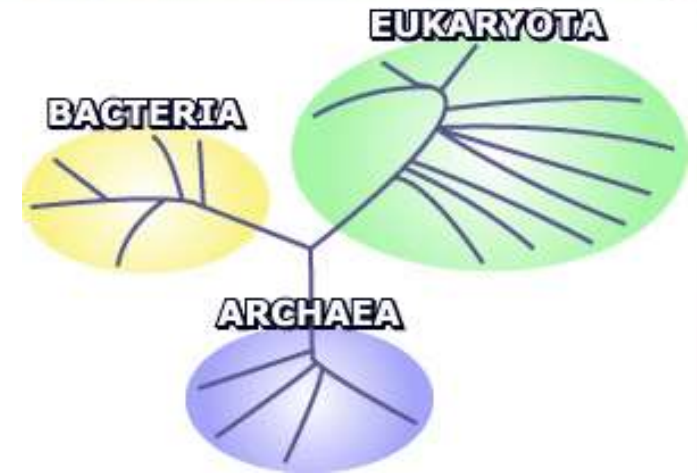




# Клетка



**1. Клетката – основна структурна и функционална единица на живия организъм**

**2. Прокариотни и еукариотни клетки**

**3. Клетъчна организация:**

- ✓ **външна морфология на клетката – големина, форма и цвят на клетките**
- ✓ **вътрешна морфология на клетката – клетъчни органели**

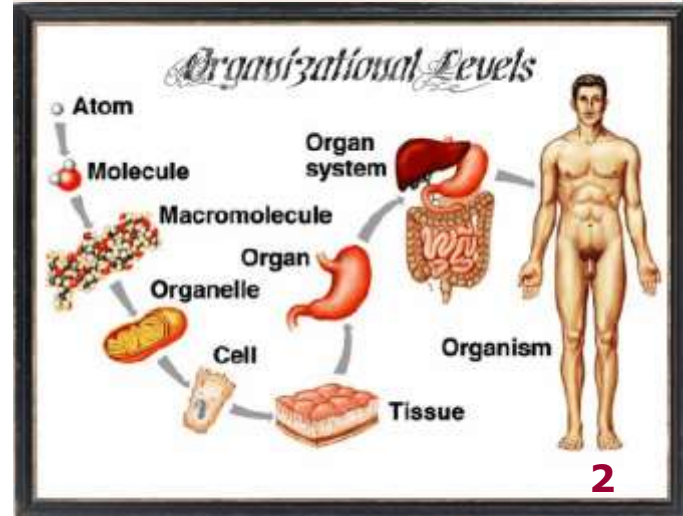
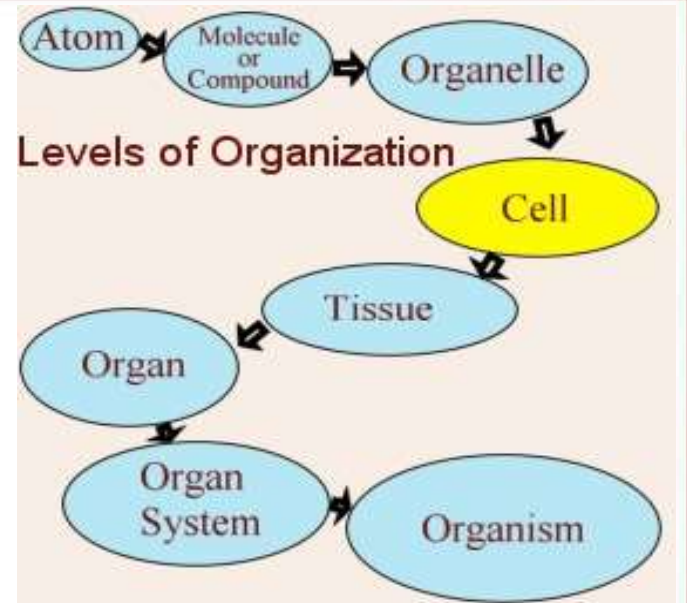
**4. Химичен състав на клетките**





# Нива на организация

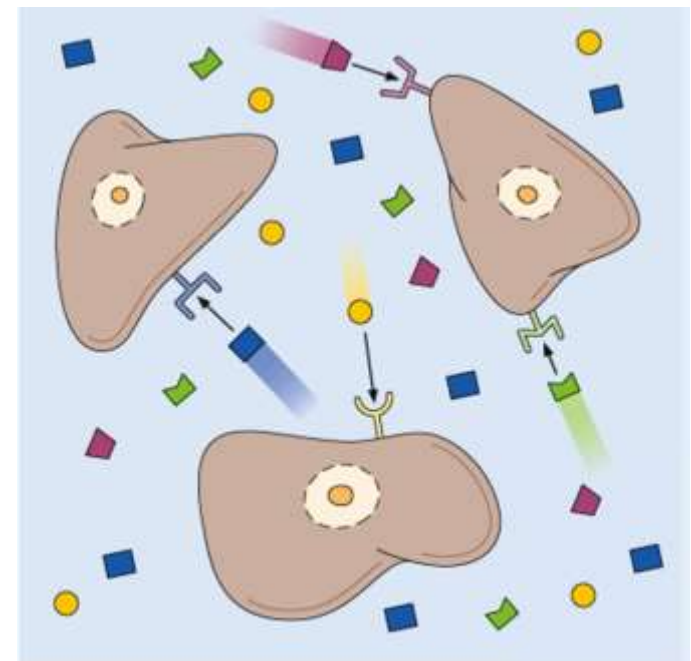
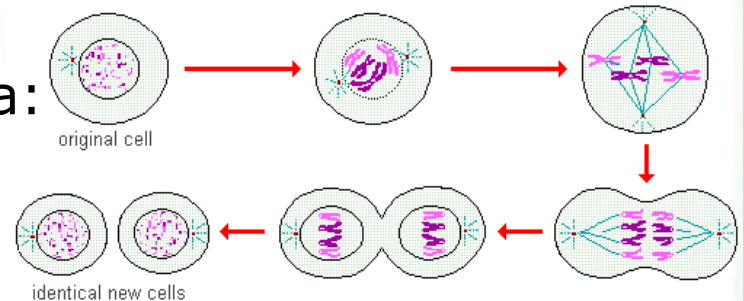
- Нива на организация на живата материя:  
клетка ⇨ тъкан ⇨ орган ⇨  
органна система ⇨ организъм
- Клетката е:
  - ✓ основната структурна и функционална единица на всички живи организми
  - ✓ най-малкият градивен блок на човешкото тяло



# Основни клетъчни свойства

## Основни клетъчни свойства:

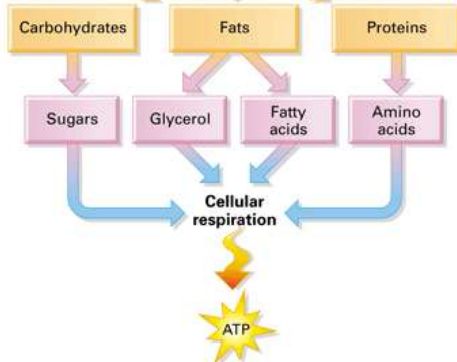
- ✓ размножаване чрез клетъчно делене
- ✓ функционирането на клетката зависи от нейната способност да извлича и използва химична енергия, съхранявана в органични молекули
- ✓ реагира на стимули като промяна в температурата, рН или нивото на хранителни вещества
- ✓ клетъчното съдържимо е ограничено от клетъчна мембрана



