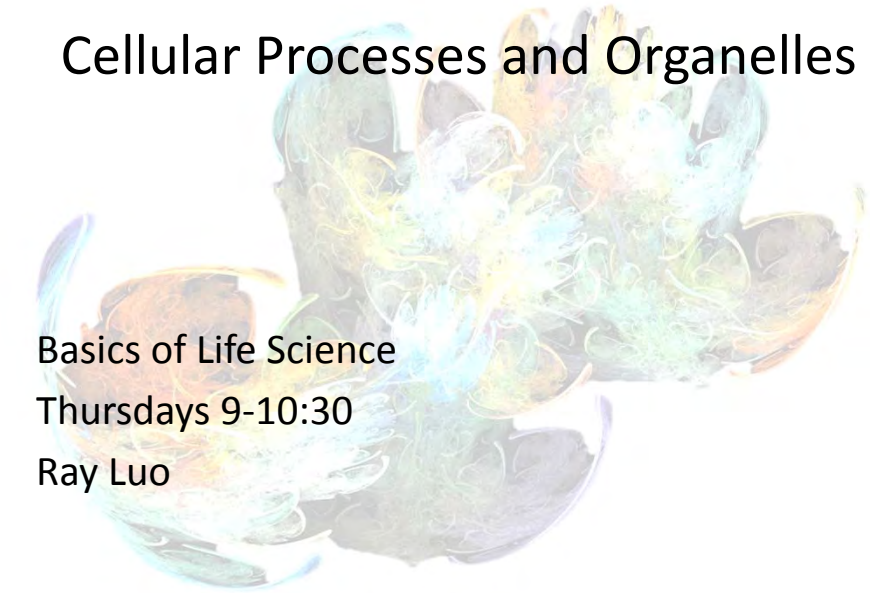
Cellular Processes and Organelles



Basics of Life Science

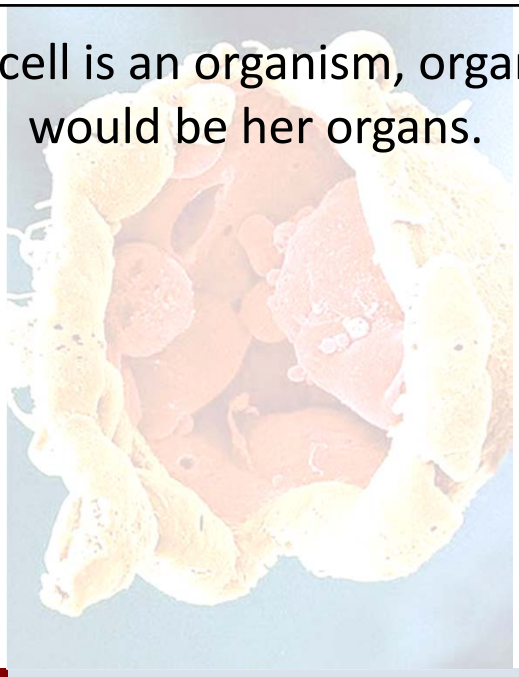
Thursdays 9-10:30

Ray Luo

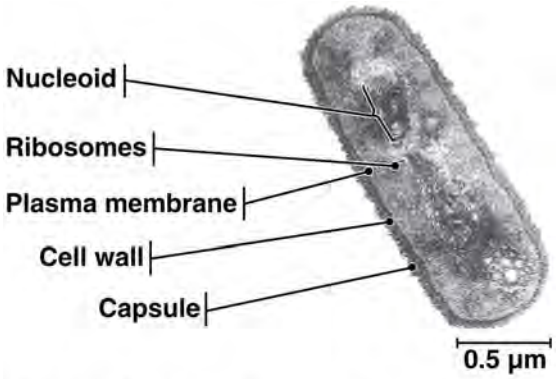
Helpful resources for learning the biology in this class.

- Campbell, Biology (8th ed or after, 10th is best), Pearson (hint: google "campbell biology 10th edition online")
- Free online books on pubmed bookshelf:
  Molecular Biology:
  http://www.ncbi.nlm.nih.gov/books/NBK21475/
  Neuroscience:
  http://www.ncbi.nlm.nih.gov/books/NBK10799/
- Online biology textbook:
  http://www2.estrellamountain.edu/faculty/farabee/biobk/biobooktoc.html

If the cell is an organism, organelles would be her organs.

