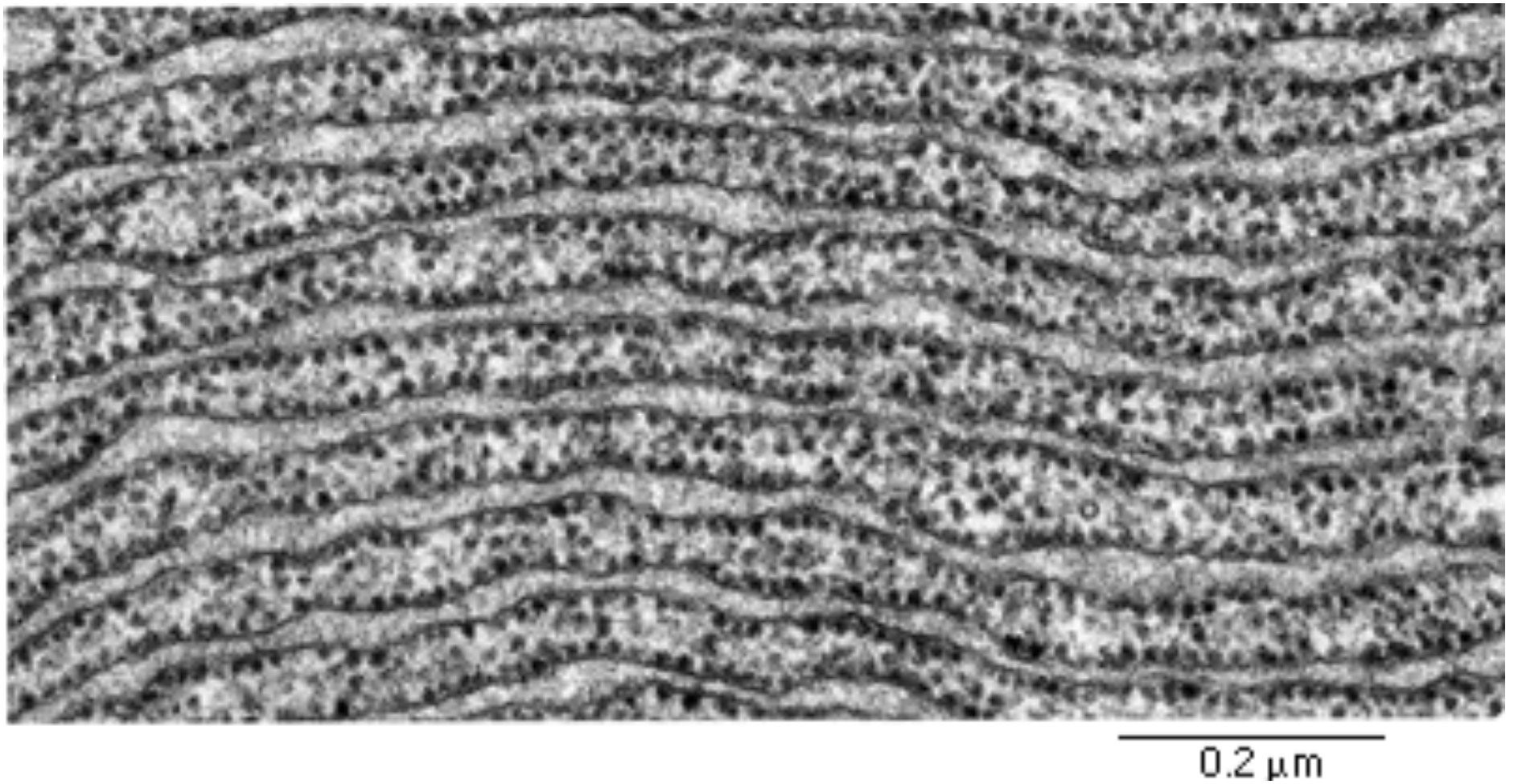
- ✧ **Smooth ER**
- synthesize **lipids** in the cell.
- store for **Ca^{+2}** (muscle)
- principal organelle involved in detoxification and conjugation of noxious substances. (liver)

•Fluorescence micrograph of a cultured mammalian cell stained with an antibody that binds to a protein retained in the ER.

•The ER extends as a network throughout the entire cytosol, so that all regions of the cytosol are close to some portion of the ER membrane.

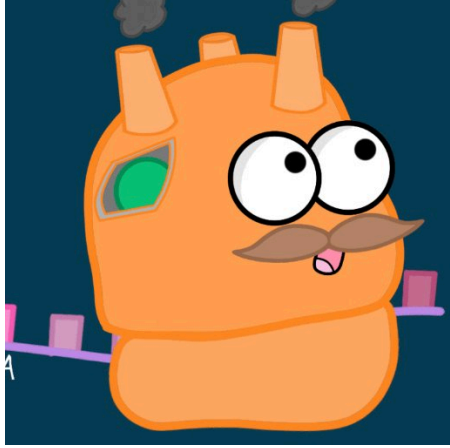


Membrane-bound Ribosomes Define the Rough ER

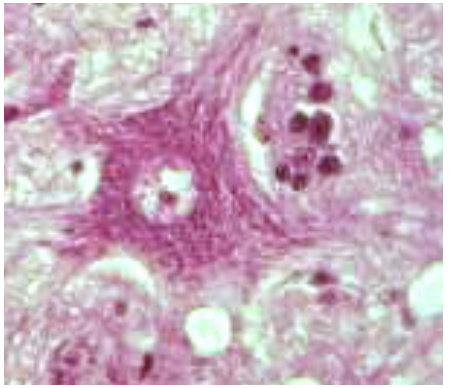


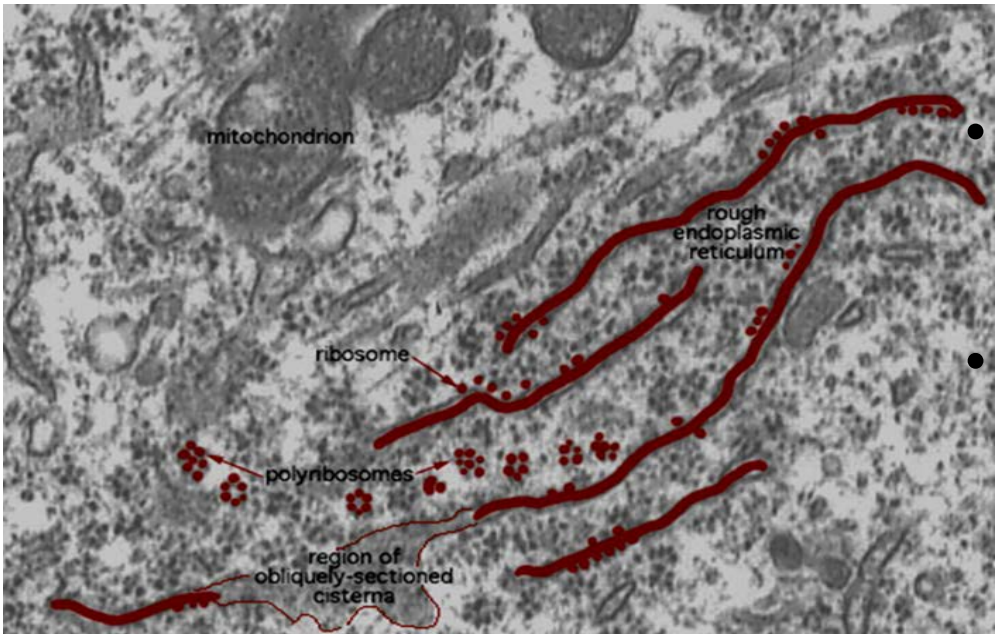
The rER is most highly developed in **active secretory cells**. Secretory cells include glandular cells, activated **fibroblasts**, **plasma cells**, odontoblasts, ameloblasts, and osteoblasts.

Ribosomes



- Ribosomes are cytoplasmic granules that help in the **synthesis of proteins**
- Some ribosomes are **free** within cytoplasm **(polyribosome, polysome) (neurons)- remain in the cell**
- most are **bounded to ER**-specialised for **secretion, lysosomal enzymes**

