

Cellular Processes and Organelles

Basics of Life Science

Thursdays 9-10:30

Ray Luo

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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>

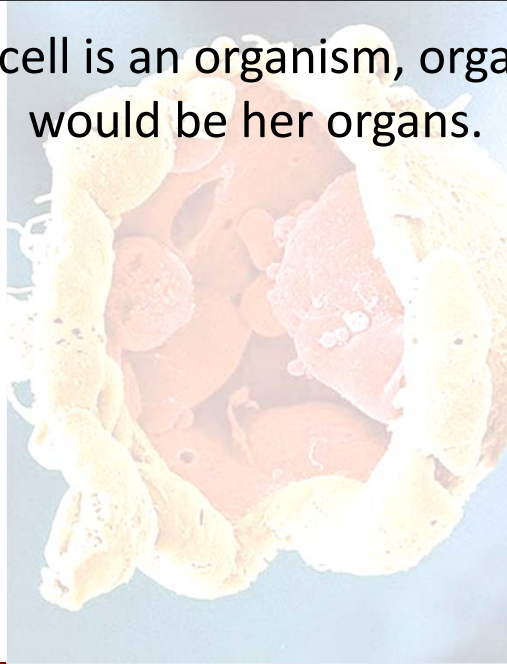
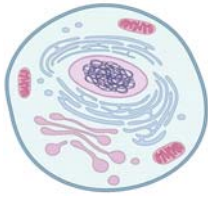
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If the cell is an organism, organelles would be her organs.



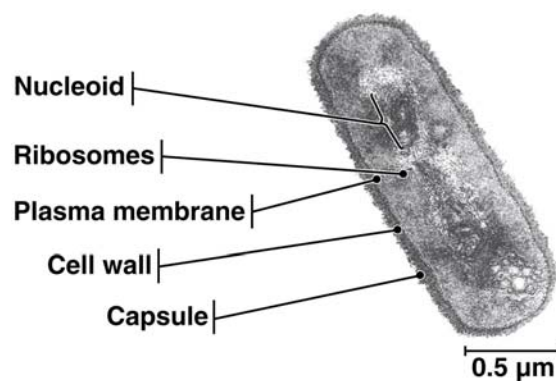
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Prokaryotic DNA is found in nucleoid and free of internal membranes.



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

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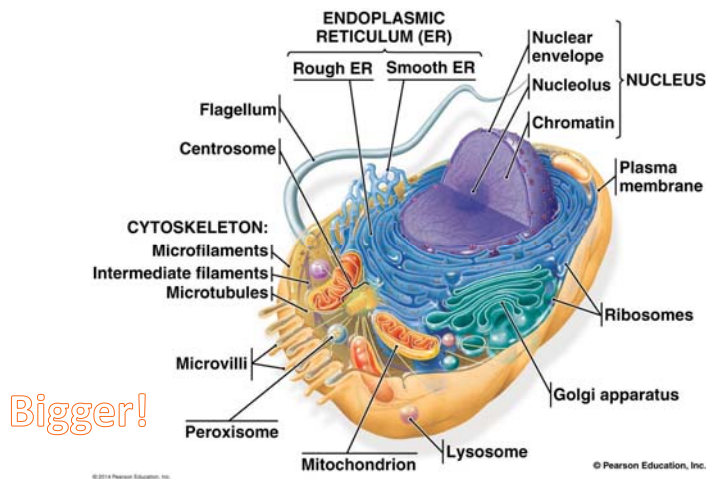
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Eukaryotic cells carry genetic info encoded in genes in the **nucleus**.

