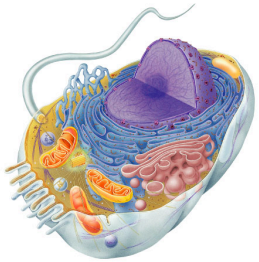


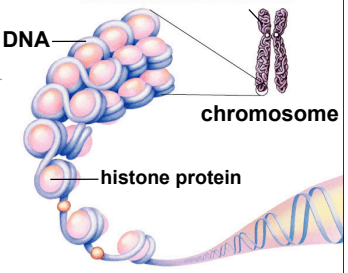
# Chapter 6: Part 2

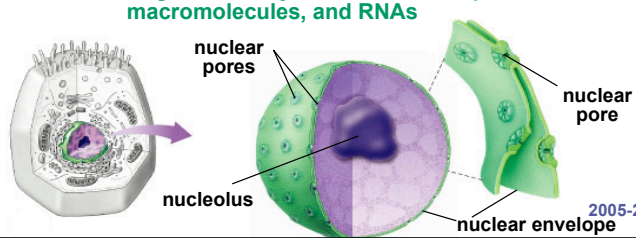
## Components of the Cells



## Nucleus

- Function
  - House & protects genetic instructions (DNA)
- Structure
  - nuclear envelope
    - double membrane - 2 bilayers!
    - membrane fused in spots to create pores
      - Each pore is ringed by proteins = Pore Complex
        - Regulates entry and exit of most proteins, macromolecules, and RNAs

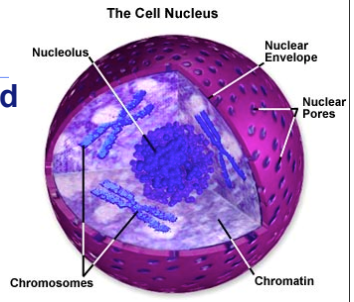


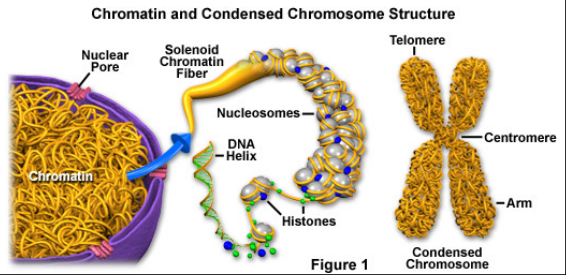





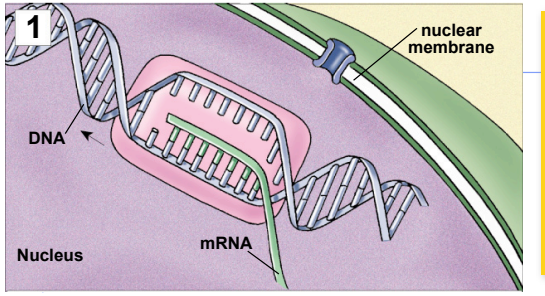

## Nucleus structure

- Within nucleus, DNA organized into fibrous material, chromatin *(DNA wrapped around histone proteins)*
  - in normal cell appears as diffuse mass
- When cell prepares to divide, chromatin fibers coil up as separate structures called chromosomes



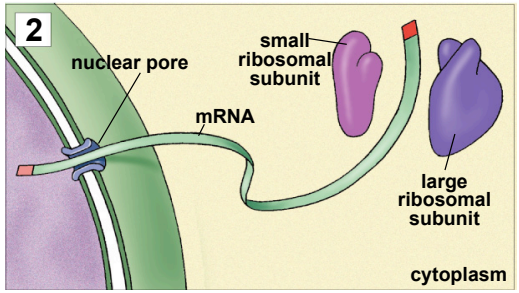



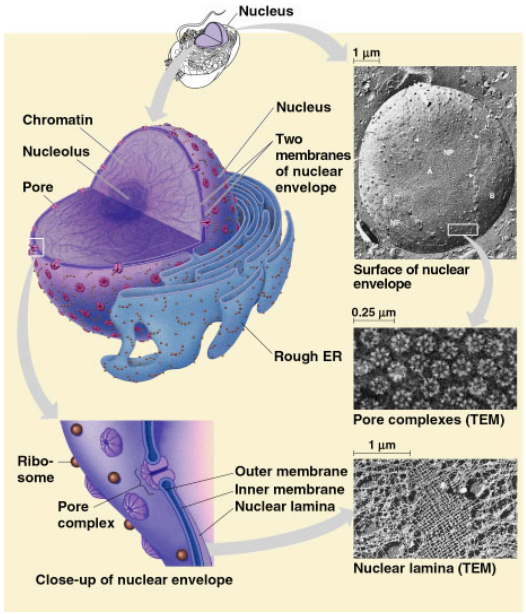


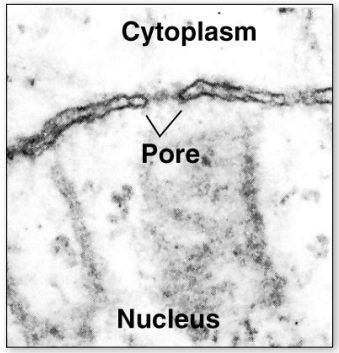




DNA does not leave the Nucleus. Messenger RNA (mRNA) is produced from DNA in the nucleus to carry instructions to the cytoplasm

mRNA travels from nucleus to ribosome in cytoplasm through nuclear pore where mRNA can be translated into the primary amino acid sequence of a polypeptide as specified in the DNA

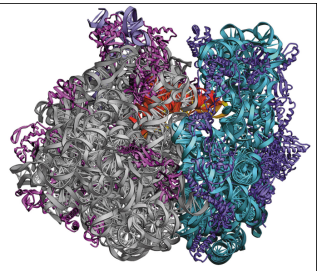




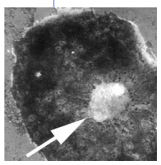



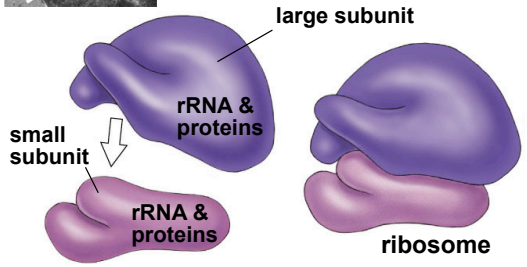

**Nucleolus:** ribosomal RNA (rRNA) is synthesized from instructions in the DNA and complexed (joined) with proteins imported from the cytoplasm to *form ribosomal subunits*

