

Cell

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E Navarro
P Fernández de Córdoba
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-
- Cell
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 - causes
 - classical cell theory
 - modern cell theory
 - Basic elements
 - life chemistry
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 - nucleic acids
 - amino acids
 - carbohydrates
 - Cell as automaton
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 - cytoskeleton
 - nucleus
 - endoplasmic reticulum
 - mitochondrion
 - chloroplast
 - Golgi apparatus
 - Prokaryote
 - Gram +
 - Gram –
 - bacterial movement
 - Macrophage vs bacterium
 - Metabolism
 - Glycolysis
 - TCA cycle
 - Electron transport chain

○ definition:

- *what is a cell?*



Robert Hooke

Cell



Micrographia, 1665

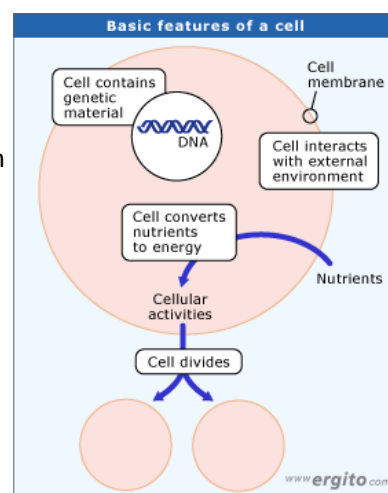
Causes

○ Formal cause: *what makes it a cell?*

- wall that separates from surroundings
- replication → genetic material
- flow of materials
- holds the structure of the wall of the cell → cytoskeleton

adapted from Cornish-Bowden, *et al.*
Proteomics (2007)

Cell



Causes

- Material cause: *what is a cell made of?*
 - phospholipids → lipids
 - nucleic acids → DNA, RNA
 - amino acids → proteins
 - metabolites → carbohydrates, ATP, NADH, NADPH, FADH₂

Cell

Causes

- Efficient cause: *what agent makes a cell?*
- Final cause: *what is a cell made for?*

Teologism? Sophism?

Cell



Classical Cell Theory (1840-60)

- Who? Schleiden, Schwann, Virchow
- All organisms are made up of one or more cells
- Cells are the basic unit of life and structure
- All cells come from pre-existing cells
 - *Omnis cellula e cellula*

Cell



Modern cell theory

- The cell is the fundamental unit of structure and function in living things
- All cells come from pre-existing cells by division
- Energy flow (metabolism) occurs within cells
- Cells contain hereditary information which is passed from cell to cell during cell division
- All cells are basically the same in chemical composition
- All known living things are made up of cells
- Some organisms are unicellular, made up of only one cell; others are multicellular, composed of countless number of cells
- The activity of an organism depends on the total activity of independent cells

Wikipedia: Cell theory

Cell



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Cell

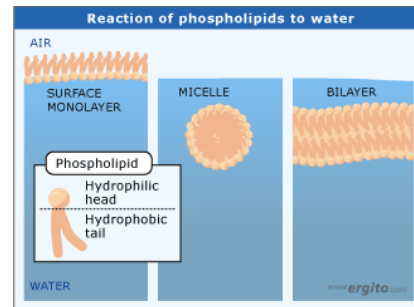
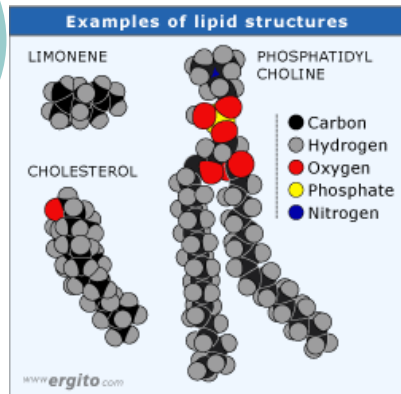


Basic elements

- Lipids
 - membranes
- Nucleic acids
 - DNA
 - RNA
- Amino acids
 - proteins
- Carbohydrates or saccharides
 - metabolites

Cell

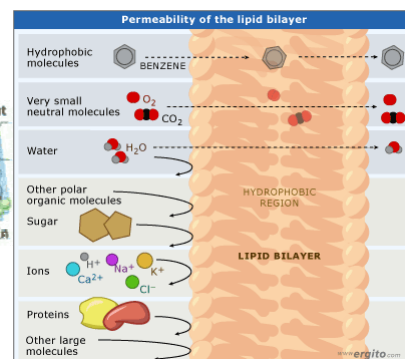
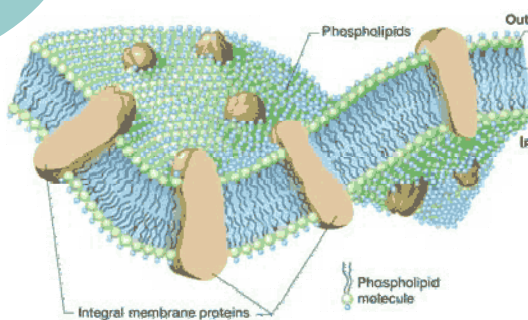
Lipids



Cell

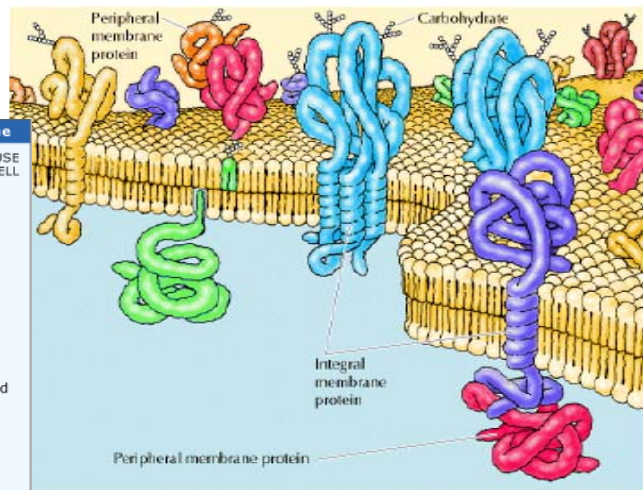
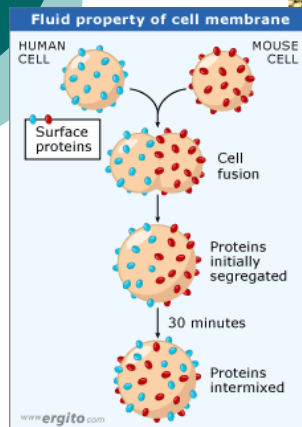
Lipids

- Membrane
- Separates from *millieu*



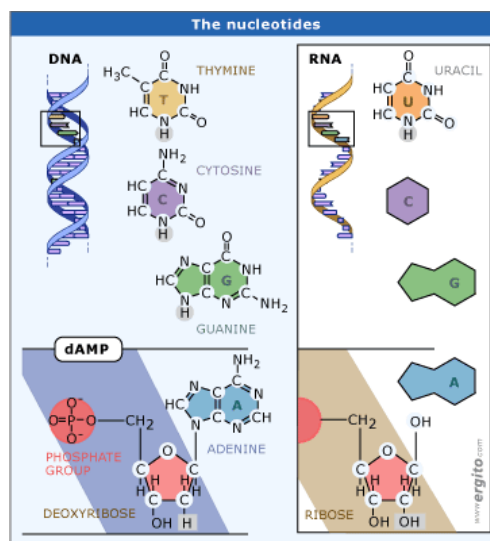
Cell

Lipids



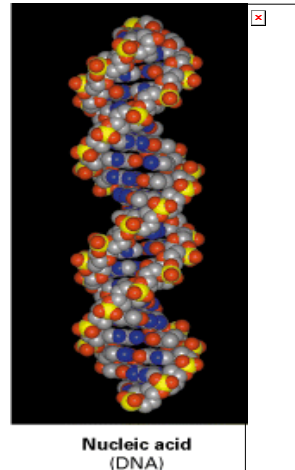
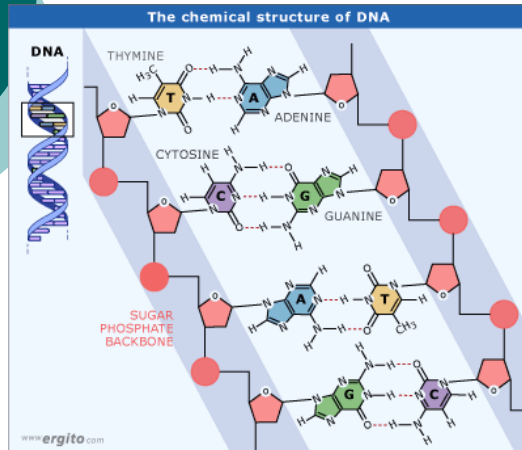
Cell