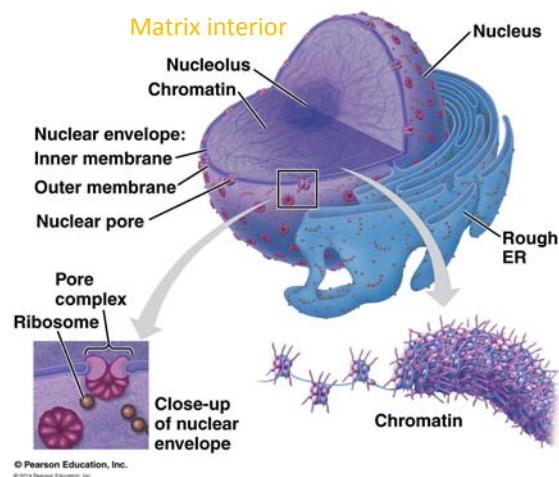


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The nuclear envelope controls access to the eukaryotic nucleus.



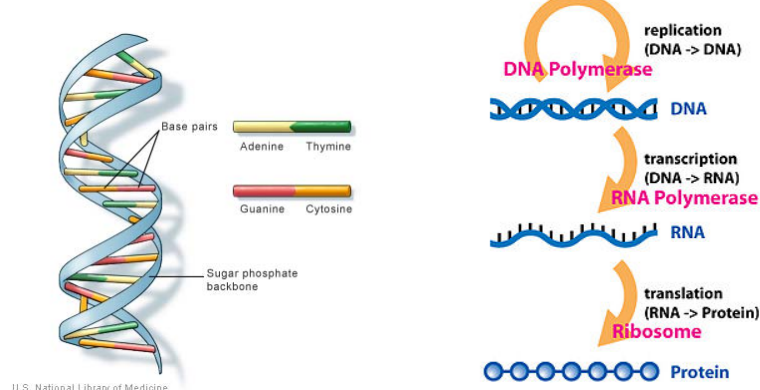
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The flow of genetic information goes from DNA to RNA to protein.

One dog to rule them all: the Central Dogma.



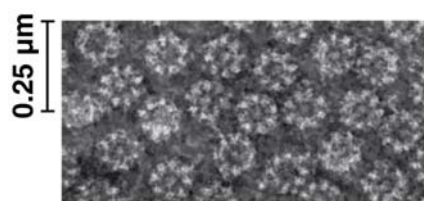
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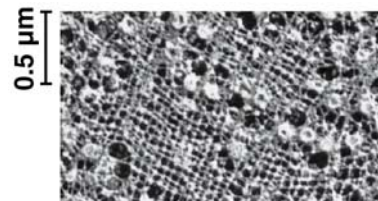


Pore complex regulates RNA traffic; nuclear lamina provides structure.



Pore complexes (TEM)

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Nuclear lamina (TEM)

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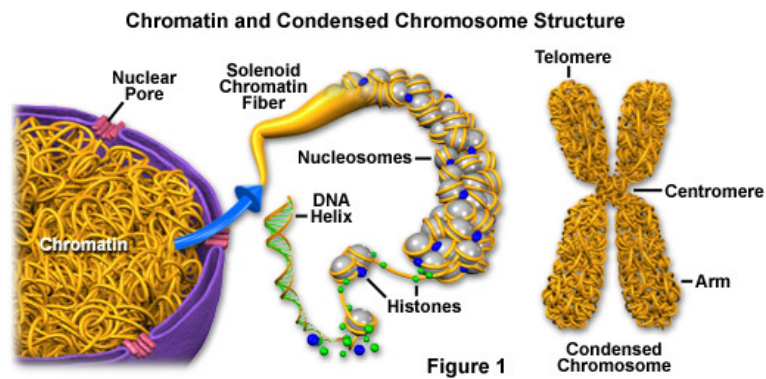
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Nuclear DNA is bundled into chromosome in chromatin complexes.