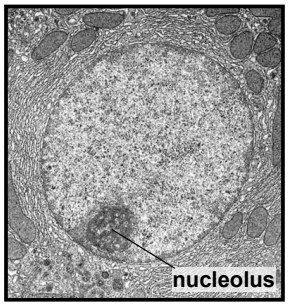
# Nucleolus



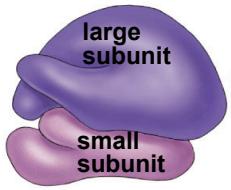
- Function
  - ribosome subunit production
    - build ribosome subunits from rRNA & proteins
    - Ribosomal subunits exit through the nuclear pores to the cytoplasm & combine when necessary to form functional ribosomes



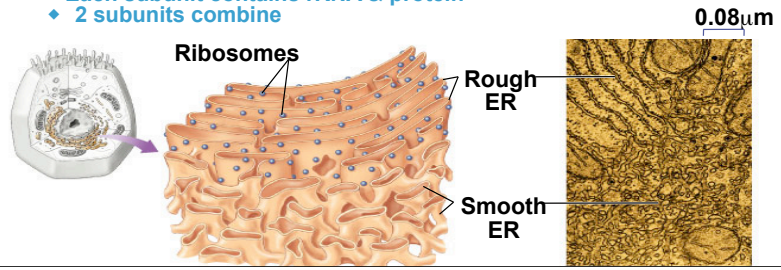



# Ribosomes



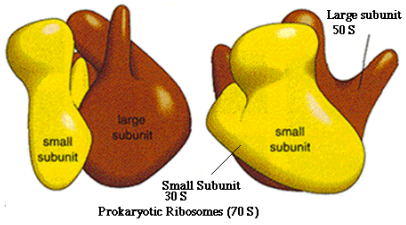

- The genes for rRNA have the greatest commonality among all living things
  *(the DNA sequences are highly conserved).*
  - There is very little difference in the DNA sequence of the rRNA genes in prokaryotes and eukaryotes.
  - Building of a ribosome is so integral to life that every cell does it almost exactly the same way.
- Function
  - protein production (synthesis)
- Structure
  - Each subunit contains rRNA & protein
  - 2 subunits combine

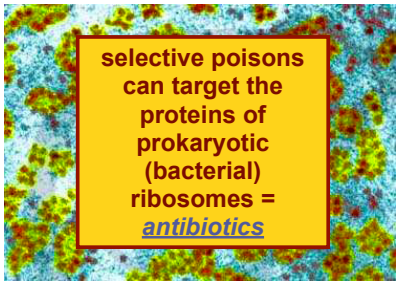



AP

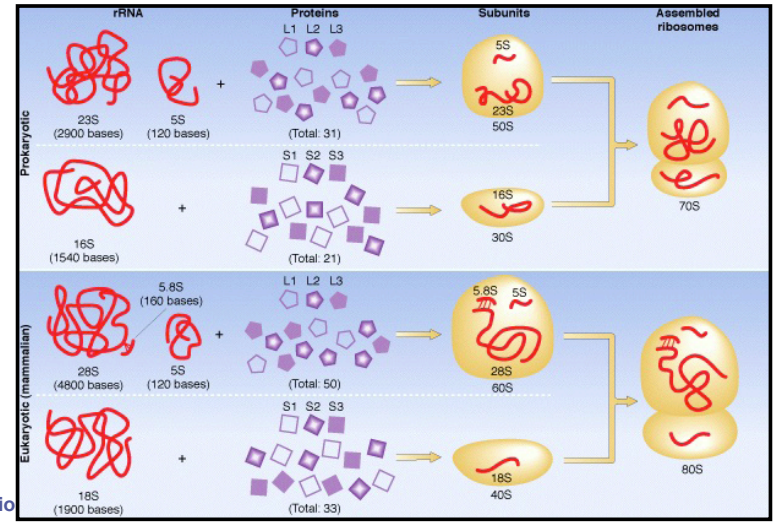
# Ribosomes

- Prokaryotes & eukaryotes have different ribosomes [no ribosome = no protein = death]
  - different size subunits
  - contain different proteins
  - can this difference be useful? *Yes, we can design drugs to attack a bacteria while not harming our own eukaryotic cells.*



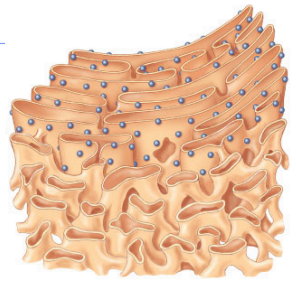
# Prokaryote vs. eukaryote ribosomes

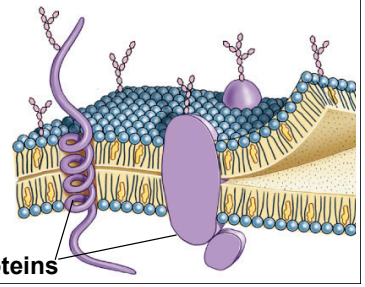





# Types of Ribosomes

- **Free** ribosomes
  - suspended in cytosol
  - synthesize proteins that function in cytosol
- **Bound** ribosomes
  - Though they start off as free ribosomes, they later attach to exterior of endoplasmic reticulum or nucleus
  - synthesize proteins for export, for use in the membrane or lumen (interior) of some organelles, the organelles that make up the endomembrane system.





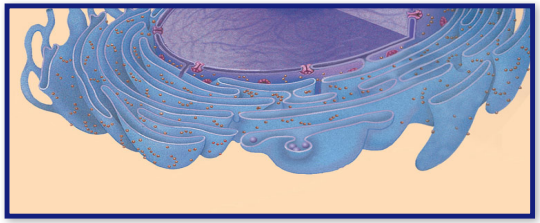


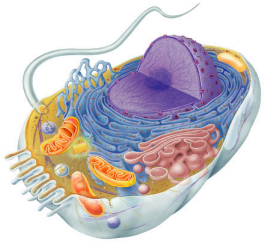

# Endoplasmic Reticulum

- extensive network of membranes

**Endomembrane System:**
Nuclear Envelope, Endoplasmic Reticulum, Golgi Apparatus, Lysosomes, Vacuoles, Vesicles, plasma membrane

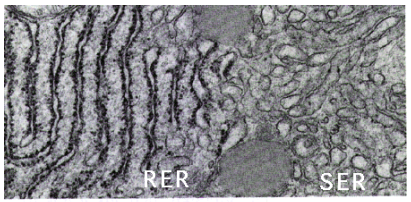
- **Function**
  - Detox toxins
  - Process certain proteins
  - Regulate protein traffic
  - Participate in metabolic functions
- **Structure**
  - Network of tubules and sacs called cisternae
  - Internal cavity is called the ER lumen or cisternal space
  - Membrane is continuous with that of the nuclear envelope & extends throughout cell