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Digestion and absorption

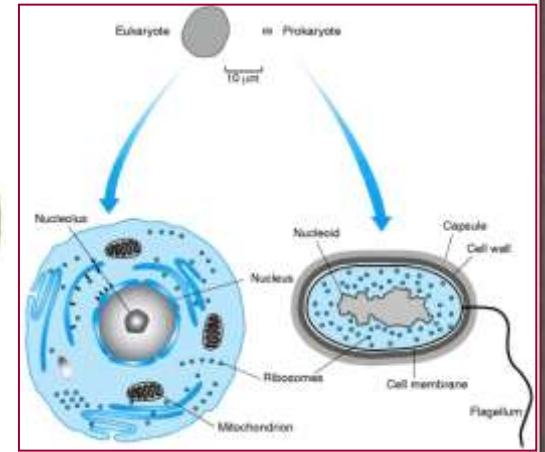
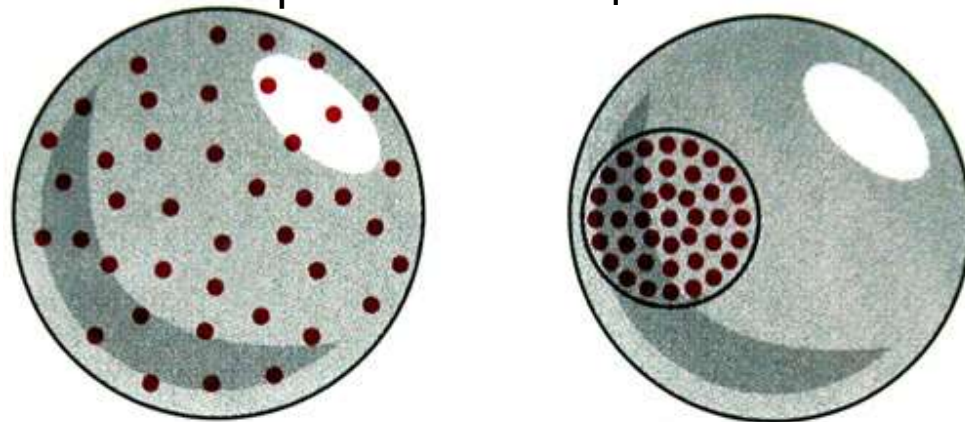
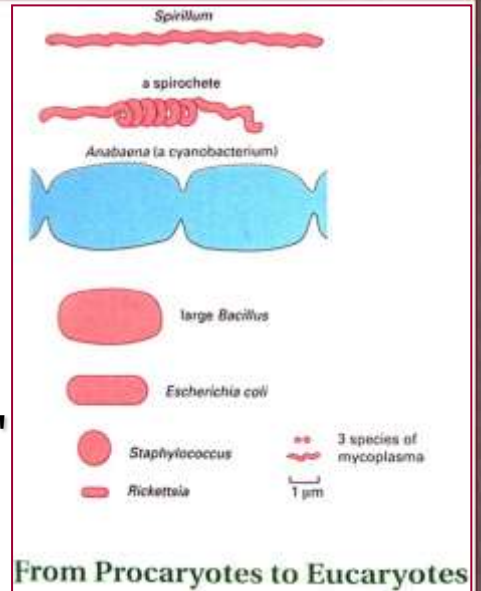
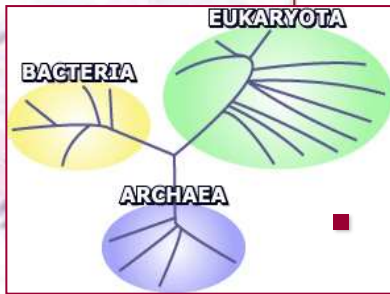




# Клетка – нива на еволюция

Биологичното разнообразие се състои от само **два типа клетки (клетъчни системи):**

- Прокариотни клетки – предядрени (Gr. *pró-* (*pro-*) "до" + *καρυόν* (*karyon*) "ядка или ядро", отнасящо се до клетъчно ядро)
  - ✓ бактерии, вкл. микоплазми
- Еукариотни клетки – "истинско ядро" (Gr. *eu-* "добър", "истински")
  - ✓ многоклетъчни организми
  - ✓ компартментализация на клетката

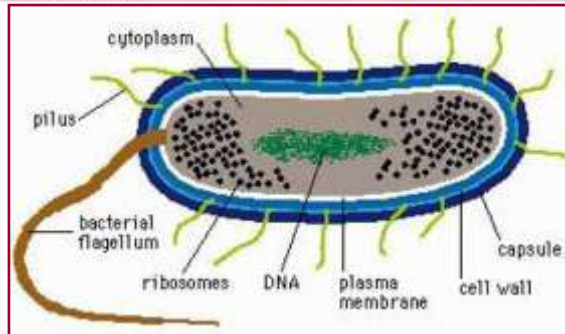


Compartmentalization

Проф. д-р Николай Лазаров



# Клетъчна йерархия



**Prokaryotes**

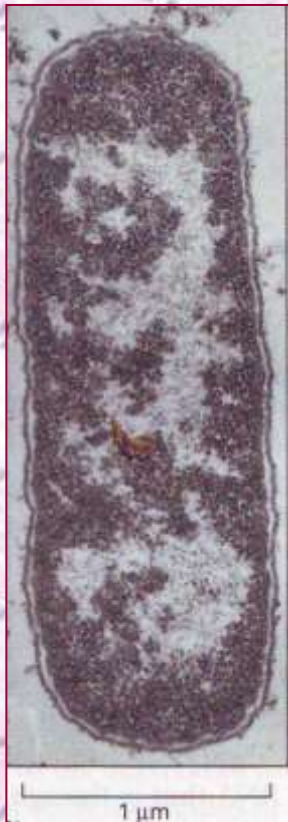
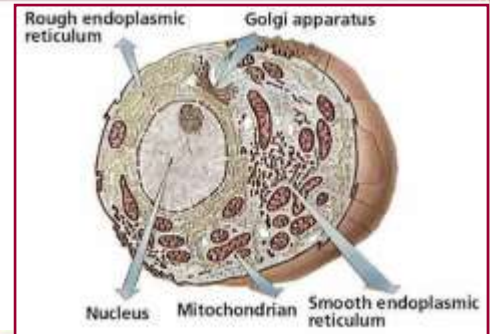
- Do not have a nucleus.
- They are cells in bacteria.
- Some of the DNA is outside the cell.
- reproduce asexually or through binary fission

**Both**

- They both contain DNA and cytoplasm.

**Eukaryotes**

- They have a nucleus
- Cells found in animals, plants, fungi, and protists.
- They are much larger than Prokaryotes.
- Reproduced through cell division.



