Biochemistry

András Szarka

szarka@mail.bme.hu

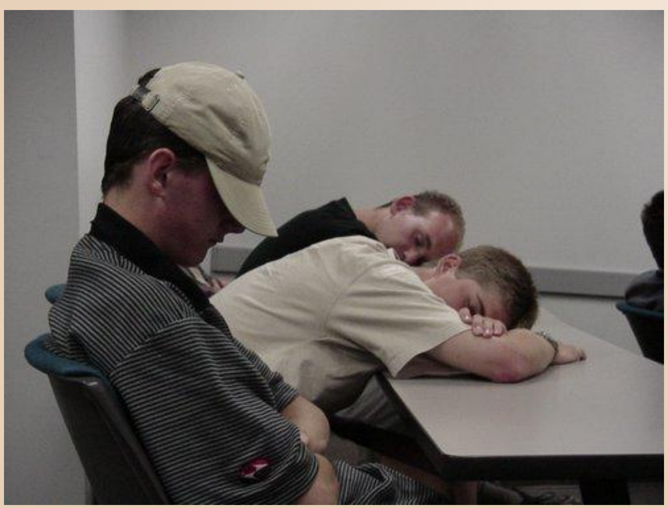
+36-1-463-3858

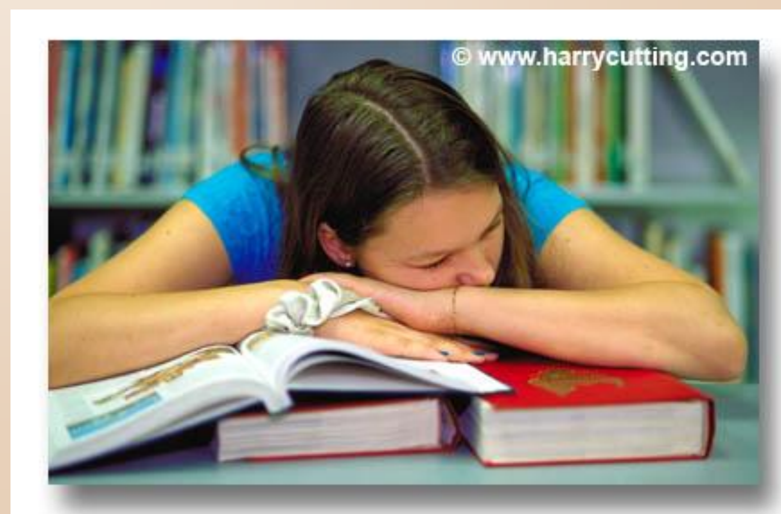
week	date	topic	test
1.	September 9.	Introduction, macromolecules, enzymes	
2.	September 16.	Holiday, University sport's day	
3.	September 23.	Enzymes, Bioenergetics	
4.	September 30.	Carbohydrate metabolism I.	
5.	October 7.	Carbohydrate metabolism II.	X
6.	October 14.	TCA cycle	
7.	October 21.	Mitochondrion, terminal oxidation	
8.	October 28.	Photosynthesis	X
9.	November 4.	Lipid metabolism	
10.	November 11.	Amino acid metabolism	
11.	November 18.	DNA replication	X
12.	November 25.	Transcription, gene expression	
13.	December 2.	Translation	
14.	December 9.	Final test	X

Date of lecture: Monday 15:15-18:00
Ch. 307. seminar room
The attendance of the **50% of the lectures and 100% of the tests is a prerequisite for the exam**.
Three short and a final test will be held.
The final remark can be given on the base of the results of these tests, or an oral exam can be taken in the exam period.

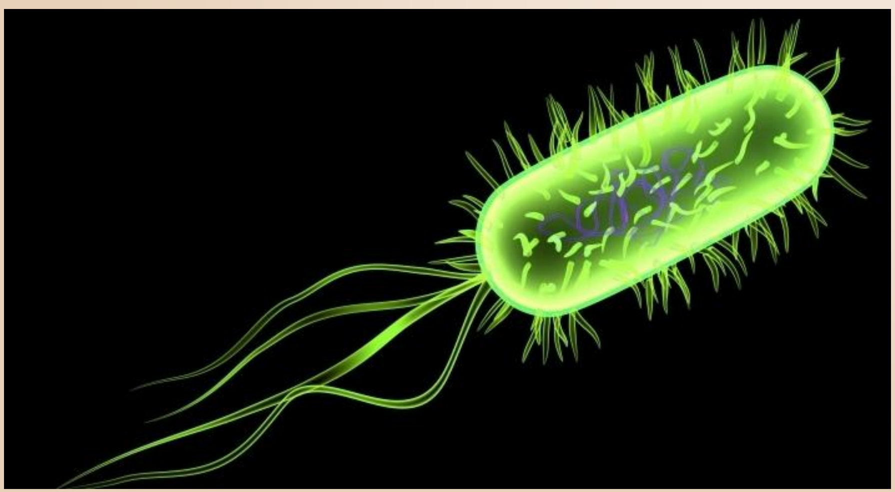
Why should we deal with biochemistry?

Is it interesting?





Biochemistry: the chemistry of living organisms



What kind of materials can be found in the human body?

How are the components of our body synthesized?

What is happening in our body during starvation?

What is in the background of different diseases?

etc.

Biochemistry and recombinant DNA technology in the Medicine

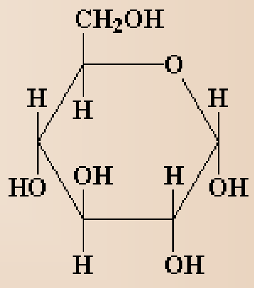
Anticoagulants	TPA (tissue plasminogen activator)
Blood clothing factors	(VIII)
Colony stimulating factor erősítése)	(supporting the immune system)
Erytropoetin	(supporting red blood cell generation)
Growth factors	
Human insulin	
Monoclonal antibodies	
Superoxid dismutese	
Vaccines	
Gene therapy	

1. The complexicity of chemical compounds in the living cells

1. Macromolecules are built up from **simple elements** (C, H, N, O).

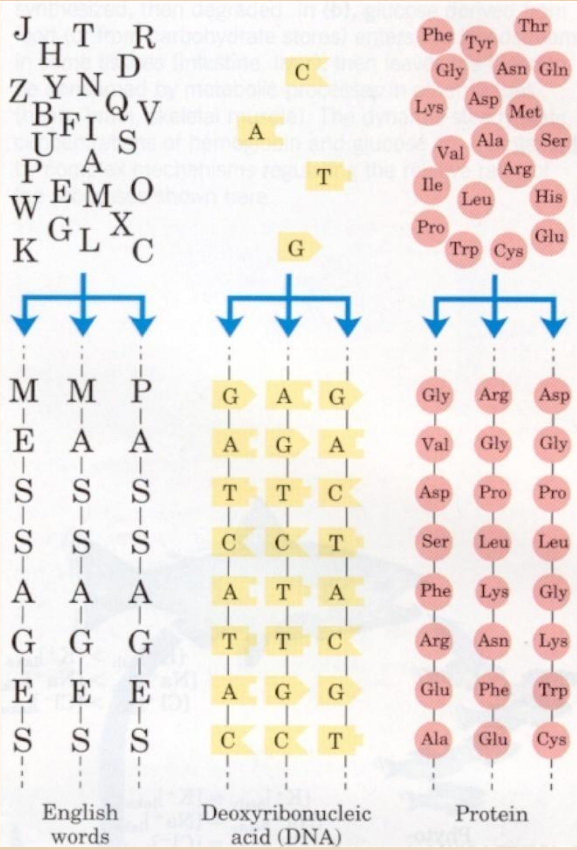
C: special bounding features.