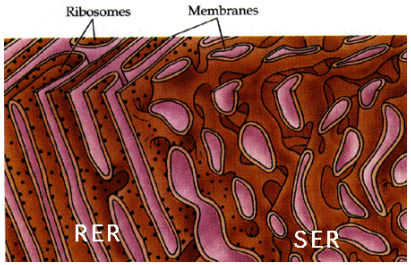




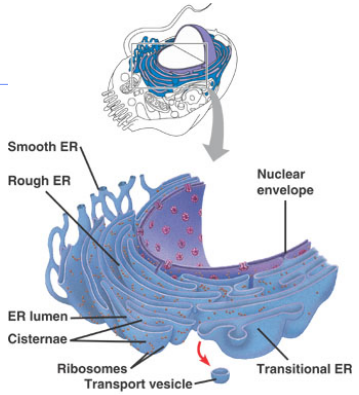
# Types of ER:

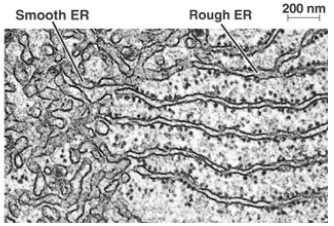
## Smooth & Rough



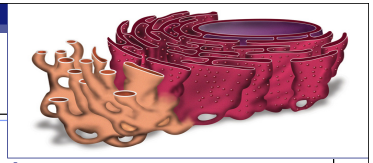




rough smooth



# Smooth ER function

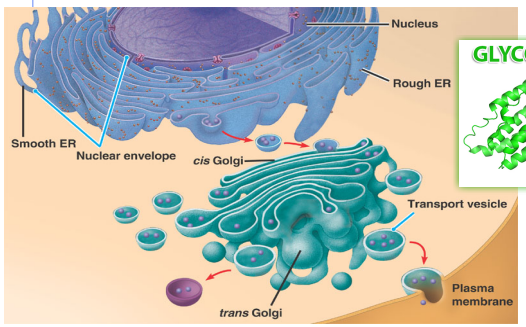


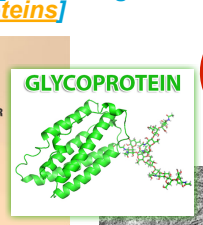
- Synthesis of lipids
  - oils, phospholipids, steroids & sex hormones
- Detoxification of drugs & poisons
  - Involves adding -OH to increase solubility so drugs can be removed from the body
    - High amount of SER found in the cells of the liver
    - Ex: alcohol & barbiturates [depressants]
      - Cell may respond to high exposure by increasing SER and its enzymes, which then increases tolerance of the organism to the drug, can increase tolerance to other drugs, or decreases effectiveness of medications over time
- Metabolism of carbohydrates
  - Synthesize and later hydrolyze glycogen into glucose
    - Again, this happens mostly in liver cells
- Storage
  - Ex: Calcium ions are stored in SER in skeletal muscles, which are ions needed for muscle contractions.

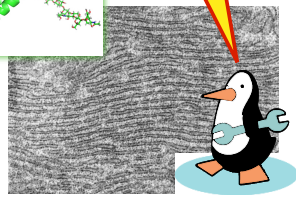
AP $Ca^{2+}$

# Rough ER function

- Produce proteins for export out of cell or inclusion in the plasma membrane or endomembrane organelles
  - High amount found in protein secreting cells
  - Proteins are packaged into transport vesicles that bud off of the RER
- Membrane supply for the cell's endomembrane organelles
- Proteins might be glycosylated *[attach oligosaccharides to protein R groups to make glycoproteins]*

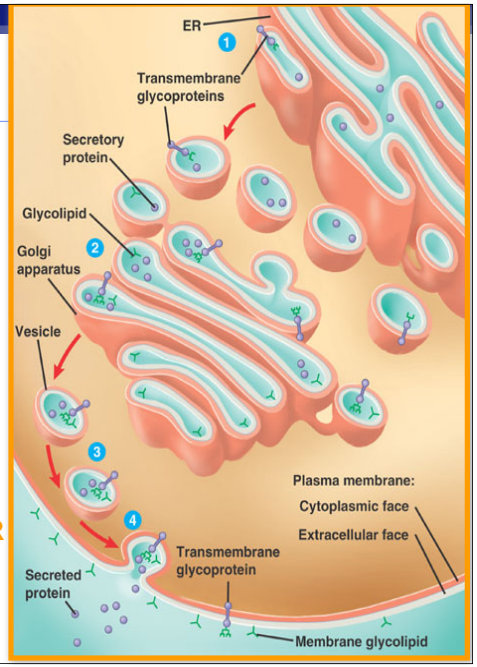



# Protein Processing

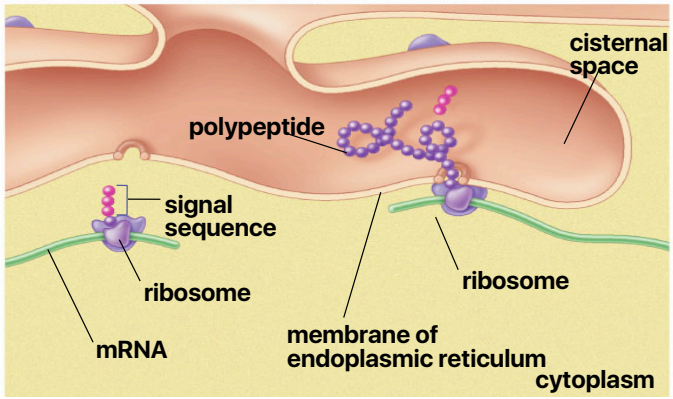
- Polypeptides destined for secretion or plasma membrane are fed into RER through pores as they are made by ribosomes on the outer surface of RER.
- Polypeptides fold into proper shapes either Inside the lumen of the RER or embedded in the membrane of the RER
- Carbohydrate moieties can be attached in the RER by RER membrane proteins.





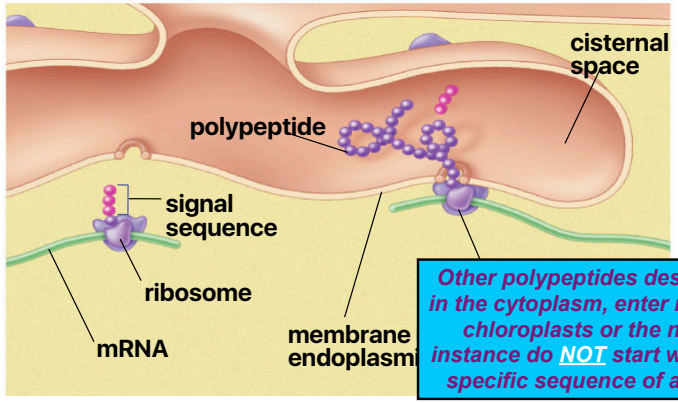

# Synthesizing proteins for secretion or endomembrane use.

1. The DNA's message, copied into mRNA, tells the ribosomes which amino acids to attach in what order when building a polypeptide.