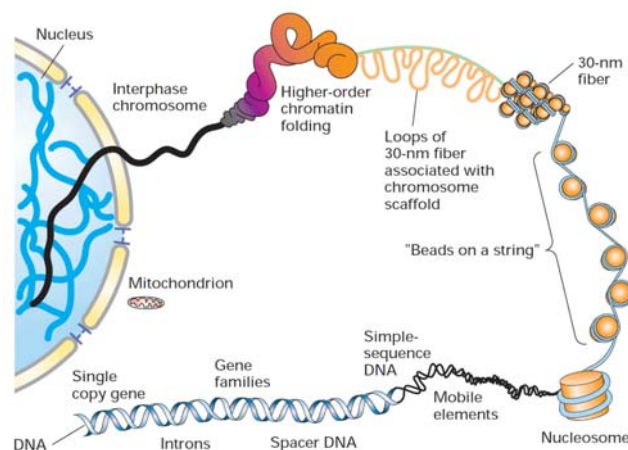
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DNA is a single strand complexed to histone proteins, mostly noncoding.



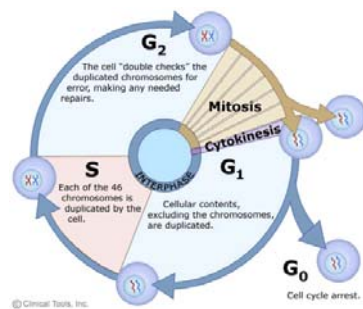
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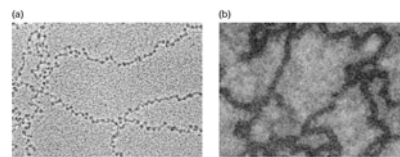
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Chromatin appearance depends on specific phase of the cell cycle.



Histone tail modification.

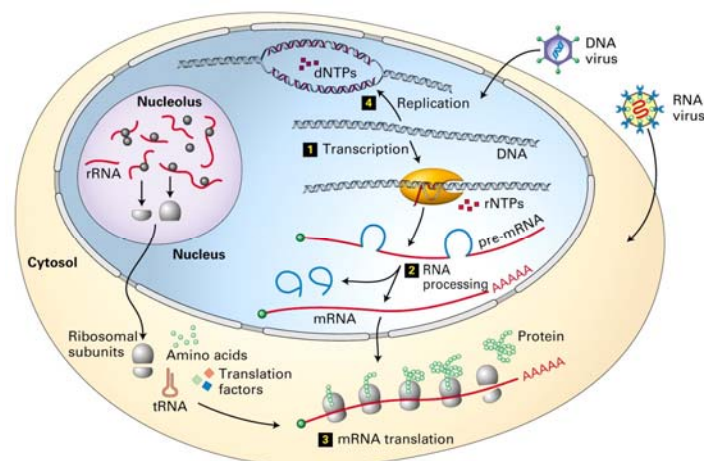


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The nucleolus is the site of rRNA synthesis and ribosome assembly.

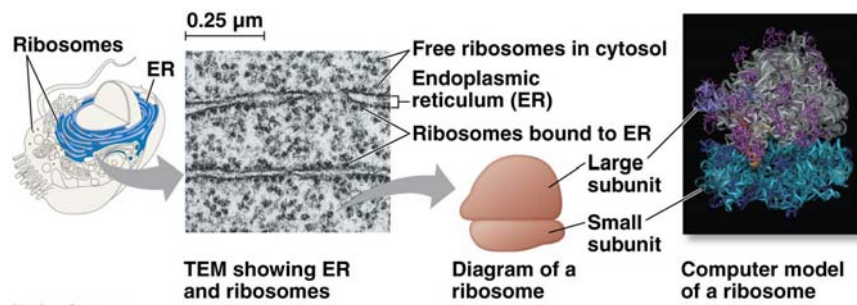


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Bound and free **ribosomes** make membrane and cytosolic proteins

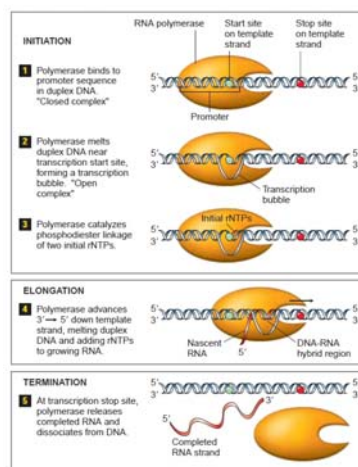


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DNA is transcribed into a RNA by RNA polymerase.