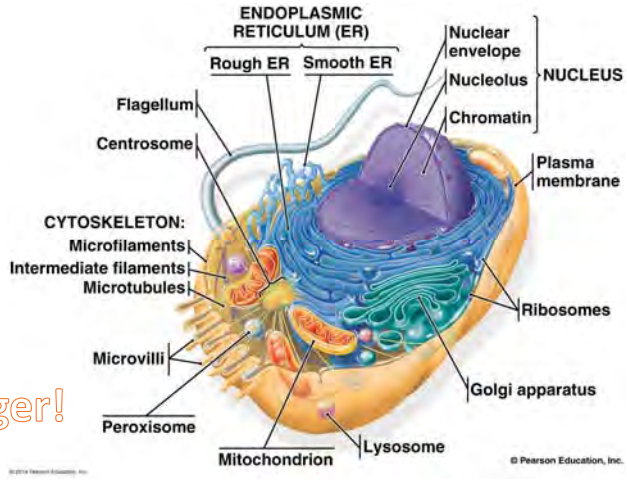


Prokaryotic DNA is found in nucleoid and free of internal membranes.



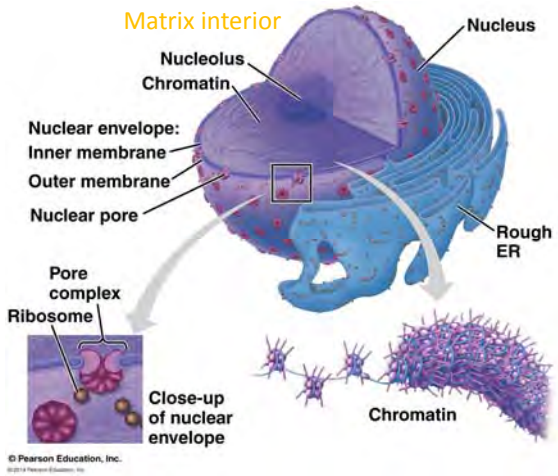
(b) A thin section through the bacterium *Bacillus coagulans* (TEM)

Eukaryotic cells carry genetic info encoded in genes in the **nucleus**.



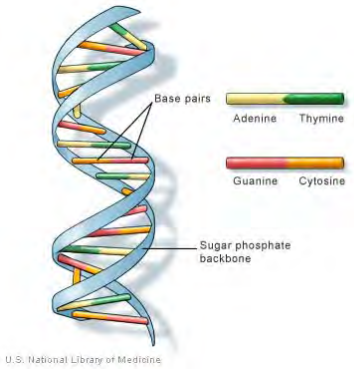
Bigger!

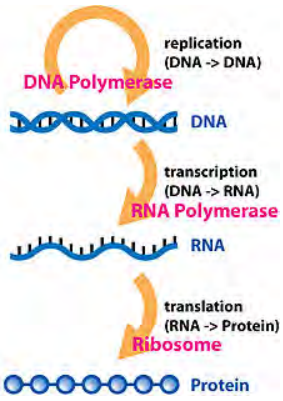
The nuclear envelope controls access to the eukaryotic nucleus.



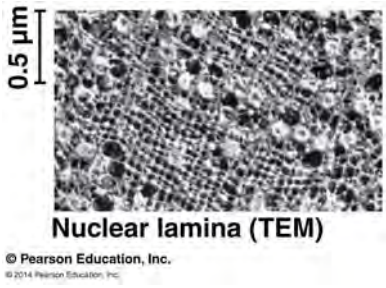
The flow of genetic information goes from DNA to RNA to protein.

One dog to rule them all: the Central Dogma.

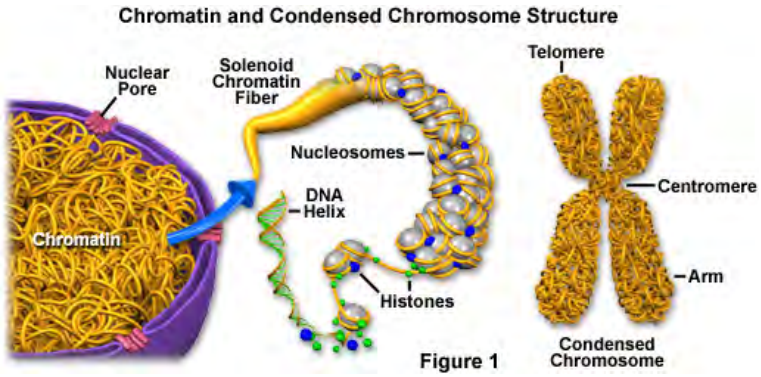




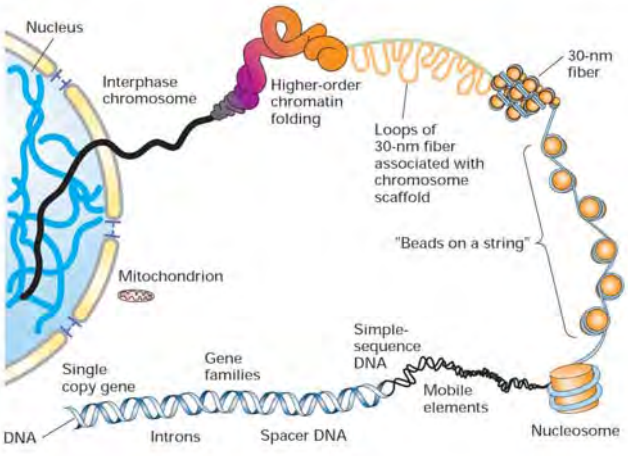
Pore complex regulates RNA traffic; nuclear lamina provides structure.