2. **Monomers**: organic compounds, $M_w<500$ (amino acids, monosaccharides, nucleotides).



glucose

3. **Macromolecules**: proteins, polysaccharides, nucleic acids

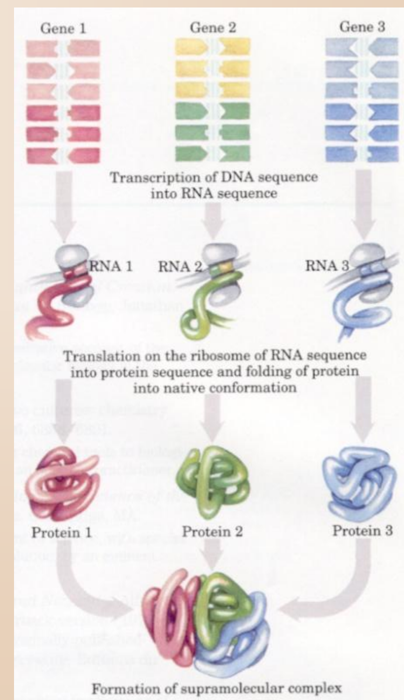


Protein: thousands of amino acids

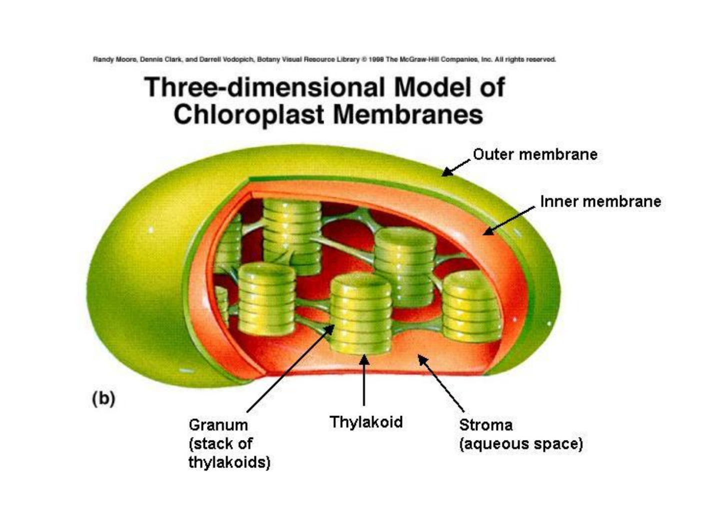
Nucleic acid: millions of nucleotides

Universal molecules: We can found the same molecules in different living organisms

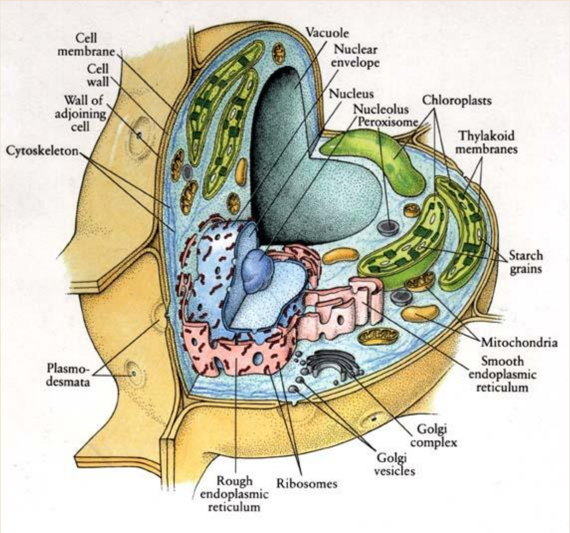
4. Supramolecular systems (ribosome, enzyme complexes…)



5. **Cellular organelles** (mitochondria, chloroplast, peroxysome, nucleus, endoplasmic reticulum, Golgi complex)



6. Cell



The Cell

The stuctural and functional base of every living organism

General features:

1. **Plasma mebrane**: it gives the boundaries of the cells

Separates the cells from their environment.

It has limited permeability.

The maintenance of metabolism → transport processes

The structural and functional integrity of the plasma membrane is the prerequisit of all cellular functions

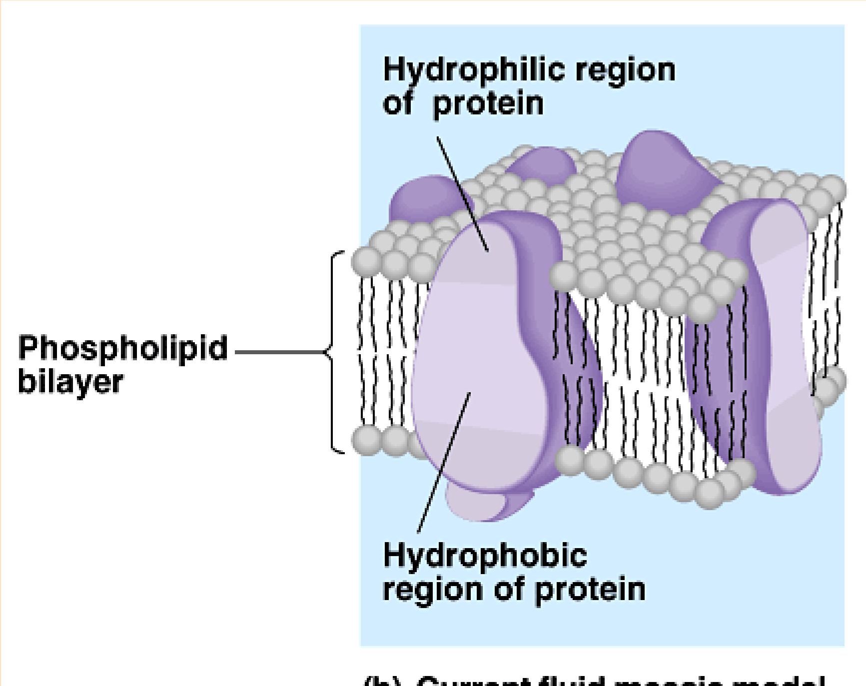
Composition: the basal structure lipids and proteins, minor: carbohydrates

Membrane thickness: 7-9 nm.

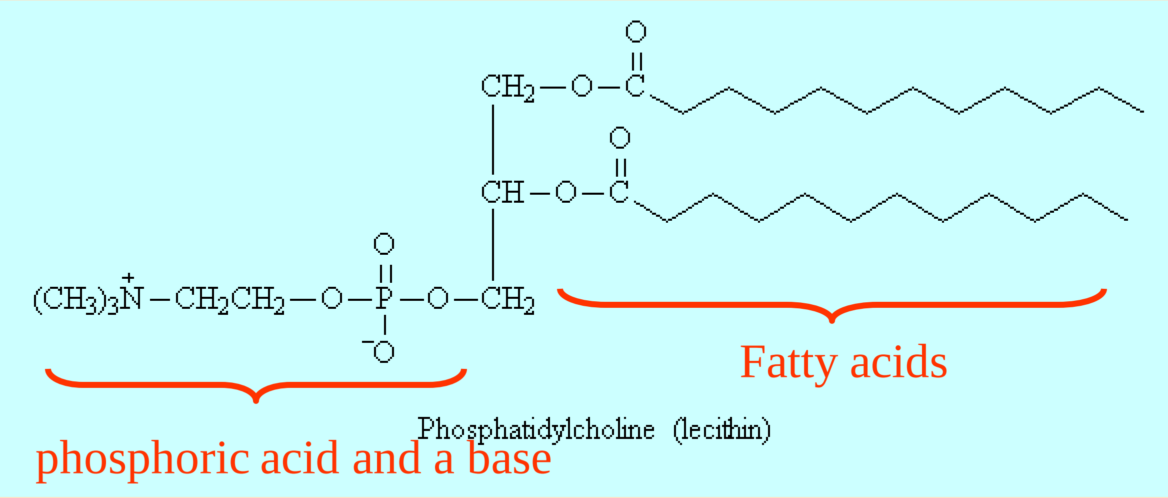
Structure: **Proteins** embeded into a **Lipid bilayer**,

The lipid bachbone is consisted of phospholipids.