**Table 1-1 Comparison of Prokaryotic and Eucaryotic Organisms**

	Prokaryotes	Eucaryotes									
Organisms	bacteria and cyanobacteria	protists, fungi, plants, and animals									
Cell size	generally 1 to 10 µm in linear dimension	generally 5 to 100 µm in linear dimension									
Metabolism	anaerobic or aerobic	aerobic									
Organelles	few or none	nucleus, mitochondria, chloroplasts, endoplasmic reticulum, etc.									
DNA	circular DNA in cytoplasm	very long linear DNA molecules containing many noncoding regions; bounded by nuclear envelope									
RNA and protein	RNA and protein synthesized in same compartment	RNA synthesized and processed in nucleus; proteins synthesized in cytoplasm									
Cytoplasm	no cytoskeleton: cytoplasmic streaming, endocytosis, and exocytosis all absent	cytoskeleton composed of protein filaments; cytoplasmic streaming; endocytosis and exocytosis									
Cell division	chromosomes pulled apart by attachments to plasma membrane	chromosomes pulled apart by cytoskeletal spindle apparatus									
Cellular organization	mainly unicellular	mainly multicellular, with differentiation of many cell types									
		<table border="1"> <thead> <tr> <th></th> <th>Eukaryotic cells</th> <th>Prokaryotic cells</th> </tr> </thead> <tbody> <tr> <td>Compartmentalized</td> <td>YES</td> <td>NO</td> </tr> <tr> <td>Cytoskeleton</td> <td>YES</td> <td>NO</td> </tr> </tbody> </table>		Eukaryotic cells	Prokaryotic cells	Compartmentalized	YES	NO	Cytoskeleton	YES	NO
	Eukaryotic cells	Prokaryotic cells									
Compartmentalized	YES	NO									
Cytoskeleton	YES	NO									



# Клетка – външна морфология

- 200 вида различни клетки

- големина – 5-200  $\mu\text{m}$

- ✓ малки – до 10  $\mu\text{m}$
- ✓ средни – 10-20  $\mu\text{m}$
- ✓ големи - > 20  $\mu\text{m}$

- форма – функционално обусловена:

- ✓ сферични
- ✓ вретеновидни
- ✓ плоски, кубични ...

- ЦВЯТ:

- ✓ безцветни
- ✓ пигментация



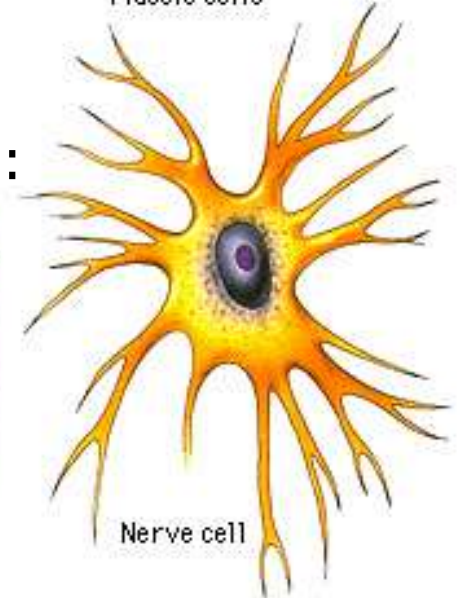
Red blood cell



Muscle cells



Leaf pore guard cells



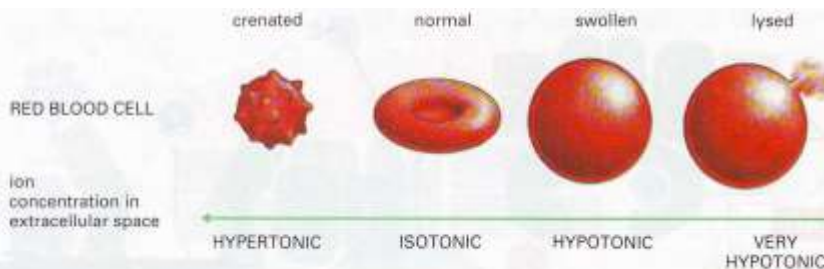
Nerve cell



Diatom



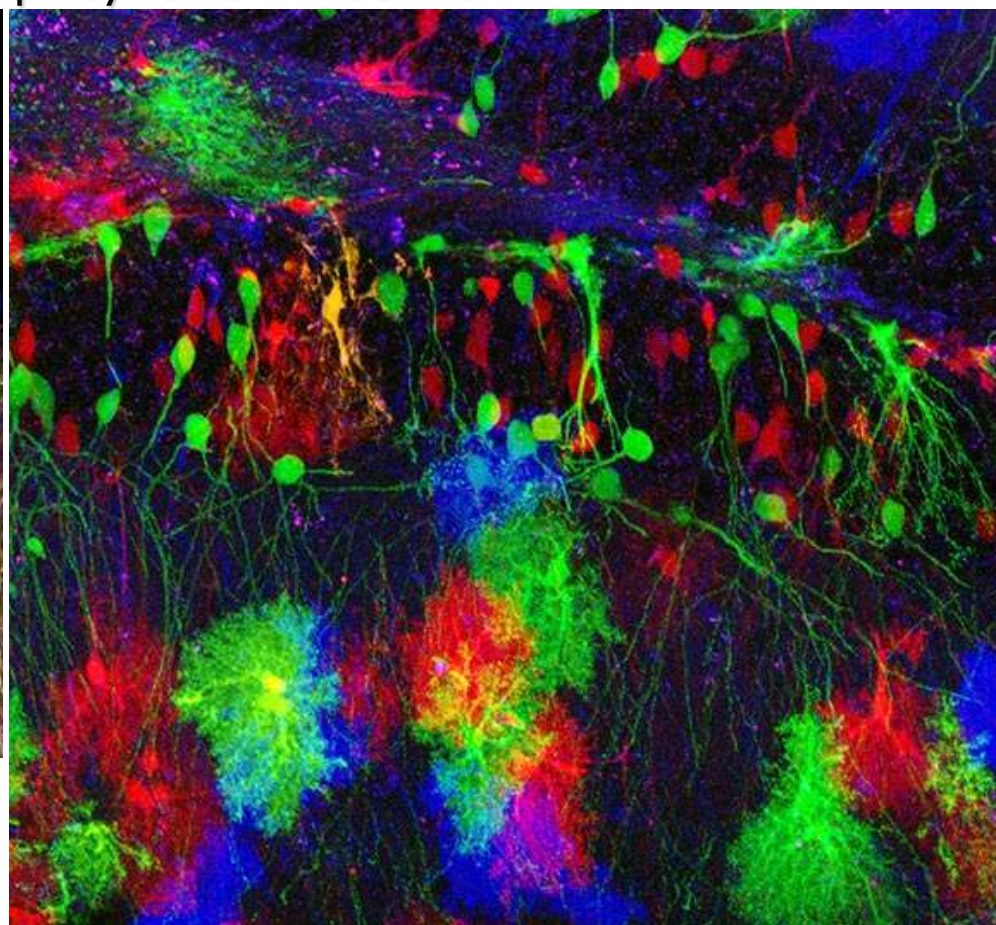
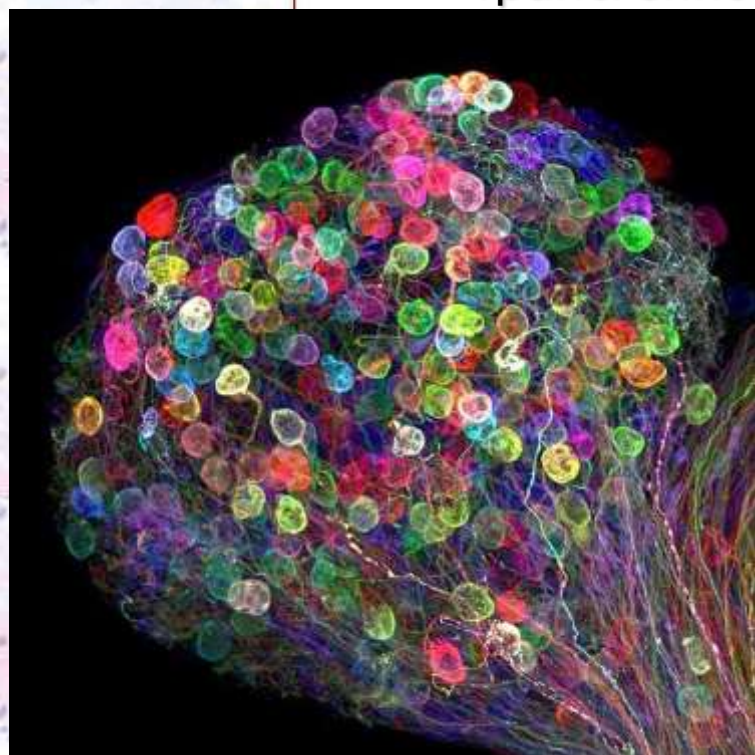
Paramecium