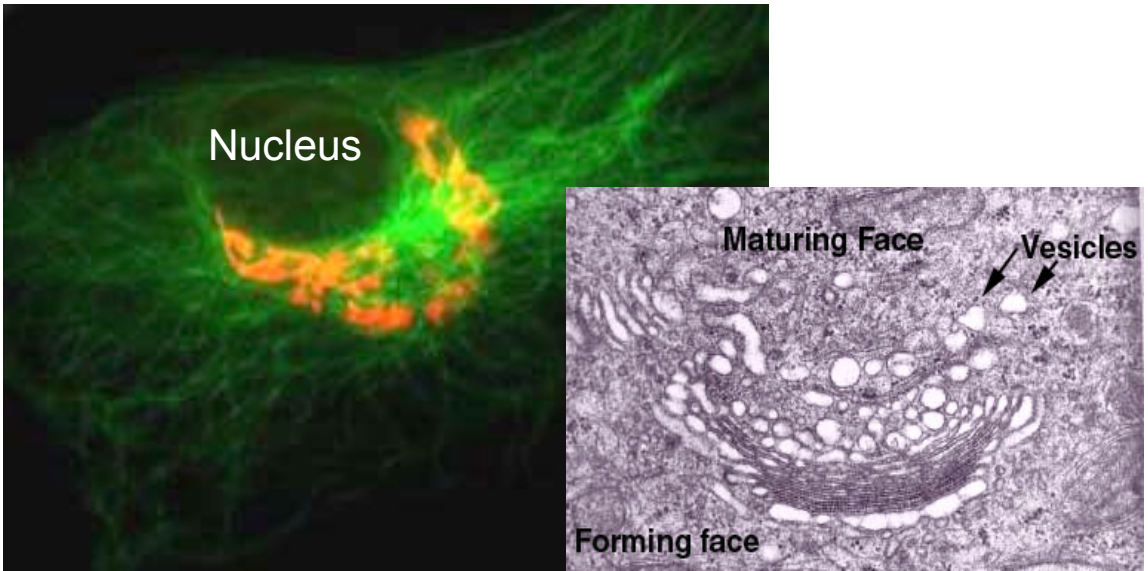


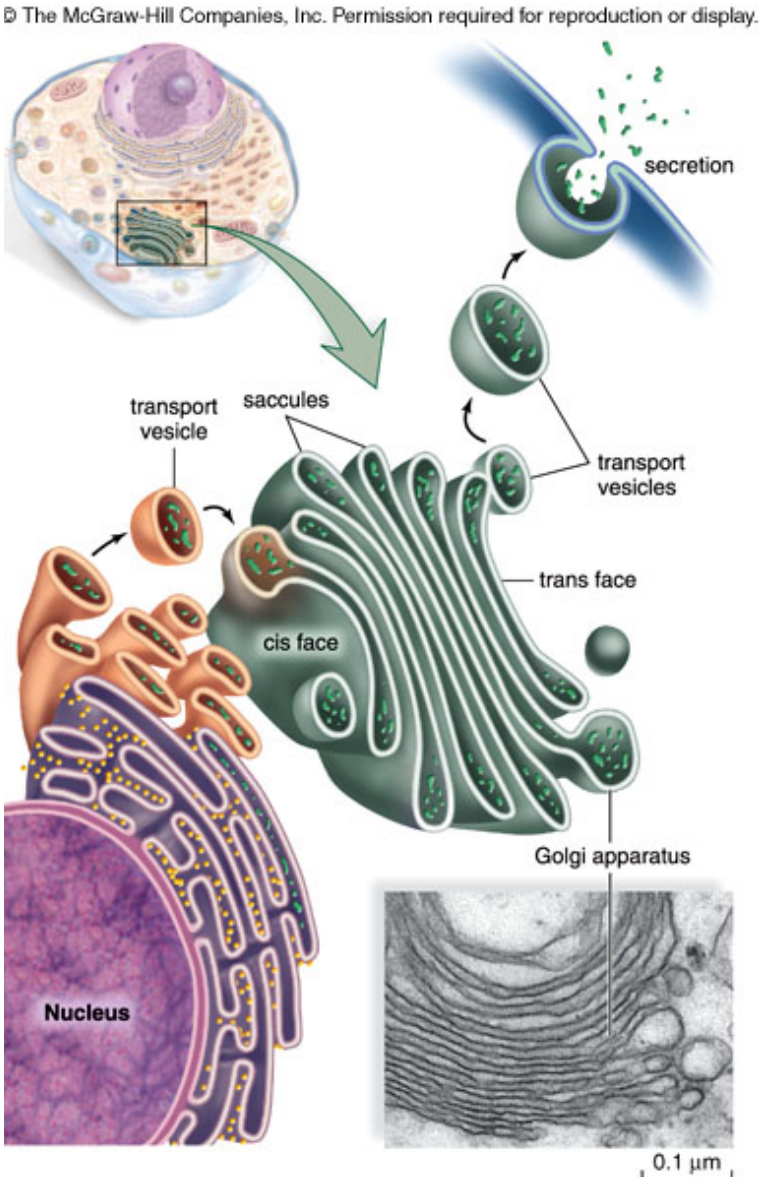


- Individual ribosomes and polysomes are **NOT visible under light microscope**.
- Cells containing large numbers of free ribosomes are basophilic **(because of the nucleic acid in the ribosomes)**

Golgi Complex (Body)

- functions in the **post-translational modification, sorting and packaging** of proteins.
- The Golgi is usually located **near the cell nucleus**, and is often close to the ***centrosome,* or *cell center***.
- The Golgi complex is composed of 3-15 parallel ***cisternae*** and associated ***vesicles***

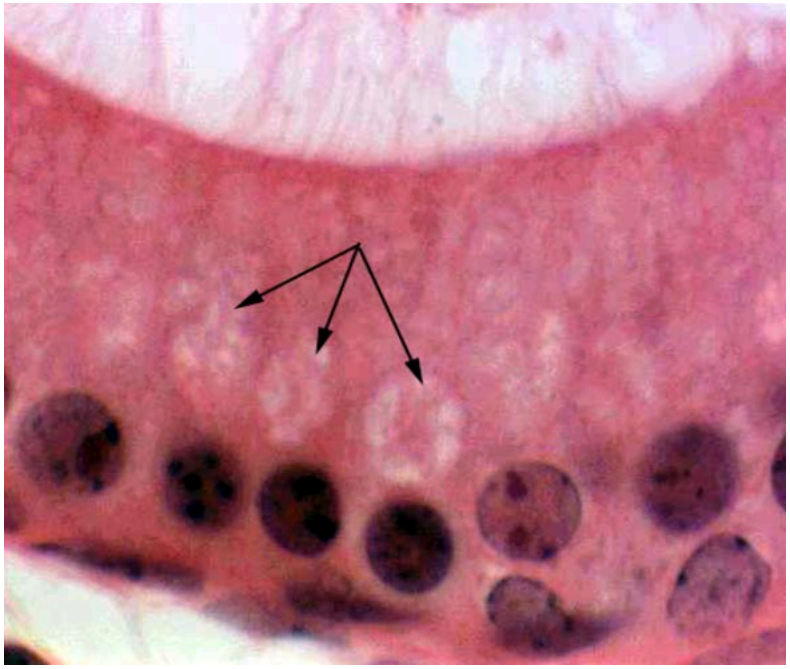


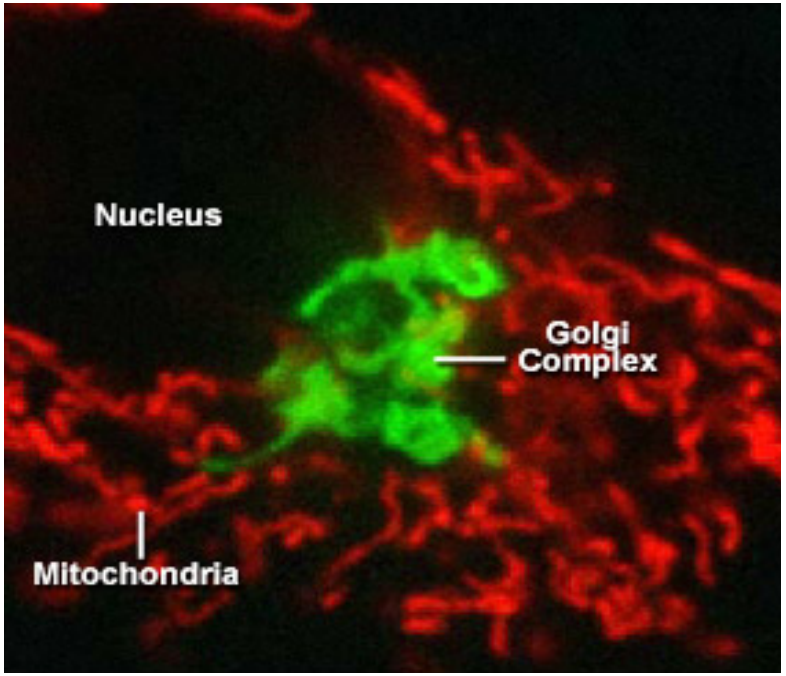


Light-microscope appearance

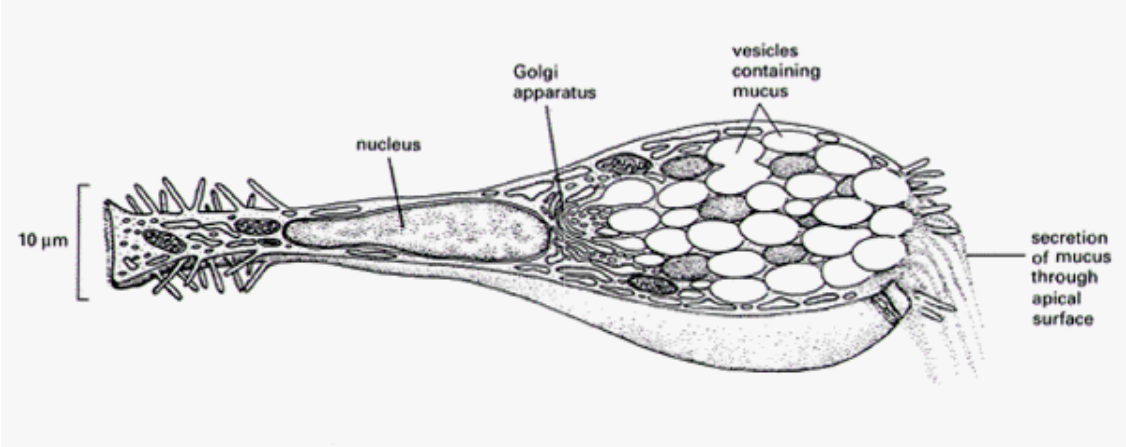
- **Not visible under light microscope** but sometimes observed as unstained image inside the well stained cytoplasm, called a **"Golgi ghost"**