The fatty acid content of phospholipids is influenced by the feeding



(b) Current fluid mosaic model

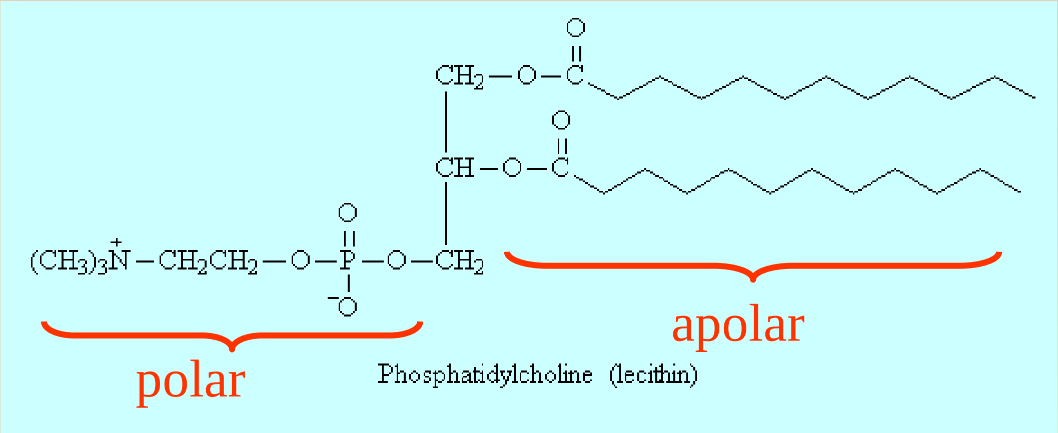


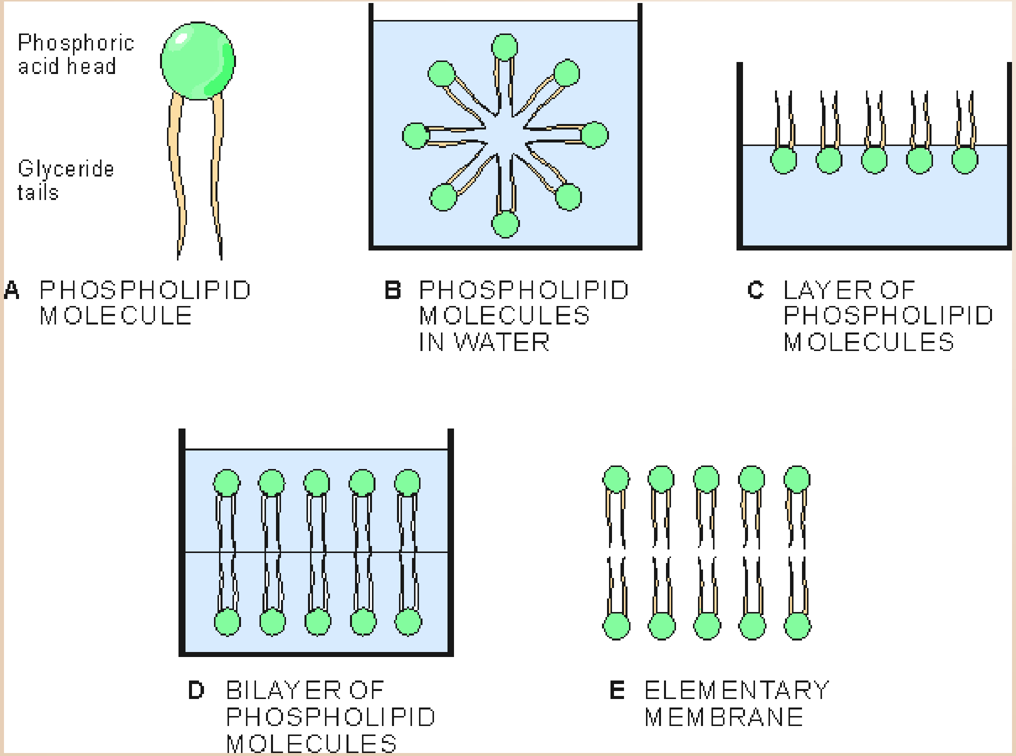
Phosphatidylcholine (lecithin)