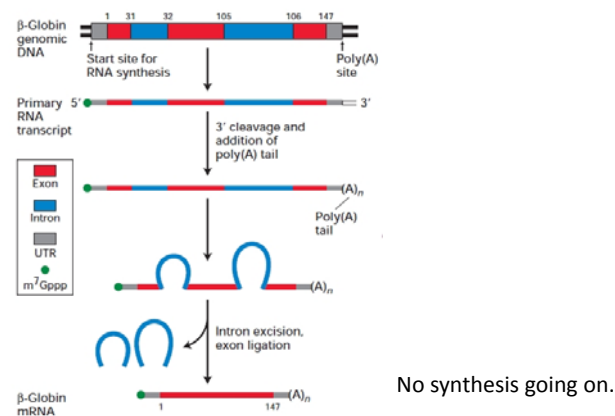


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Transcribed RNA processed into mRNA
by 5' cap, poly A tail, and splicing.



No synthesis going on.

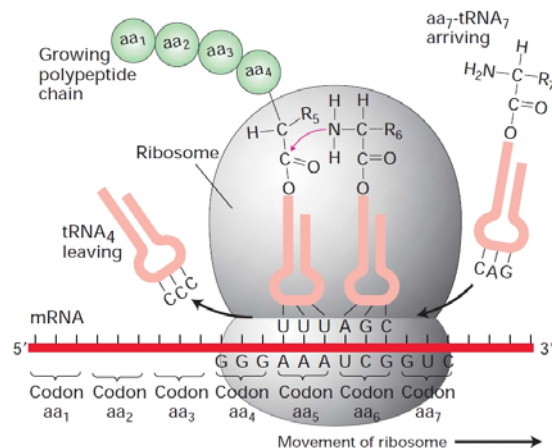
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tRNA and rRNA participate in translation of mRNA into protein.



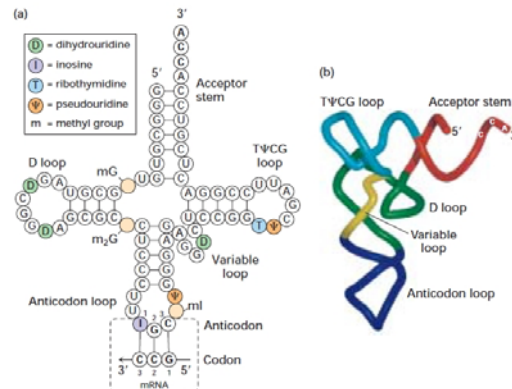
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tRNA reads the codon on mRNA and presents the appropriate amino acid.



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

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

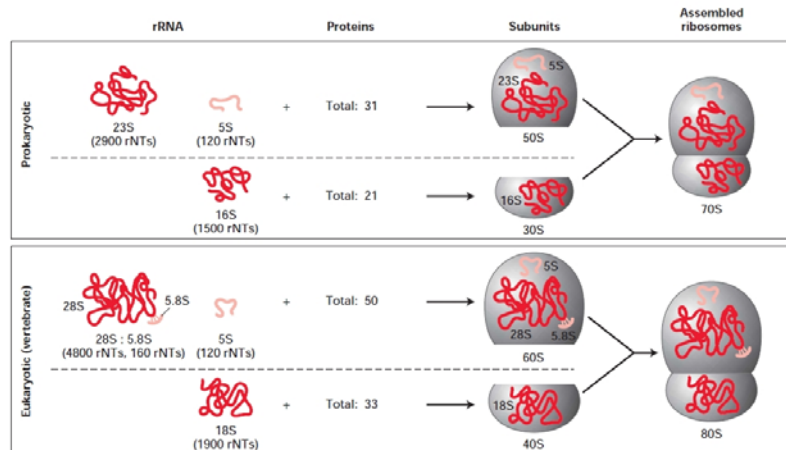
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Prokaryotic and eukaryotic ribosomes contain different sized subunits.