- Can be demonstrated with **heavy metal staining (silver or osmium).**



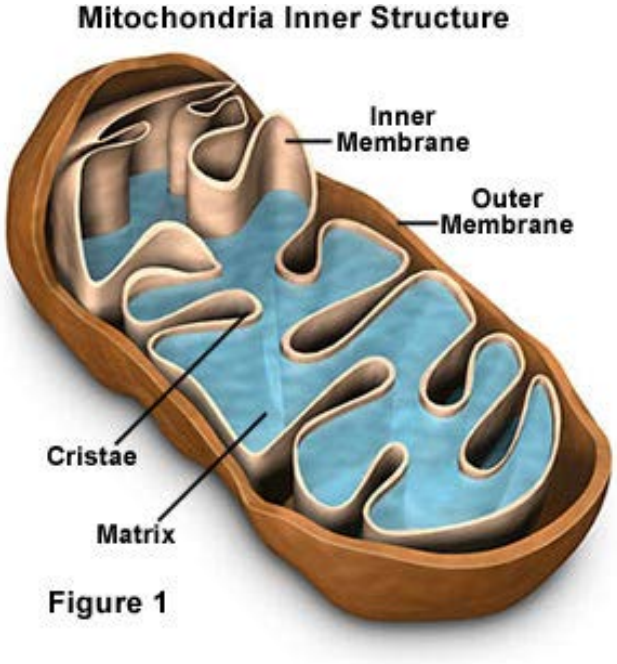


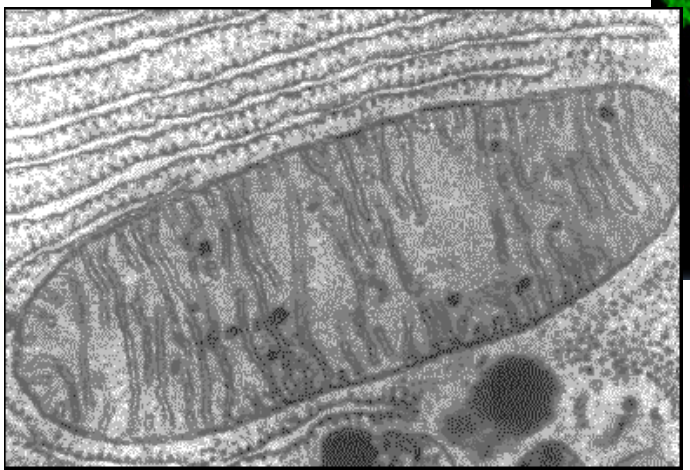
The Golgi apparatus is especially prominent in cells that are specialized for **secretion,** such as the **goblet cells** of the intestinal epithelium, which secrete large amounts of polysaccharide-rich mucus into the gut.

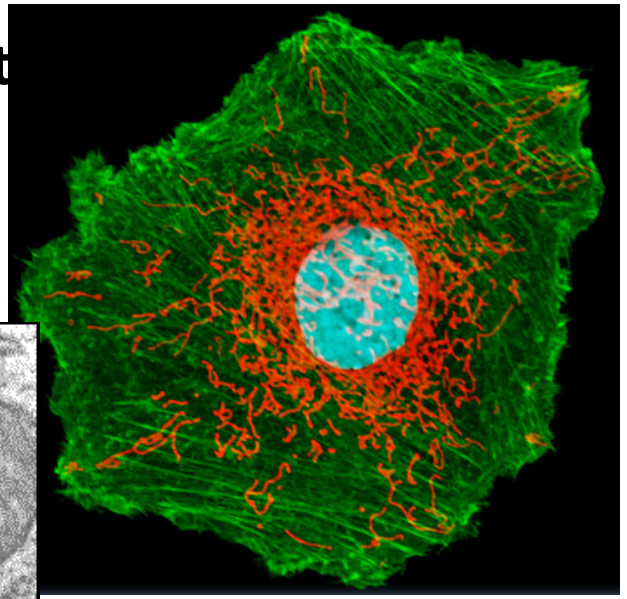


Mitochondria (singular: mitochondrion)

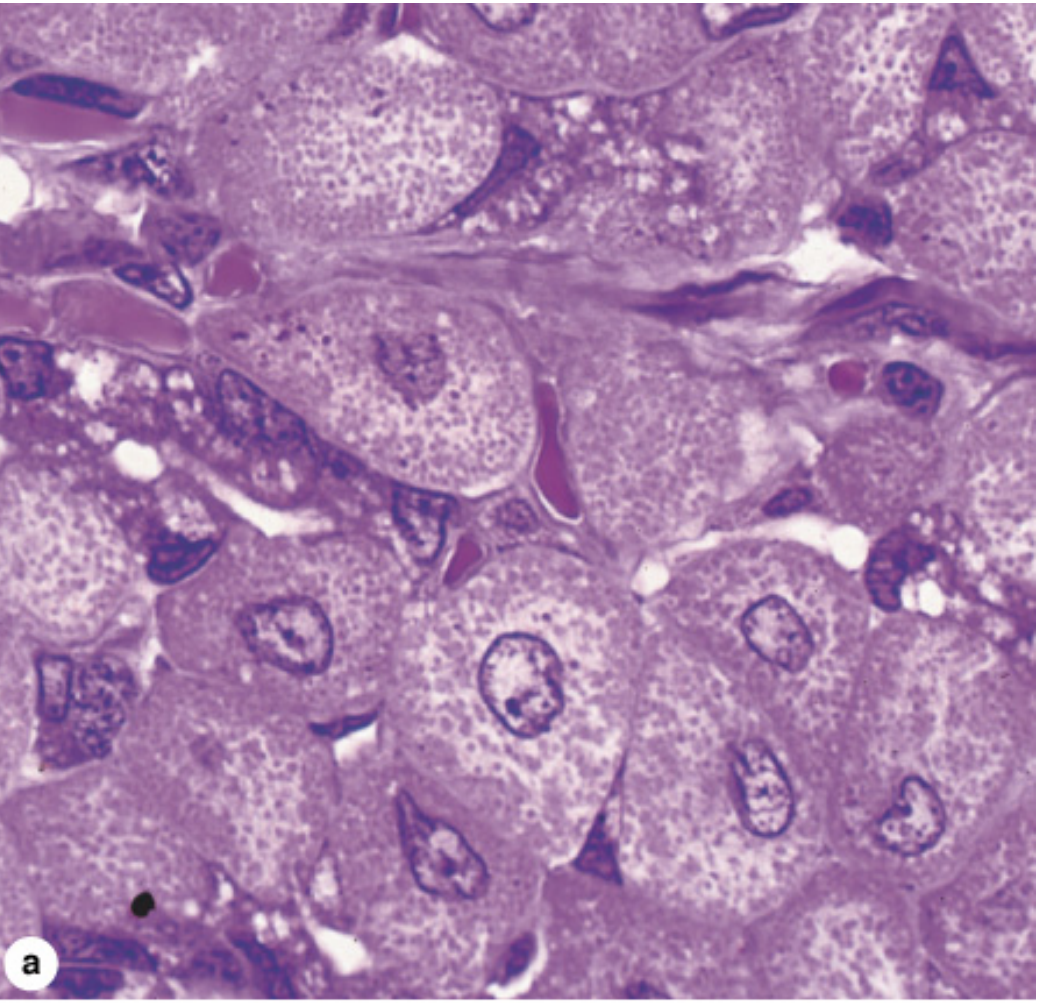
- **Sites of energy production**.
  - sugars + O_2 - - > **ATP** + CO_2 + H_2O
  - mobile power generators
- Has its **own DNA**, increase their numbers by **division**, **synthesize** some of their structural proteins
- decide whether the cell lives or dies. **(Apopt**







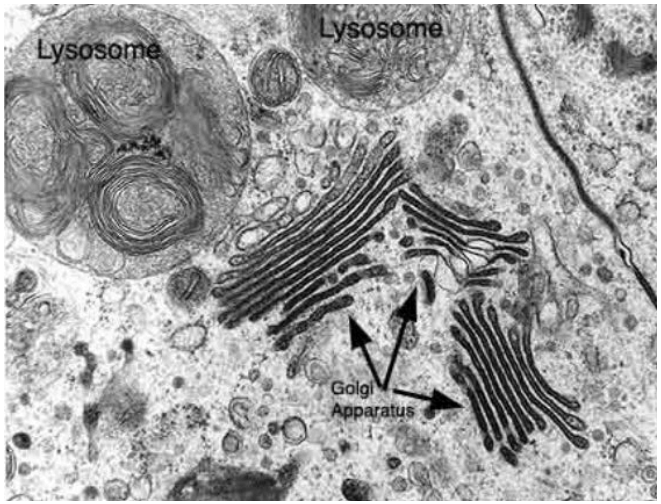
Mitochondria in the light microscope



Sometimes observed in favorable situations (e.g., liver or nerve cells) as miniscule, dark dots.