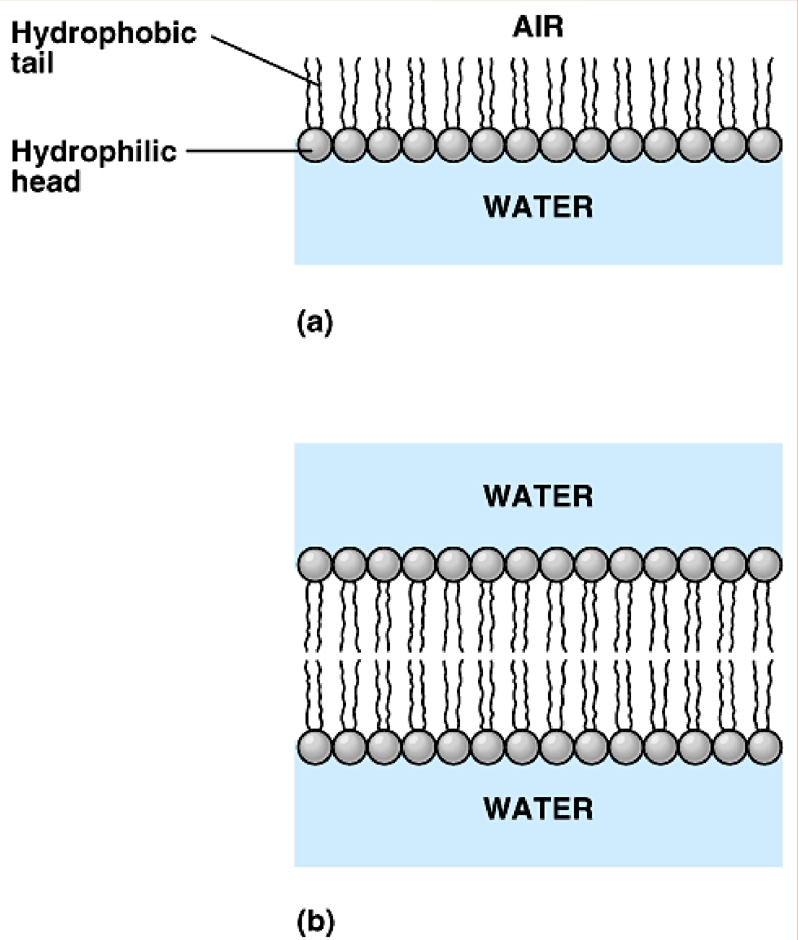
1. C-atom: saturated fatty acid

2. C-atom unsaturated fatty acid

Phospholipids are amphiphatic

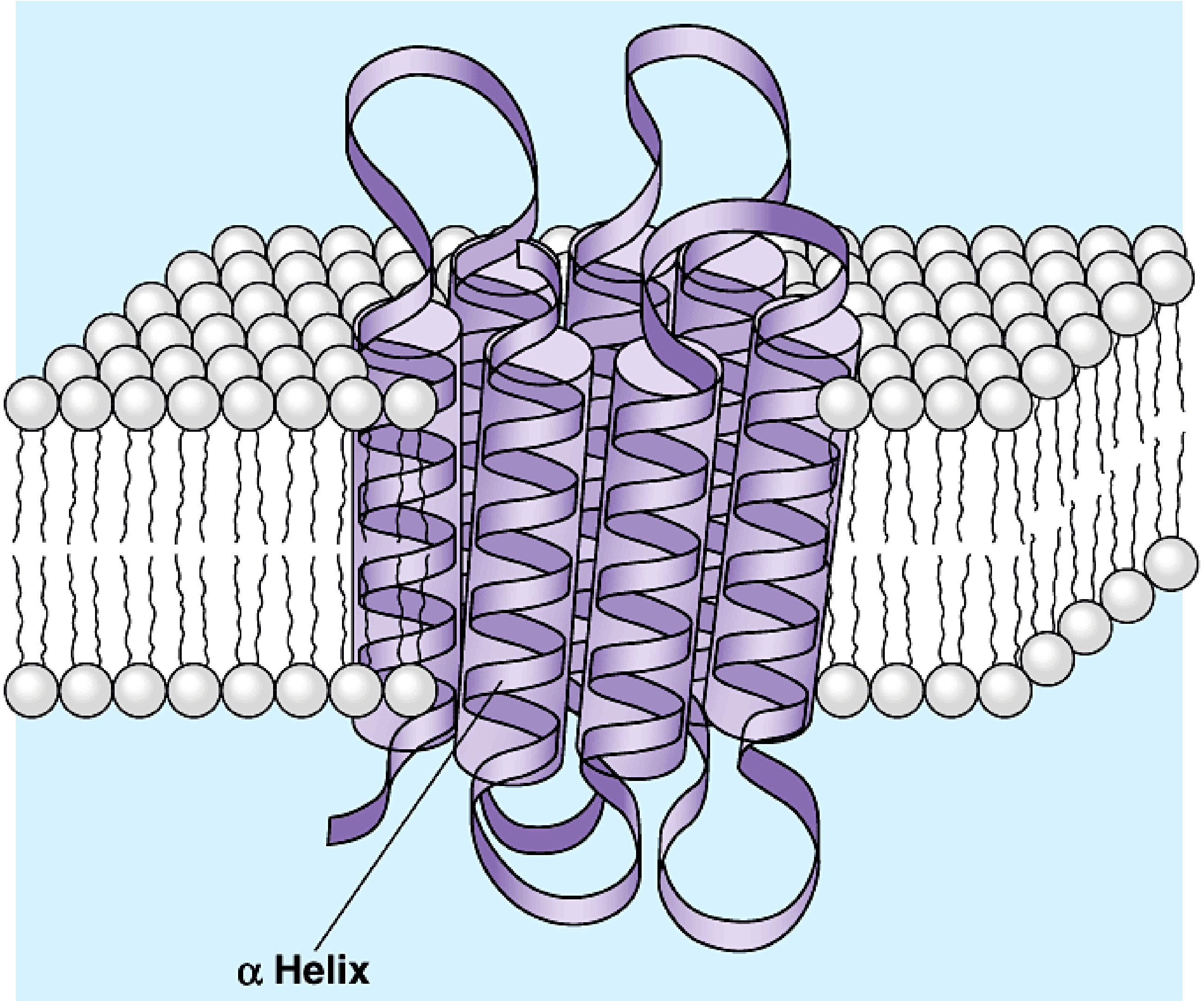






Membrane proteins: A hyrophobic part is passing through the the lipid bilayer. There are membrane proteins with one or more intermembrane units.

An α-hélix consisted of 25 apolar amino acids is long enough to pass through the membrane



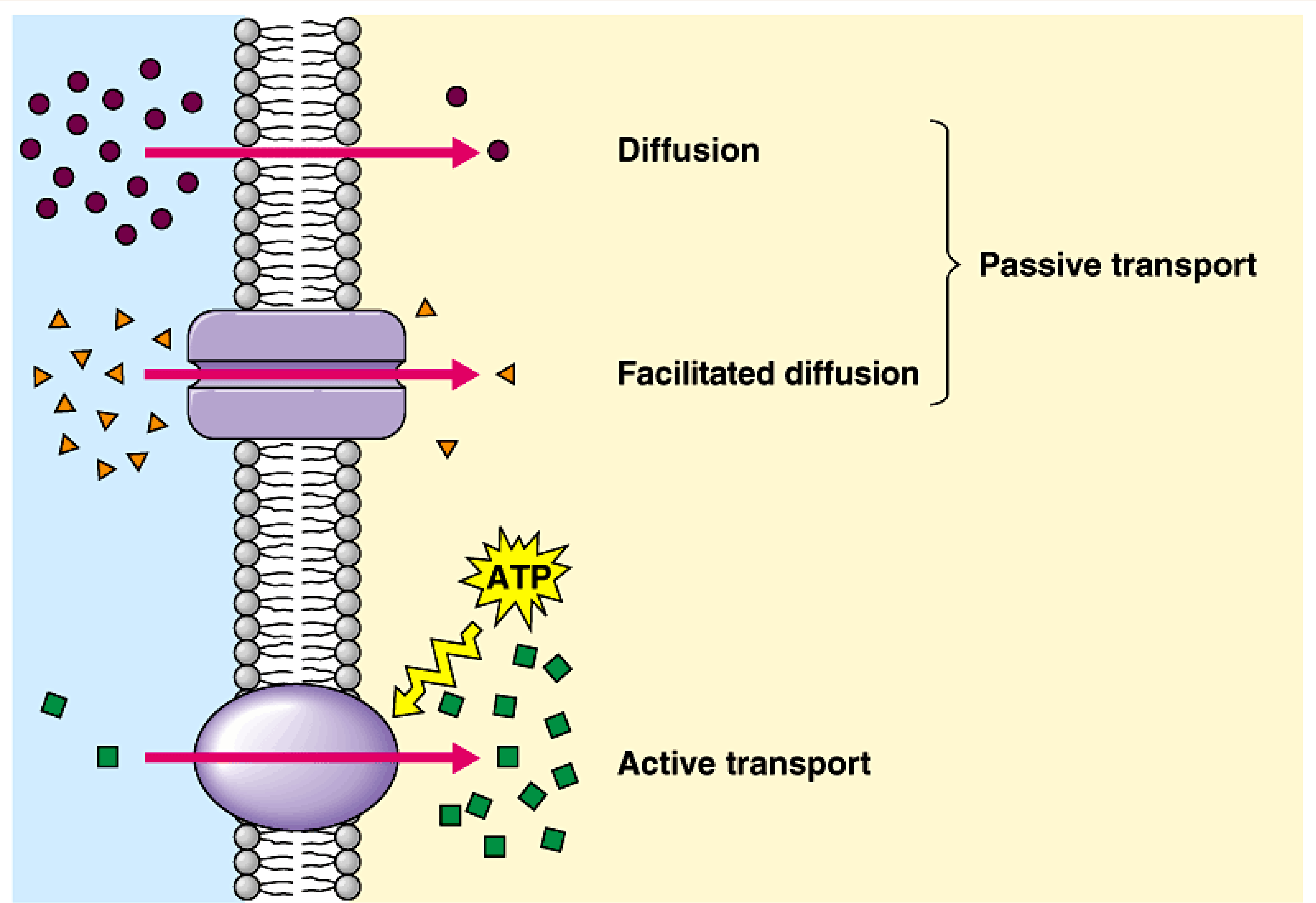
Membrane transport processes

Membranes are selective barriers. The base of limited permeability is the lipid bilayer.

The transport of polar compounds through the inner hydrophobic core of lipid bilayer requires a significant amount of energy ⟶ Charged or hydrophilic compounds are not able to pass it or the transport of them is highly limited. There are only one excetion: the water. Its permeation is free.

The gases are able to pass through the membrane by simple diffusion. Membranes are permeable to uncharged and hydrophobic compounds.

Simple diffusion: the compouns permeate freely through the membrane to the direction of concentration gradient. Quite rare.



2. **Cytoplasm**: the space surrounded by the plasma membrane. It is consist of the cytosol (aqueous solution) and the insoluble materials suspended in the cytosol

Cytosol: It is a highly concentrated aqueous solution, with gel like consistency.