## Synthesizing proteins for secretion or endomembrane use.

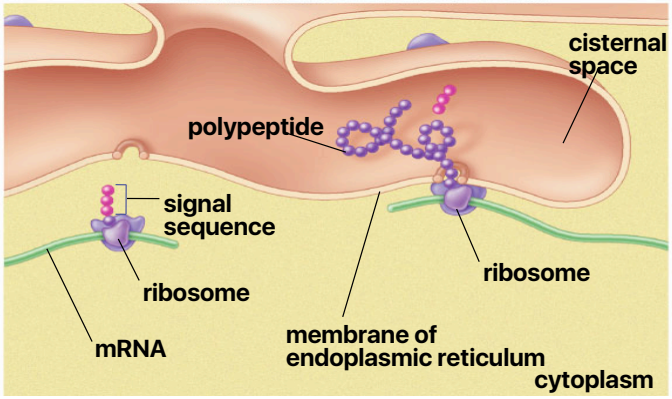
2. Polypeptides that are destined for the RER are build with a specific initial short sequence of amino acids called the Signal Sequence.




*Other polypeptides destined to stay in the cytoplasm, enter mitochondria, chloroplasts or the nucleus for instance do NOT start with this same specific sequence of amino acids.*

## Synthesizing proteins for secretion or endomembrane use.

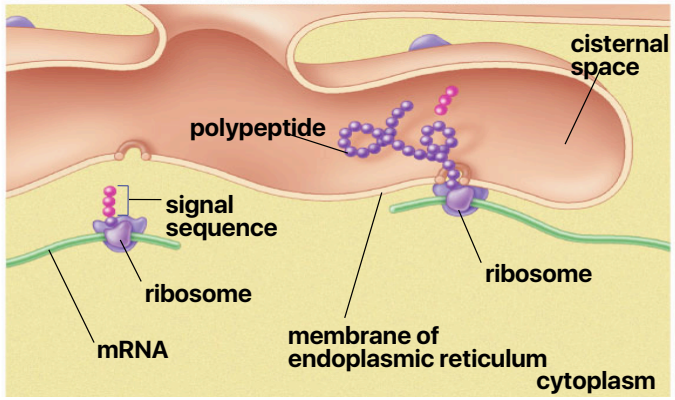
3. The Signal Sequence is recognized by cytosolic proteins, which attract themselves to the growing polypeptide. *These proteins also are attracted to the proteins in the membrane of the RER, which make up the pore complex.*




AP

## Synthesizing proteins for secretion or endomembrane use.

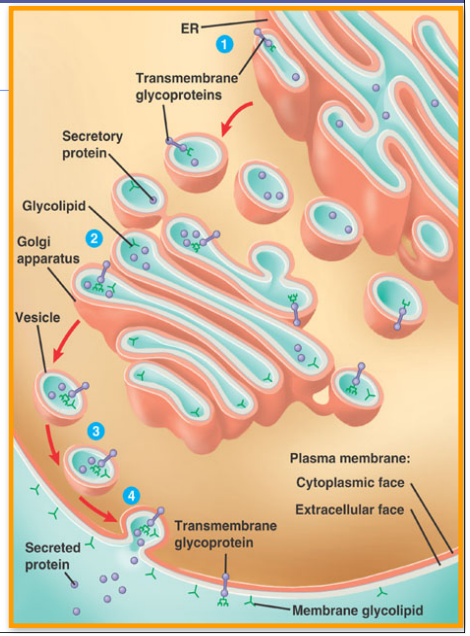
4. In this way, the mRNA, ribosome, and growing polypeptide are pulled to the surface of the RER so the growing polypeptide can be fed into the RER partially or fully through the RER's pores.




AP

## Membrane Factory

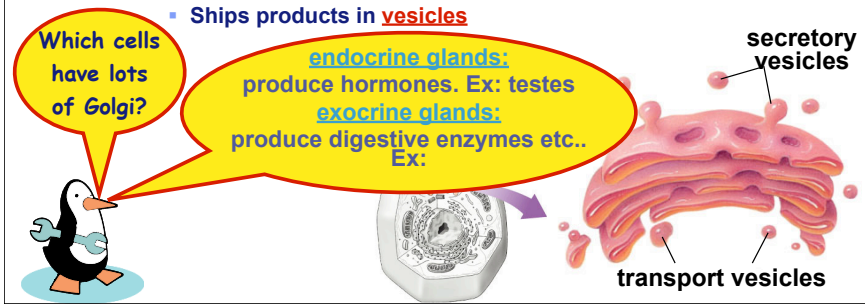
- The RER is able to build new membrane for the cell
  - It can synthesize its own phospholipids
  - ER membrane expands by adding phospholipids and membrane proteins to its own existing membrane
    - This membrane can bud off & transfer to other endomembrane parts of cell that need membranes including the plasma membrane



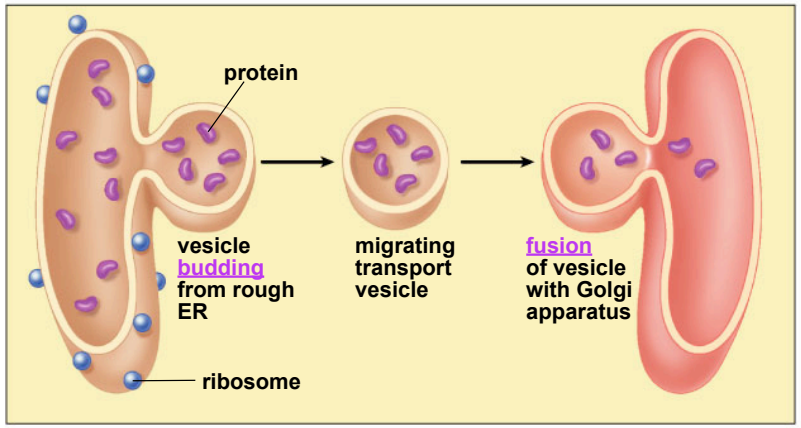

AP Biology

# Golgi Apparatus

- Composed of membrane sacs called cisternae
- Function
  - Modifies, stores, sorts, & ships the cell's ER protein and glycoprotein products
    - like "UPS shipping department"
    - Ex: may add phosphate groups to certain sugars of glycoproteins
  - Produces certain macromolecules including carbohydrates like non-cellulose polysaccharides
    - Ships products in vesicles