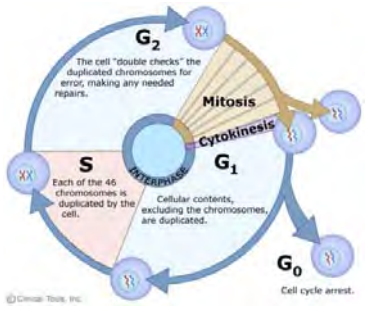
Nuclear DNA is bundled into chromosome in chromatin complexes.



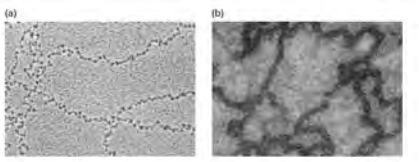
DNA is a single strand complexed to histone proteins, mostly noncoding.



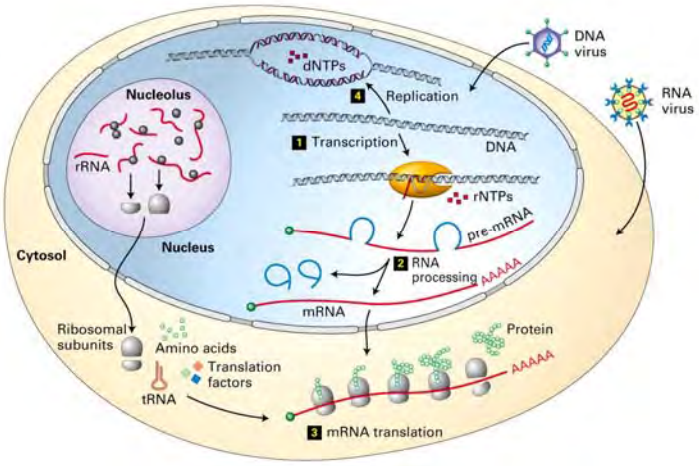
Chromatin appearance depends on specific phase of the cell cycle.



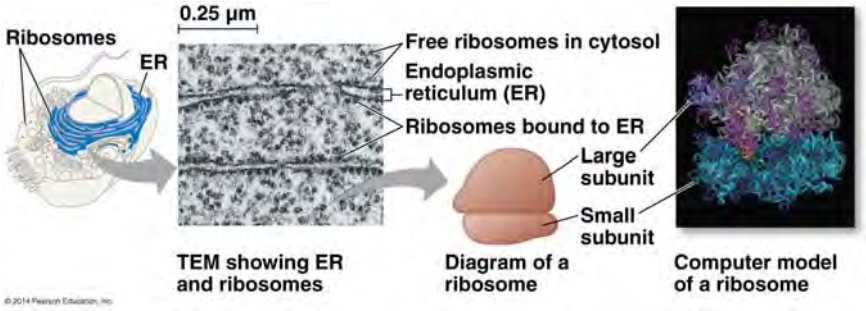
Histone tail modification.



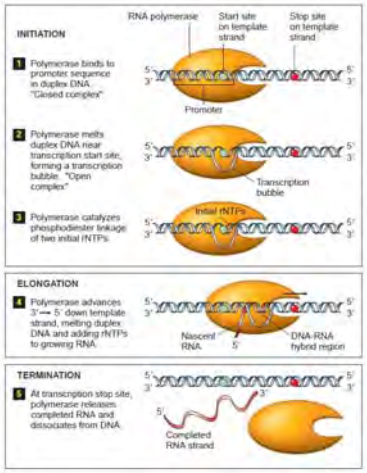
The nucleolus is the site of rRNA synthesis and ribosome assembly.



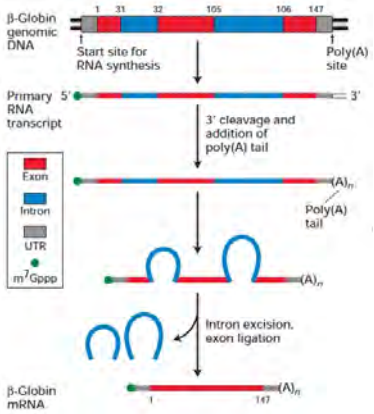
Bound and free **ribosomes** make membrane and cytosolic proteins



DNA is transcribed into a RNA by RNA polymerase.