# Биоестетика: цветовете на мозъка

- *астроцити: you are so beautiful ... Joe Cocker (1944-2014)*
- **brainbow (мозъчна дъга)**
  - ✓ трангенно рисуване в мозъка



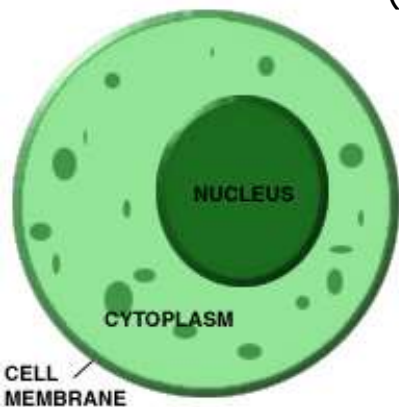
# Клетка – вътрешна морфология

- ядро (Lat., *nux*, орех)

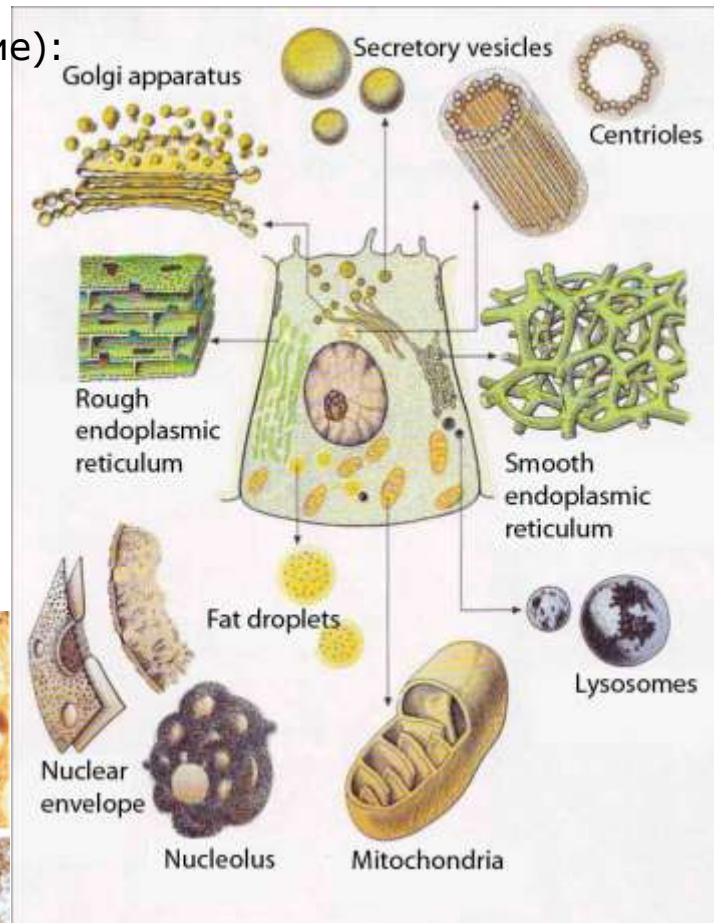
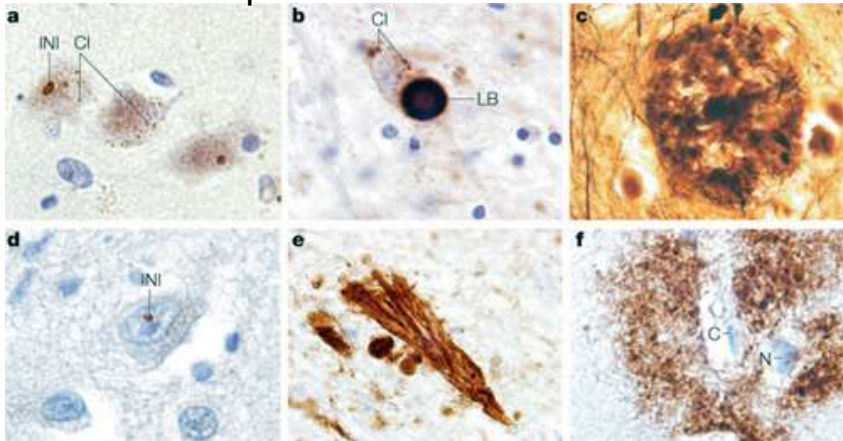
- цитоплазма:

(Gr. *kytos*, клетка + *plasma*, образуване):

- ✓ клетъчни органели
  - от общ тип (задължителни) и специализирани
  - мембранни и немембранни
- ✓ клетъчни включения
  - отлагания от въглехидрати, липиди и пигменти
- ✓ цитозол (клетъчен матрикс)
  - вода (до 90%)
  - протеини (20-25%)
  - въглехидрати
  - електролити
  - рН 6.8



CELL MEMBRANE





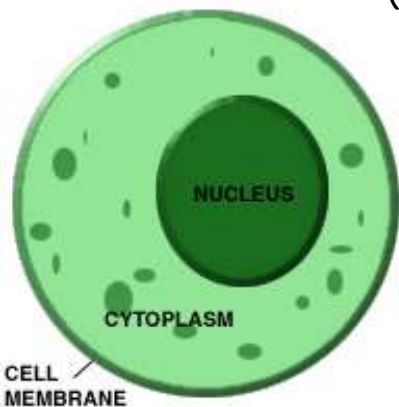
# Клетка – вътрешна морфология

- ядро (Lat., *nux*, орех)

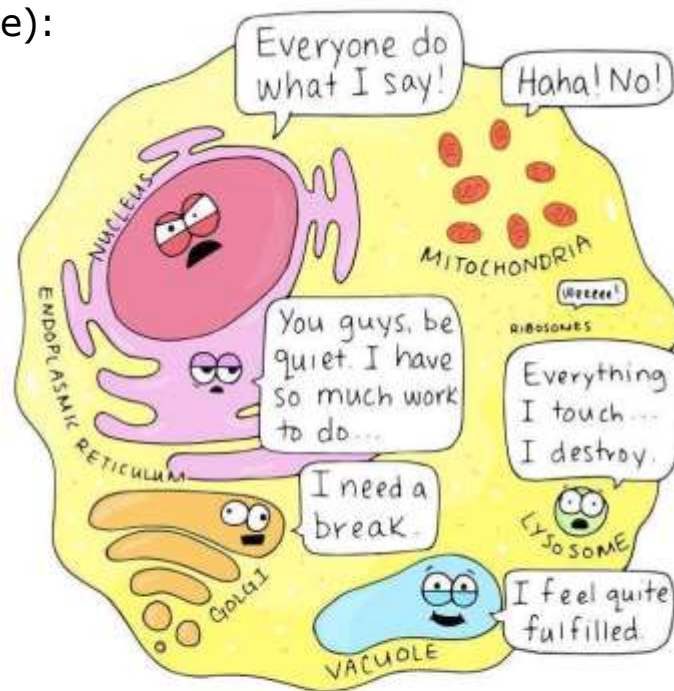
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- ✓ клетъчни органели
  - от общ тип (задължителни) и специализирани
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  - въглехидрати
  - електролити
  - рН 6.8