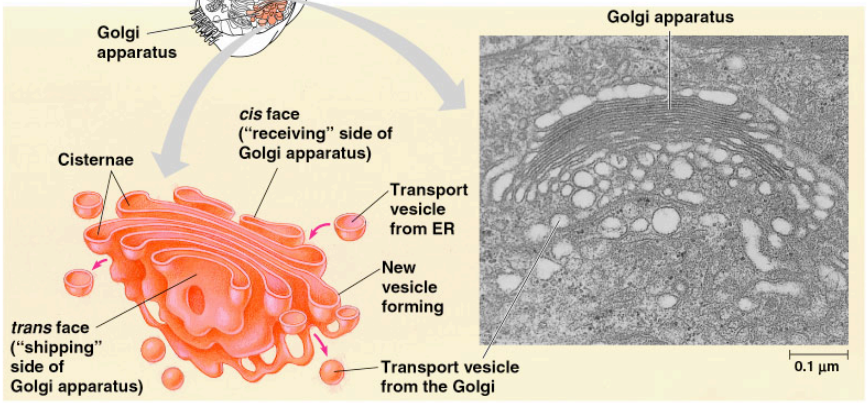

# Vesicle transport






# Golgi Apparatus

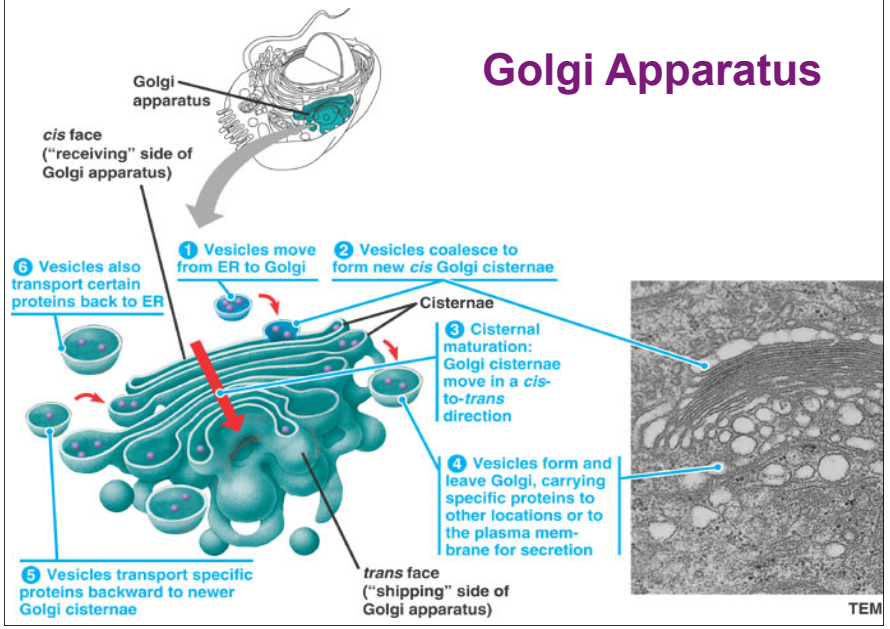
Products are modified as they are transported from the cis to the trans face.




## 2 sides = 2 functions

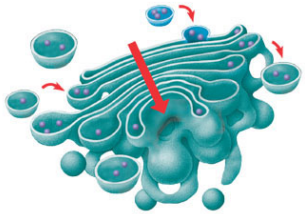
- cis = receives material by fusing with vesicles = "receiving"
- trans = buds off vesicles that travel to other sites = "shipping" (transport)

# Golgi Apparatus



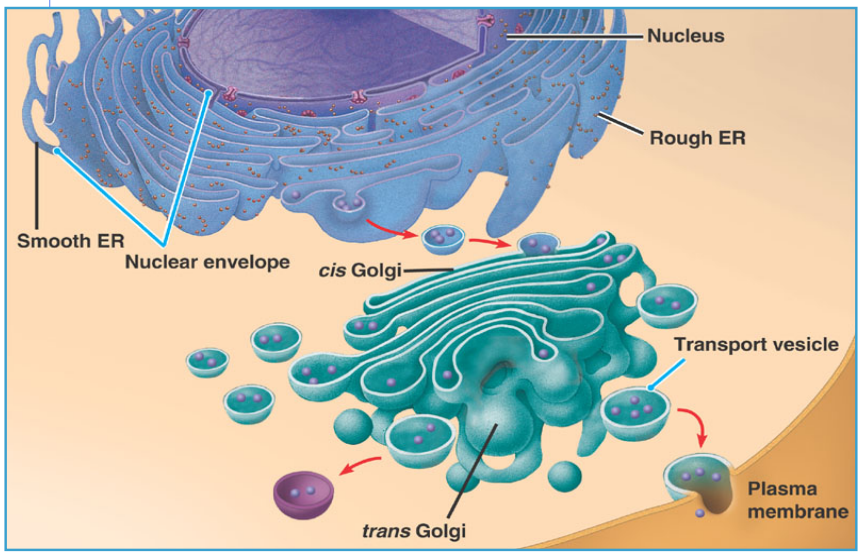
# Golgi processing

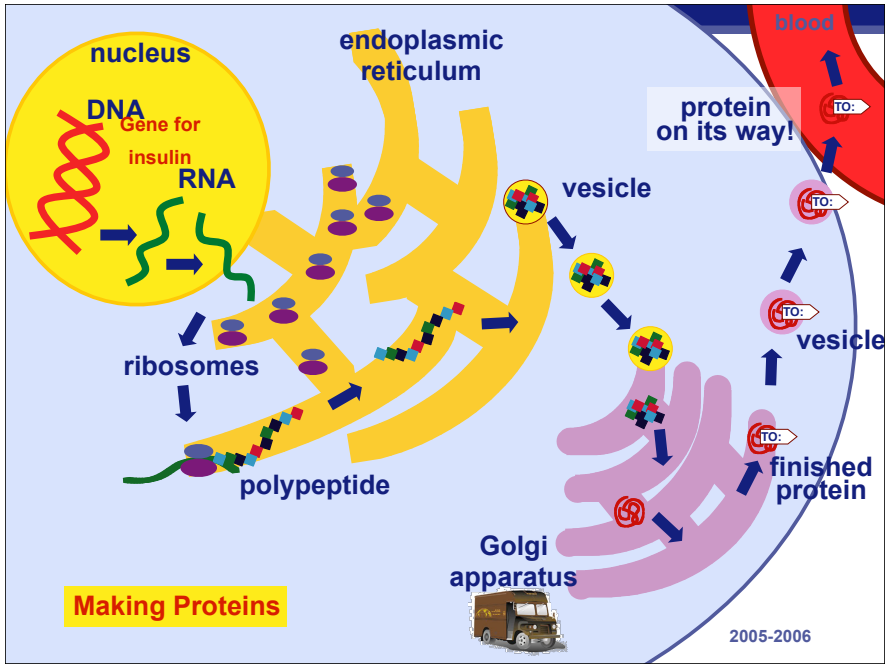
- During path from cis to trans, protein/glycoprotein products from ER are modified physically or chemically into final form
- Tags, sorts, & packages materials into transport vesicles
  - Transport vesicles deliver packages to the parts of the cell that need the carbohydrate or protein products
    - Transport seems to occur by moving the vesicle along microtubules using motor proteins
  - Vesicles recognize protein docking sites on the surface of other organelles or plasma membrane