Insoluble materials: ribosomes, other supramolecular systems

3. **Nucleus, nucleoid**: It contains the genom. It can be found in every living organism. Practically it is the packed DNA.

Bacterial nucleoid: it is unbounded, embedded into the cytoplasm

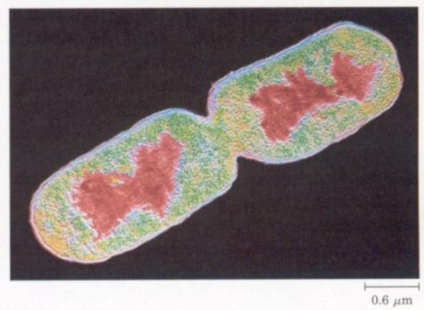
Eukariotic nucleus: it is bonded by a double membrane

Dimensions of the cells

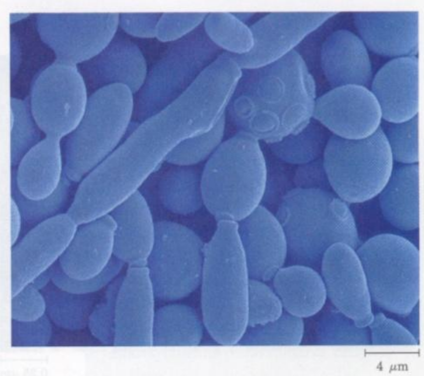
Microscopic diameter of the cells animal, plant: 5-100 μm

bacterial: 1-2 μm

Cell size is limited.

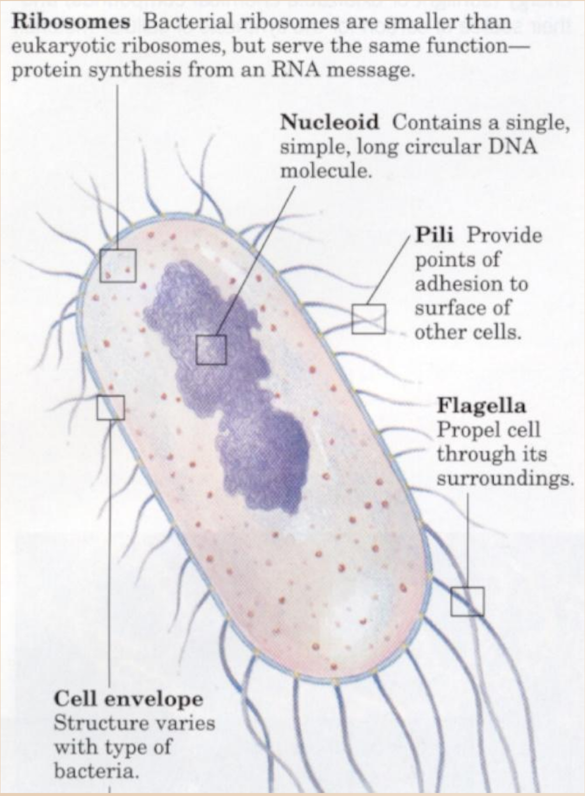


A dividing *Escherichia coli* cell.



Dividing *Saccharomyces cerevisiae* (baker's yeast) cells.

Prokaryotes



Escherichia Coli

Small cells with simple structure

There is no nuclear envelope membrane a DNA is located in the cytoplasm

↓

The synthesis of RNA and proteins can be occurred paralel.

There is no organellar structure.

The plasma membrane is surrounded by an additional solid cell wall (Gram+, or Gram-).

Eukaryotic cells

Novel eukaryotic features:

1. **Bigger DNA content**

(Bacterial genome: a few million basepair, human genome: $3.2 \cdot 10^9$ base pair)

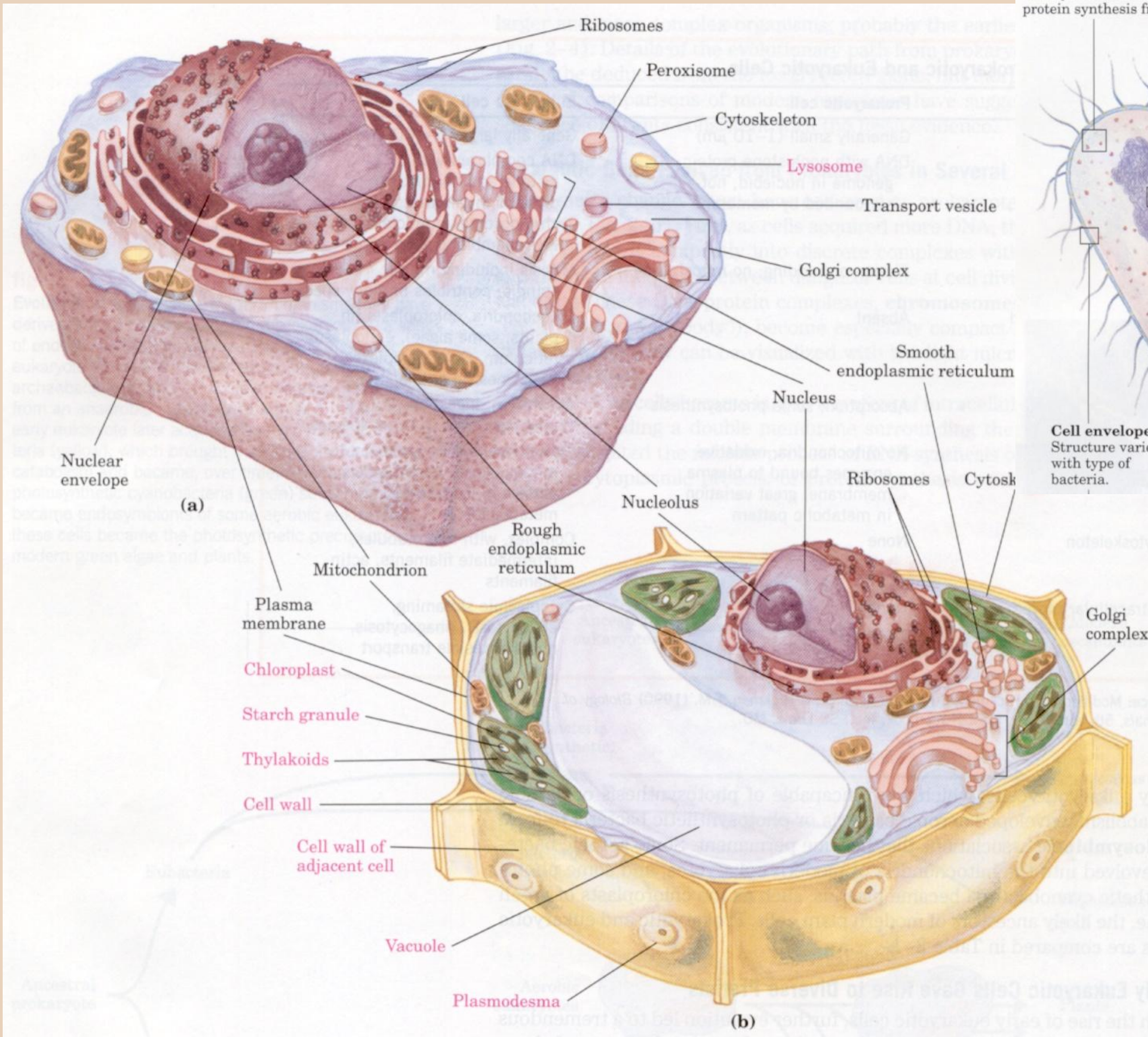
- more complex packing (aided by proteins) chromosomes