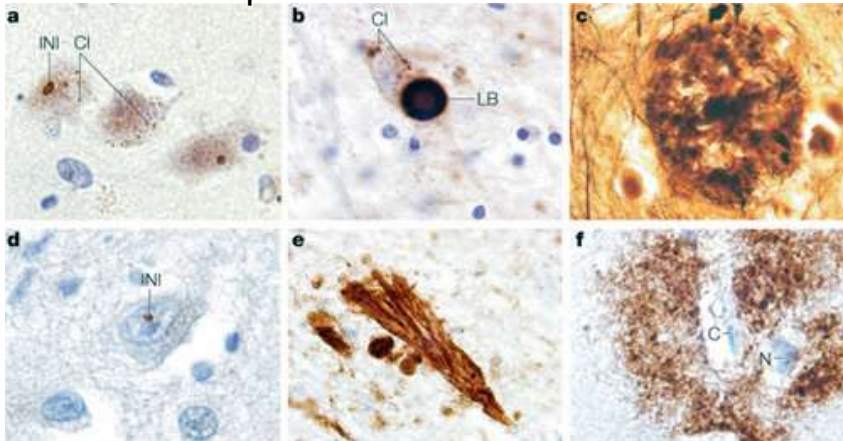


CELL MEMBRANE



If organelles could talk

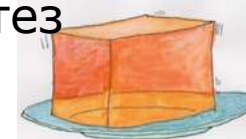
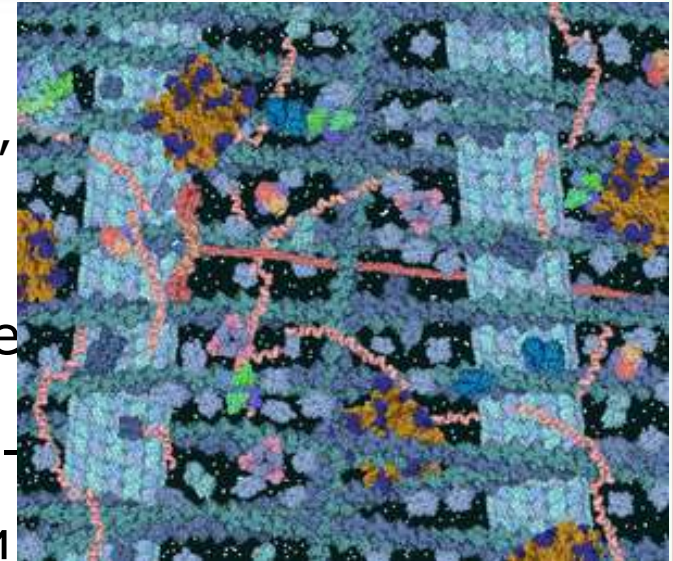
Beatrice the Biologist





# Клетъчен матрикс

- **ЦИТОЗОЛ** (цитоплазмен матрикс, хиалоплазма – Heinstein, 1880)
  - ✓ ~70% от клетъчния обем
  - ✓ крайната фракция от клетъчното фракциониране
  - ✓ прозрачна течност, рН 6.8
  - ✓ тънка 3D микротрабекуларна мрежа (цитоскелет) – интермедиерни и актинови филаменти, микротубули
  - ✓ субстрат за цитоплазмените функции
  - ✓ вода (до 90%)
  - ✓ макромолекули:
    - ✓ протеини (20-25%), вкл. разтворими ензими
    - ✓ цялата машинерия за синтез на протеини (рРНК, иРНК, тРНК, ензими)
    - ✓ въглехидрати
    - ✓ соли и електролити



Cytosol = Jell-O



Cytoplasm = Veggie-stew

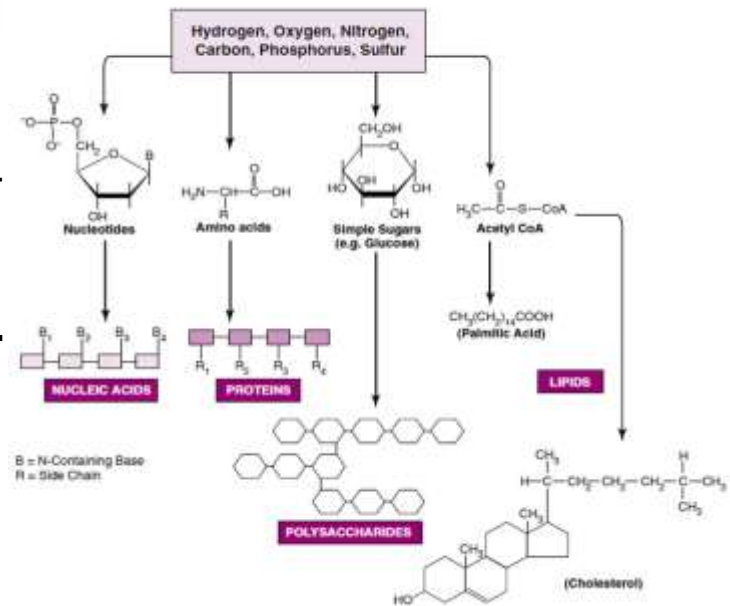
10



# Клетка – химичен състав



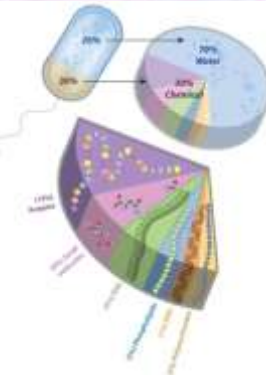
Formation of Macromolecules Within Cells



- Основни елементи:
  - ✓ макроелементи – 98-99% от клетъчната маса – C, N, O, H
  - ✓ микроелементи – до 0.000001% – Cu, Zn, Mg и др.
  - ✓ ултрамикроелементи – ≤0.000001% – Hg, Ag, U, Ra
- Вода – 70-80%
  - ✓ екзогенна – 2/3
  - ✓ ендогенна – 1/3
- Неорганични вещества:
  - ✓ свободни – йони
  - ✓ свързани с органични и неорганични съединения
- Органични съединения:
  - ✓ въглехидрати
  - ✓ липиди
  - ✓ протеини – 60%
  - ✓ нуклеинови киселини

APPROXIMATE PERCENTAGE OF CHEMICAL SUBSTANCES IN A CELL

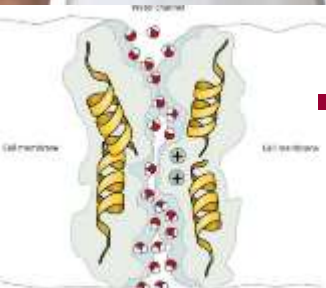
Sl No	Main class of chemical substances	Approximate percentage composition	
1.	Water	80.0	Inorganic
2.	Inorganic salts	1.0	
3.	Carbohydrates	1.0	
4.	Lipids	0.5	Organic
5.	Proteins	12.0	
6.	Nucleic acids	2.0	
7.	Other organic substances	0.5	



# Клетка – водно съдържимо



- **Вода – свойства:**
  - ✓ необходима за съществуването на всички живи същества
  - ✓ 99% от молекулите в живите клетки са водни молекули
  - ✓ 70-80% от теглото в повечето клетки



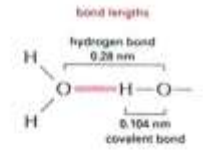
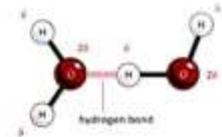
- **Основни функции:**
  - ✓ “матрица на живота”
  - ✓ универсален разтворител и дисперсна среда
  - ✓ помага на тялото да
    - поддържа постоянна телесна температура
    - елиминира остатъчните продукти от клетката

- **Водни канали:**
  - ✓ аквапорини – Peter Agre



## HYDROGEN BONDS

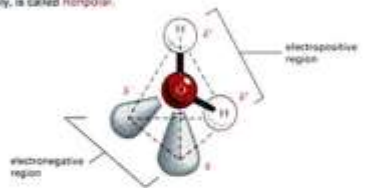
Because they are polarized, two adjacent H<sub>2</sub>O molecules can form a linkage known as a hydrogen bond. Hydrogen bonds have only about 1/20 the strength of a covalent bond.