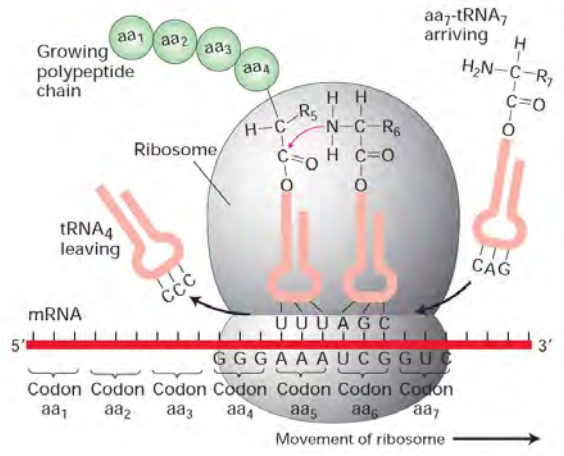


Transcribed RNA processed into mRNA by 5’ cap, poly A tail, and splicing.

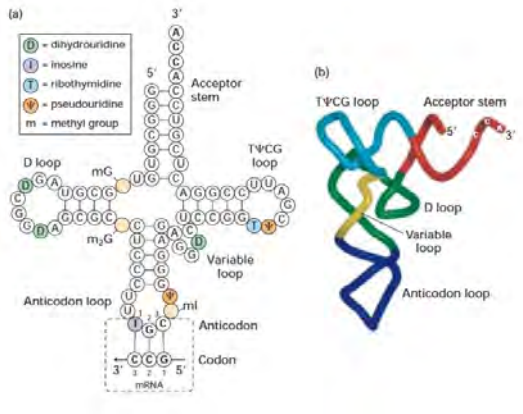


No synthesis going on.

tRNA and rRNA participate in translation of mRNA into protein.



tRNA reads the codon on mRNA and presents the appropriate amino acid.

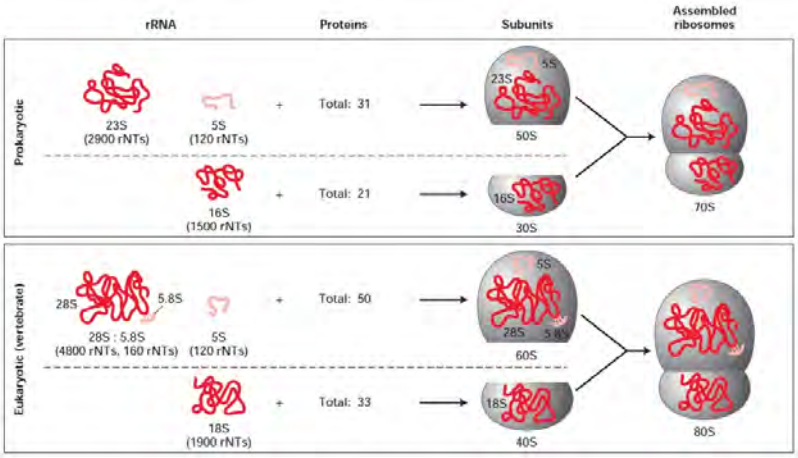


Codons on mRNA are read out as part of the genetic code.

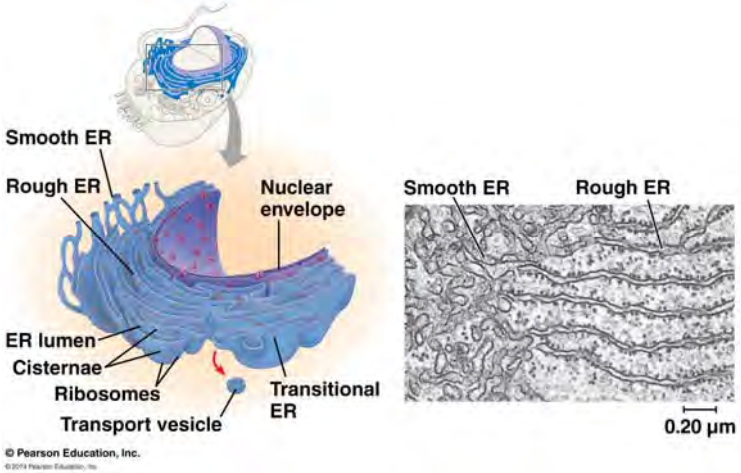
Second letter

First letter	U	C	A	G	Third letter
U	UUU Phe, UUC Phe	UCU Ser, UCC Ser, UCA Ser, UCG Ser	UAU Tyr, UAC Tyr	UGU Cys, UGC Cys	U
	UUA Leu, UUG Leu		UAA Stop, UAG Stop	UGA Stop, UGG Trp	C, A, G
C	CUU Leu, CUC Leu, CUA Leu, CUG Leu	CCU Pro, CCC Pro, CCA Pro, CCG Pro	CAU His, CAC His, CAA Gln, CAG Gln	CGU Arg, CGC Arg, CGA Arg, CGG Arg	U, C, A, G
A	AUU Ile, AUC Ile, AUA Ile	ACU Thr, ACC Thr, ACA Thr, ACG Thr	AAU Asn, AAC Asn, AAA Lys, AAG Lys	AGU Ser, AGC Ser, AGA Arg, AGG Arg	U, C, A, G
	AUG Met				
G	GUU Val, GUC Val, GUA Val, GUG Val	GCU Ala, GCC Ala, GCA Ala, GCG Ala	GAU Asp, GAC Asp, GAA Glu, GAG Glu	GGU Gly, GGC Gly, GGA Gly, GGG Gly	U, C, A, G