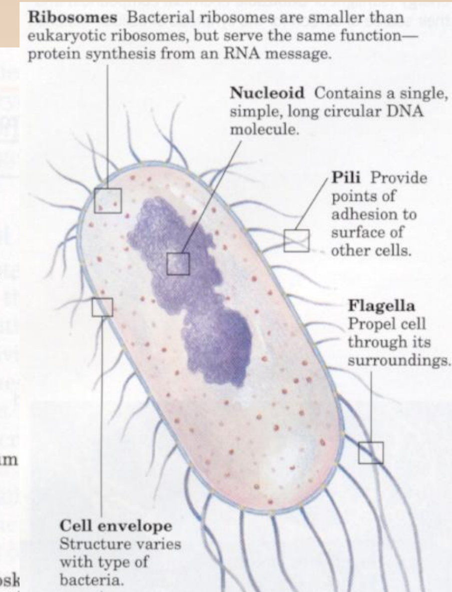
- more complex fission of cells

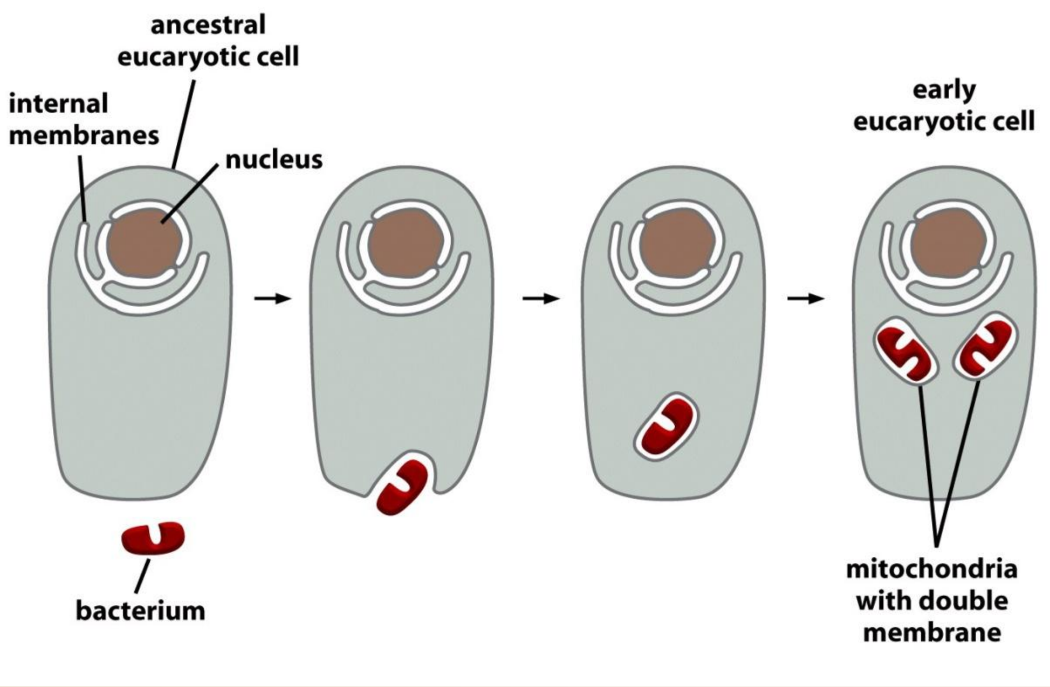
2. Membrane bounded inner structures. The synthesis of RNA and ptoteins are separated both in time and space

3. Symbiosis of energy producing prokaryotes and early type of eukaryotes (the origin of mitochondria and chloroplast)

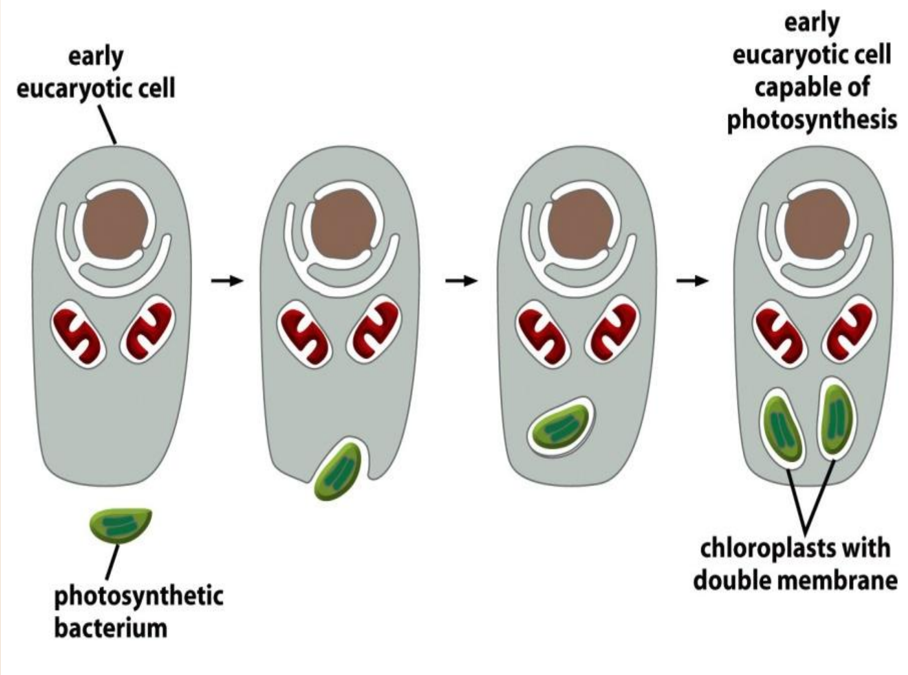
The most important structural features of eukaryotic cells







The origin of mitochondria.