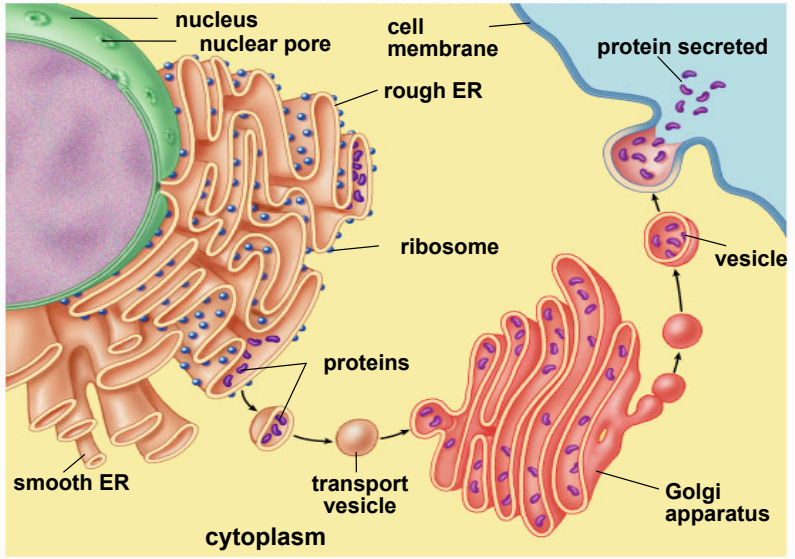
# Putting it together…




# Putting it together…

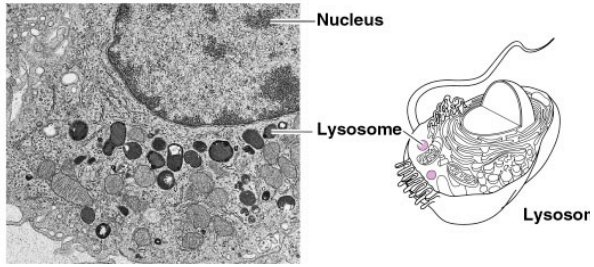
Making secretory or plasma membrane proteins



# Lysosomes - "digestive" organelles

- **Structure**
  - membrane-bounded sac of hydrolytic enzymes that digests macromolecules *(I.e. proteases, lipases, nucleases etc..)*
    - enzymes & membrane of lysosomes are synthesized by rough ER & transferred to the Golgi
      - Lysosome arises by budding of Golgi's trans face

Only found in animal cells

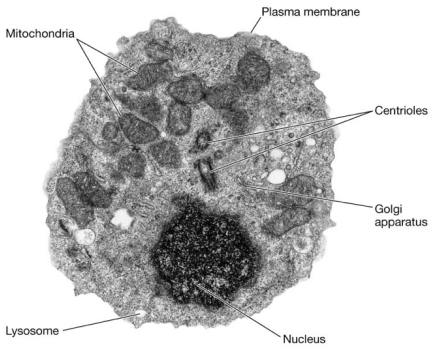




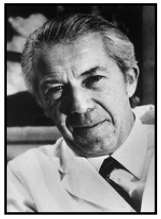

# Lysosomes

1960 | 1974

- **Function**
  - a little "stomach" for the cell
    - lyso– = breaking things apart
    - –some = body
  - they are the "clean up crew" of the cell




**Why was this discovery so important?**

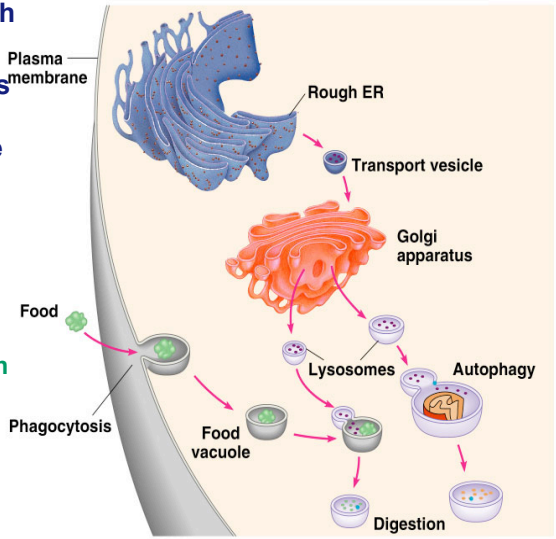


1974 Nobel prize: Christian de Duve
Lysosomes discovery in 1960s



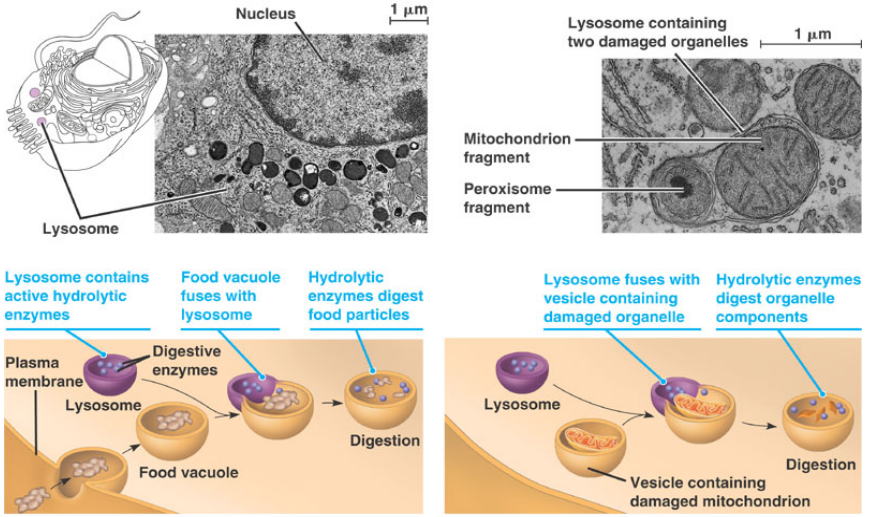
# Cellular digestion & recycling

- Lysosomes fuse with food vacuoles
- Fuse with organelles or macromolecules in cytosol to recycle materials
  - Polymers are digested (hydrolyzed - using water) into monomers
  - Monomers are then passed to cytosol to become nutrients of cell