Prokaryotic and eukaryotic ribosomes contain different sized subunits.



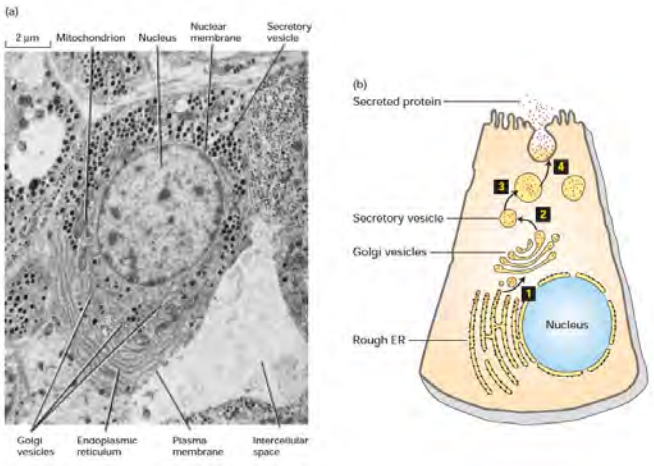
The **endoplasmic reticulum** is a metabolic membrane complex.



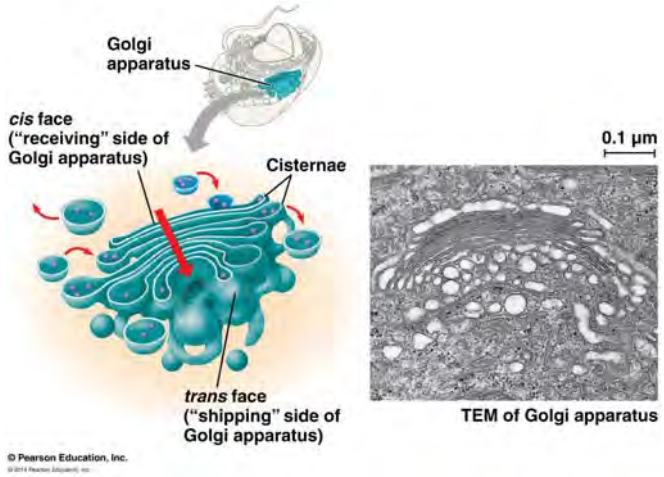
ER lumen (inner folds) emanate from inner side of the nuclear envelope.

- *Smooth* ER lacks ribosomes
  - Making lipids (membrane) and steroids.
  - Detoxification (adding OH to make soluble).
  - Sarcoplasmic reticulum calcium accumulation.
- *Rough* ER produces proteins via ribosomes.
  - Polypeptides fold into proteins in the lumen.
  - Vesicles containing proteins bud off.
  - Make phospholipids from cytosolic precursor.

Hormone secreting cells are abundant in rough ER, from which vesicles bud.



The **Golgi apparatus** is a cellular post office addressing system.

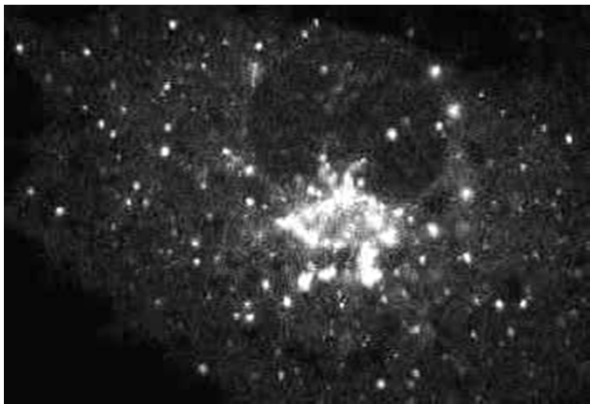


Stacks of the Golgi called cisternae receive transport from the ER

- *Cis* side of Golgi receives cargo from ER.
- *Trans* side of Golgi buds off transport vesicles.
- Golgi is a dynamic cargo modification system.
  - Modifying carbohydrates.
  - Molecular tagging (phosphates).
  - Membrane substrates for destination receptors.
- Exocytosis: send stuff outside the cell, ER to Golgi to vesicles