Hydrogen bonds are strongest when the three atoms lie in a straight line.

## WATER

Two atoms, connected by a covalent bond, may exert different attractions for the electrons of the bond. In such cases the bond is *polar*, with one end slightly negatively charged (δ<sup>-</sup>) and the other slightly positively charged (δ<sup>+</sup>). A bond in which both atoms are the same, or in which they attract electrons equally, is called *nonpolar*.



Although a water molecule has an overall neutral charge (having the same number of electrons and protons), the electrons are asymmetrically distributed, which makes the molecule polar. The oxygen nucleus draws electrons away from the hydrogen nuclei, leaving these nuclei with a small net positive charge. The excess of electron density on the oxygen atom creates weakly negative regions at the other two corners of an imaginary tetrahedron.

## WATER STRUCTURE

Molecules of water join together transiently in a hydrogen bonded lattice. Even at 37°C, 15% of the water molecules are joined to four others in a short-lived assembly known as a “fluctuating cluster.”



The cohesive nature of water is responsible for many of its unusual properties, such as high surface tension, specific heat, and heat of vaporization.

## HYDROPHILIC AND HYDROPHOBIC MOLECULES

Because of the polar nature of water molecules, they will cluster around ions and other polar molecules.



Molecules that can thereby be accommodated in water's hydrogen-bonded structures are *hydrophilic* and relatively water-soluble.

Nonpolar molecules interrupt the H-bonded structure of water without forming favorable interactions with water molecules. They are therefore *hydrophobic* and quite insoluble in water.



The Nobel Prize in Chemistry 2003

# Клетка – органични съединения

захариди (Gr. *sakchar*, захар)

## Въглехидрати:

✓ монозахариди

➤ пентози

➤ хексози

✓ дизахариди

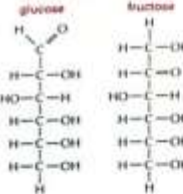
✓ полизахариди



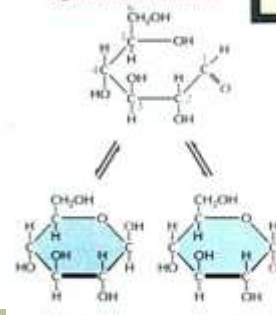
Common sources of carbohydrates include bread, cereals, pasta and potatoes.

### HEXOSES $n=6$

Two common hexoses are



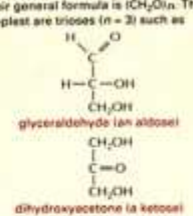
D-glucose (open-chain form)



STEREISOISOMERS

### MONOSACCHARIDES

Monosaccharides are aldehydes or ketones that also have two or more hydroxyl groups. Their general formula is  $\text{C}_n\text{H}_{2n}\text{O}_n$ . The simplest are trioses ( $n=3$ ) such as



### RING FORMATION

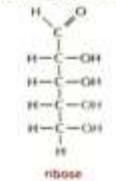
The aldehyde or ketone group of a sugar can react with a hydroxyl group. For the larger sugars ( $n>4$ ) this happens within the same molecule to form a 5- or 6-membered ring.

### NUMBERING

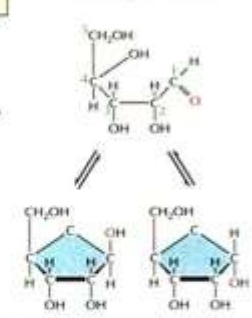
The carbon atoms of a sugar are numbered from the end closest to the aldehyde or ketone.

### PENTOSES $n=5$

A common pentose is



D-ribose (open-chain form)

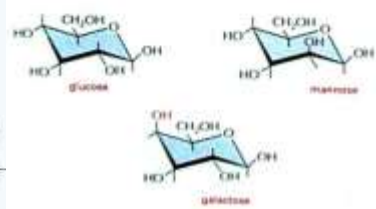


STEREISOISOMERS

CLASSIFICATION OF CARBOHYDRATES	
CARBOHYDRATES	
	<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><b>Saccharides (Sugars)</b></p> <ul style="list-style-type: none"> <li>* Low molecular weight</li> <li>* Soluble in water</li> <li>* Sweet to taste</li> </ul> <p>Physical Properties</p> </div> <div style="width: 45%;"> <p><b>Polysaccharides (Complex sugars)</b></p> <ul style="list-style-type: none"> <li>* High molecular weight</li> <li>* Insoluble in water</li> <li>* Tasteless</li> </ul> <p>Physical Properties</p> </div> </div>
	<div style="display: flex; justify-content: space-between;"> <div style="width: 30%;"> <p><b>Monosaccharides</b> Simple sugars</p> </div> <div style="width: 30%;"> <p><b>Disaccharides</b> Double sugars</p> </div> <div style="width: 30%;"> <p><b>Multiple sugars</b></p> </div> </div> <p>Composition</p>
	<p>Diagrammatic representation</p>
	<p><b>General formula</b></p> <p><math>(\text{C}_2\text{O})_n</math> When <math>n=3</math> to 7</p> <p><math>\text{C}_{12}\text{H}_{22}\text{O}_{11}</math></p> <p><math>\text{C}_x(\text{H}_2\text{O})_n</math></p>
	<p><b>Common examples</b></p> <p>Glyceraldehyde, Glucose, Fructose, Galactose, Ribose sugar</p> <p>Maltose, Sucrose, Lactose</p> <p>Starch, Glycogen, Cellulose, Lignin, Chitin</p>

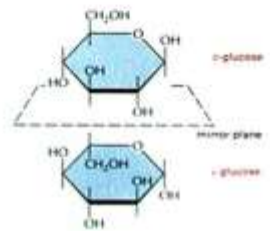
### ISOMERS

Monosaccharides have many isomers that differ only in the orientation of their hydroxyl groups—e.g., glucose, mannose, and galactose are isomers of each other.