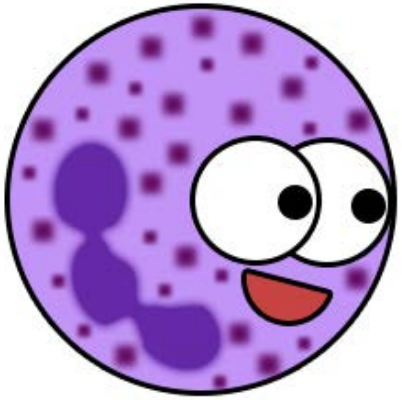
Lysosomes

- Membrane-bound organelles that contain **digestive** enzymes (proteases, nucleases, glycosidases, lipases, and phospholipases)

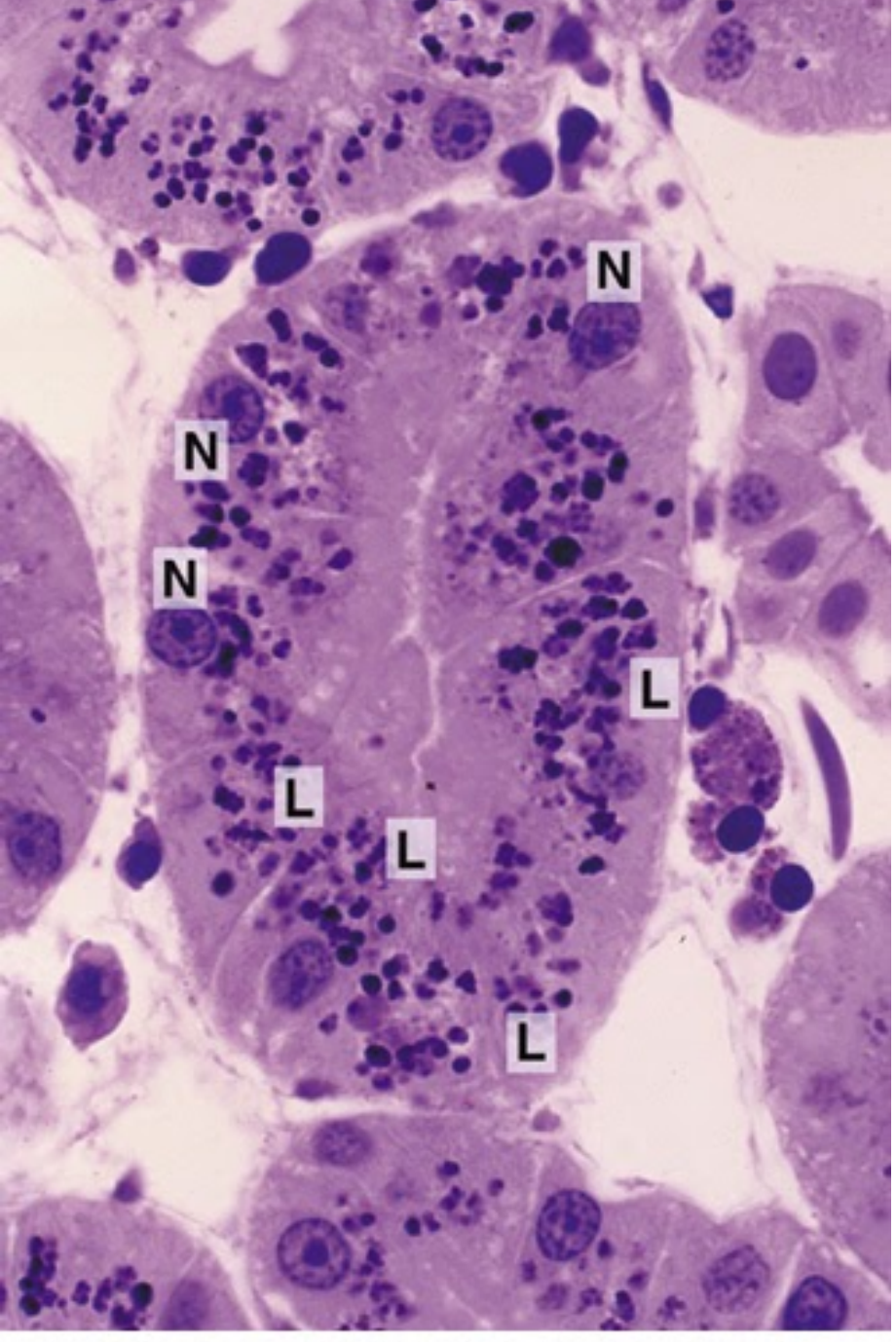


- Round shape-spherical bodies bounded by a **single membrane** & **proteins and membrane are manufactured by the Golgi.**

- some cells (osteoclast, neutrophils) may release lysosomal enzymes directly into ECM



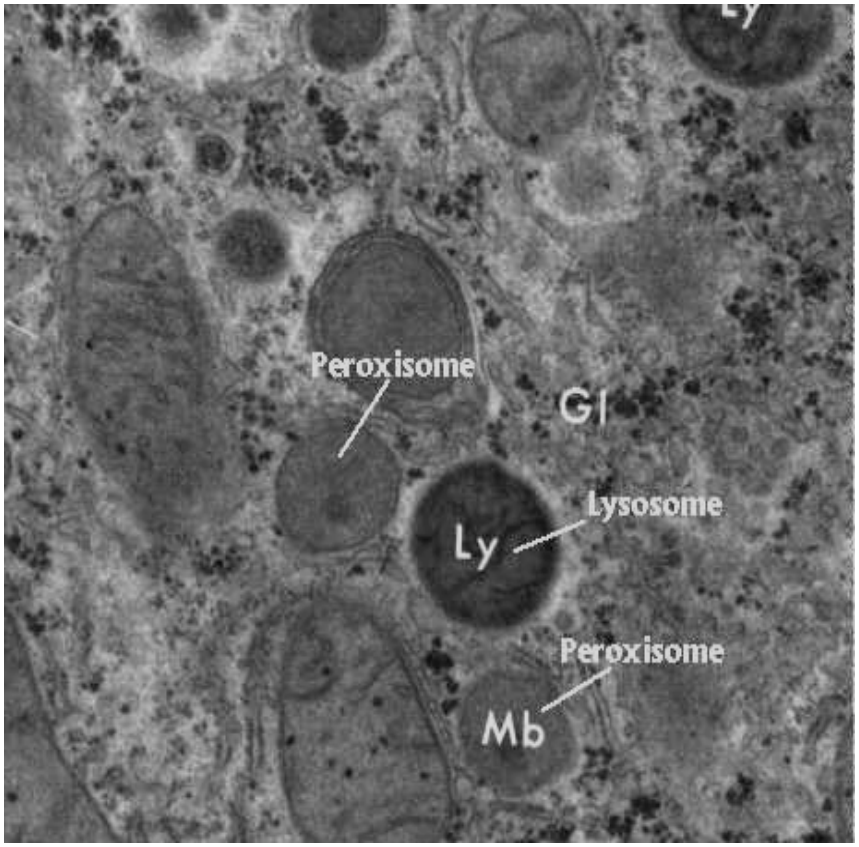
Lysosomes in the light microscope

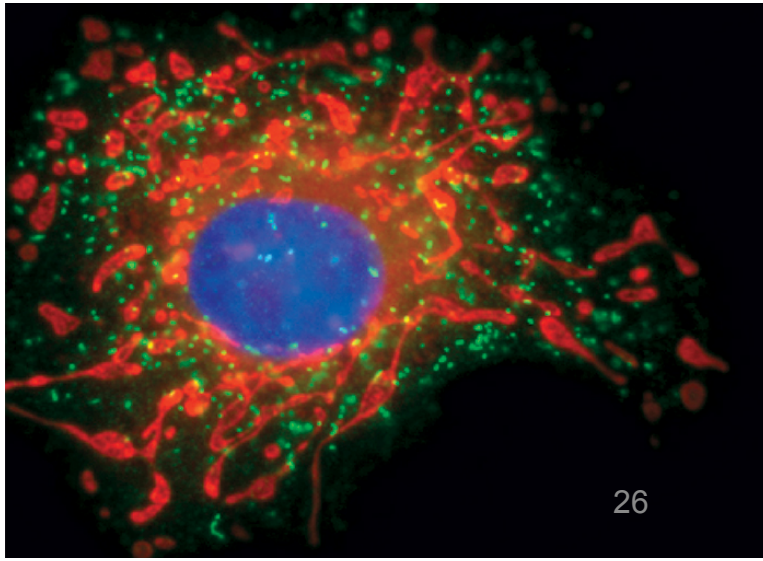


Cells in a **kidney tubule** show numerous **purple** lysosomes (L) in the cytoplasmic area between the basally located nuclei (N) and apical ends of the cells at the center of the tubule. Using **endocytosis**, these cells actively take up **small proteins** in the lumen of the tubule, **degrade** the proteins in lysosomes, and then release the resulting **amino acids** for reuse.