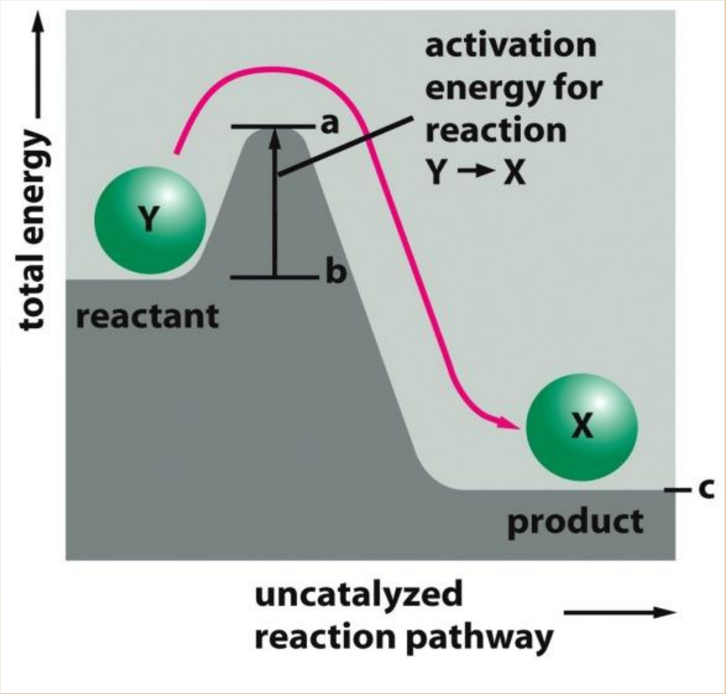


The origin of chloroplasts

Enzymes

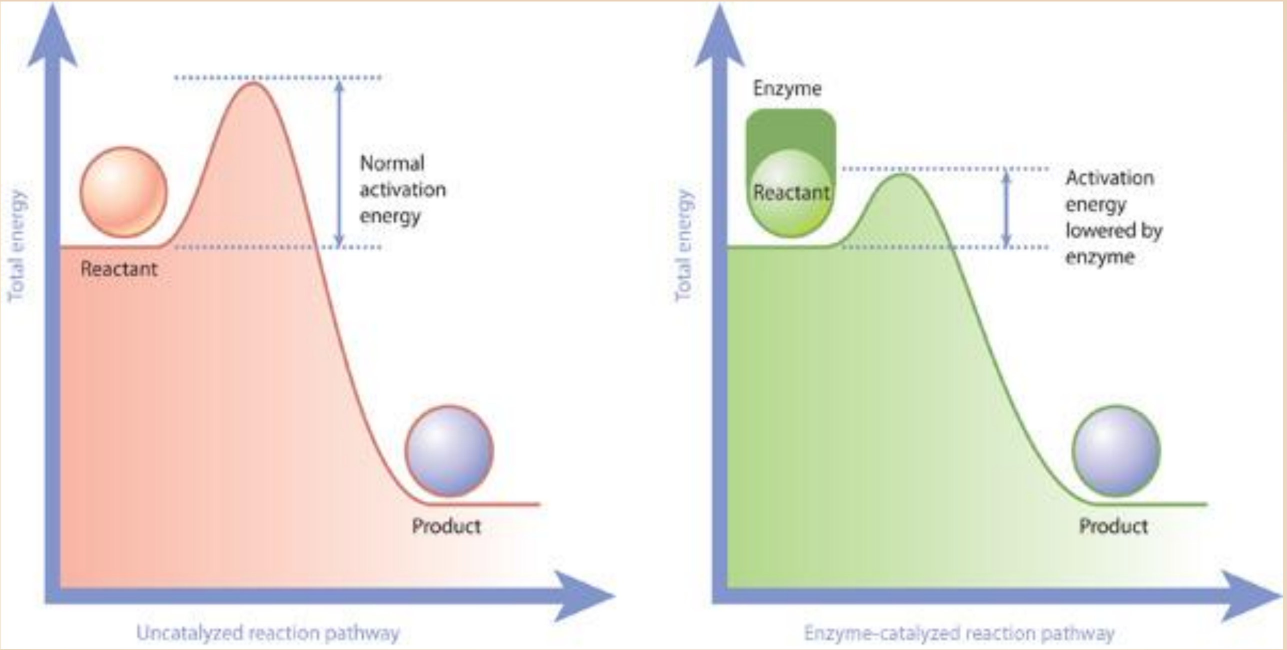
paper + O_2 ⟶ smoke + ash + heat + CO_2 + H_2O

The direction of chemical reactions is determined by the direction of decerease of free energy



Why all materials are not converted to their most stable form?

Answer: activation energy



Enzymatic acceleration of chemical reactions by decreasing the activation energy

Enzyme features

Only thermodynamically favoured reactions are catalyzed by enzymes

They “just” lower the activation energy: Biocatalyzators

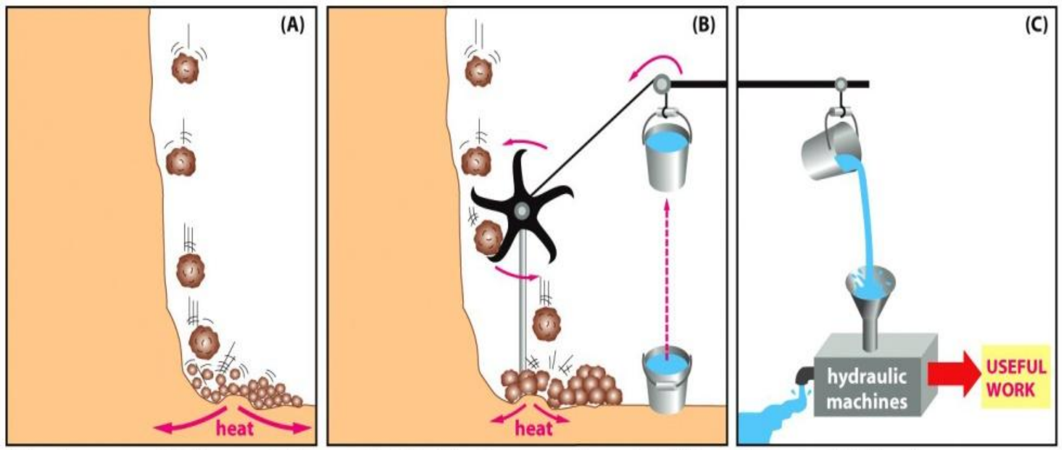
What about thermodynamically unfavoured reactions?

Coupled reactions

Exergonic reactions (with negative ΔG): spontaneous, occur without any energy investment

Endergonic reactions (with positive ΔG): do not occur spontaneously

It can occur if an exergonic reaction is coupled to it and the cumulative ΔG is negative

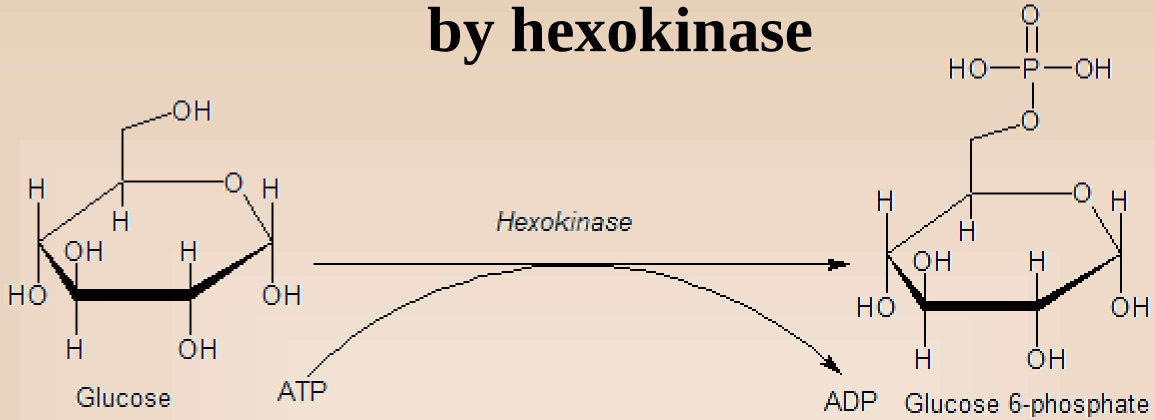


kinetic energy of falling rocks is transformed into heat energy only

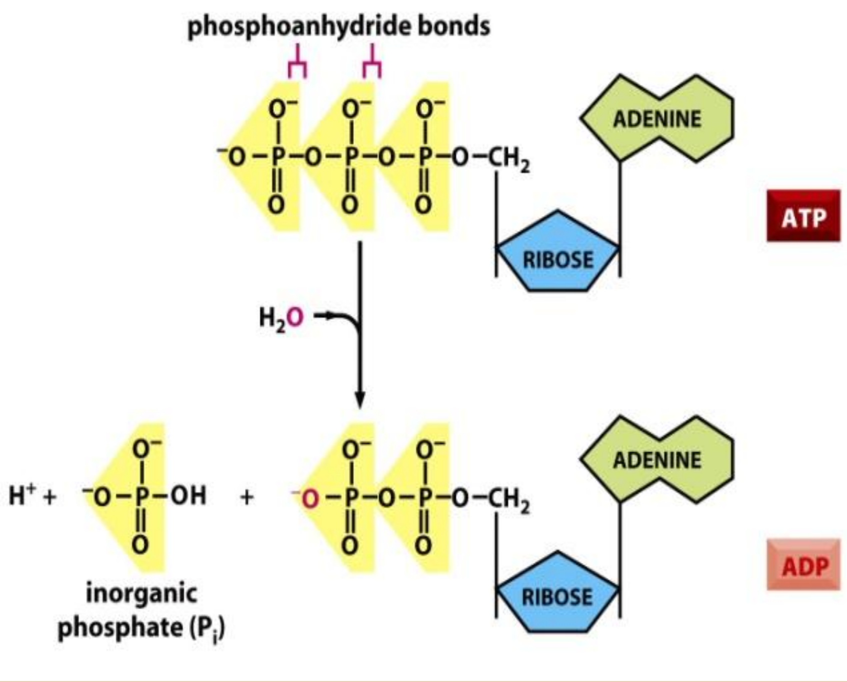
part of the kinetic energy is used to lift a bucket of water, and a correspondingly smaller amount is transformed into heat

the potential kinetic energy stored in the raised bucket of water can be used to drive hydraulic machines that carry out a variety of useful tasks