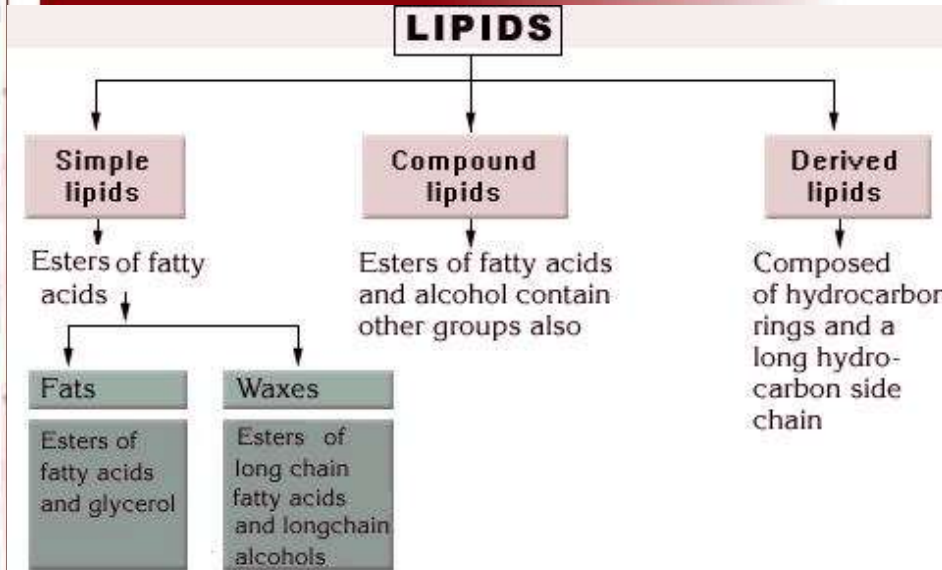
### D AND L FORMS

Two isomers that are mirror images of each other have the same chemistry and therefore are given the same name and distinguished by the prefix D or L.



# Клетка – органични съединения

## ■ Липиди (Gr. *lipos*, масти)



**LIPID AGGREGATES**

Fatty acids have a hydrophilic head and a hydrophobic tail.

In water they can form a surface film or form small vesicles.

Their derivatives can form larger aggregates held together by hydrophobic forces.

Triglycerides form large spherical fat droplets in the cell cytoplasm.

Phospholipids and glycolipids form self-assembling lipid bilayers that are the basis for all cellular membranes.

**OTHER LIPIDS**

Lipids are defined as the water-insoluble molecules in cells that are soluble in organic solvents. Two other common types of lipids are steroids and polyisoprenoids. Both are made from isoprene units.

**STERIODS**

Steroids have a common multiple ring structure.

Cholesterol—found in many membranes

Testosterone—male steroid hormone

**GLYCOLIPIDS**

Like phospholipids, these compounds are composed of a hydrophilic region, containing two long hydrocarbon tails, and a polar region, which now contains one or more sugar residues and no phosphate.

long chain polyene of isoprene

diphosphat phosphate—used to carry activated sugars in the membrane-associated synthesis of glycosphingolipids and some glycosphingolipids



**TRIGLYCERIDES**

Fatty acids are joined as an energy reserve that through an ester linkage to glycerol to form triglycerides.

**CARBOXYL GROUP**

If this, the carboxyl group of a fatty acid will be ionized.

But more usually it is linked to other groups to form other esters.

**PHOSPHOLIPIDS**

Phospholipids are the major constituents of cell membranes.

In phospholipids one of the -OH groups in glycerol are linked to fatty acids while the other -OH group is linked to phosphoric acid. The phosphoric is further linked to one of a variety of small non-polar head groups including:

**PHOSPHOLIPIDS**

hydrophilic head and hydrophobic tail and

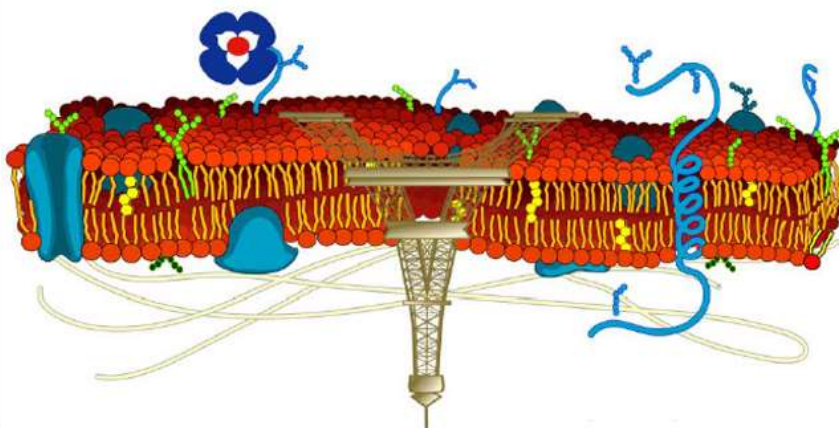




# Клетка – органични съединения

## ■ **Протеини** [Gr. *πρῶτος* (*prótos*), първичен]

- **Обща характеристика:**
  - ✓ много големи молекули от последователно свързани субединици, наречени аминокиселини
  - ✓ 60% of сухата маса на клетката (15% от общата маса)
  - ✓ определят формата и структурата на клетката
  - ✓ служат за основни инструменти за молекулярно разпознаване и катализа





# Класификация на протеините

## ■ Протеини [Gr. πρῶτος (prótos), първичен]

### ■ класификация - ~10000 различни вида:

#### ✓ структурни видове:

- прости протеини – албумини, глобулини, хистони, колаген
- сложни протеини
  - гликопротеини
  - липопротеини
  - нуклеопротеини
  - металопротеини

#### ✓ функционални класове:

- структурни протеини
- ензими
- транспортни протеини
- резервни протеини
- защитни протеини
- контрактилни протеини

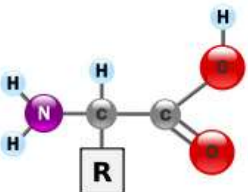
### Protein types

Type	Function	Examples
Structural	Give shape and structure to cell or organelles	Actin Tubulin
Enzymes	Catalyse biological reactions	Trypsin Adenylate cyclase
Receptors	Bind to other molecules and transmit signal	Glutamate R. Steroid R.
Other functional proteins	Have specific functions	Antibodies Nuclear factors Neuropeptides





# Строителни блокове на протеините

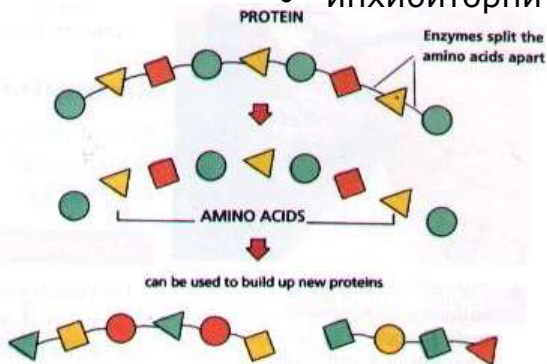


## THE ESSENTIAL AMINO ACIDS

- THREONINE
- METHIONINE
- LYSINE
- VALINE
- LEUCINE
- ISOLEUCINE
- HISTIDINE
- PHENYLALANINE
- TRYPTOPHAN

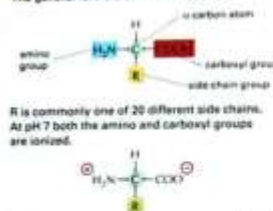
## аминокиселини:

- ✓ 20 различни вида:
  - "есенциални" (незаменими)
  - "неесенциални"
- ✓ главни функции:
  - най-малките единици и строителни блокове на протеините
- ✓ непротеинни функции:
  - предшественици за синтеза на някои биологични молекули
  - образуват части на коензими
  - междинни продукти на метаболизма
  - невротрансмитери:
    - възбудни
    - инхибиторни



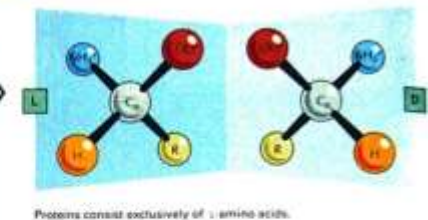
## THE AMINO ACID

The general formula of an amino acid is



## OPTICAL ISOMERS

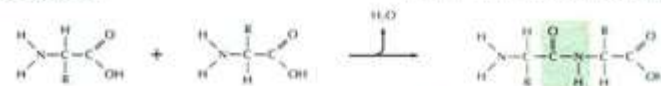
The alpha carbon atom is asymmetric, which allows for two mirror images for stereoisomers, L and D.