Peroxisome

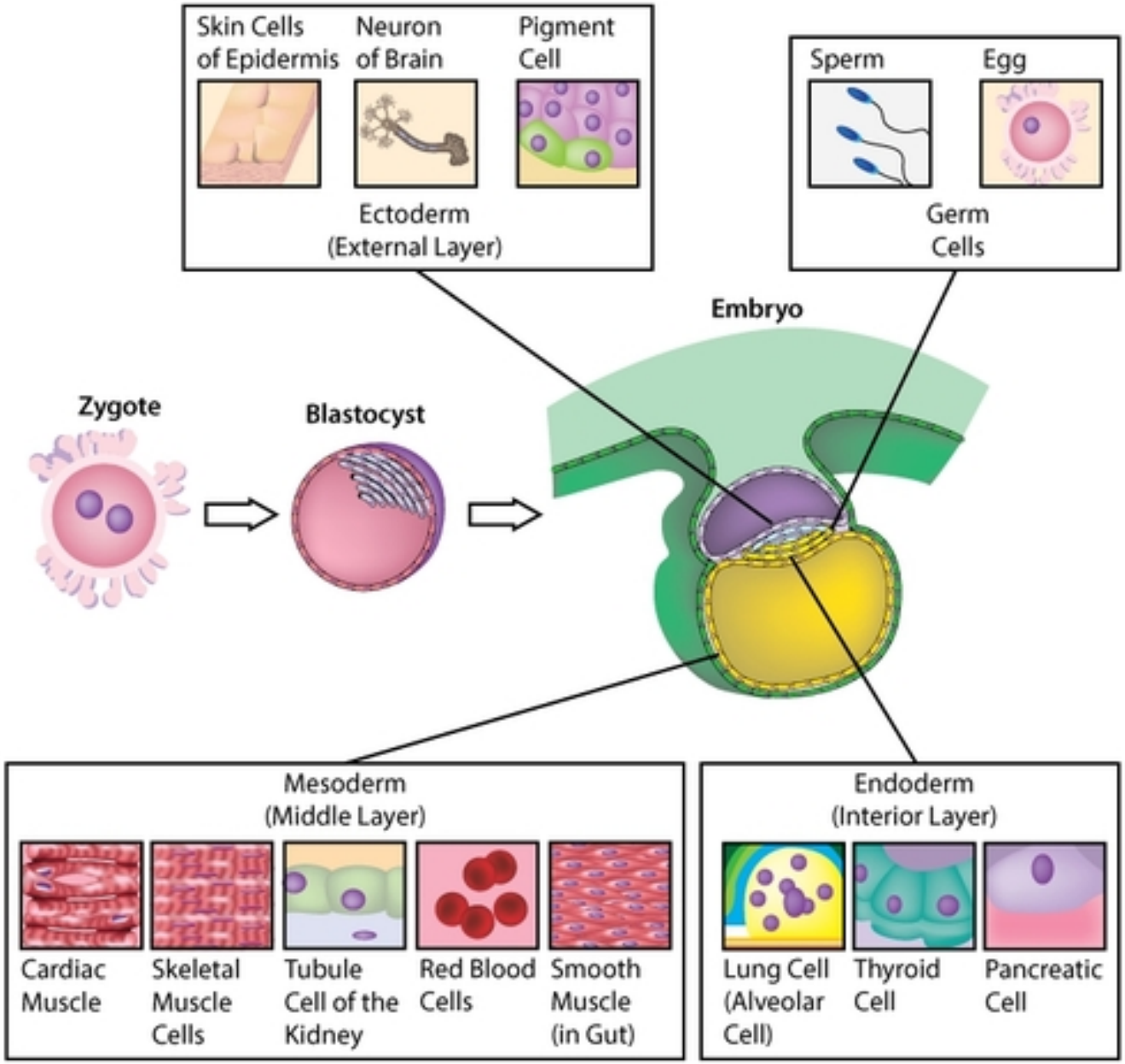
- single membrane-bounded organelles containing oxidative enzymes.
- function to rid the body of **toxic substances** like hydrogen peroxide, or other metabolites.
- They are a major site of oxygen utilization and are numerous in the **liver** where toxic products are going to accumulate.



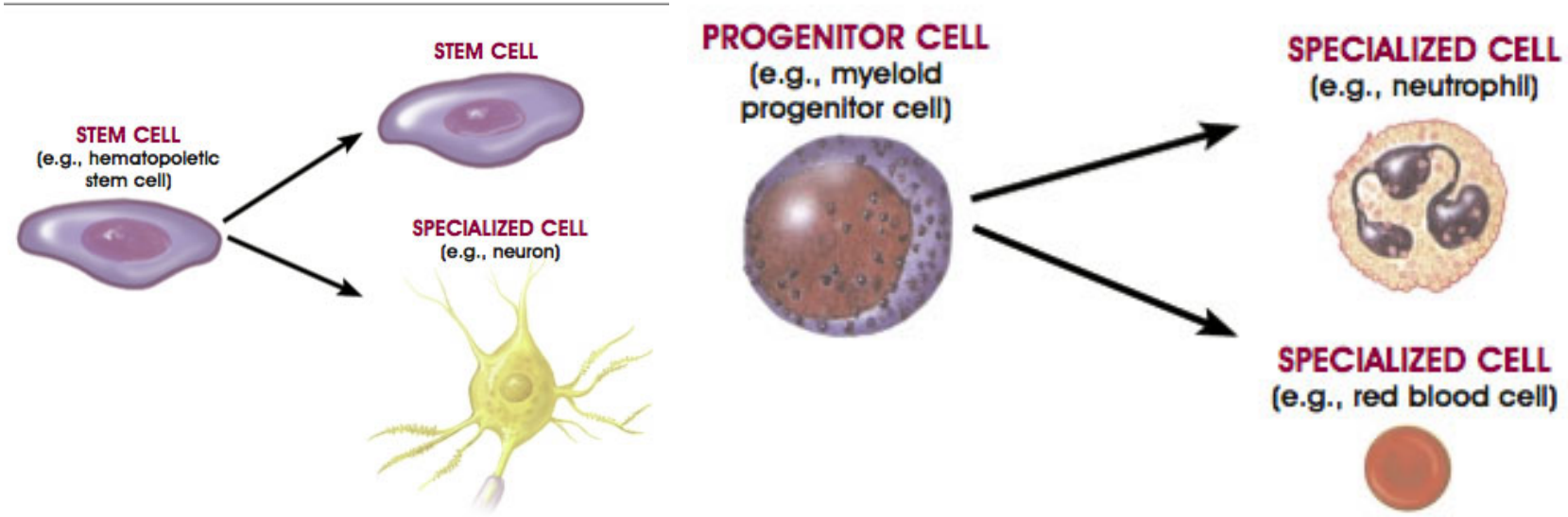


Cellular Differentitation

Human organism includes 200 different cell types all derived from zygote



- Cells arise in the body from **progenitor or stem cells** and become specialized for one or more distinct functions such as
  - contraction, nerve conduction, secretion, absorption, protection
- This process of cell specialization is known as cell **differentiation.**
- Structural (become very efficient for specialized function) or morphological (change in shape) modifications during differentiation are accompanied by **biochemical changes**
- (Ex; formation of red blood cells requires the differentiating cells to make specialized proteins for oxygen transport).

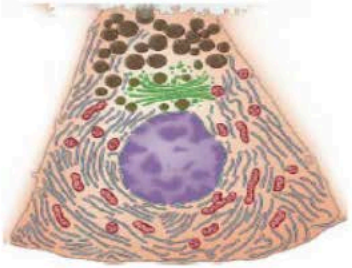


Vary in their shape and size

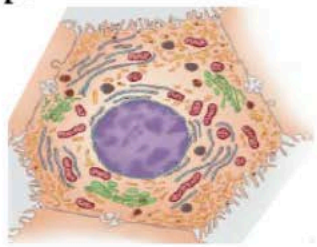
Various cell types; shape, size, intracellular organizations, polarization – Functions

These three cells all belong to "Intestinal Epithelial Cell" groups

Small Intestine
(Absorptions)