Coupled reaction of glucose phosphorylation and ATP hydrolysis by hexokinase



The hydrolysis of ATP to ADP and inorganic phosphate



Enzyme features

Only thermodynamically favoured reactions are catalyzed by enzymes

They “just” lower the activation energy: Biocatalyzators

Enzymes are not changed during the reactions

They are specific:

- Substrate
- Reaction

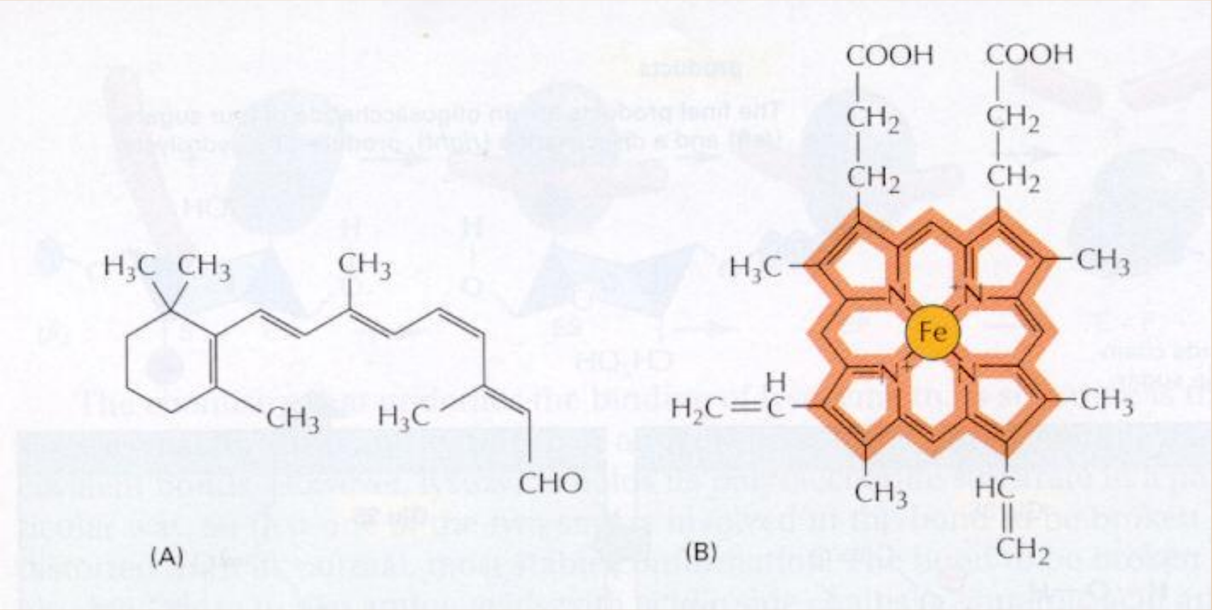
e.g.: hexokinase

Most enzymes are proteins

The primary, secondary, tertiary, and quaternary **structures of protein enzymes are essential to their catalytic activity**

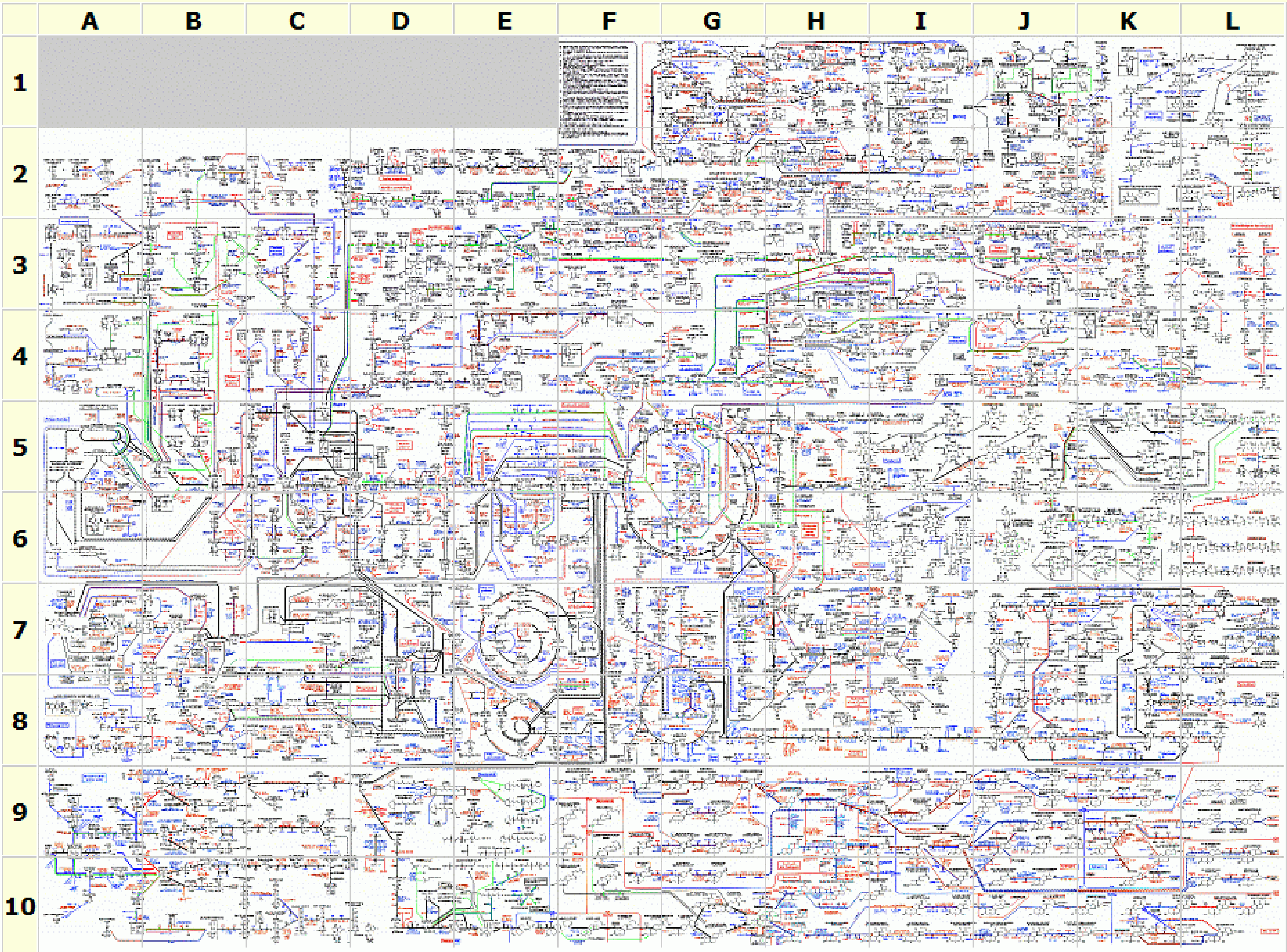
Several enzymes require an additional chemical component called a **cofactor**

A **coenzyme or metal ion** that is very tightly or even covalently **bound to the enzyme protein** is called a **prosthetic group**



Enzymes are classified by the reactions they catalyze

Class no.	**Class name**	**Type of catalyzed reaction**
1	Oxidoreductases	Transfer of electrons (hydride ions or H atoms)
2	Transferases	Group transfer reactions
3	Hydrolases	Hydrolysis reactions (transfer of functional groups to water)
4	Lyases	Addition of groups to double bonds, or formation of double bonds by removal of groups
5	Isomerases	Transfer of groups within molecules to yield isomeric forms
6	Ligases	Formation of C-C, C-S, C-O, and C-N bonds by condensation reactions coupled to cleavage of ATP or similar cofactor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