# Phagocytosis versus Autophagy




(a) Phagocytosis: lysosome digesting food

(b) Autophagy: lysosome breaking down damaged organelle

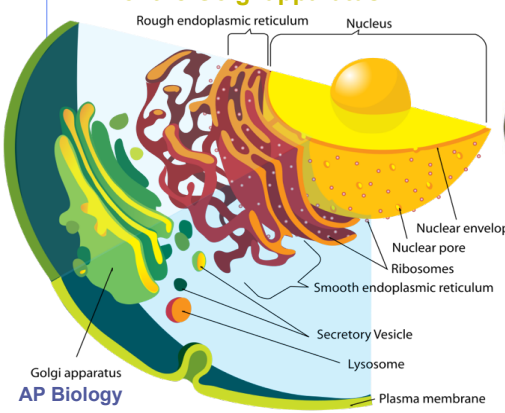
# Lysosomal enzymes

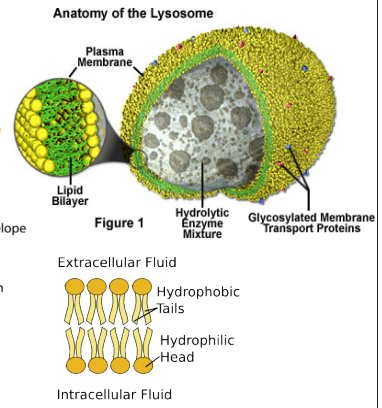
- **Lysosomal enzymes work best at pH 5**
  - organelle creates compartment with a custom pH, the optimal environment for the hydrolytic enzymes to have their most perfect shape and, therefore, work at their maximum rate of catalysis
    - Rupturing of many lysosomes can destroy a cell as H+ will leak into the cytoplasm and change the pH of the cytosol.
  - How does lysosome maintain low pH environment?
    - proteins in lysosomal membrane pump $H^+$ ions from the cytosol into lysosome to change internal pH
  - Why?
    - enzymes are very sensitive to pH and pH affects proper structure of digestive enzymes (proteins)
  - Why evolve digestive enzymes which function at pH different from cytosol?
    - Don't want to digest yourself! Want hydrolytic proteins only active where and when needed, but not when being made in the RER and Golgi.



# Lysosomes

- **Like any cellular membrane...lysosomal membranes are phospholipid bilayers.**
  - Remember too that lysosomes are made by the pinching off of the Golgi apparatus



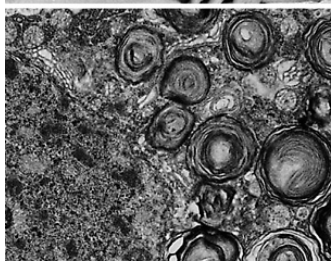






# When things go wrong…

Tay-Sachs

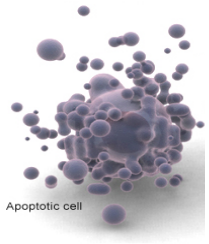
- **What if a lysosome digestive enzyme doesn't function?**
  - Cells can't digest biomolecules
    - instead biomolecules collect in lysosomes
    - lysosomes fill up with undigested material
  - lysosomes grow larger & larger
    - eventually disrupt cell & organ function
- **"Lysosomal storage diseases" are usually fatal**
  - Tay-Sachs disease
    - lipids build up in brain cells
    - child dies before age 5





# Apoptosis of a cell can be triggered by internal and external signals

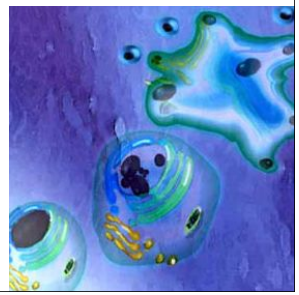
- **Apoptosis = programmed cell death**
  - plays a critical role in the adaptive, necessary destruction of cells in multi-cellular organisms
    - this is an auto-destruct mechanism cells can activate when necessary
      - Note: This is not the same as necrosis - death of a cell due to disease or damage)




- Feedback mechanism help regulate apoptosis
  - There are sensors in the cell that monitor growth & DNA damage.
  - These systems trigger self-destruction when they sense processes gone awry or when they receive a chemical message to do so during normal development or activity.

# Sometimes its supposed to work that way…

- some cells have to die in an organized fashion, especially during development
  - ex: development of space between your fingers during embryonic development
  - ex: if cell grows improperly this self-destruct mechanism is triggered to remove damaged cell
    - cancer over-rides this to enable tumor growth
  - ex: Brown spots on leaves too: Virus infected plant cell auto-destructs and even kills cells around it to wall off virus.

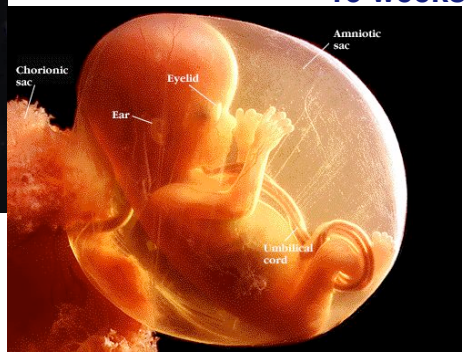




# Fetal development - *when apoptosis fails, digits remain fused*

**syndactyly**


**15 weeks**




**6 weeks**



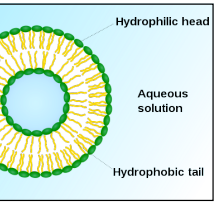
# Vesicles & vacuoles

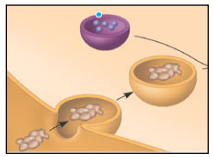
**Vesicle Function**

- little "transfer ships" for transport within the cell

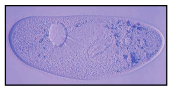
**Vacuoles Function** *[often larger than vesicles]*

- Food vacuoles
  - Created through phagocytosis. They fuse with lysosomes for digestion in certain protists and animal cells

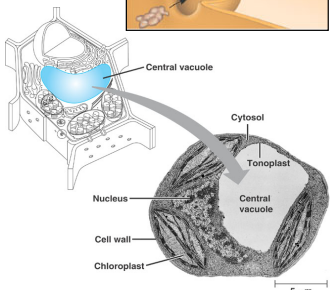


- Contractile vacuoles
  - in freshwater protists, pump excess $H_2O$ out of cell



- Central vacuoles
  - in many mature plant cells
  - Derived form ER and Golgi
  - Filled with cell sap which has a different functions