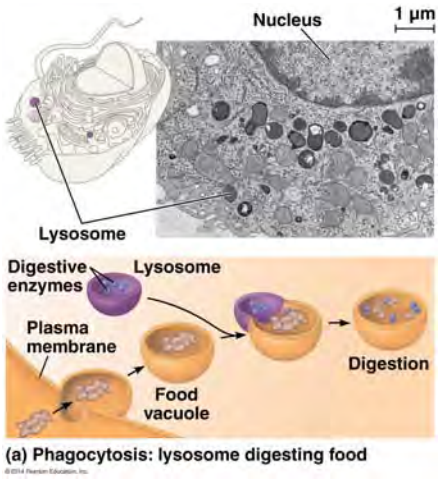
Transport vesicles come in from the cis side, exit from trans side of Golgi.

ER to Golgi transport can be observed by fluorescence labeling.

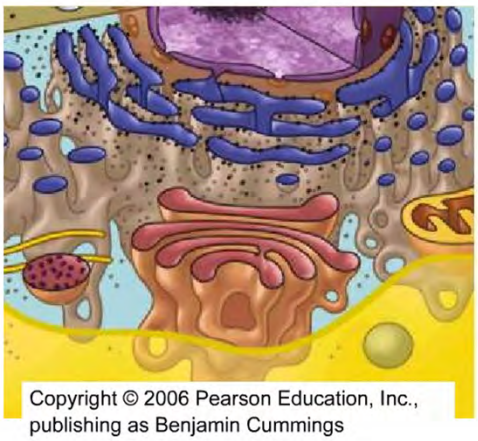


Lysosomes hydrolyzes macromolecules in an acidic environment.

Found only in animal cells, not plants



Formation of the lysosome from rough ER onto Golgi.



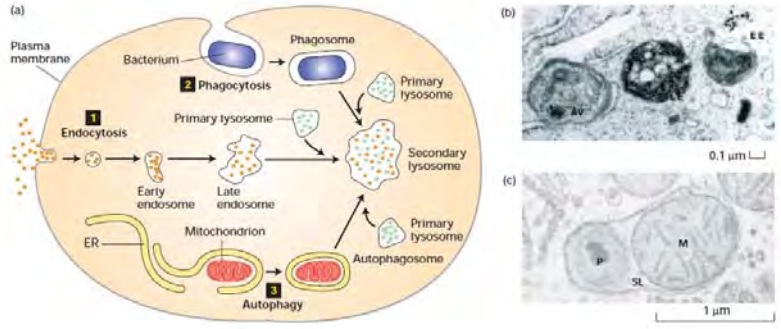
Phagocytosis and autophagy present materials for lysosomes.

- Lysosomal enzymes tend NOT to work at pH 7.
- Lysosomal inner membrane protein shape.
- Phagocytosis takes in food, organisms.
  - Food vacuole fusing with lysosome.
  - Human example: macrophages.
- Autophagy recycles cell's own materials.
  - Lysosome fuses with damaged organelle material.
  - Organic compounds diffuse into cytosol.
- Tay-Sachs disease: enzyme def, lipid accumulate.

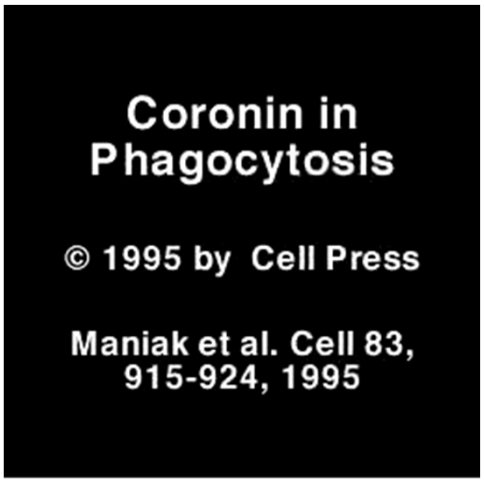
Endosomes form from clathrin mediated invagination.

- Endosomes take up materials for lysosomes.
- Plasma membrane becomes "coated pit."
- Lysosomes only in animal cells, contain acid hydrolases.
- Primary lysosomes not particulate.
- Secondary lysosomes irregularly shaped, larger, contain particles being digested.