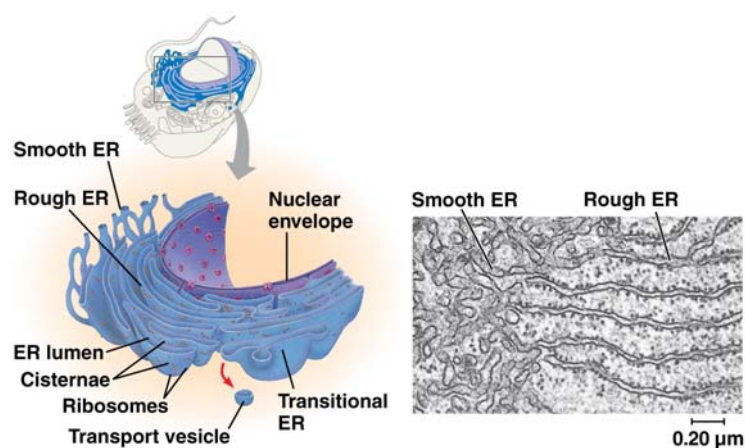
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The endoplasmic reticulum is a metabolic membrane complex.

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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.

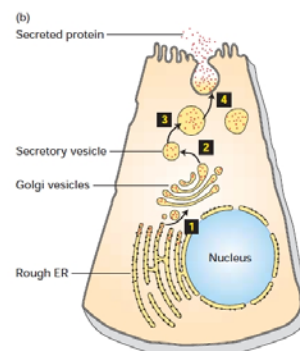
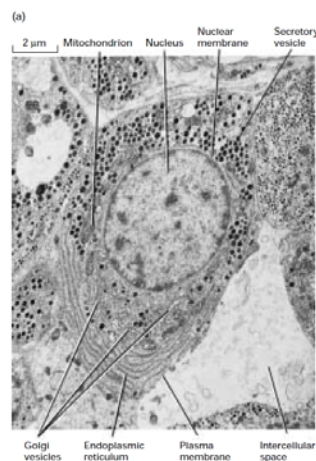
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Hormone secreting cells are abundant in rough ER, from which vesicles bud.



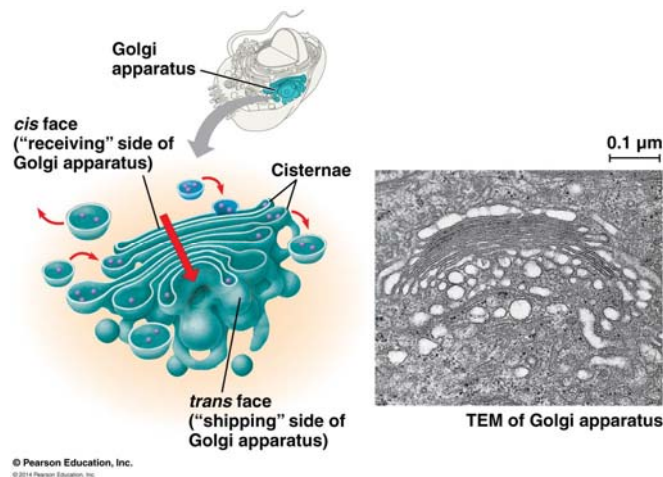
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The **Golgi apparatus** is a cellular post office addressing system.



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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

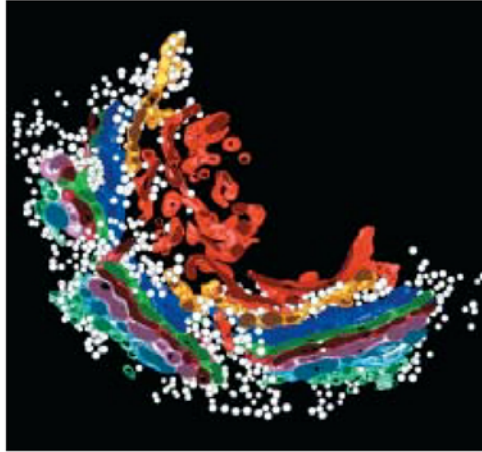
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Transport vesicles come in from the cis side, exit from trans side of Golgi.