Nucleic acids



Cell

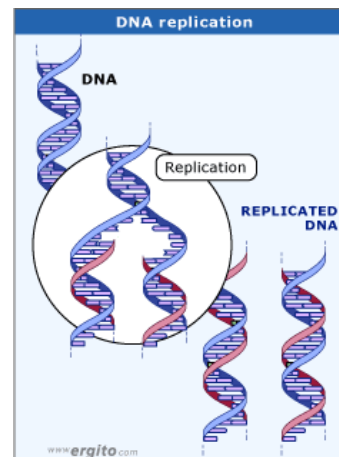
Nucleic acids



Cell

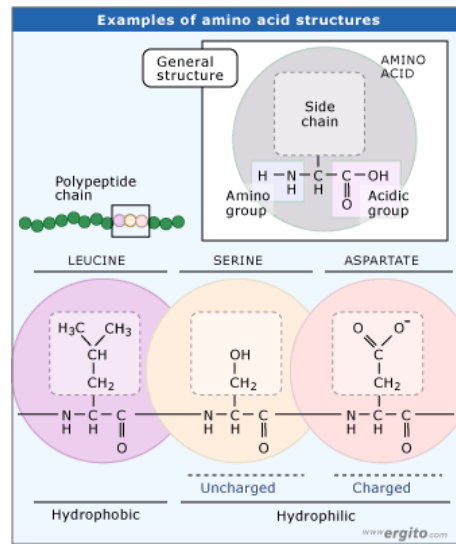
Nucleic acids

- Genetic material → information storage
- DNA
 - Stores information
 - Nuclei or nucleoid (tautology)
- RNA
 - Transmits information
 - intermediary to proteins
 - Catalysis with proteins
 - Cytosol



Cell

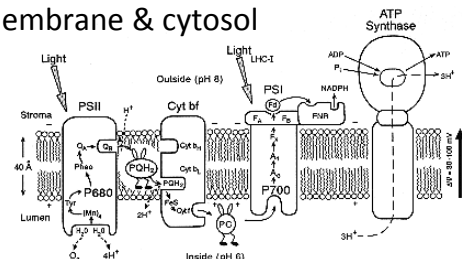
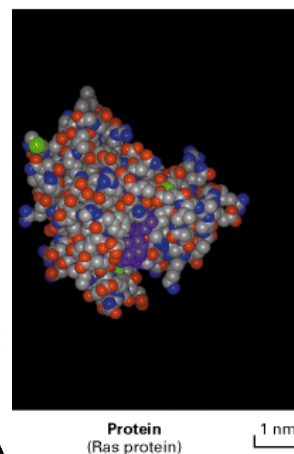
Amino acids



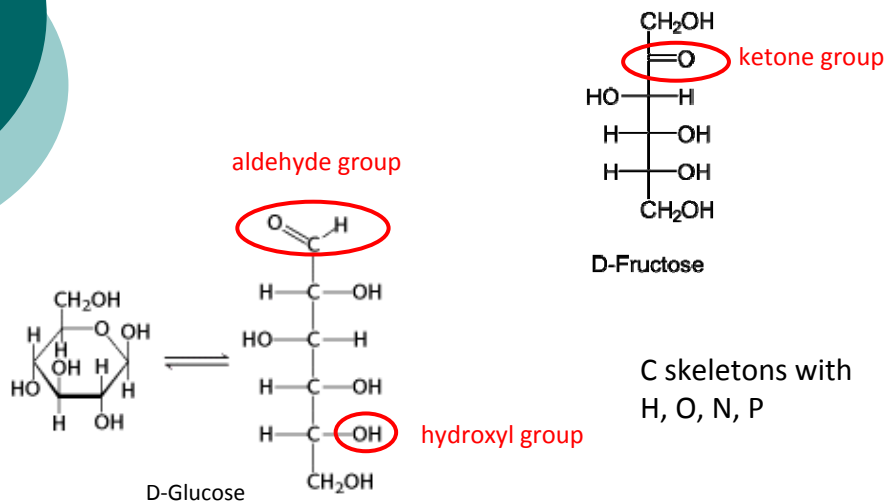
- peptide is an amino acid chain or polymer
- protein and polypeptide are synonyms

Amino acids

- Proteins
- Functions (structure = function)
 - catalysis
 - different proteins in different organelles
 - structural
 - holds the structure of the wall of the cell
- membrane & cytosol



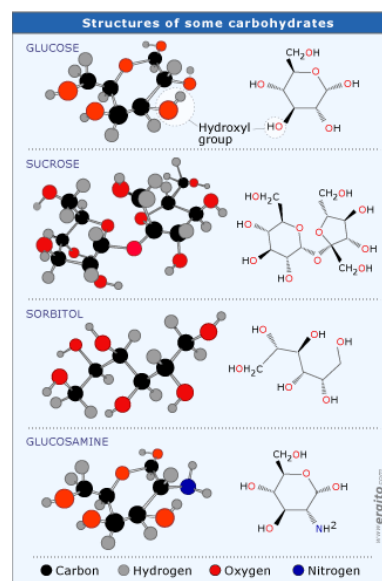
Carbohydrates



Cell

Carbohydrates

- Also called saccharides
- Ingested or formed inside
- Used by metabolic proteins in cytosol and/or mitochondrion
- Metabolites of Metabolism
 - energy
 - reducing power



Cell

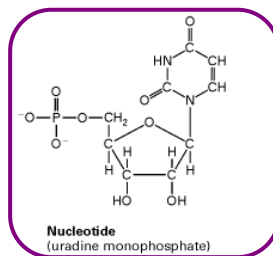
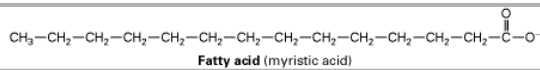
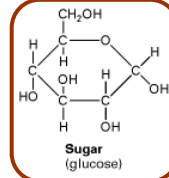
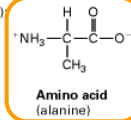
○ dissolved elements

(a) Water, ions, and small molecules (77%)

Water (70%): $\text{H}-\text{O}-\text{H}$

Inorganic ions (1%): Na^+ Cl^- K^+ H_2PO_4^-

Small molecules (6%)



33% DNA + proteins

Cell as an automaton

○ automata

- autopoiesis
- self construction



J. Von Neumann

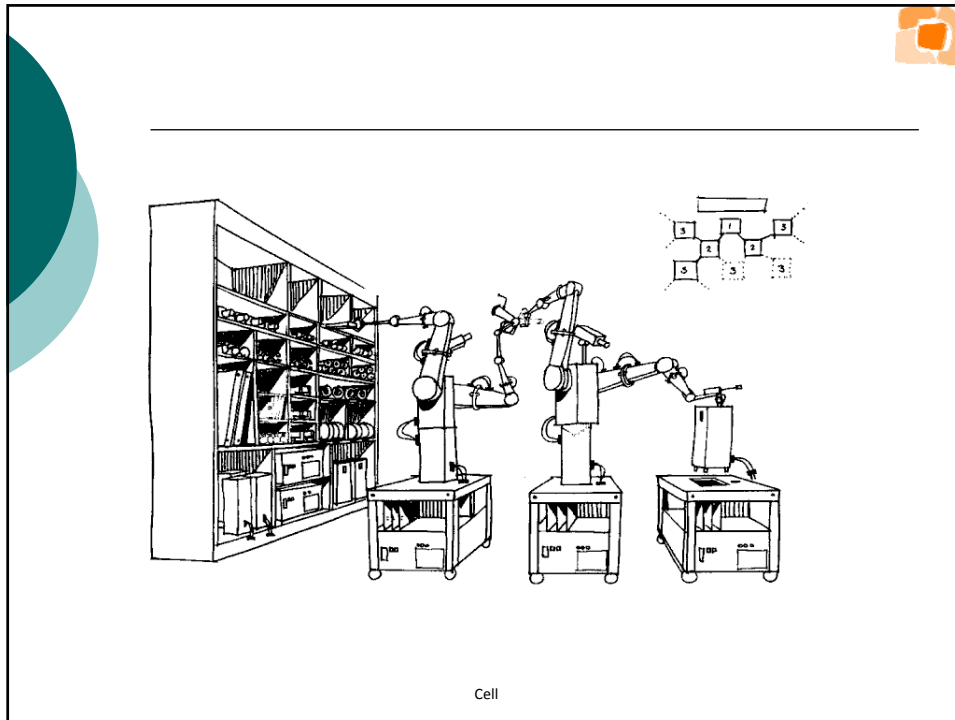
○ 3 parts:

- information
- read and copy information
- body




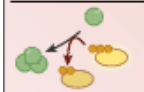
○ 3 functions:

- copy instructions
- functional part
- copy body

J. Von Neumann. *The general and logical theory of automata*, Pergamon Press, 1961

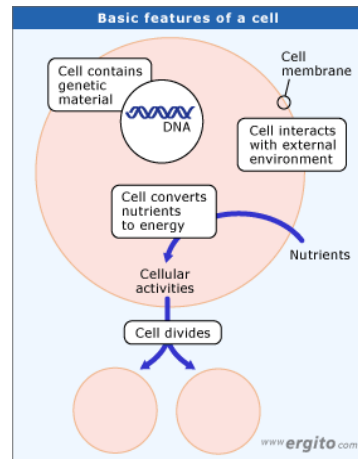


Cell

Minimal features of a cell		
	Plasma membrane Segregate cell from environment	body
	Genome Codes for all cellular structures	instructions
	Information transfer Express information stored in genetic code	read & copy instructions
	Energy utilization Harness energy to build more complex components	copy body

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Cell



- Instructions : genome
- Separated from environment : membrane
- Nutrients : from environment to cellular activities
- Function ??
 - integrity & division ?

Cell

cells grow

- G_1 phase : central control
 - prepares S phase
- S phase : synthesis
 - copies genome
- G_2 phase
 - cell growth
- M phase : mitosi
 - divides in two cells
- G_0 phase
 - paused phase

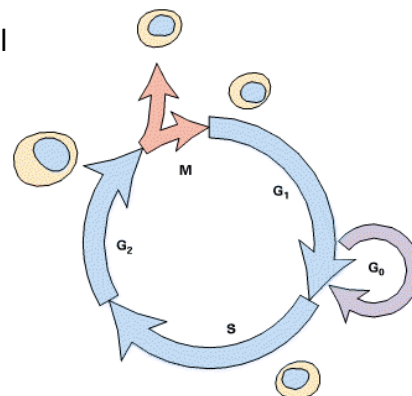
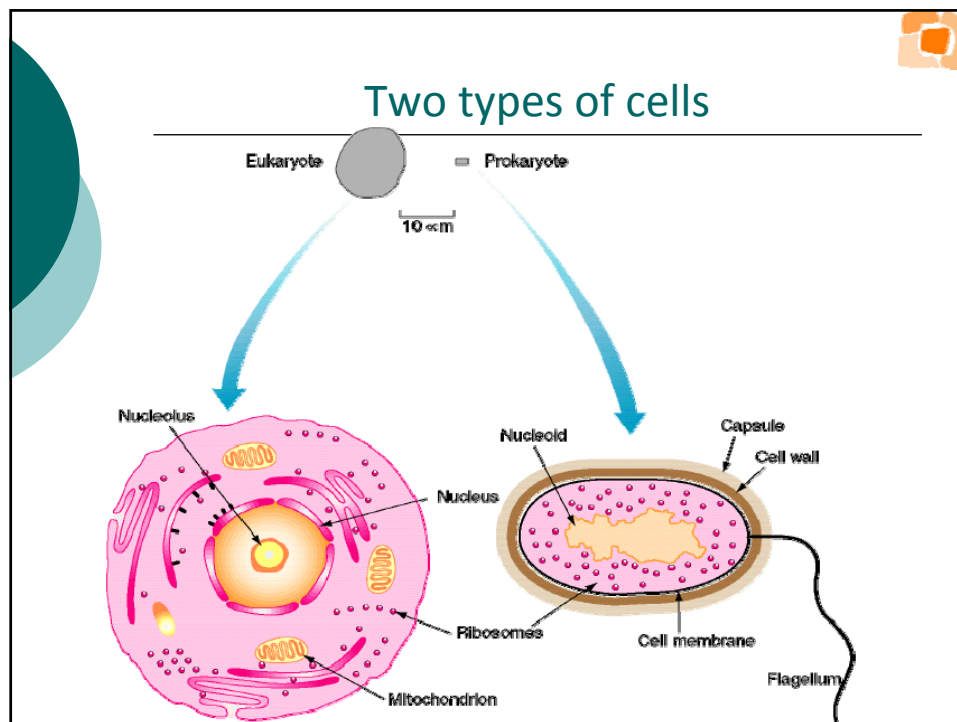


Figure 1-9. The eukaryotic cell cycle.
(Lodish *et al*, 2000)

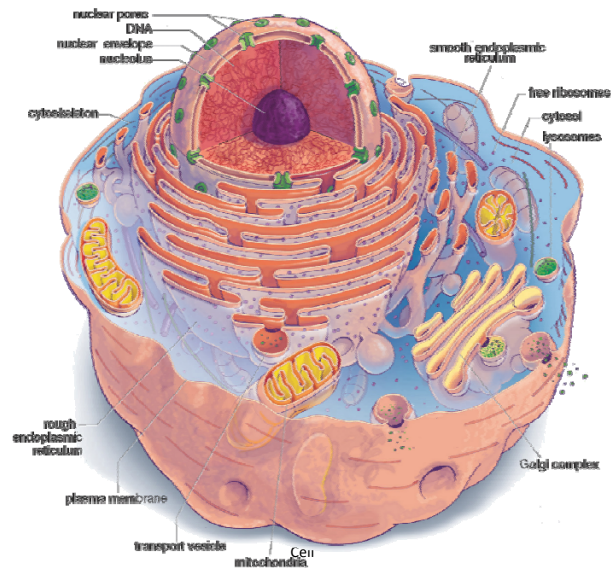
Cell



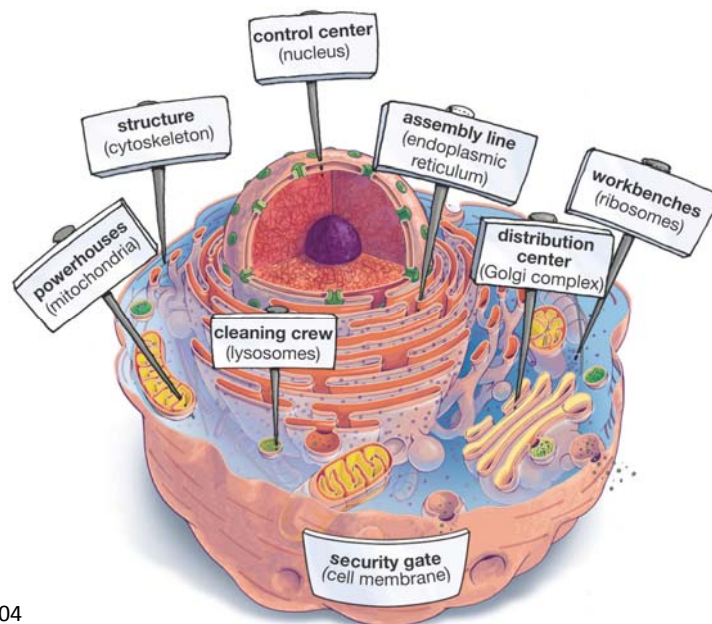
	Prokaryotes	Eukaryotes
DNA	<p>in "nucleoid" region</p>	<p>within membrane-bound nucleus</p>
Size	<p>usually smaller</p>	<p>usually larger</p>
Organization	<p>usually single-celled</p>	<p>often multicellular</p>
Metabolism	<p>may not need oxygen</p>	<p>usually need oxygen to exist</p>
Organelles	<p>no membrane-bound organelles</p>	<p>membrane-bound organelles</p>