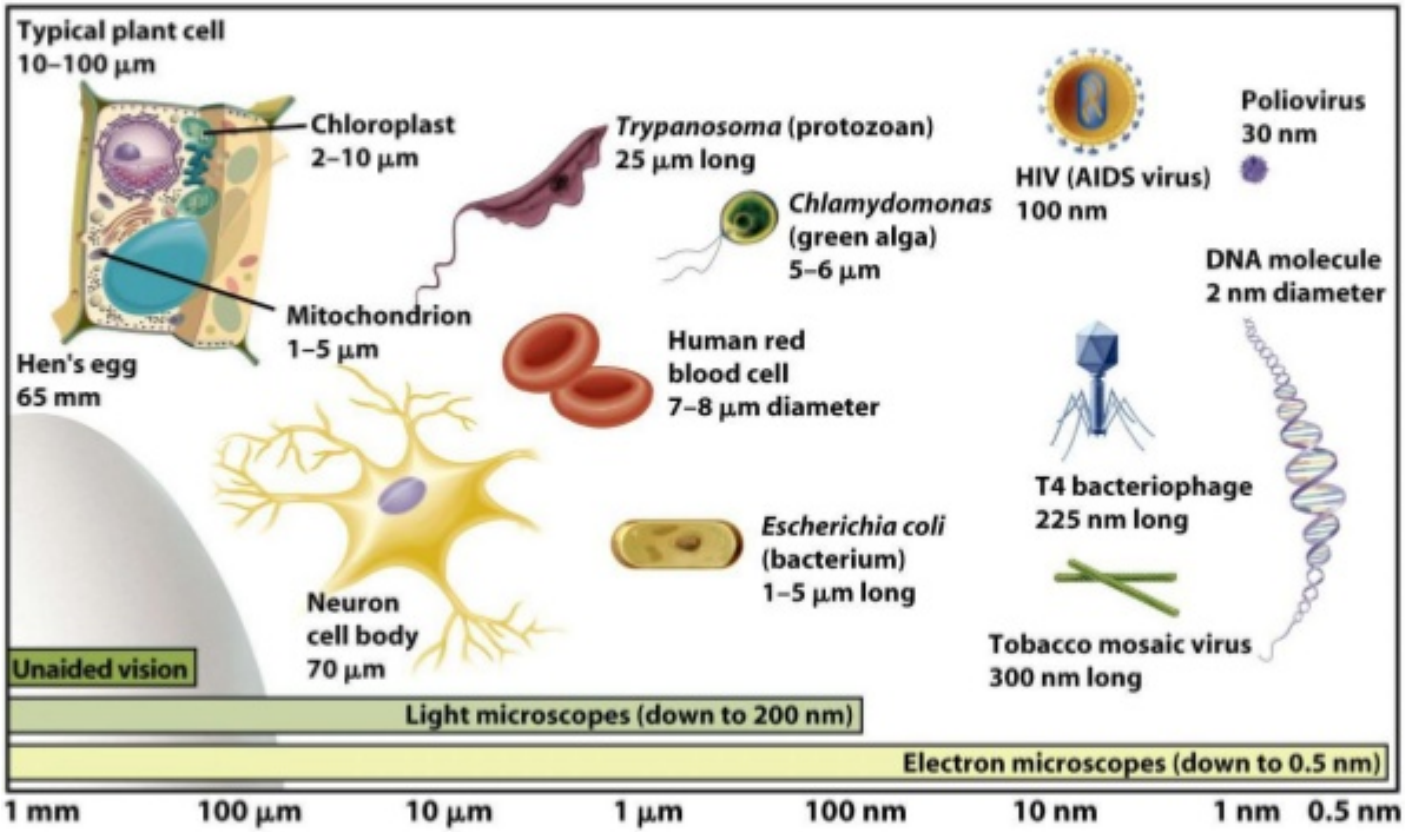


Pancreatic Acinar cell
(Digestive enzyme production)



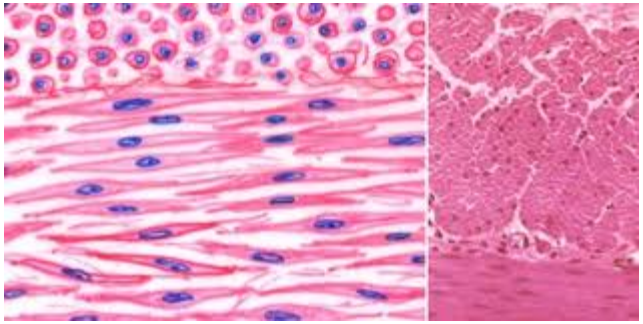
Liver Hepatocyte
(Metabolism, protein production
Bile secretion etc)

200 micron (oocyte)
150 micron (neuron body)
4-5 micron (eritrocytes)

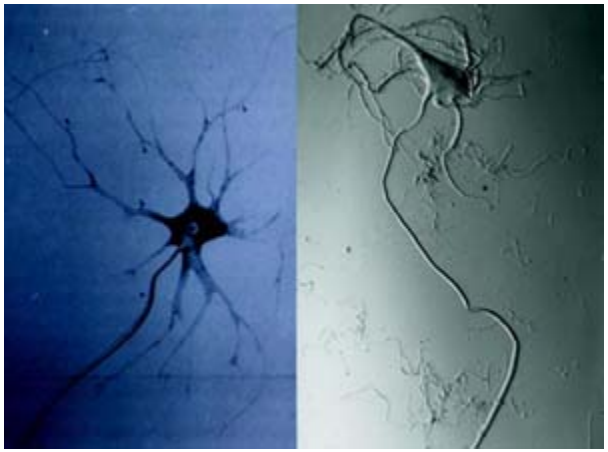


Cell structure closely relates function

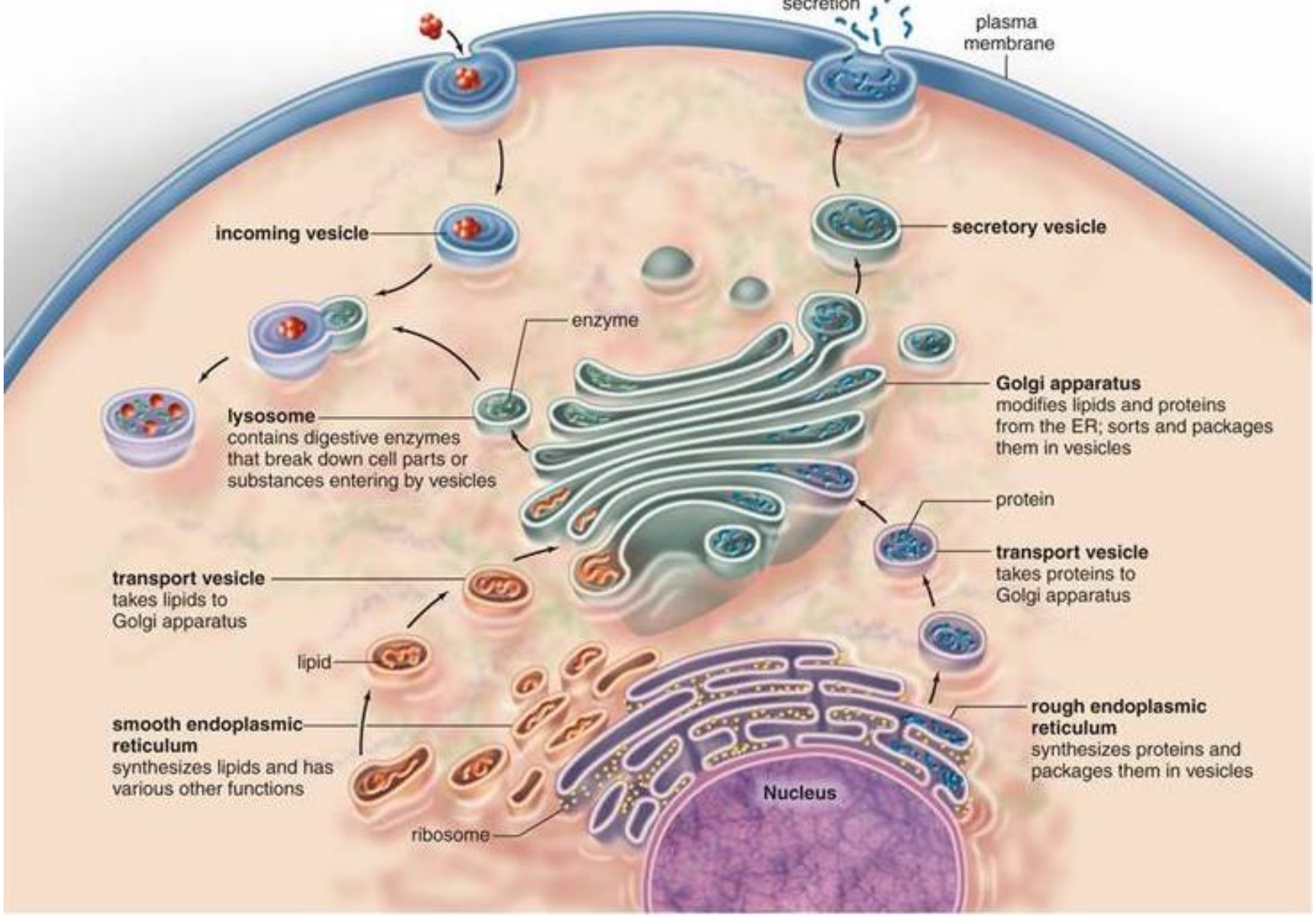
- **Muscle cells** contain numerous organelles providing energy required for muscle contraction.



- **Nerve cells** are long and thin to carry impulses over distance.