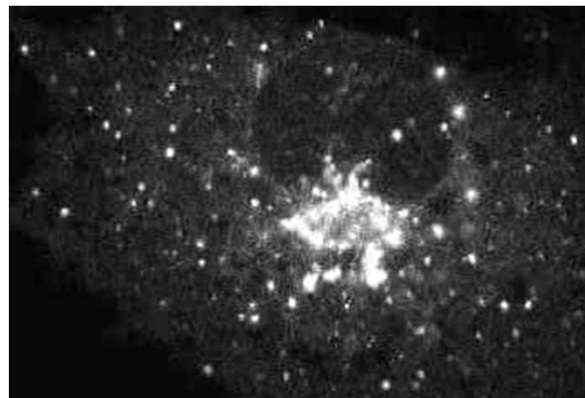
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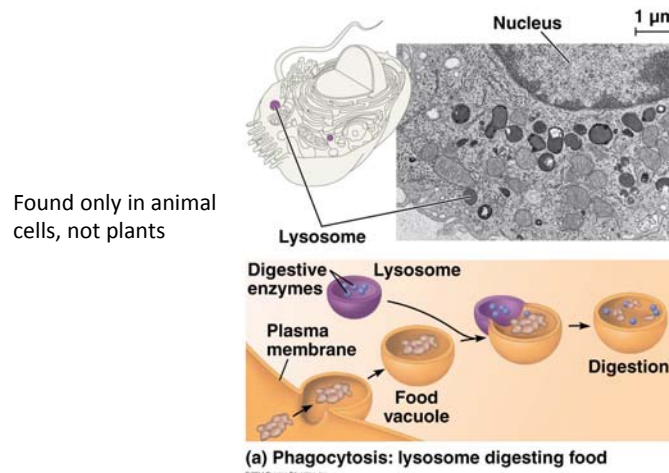
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ER to Golgi transport can be observed by fluorescence labeling.



Lysosomes hydrolyzes macromolecules
in an acidic environment.



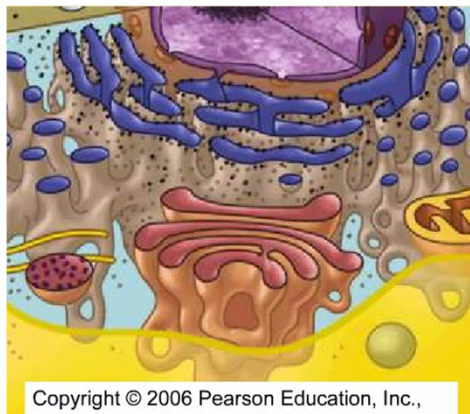
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Formation of the lysosome from rough
ER onto Golgi.



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.

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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.

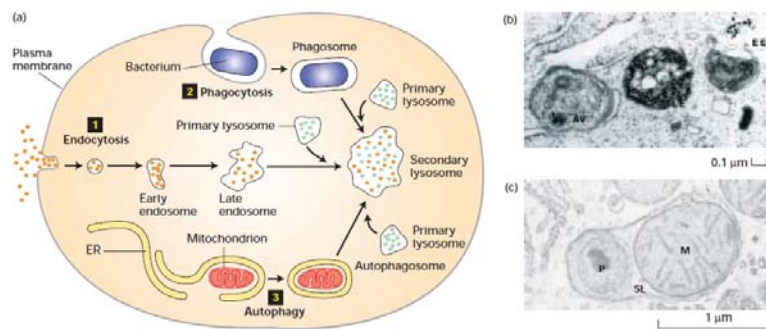
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Role of Endocytosis, phagocytosis, and autophagy in working with lysosomes.