Krogh, 2004

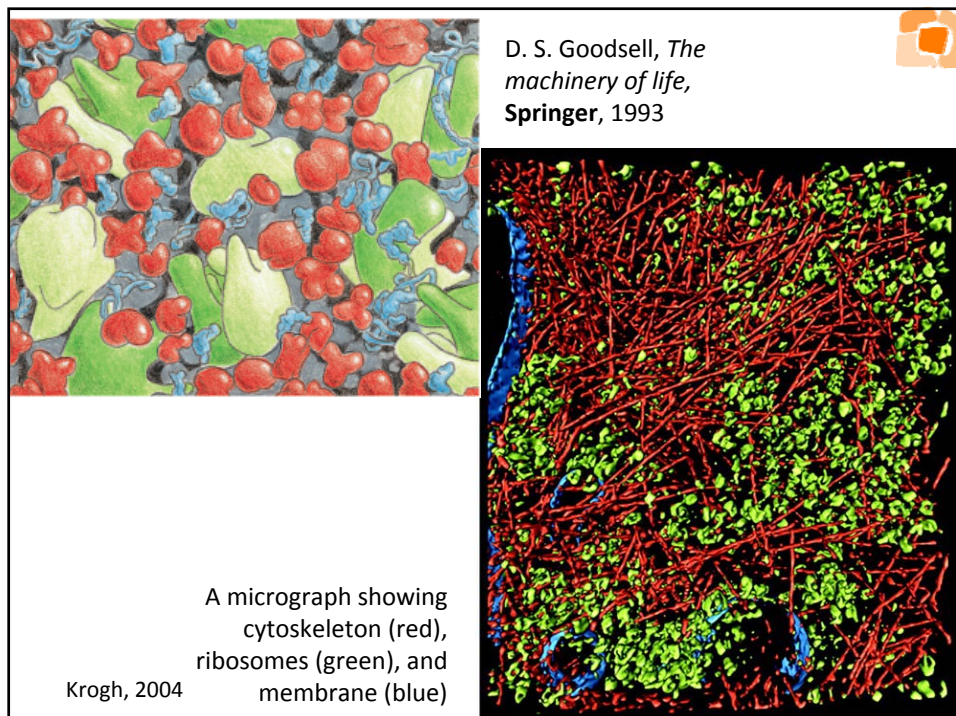
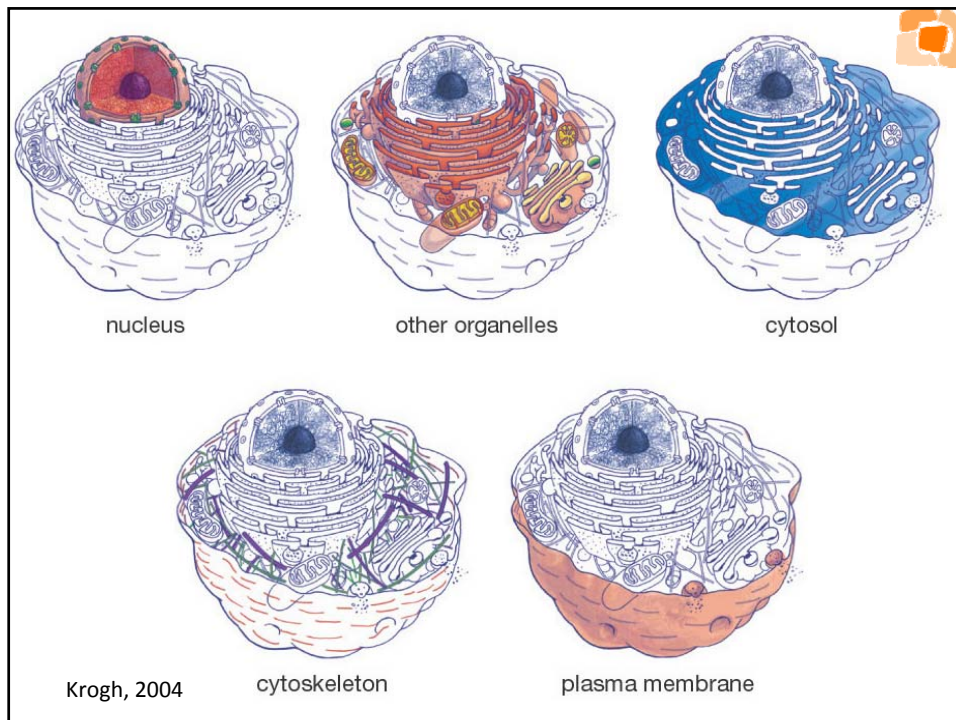
Eukaryota



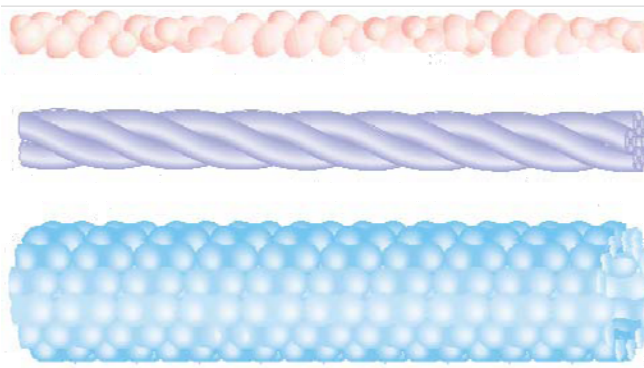
Krogh, 2004



Krogh, 2004



Cytoskeleton



actin
filaments

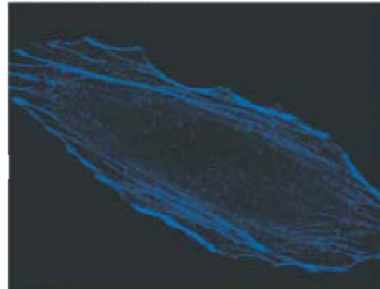
intermediate
filaments

microtubule
filaments

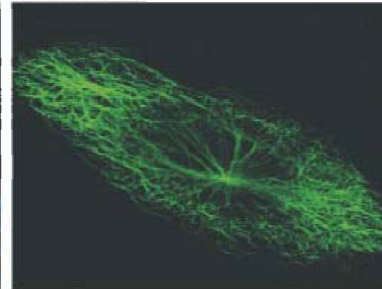
Lodish *et al*,
2000

Cell

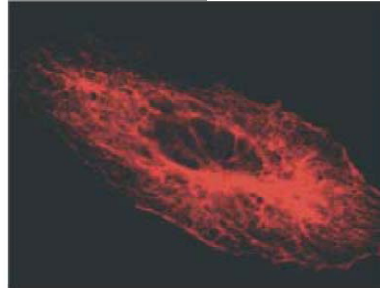
(a) Microfilaments "muscle function"



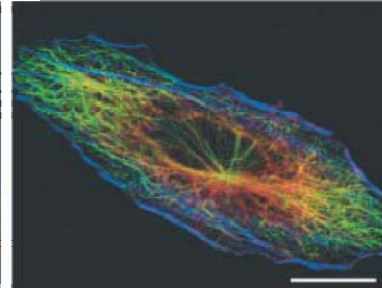
(b) Microtubules "highway function"



(c) Intermediate filaments "scaffold function"