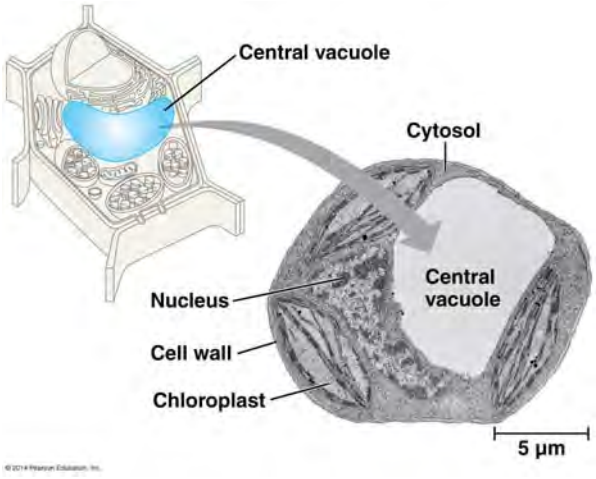
Role of Endocytosis, phagocytosis, and autophagy in working with lysosomes.



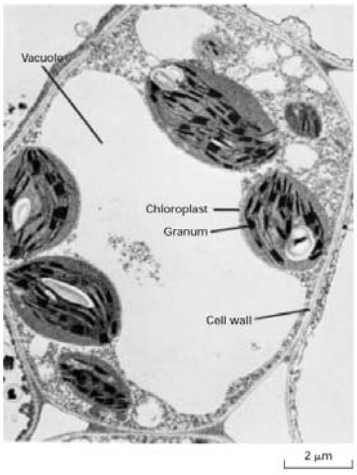
GFP expressing Dictyostellium cell consuming yeast cells (phagocytosis).



Plant **vacuoles** store ions, degrade debris, allow water entry.



High solute concentration - water enter vacuoles by osmotic pressure.



Turgor pressure inside,
Strong cellulose.

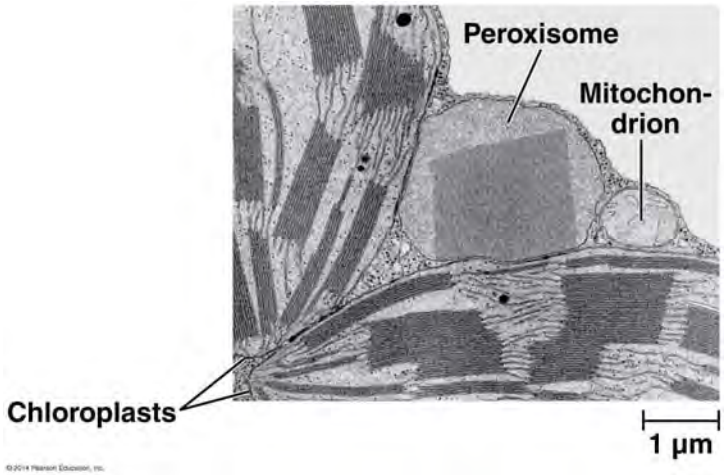
Other vacuoles:
Food vacuoles,
Contractile vacuoles,
Pigment vacuoles.

Peroxisomes use oxidases to oxidize organic substances.

- Oxygen to hydrogen to produce hydrogen peroxide, which is often converted to water.
- Single membrane.
- Break down fatty acids for energy (and heat).
- Detoxify ethanol (by removing hydrogens).
- Called glyoxysomes in plants, which convert stored fatty acids to sugar.
- ADL (X-linked adrenoleukodystrophy) mid child.

Fixing the toxicity by catalases:

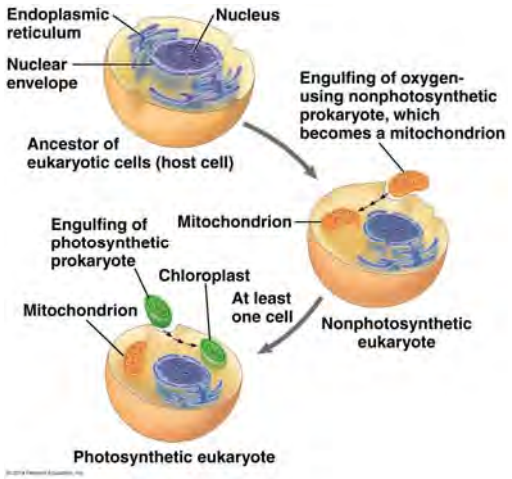
$2H_2O_2 \rightarrow 2H_2O + O_2$



Team activity: answer these questions in teams of 3 or 4 (and justify):

- 1. Enzymes responsible for biosynthesis of membrane lipids are located in what part of an animal cell?
  - A. endoplasmic reticulum
  - B. Nucleus
  - C. Lysosomes
  - D. Golgi
  - E. plasma membrane
- 2. A eukaryotic cell carries out phagocytosis and engulfs a bacterial cell, which ends up in the resulting food vacuole. To go from the cytosol of this bacterial cell to outside of the eukaryotic cell that has taken it in, what is the least number of biological membranes that would have to be crossed?
  - A. 1
  - B. 2
  - C. 3
  - D. 4
  - E. 5
- 3. What is the correct order of the exocytosis or secretion pathway?
  - A. rough ER, endosome, Golgi, smooth ER
  - B. rough ER, Golgi, smooth ER, plasma membrane
  - C. smooth ER, rough ER, exocytosis, Golgi
  - D. rough ER, Golgi, transport vesicle, plasma membrane
  - E. rough ER, Golgi, endosome, plasma membrane, transport vesicle
- 4. What is the correct sequence of processes of genetic information flow from DNA to proteins in cells?
  - A) translation to replication to transcription
  - B) replication to transcription to translation
  - C) transcription to replication
  - D) translation to transcription