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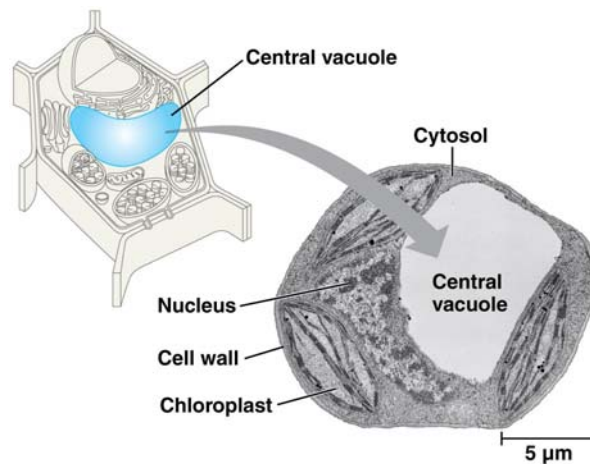
GFP expressing Dictyostellium cell
consuming yeast cells (phagocytosis).

Coronin in Phagocytosis

© 1995 by Cell Press

Maniak et al. Cell 83,
915-924, 1995

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



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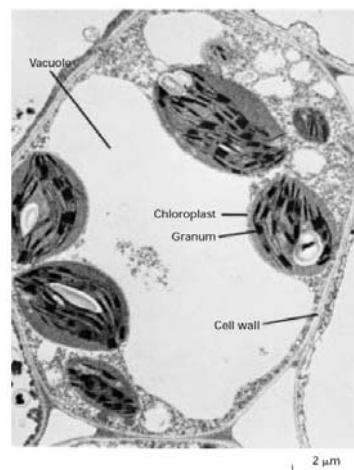
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High solute concentration - water enter vacuoles by osmotic pressure.



Turgor pressure inside,
Strong cellulose.

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

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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.

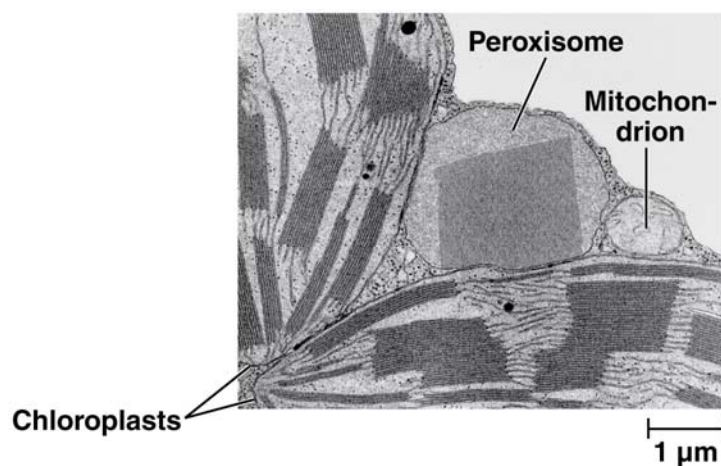
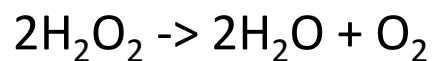
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Fixing the toxicity by catalases:



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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

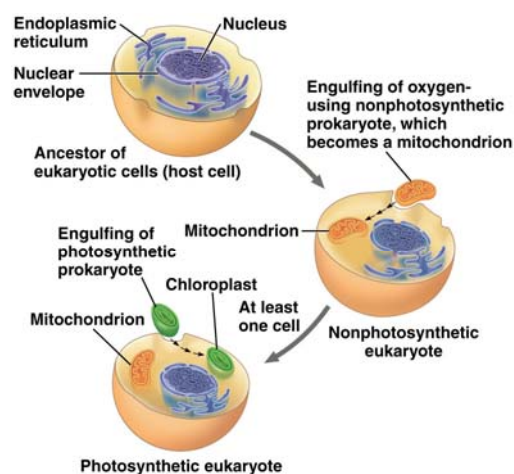
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Endosymbiosis theory for mitochondria and chloroplasts.