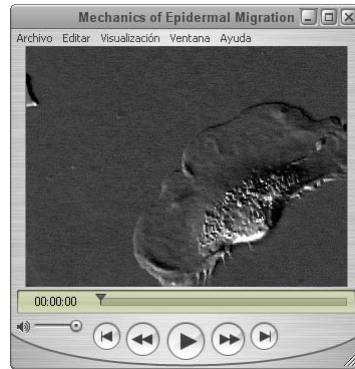


a + b + c merge



Omary *et al*,
2006

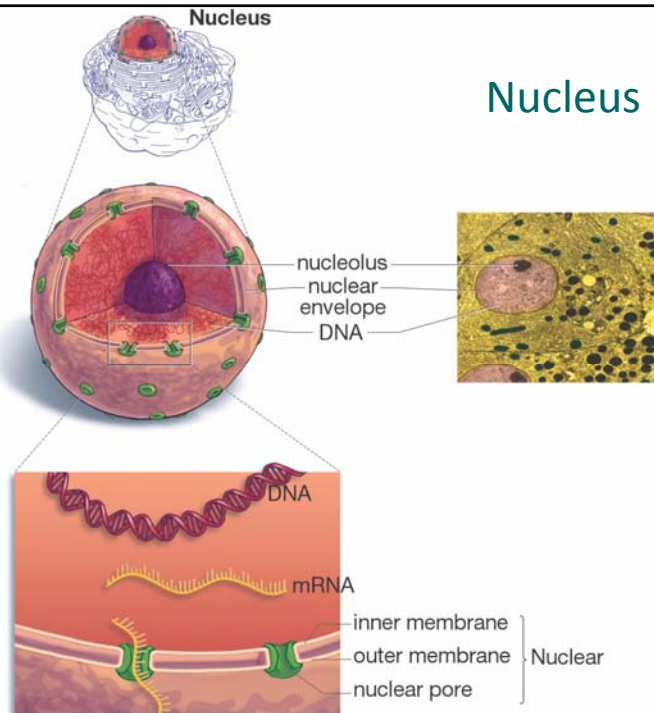
movie



Ch18anim4. Lodish *et al*, 2000

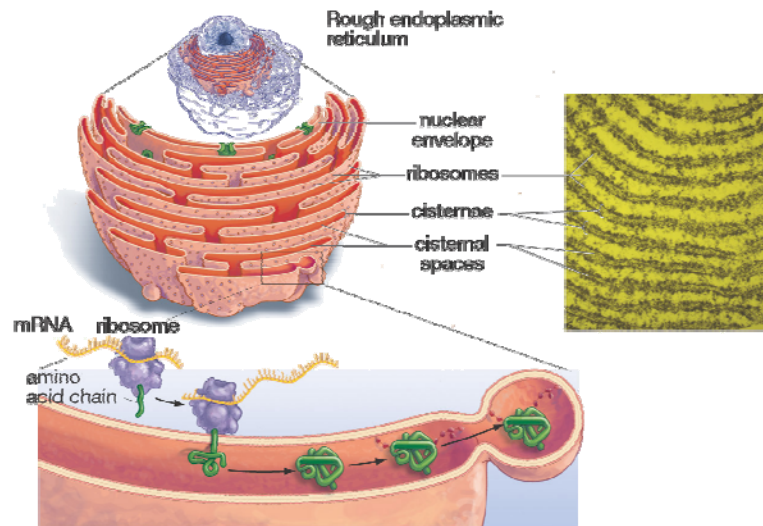
Cell

Nucleus



Krogh, 2004

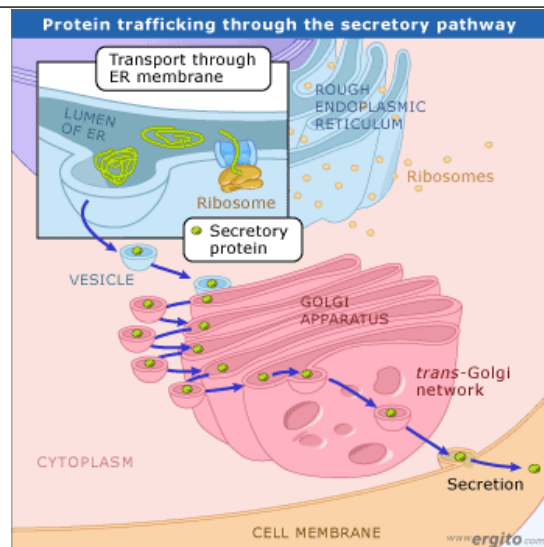
Endoplasmic reticulum



Krogh, 2004

Cell

Golgi apparatus



Cell

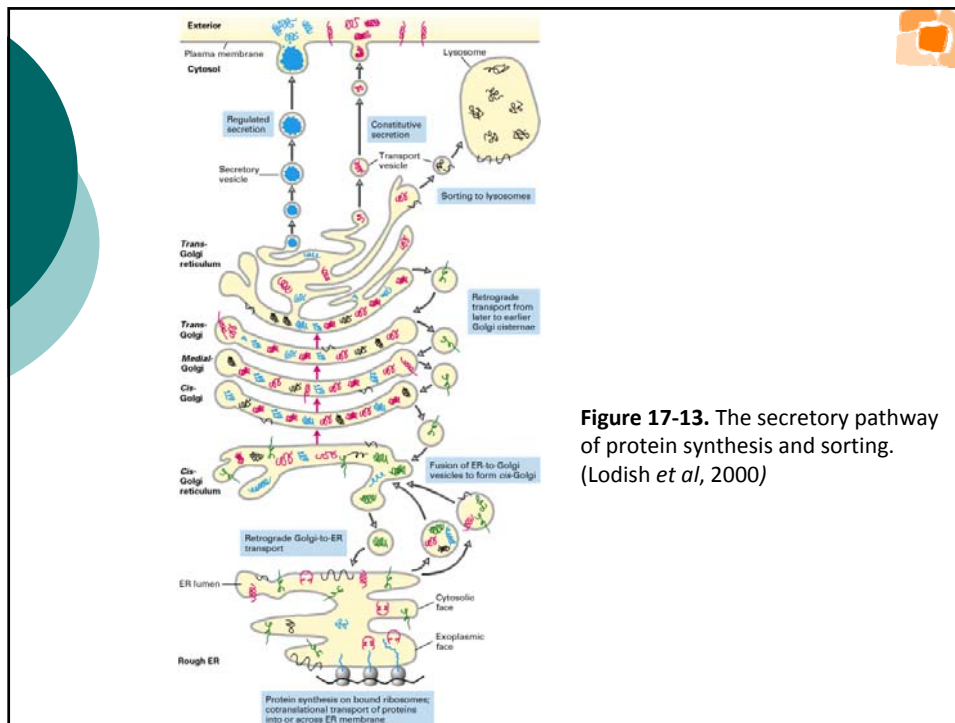
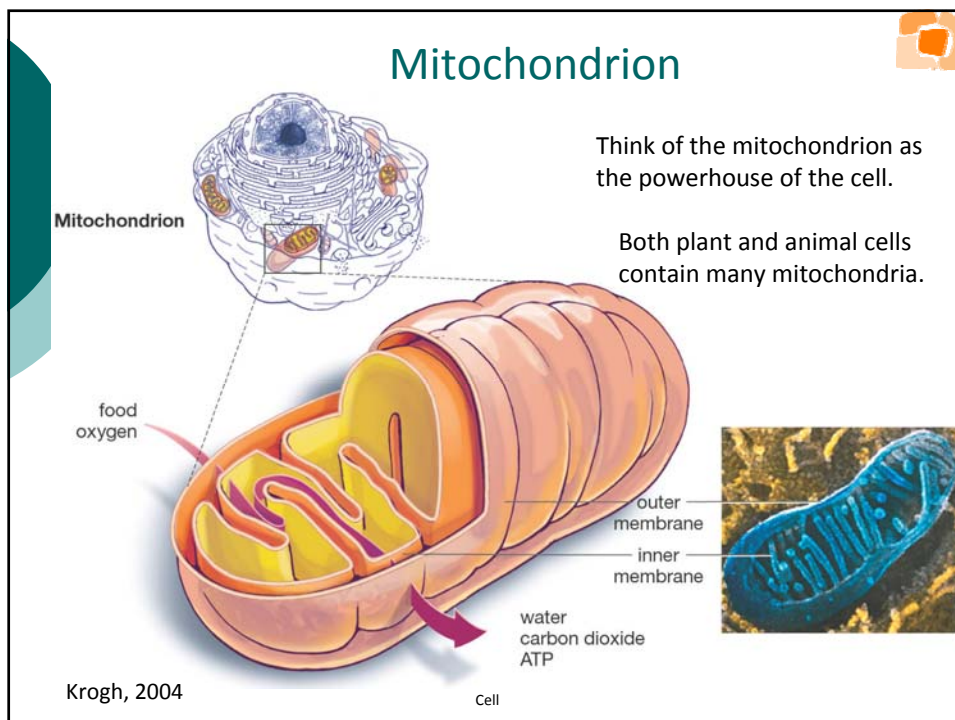
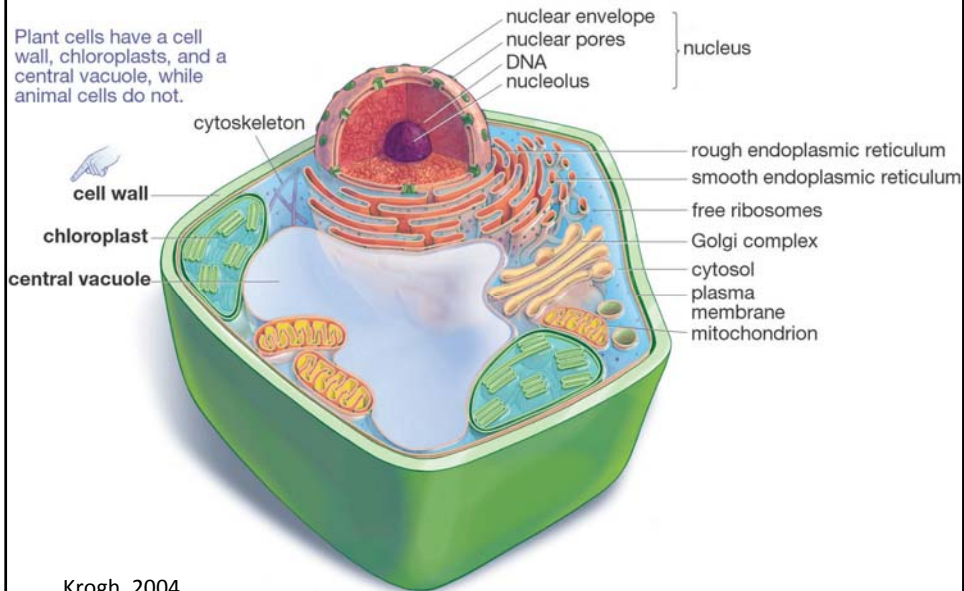