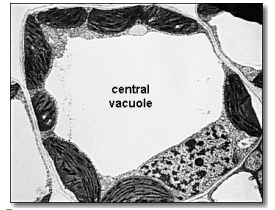


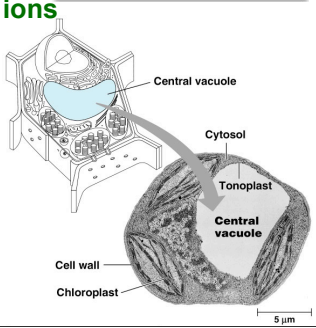



# The Central Vacuole in Plants

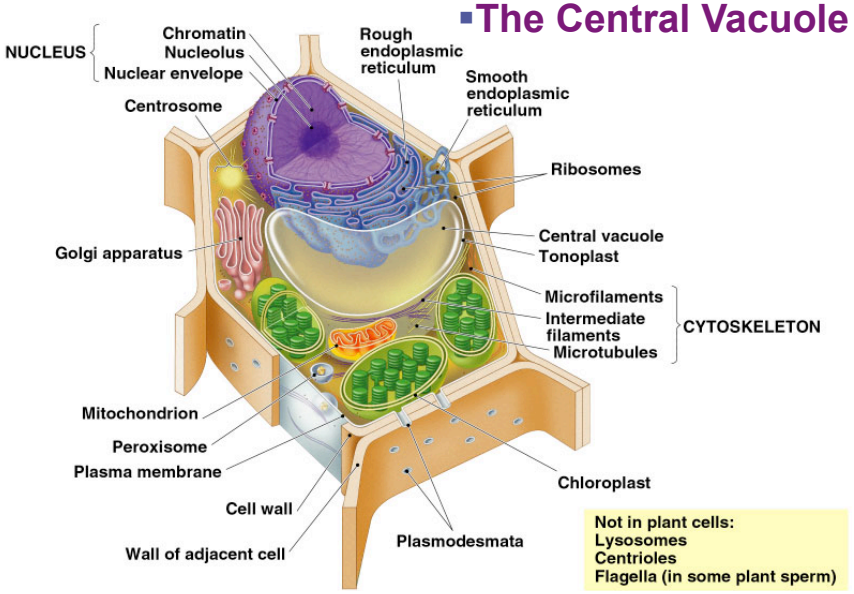
**Functions**

- Growth
  - Plays major role in plant cell growth when it absorbs water and expands
- Storage
  - stockpiling proteins or inorganic ions
  - depositing metabolic byproducts
  - storing pigments
  - storing defensive compounds against herbivores
  - selective membrane
    - control what comes in or goes out



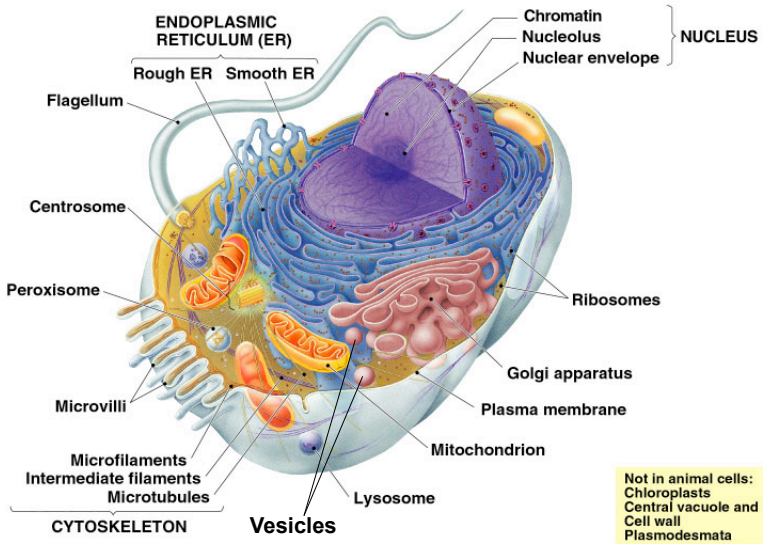



## The Central Vacuole



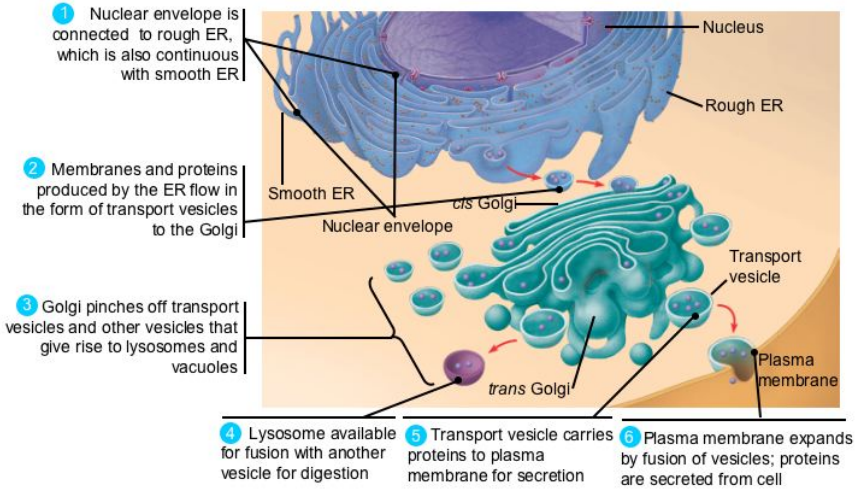

Not in plant cells:
Lysosomes
Centrioles
Flagella (in some plant sperm)

## Transport Vesicles

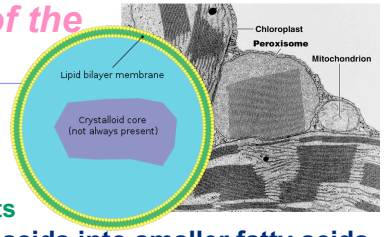



Not in animal cells:
Chloroplasts
Central vacuole and tonoplast
Cell wall
Plasmodesmata

## Putting it all together…




## Peroxisomes - *not part of the endomembrane system*




- **Digestive enzyme sacs**
  - **Bound by single phospholipid bilayer membrane**
    - **Found in both animals & plants**
  - **breakdown of long chain fatty acids into smaller fatty acids and small sugars through process called BETA OXIDATION**
    - **these small chain fatty acids and sugar are easier to transport & use as energy sources in the cells mitochondria**
  - **detoxify cell**
    - **also helps detoxify alcohol & other poisons in the liver**
  - **make specialized phospholipids for animal membranes**
  - **produce peroxide ($H_2O_2$) by transferring hydrogen from organic substances to $O_2$**
    - **Then they breakdown $2H_2O_2 \rightarrow 2H_2O + O_2$ with the help of Catalase enzyme since $H_2O_2$ is reactive/damaging to the cell**
  - **Split in two when they reach a certain size**