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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.

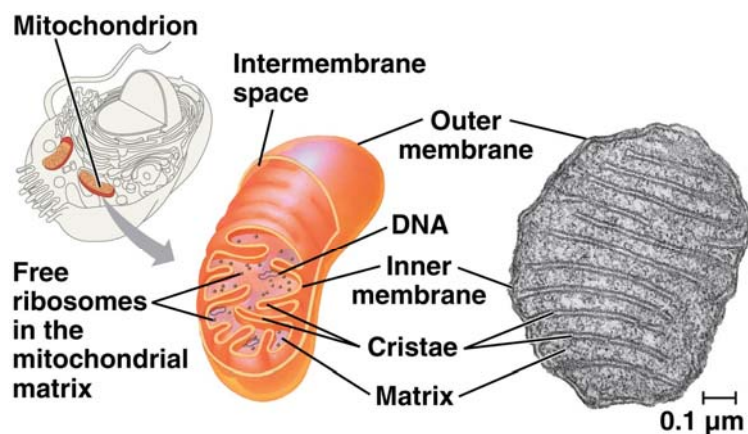
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Mitochondria are energy power houses of the cell.



(a) Diagram and TEM of mitochondrion

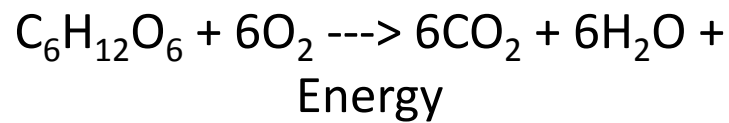
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- Inner membrane contain convoluted foldings called cristae enclosing the matrix.
- Foldings give large inner surface area for membrane proteins in cellular respiration.
- Outer membrane contains porins that allow large macromolecules to enter and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

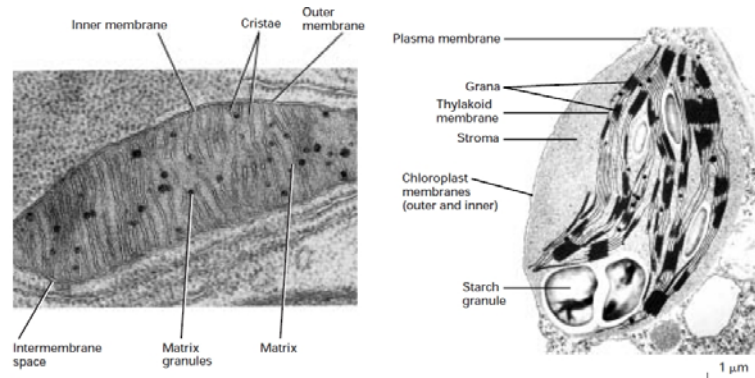
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Chloroplasts and mitochondria have the same evolutionary origin?



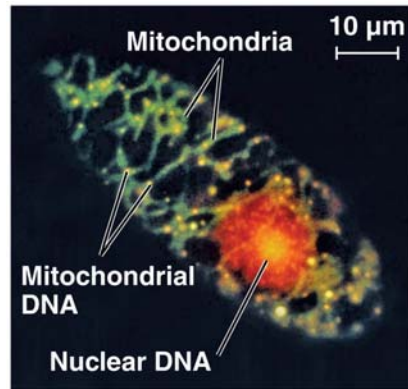
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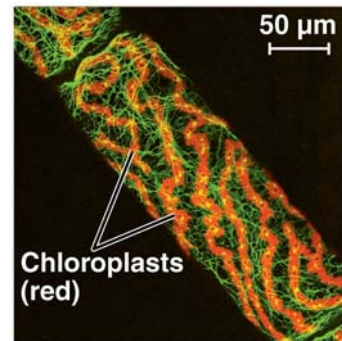


Chloroplasts and mitochondria have the same evolutionary origin?



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

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(b) Chloroplasts in an algal cell

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