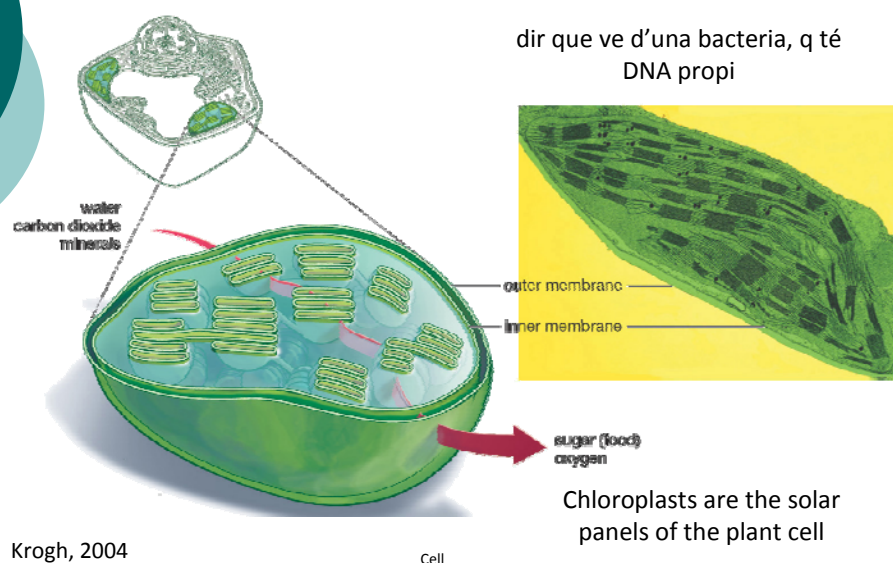
Figure 17-13. The secretory pathway of protein synthesis and sorting. (Lodish *et al*, 2000)