Pictures adapted from www.imgarce.com

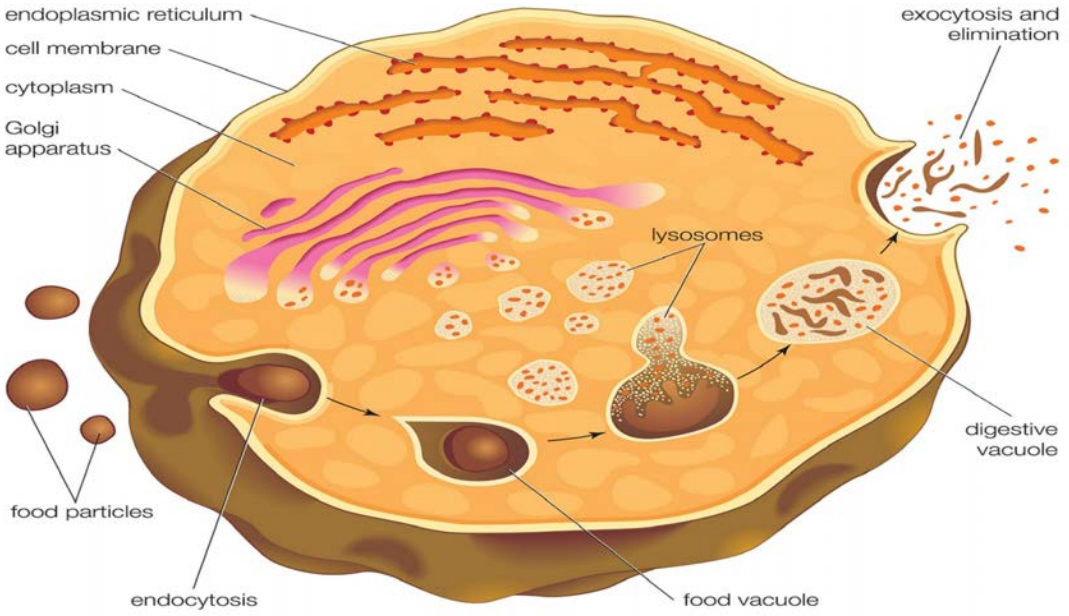


The Endomembrane System includes Nucleus, ER, Golgi, Plasma Membrane, Lysosomes: these are connected by transport vesicles.

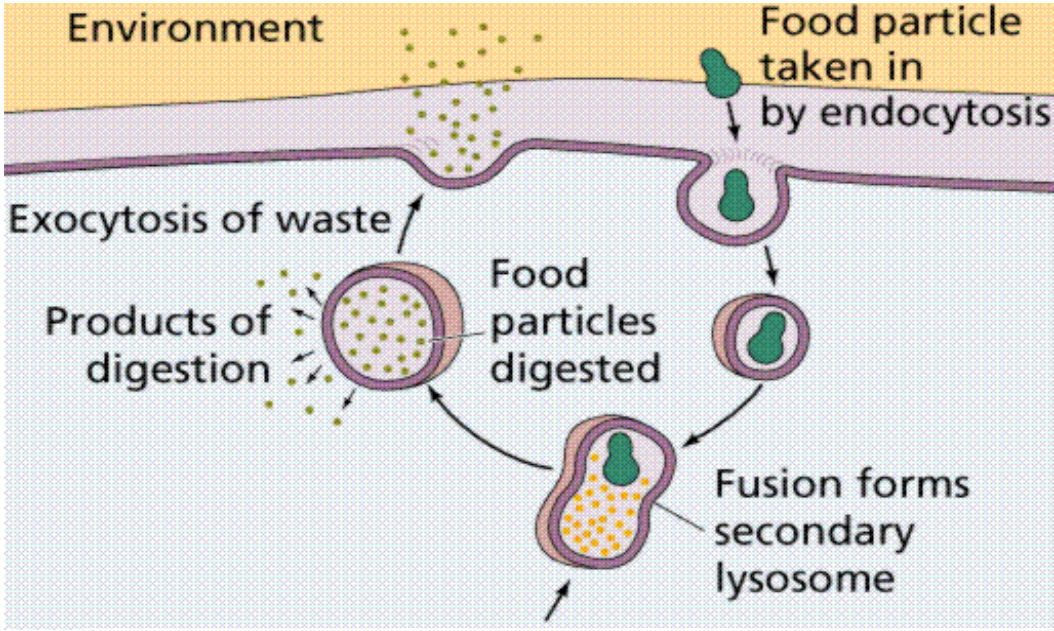
Endocytosis and Exocytosis

- The group of processes called **endocytosis** brings macromolecules, large particles, small molecules, and even other cells into the eukaryotic cell.

- There are three types of endocytosis: **phagocytosis, pinocytosis, and receptor-mediated endocytosis.**

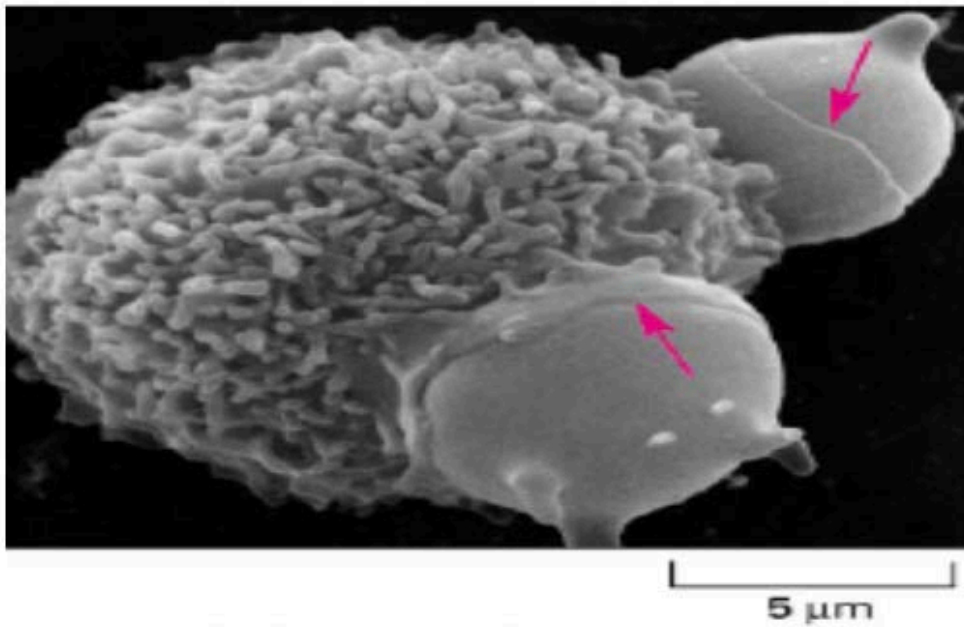


① **Phagocytosis** is the engulfing of solid particles.



② **Pinocytosis** is cellular drinking. The engulfing of liquid droplets.

.

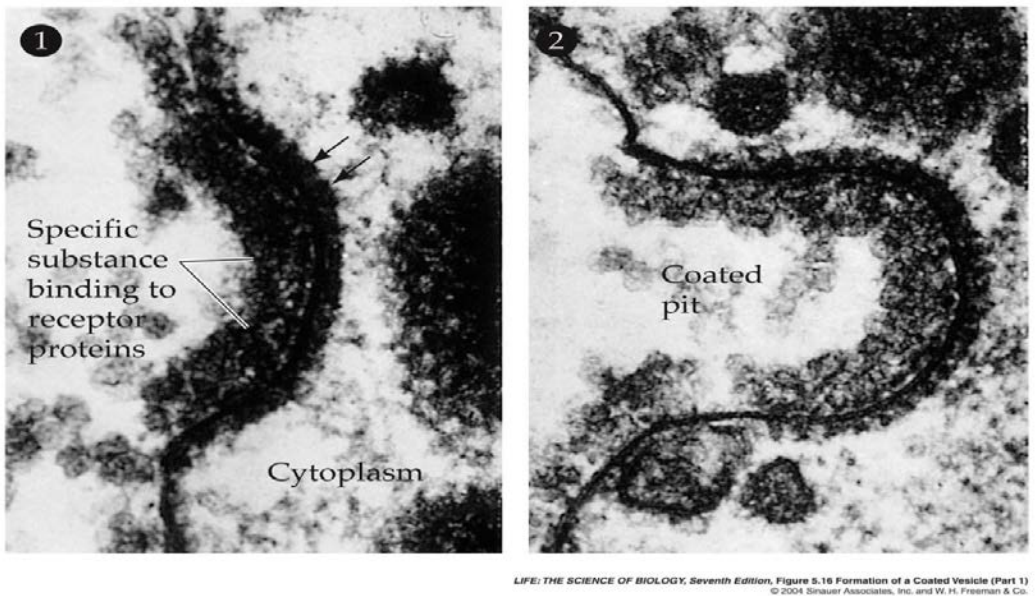


Macropharge engulfing two red blood cells

③ **Receptor-mediated endocytosis** is similar to pinocytosis, but it is **highly specific** and it occurs when the material to be transported binds to certain specific molecules in the membrane.

*Ex; the transport of **insulin** and **cholesterol** into animal cells.