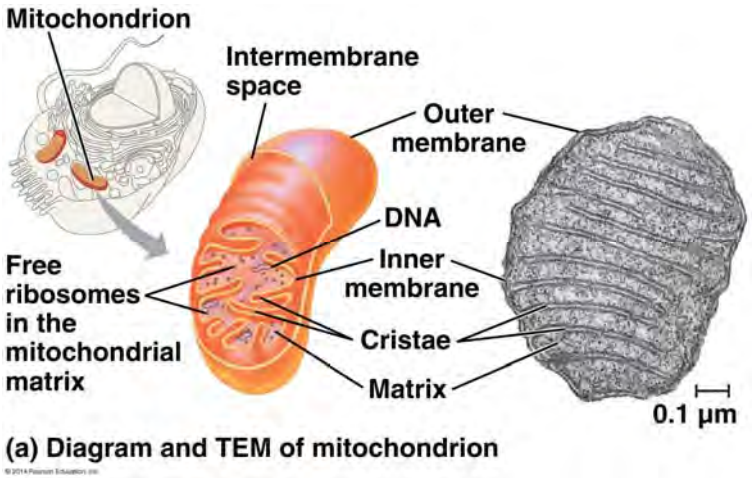
Endosymbiosis theory for mitochondria and chloroplasts.



Endosymbiosis theory evidence for evolutionary origin.

- Mitochondria and chloroplasts are double membraned unlike other organelles.
- Contain its own circular DNA and ribosomes.
- Reproduce within the cell by binary fission.
- If removed, cells cannot make new ones.
- Enzymes and machinery of mitochondria and chloroplasts resemble bacteria and cyanobac.

Mitochondria are energy power houses of the cell.

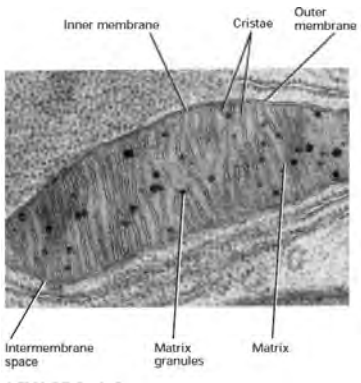


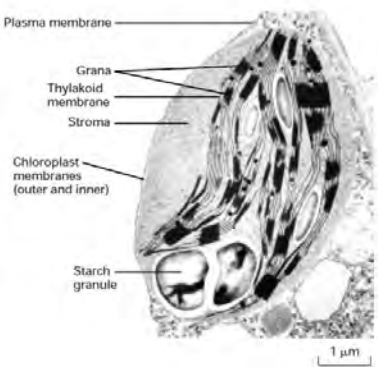
(a) Diagram and TEM of mitochondrion

$C_6H_{12}O_6 + 6O_2$ ---> $6CO_2 + 6H_2O$ + Energy

- Inner membrane contain convoluted foldings called cristae enclosing the matrix.
- Foldings give large inner surface area for membrane proteins in cellular respiration.
- Outer membrane contains porins that allow large macromolecules to enter and leave.
- Couple glucose degradation (producing CO_2 and H_2O) to ATP generation (28).

Chloroplasts and mitochondria have the same evolutionary origin?





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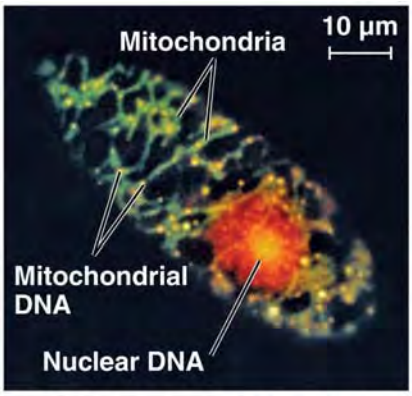
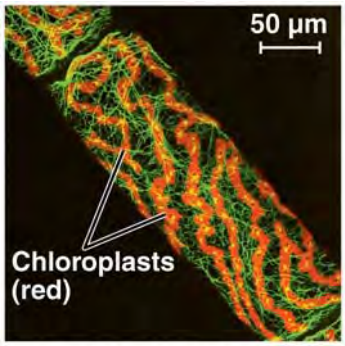


(b) Network of mitochondria in *Euglena* (LM)



(b) Chloroplasts in an algal cell