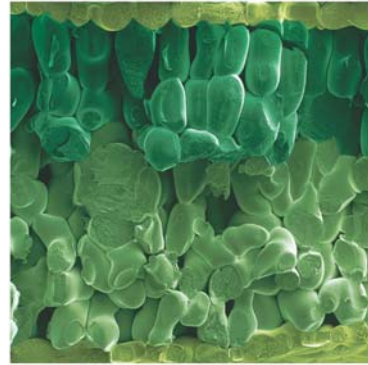
Vegetal



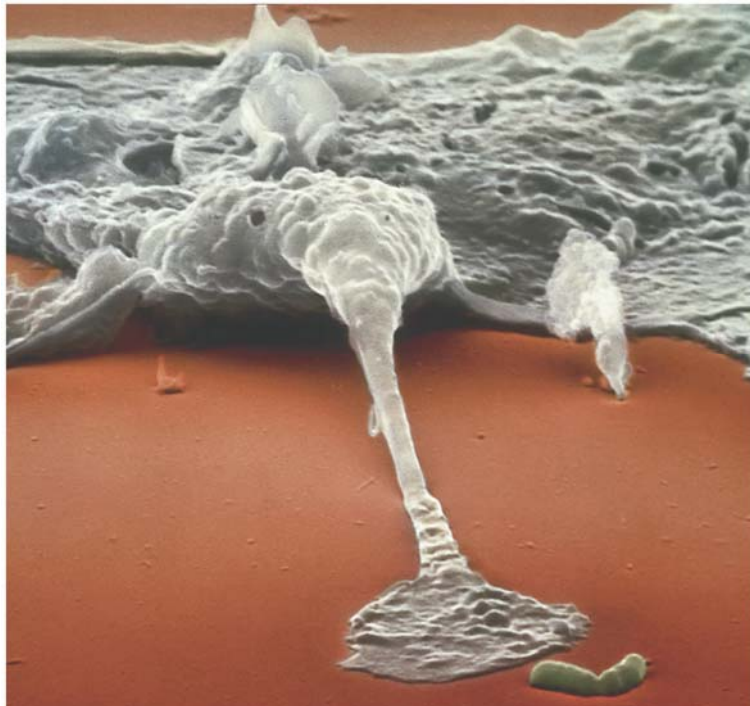
Vegetal : Chloroplasts



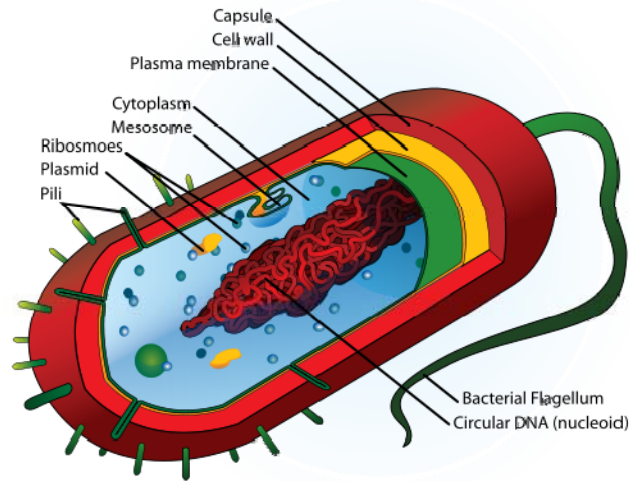
Diversity



Cell



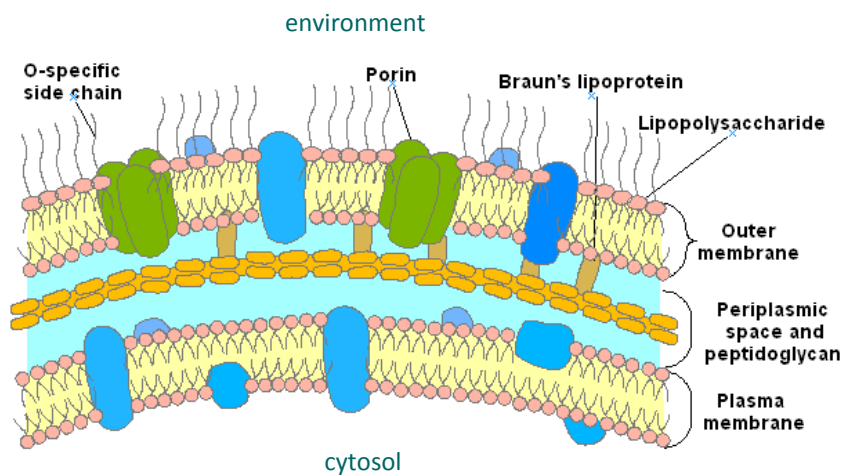
Prokaryote



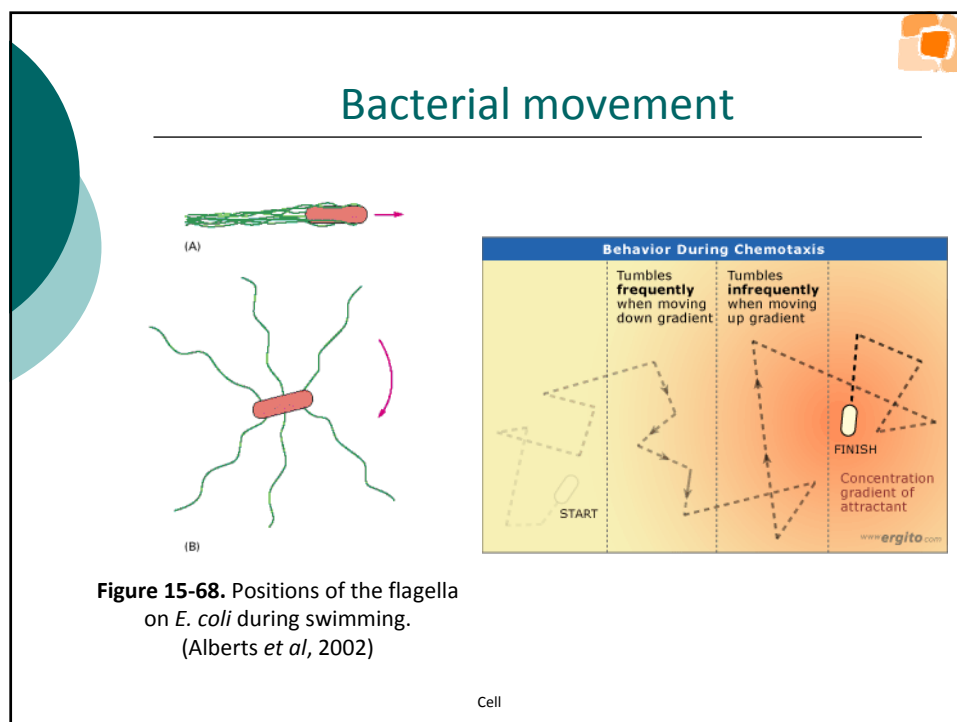
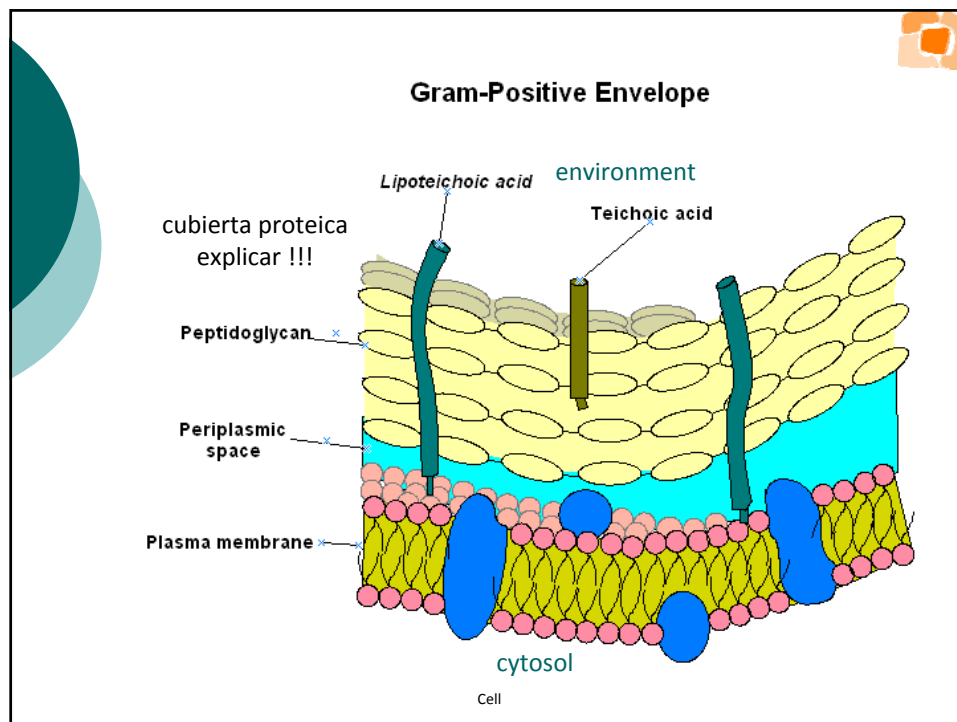
lacks organelles !!

Cell

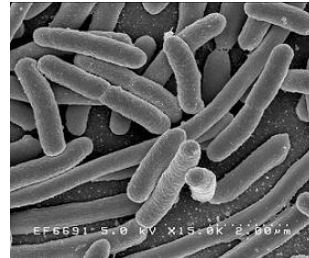
Gram-Negative Envelope



Cell

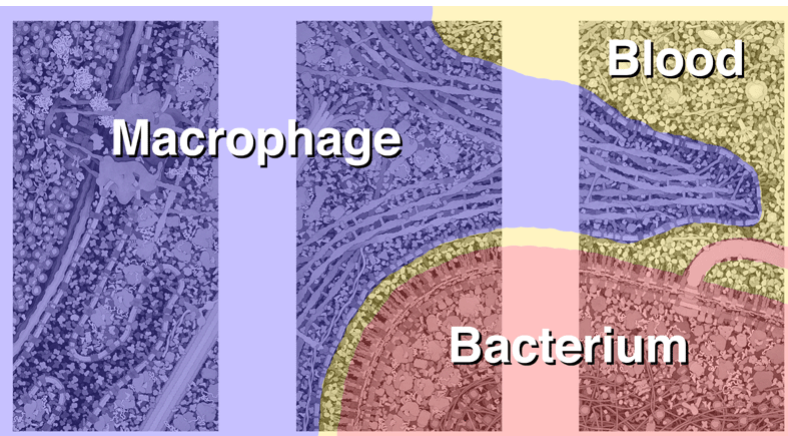


Diversity



Cell

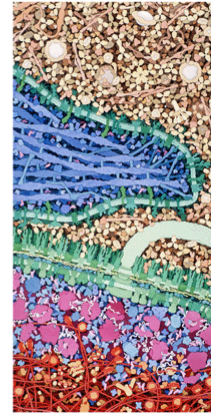
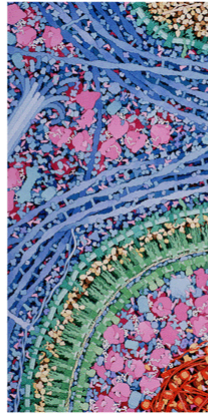
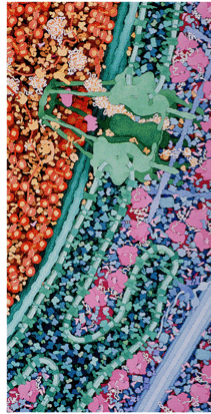
Macrophage vs bacterium



Cell

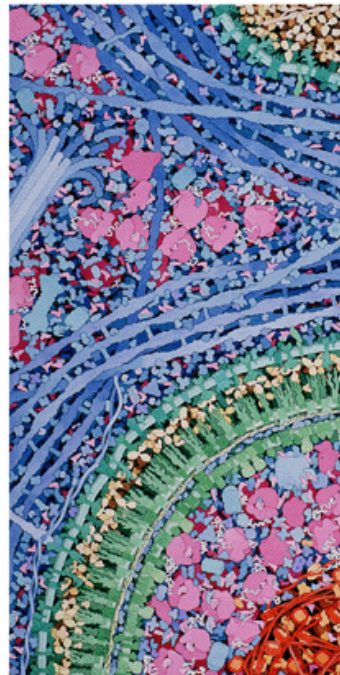
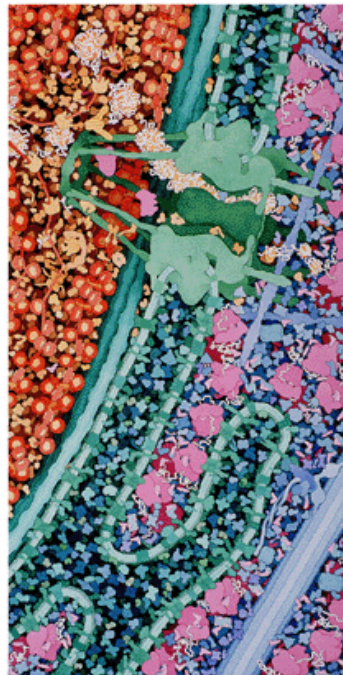
D. S. Goodsell