1985- Nobel Prize (Brown & Goldstein)



LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 5.16 Formation of a Coated Vesicle (Part 1)
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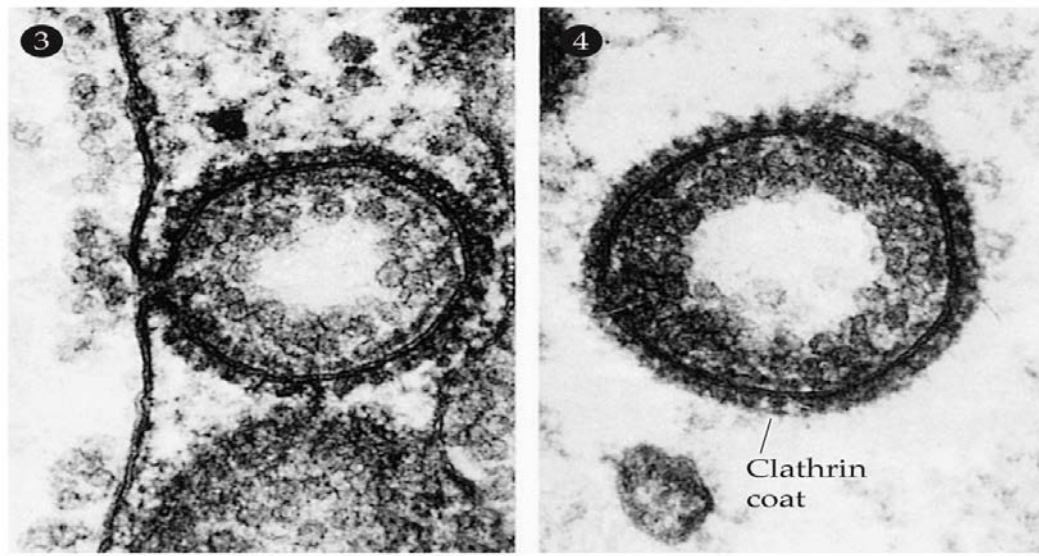

LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 5.16 Formation of a Coated Vesicle (Part 2
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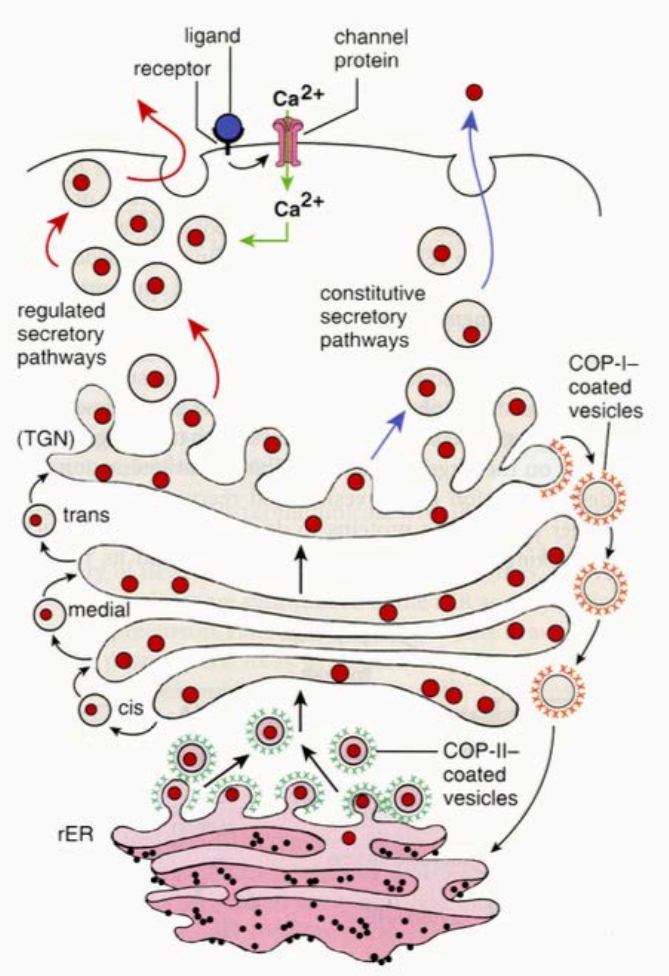
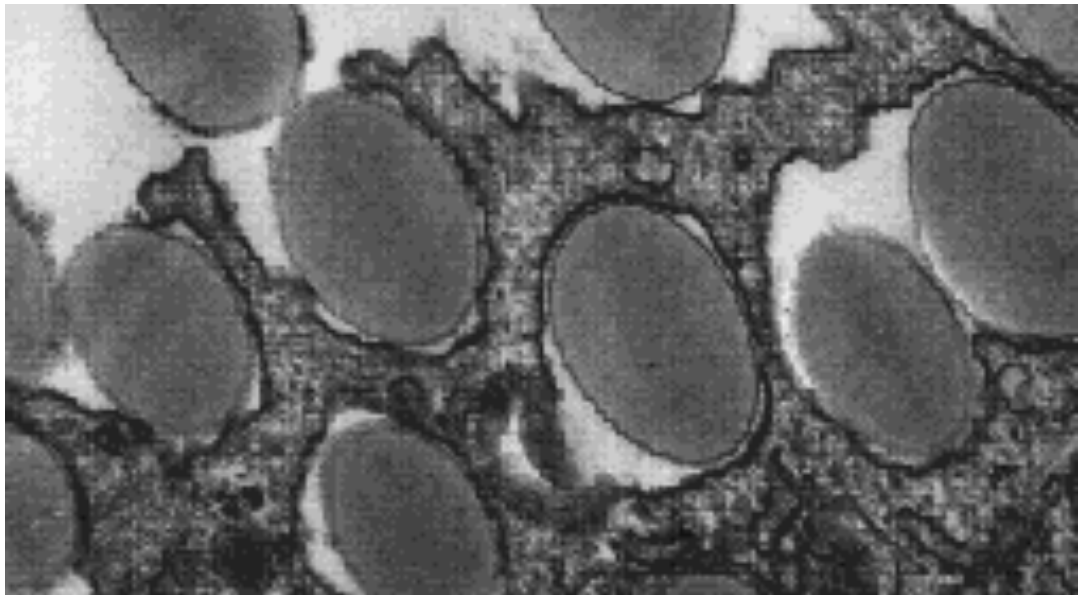
Exocytosis

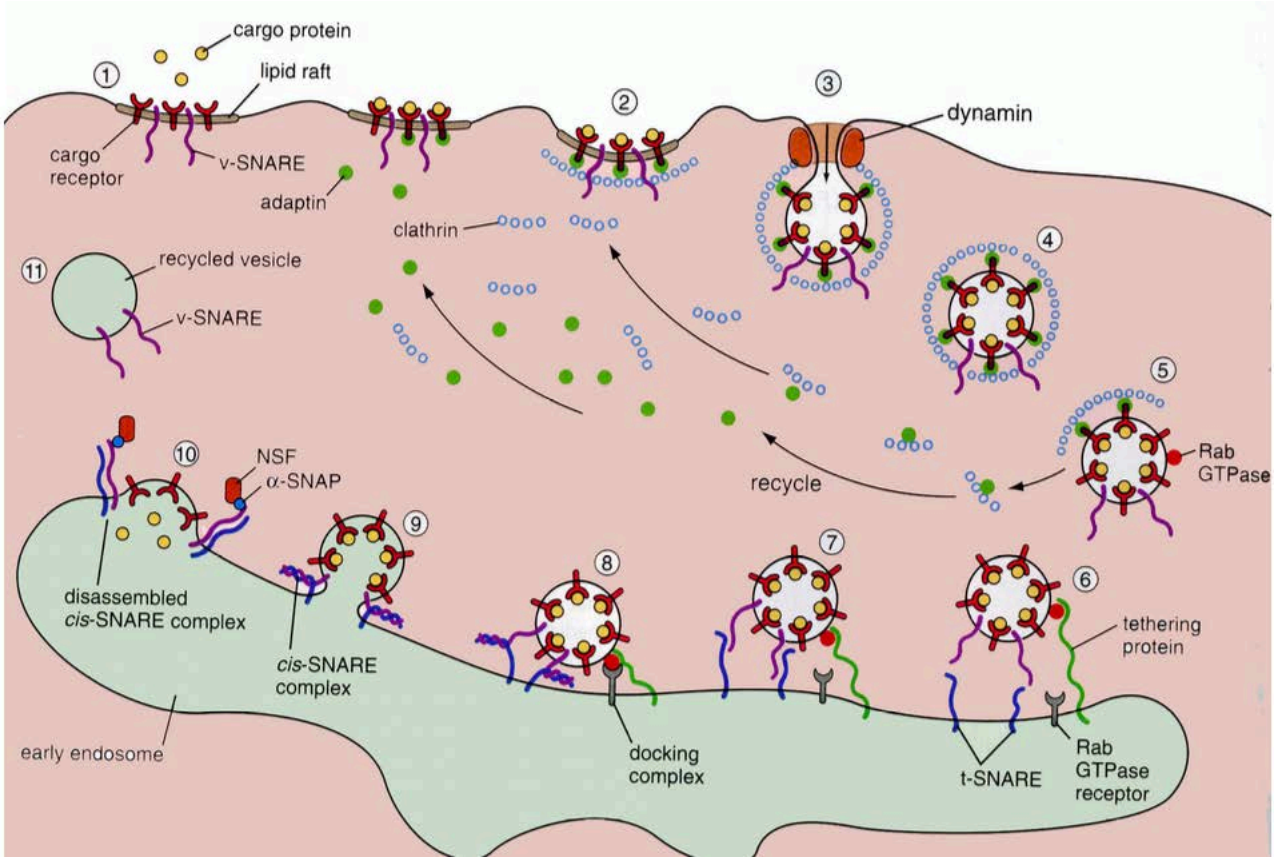
- The opposite of endocytosis is exocytosis.
  Large molecules that are manufactured in the cell are **released** through the cell membrane.





Vesicle-Mediated Transport

- Vesicles and vacuoles that fuse with the cell membrane may be utilized to release or transport chemicals out of the cell or to allow them to enter a cell



Inclusions

- Non living parts of the cell
- Have no metabolic activities
- Do not have membrane
- Exist in the cytoplasm

Glycogen
lipid droplets
pigment granules
cristaloids (Reinke crystals in Leydig cells)
Secretion granules
Residual body (waste)
lipofuscin

THE END

Next Week

Epithelial Tissues