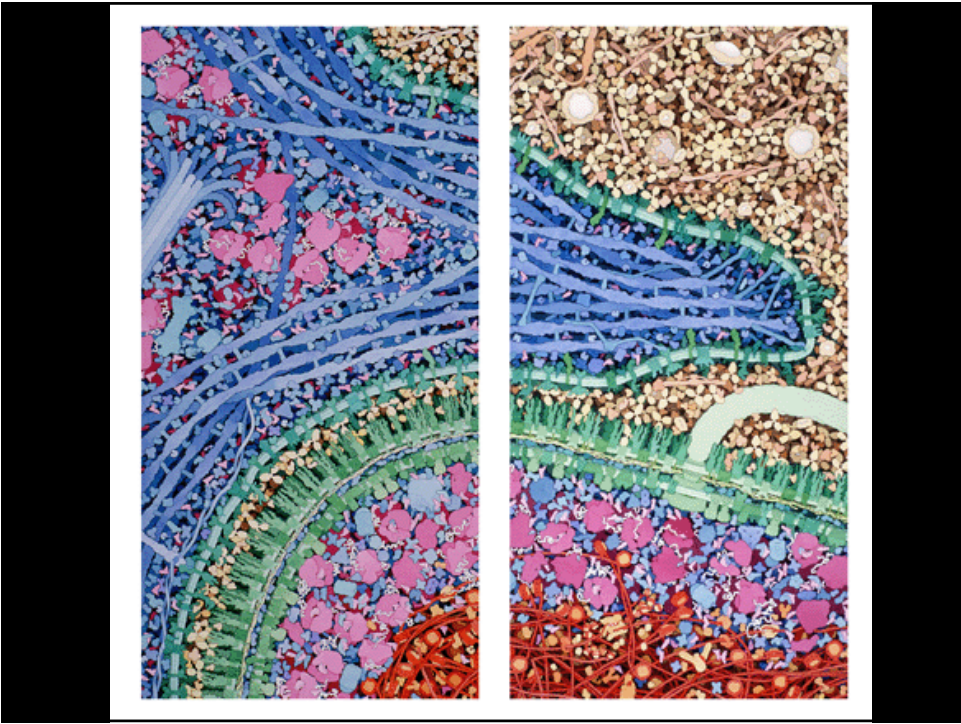
Macrophage vs bacterium



Cell

D. S. Goodsell



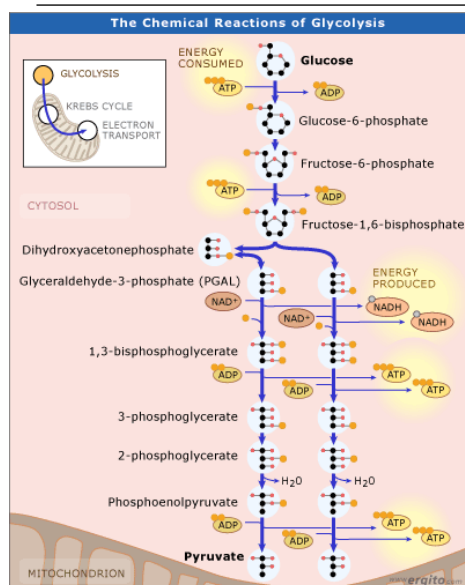


Metabolism

- catabolism
 - from carbohydrate to CO₂, ATP & NADH
- anabolism
 - from CO₂, ATP & NADH to carbohydrate
- central carbon metabolism
 - glycolysis / glycogenesis
 - TCA cycle
 - electron transport chain
- secondary metabolism
 - industrial applications

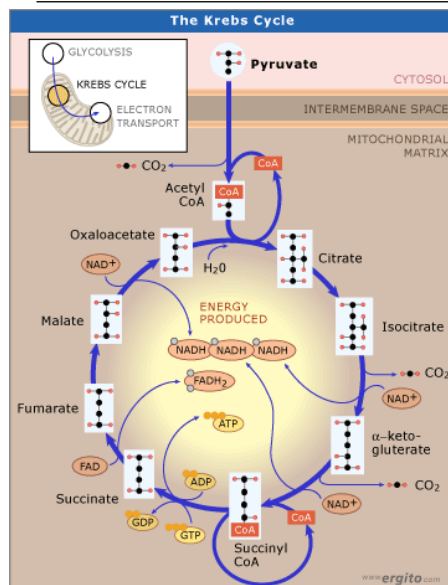
Cell

Glycolysis



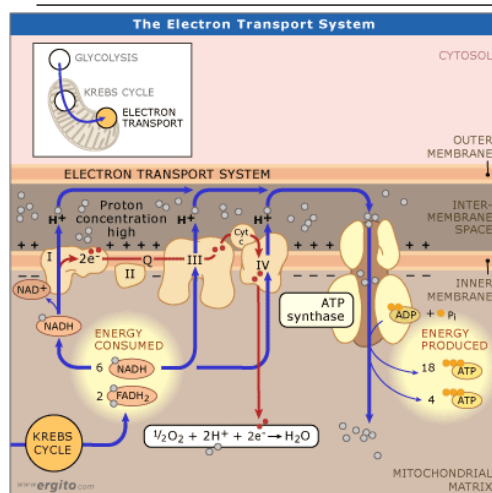
- glucose enters the cell
- protein (enzymes) in cytosol degrade glucose in pyruvate
- producing energy (ATP) & reducing power (NADH)
- pyruvate goes into mitochondrion

TCA cycle



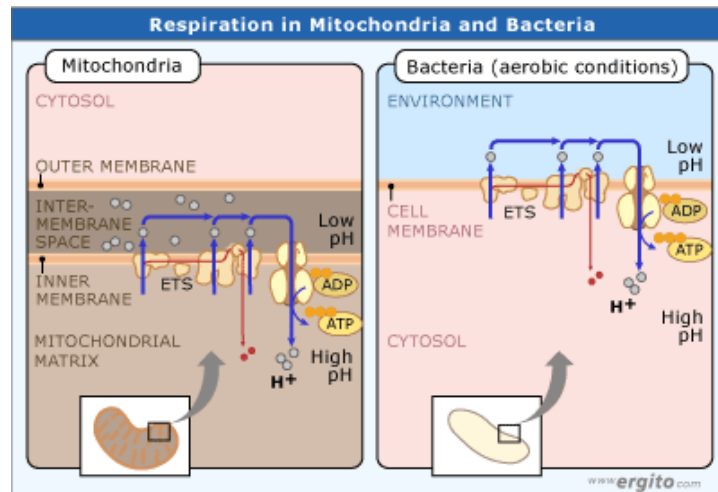
- protein (enzymes) in mitochondrion degrade pyruvate completely
- producing energy (ATP) & reducing power (NADH)
- NADH goes into electron transport chain
- ATP is widely used throughout the cell as energy

Electron transport chain



- protein (enzymes) in mitochondrion use NADH degradation for H⁺ gradient
- ATP synthase uses H⁺ gradient producing energy (ATP)
- ATP is widely used throughout the cell as energy

Mitochondria vs bacterium



Cell

sources

- Krogh, *Biology*, Custom Core Edition, **Prentice Hall**, 3rd ed., 2004
- Alberts *et al*, *Molecular Biology of the Cell*, **Garland Science**, 4th ed., 2002
- Lodish *et al*, *Molecular Cell Biology*, **Freeman & Co.**, 4th ed., 2000
- Cornish-Bowden *et al*, *Beyond reductionism: Metabolic circularity as a guiding vision for a real biology of systems*, **Proteomics**, 2007
- J. Von Neumann. *The general and logical theory of automata*, **Pergamon Press**, 1961
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- D. S. Goodsell, *The machinery of life*, **Springer**, 1993
- www.ergito.org



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