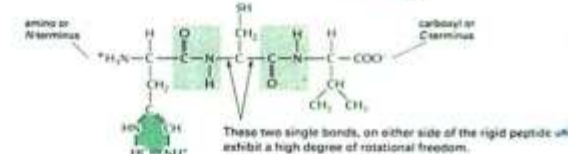
## PEPTIDE BONDS

Amino acids are commonly joined together by an amide linkage, called a peptide bond.

peptide bond: The four atoms in each gray box form a rigid planar unit. There is no freedom of rotation about the C-N bond.



Proteins are long polymers of amino acids linked by peptide bonds, and they are always written with the N-terminus toward the left. The sequence of this tripeptide is His Cys Val.



## FAMILIES OF AMINO ACIDS

The common amino acids are grouped according to whether their side chains are

acidic  
basic  
uncharged polar  
nonpolar

These 20 amino acids are given both three-letter and one-letter abbreviations. Thus, alanine = Ala = A

## BASIC SIDE CHAINS

**Lysine**  
(Lys, or K)

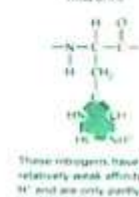


This group is very basic because its positive charge is stabilized by resonance.

**Arginine**  
(Arg, or R)



**Histidine**  
(His, or H)



These nitrogen atoms have a relatively weak affinity for an H<sup>+</sup> and are only partly protonated at neutral pH.

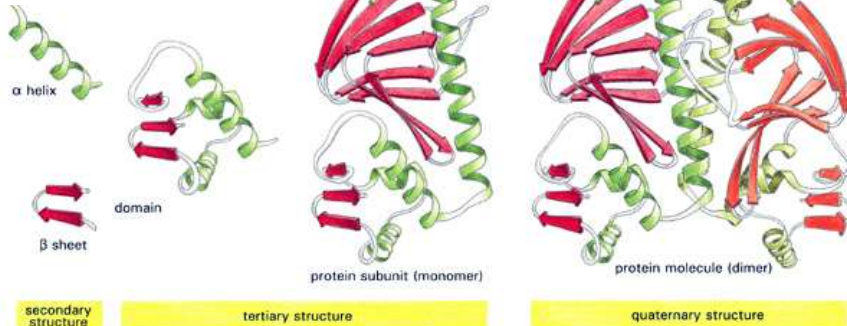
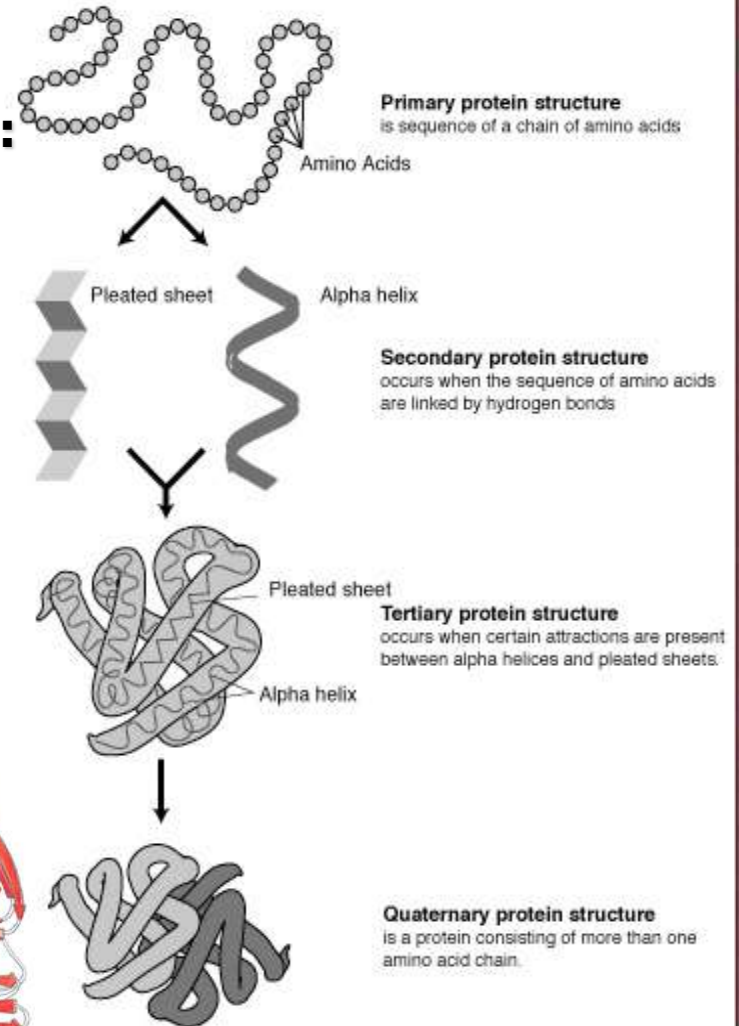


# Структура на протеините



## Четири нива на структурна организация:

- ✓ Първична структура:
  - последователността на аминокиселините
- ✓ Вторична структура:
  - правилно повтарящи се структури, стабилизирани с водородни връзки
- ✓ Третична структура:
  - образуване на протеинни субединици чрез нагъване
- ✓ Четвъртична структура:
  - обединяване на полипептидни вериги и образуване на мултимерни протеини



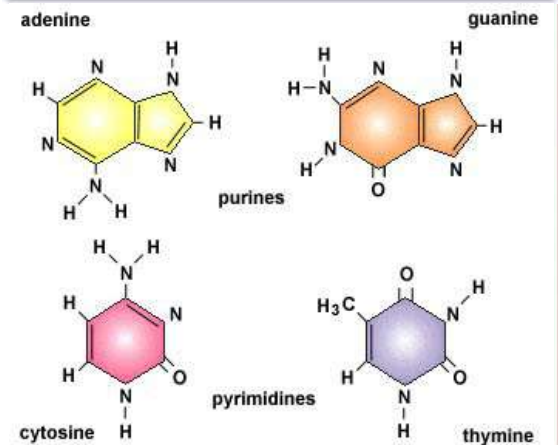
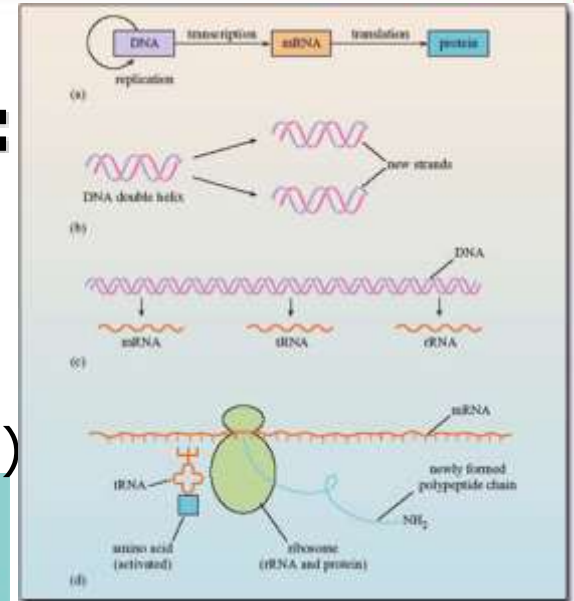
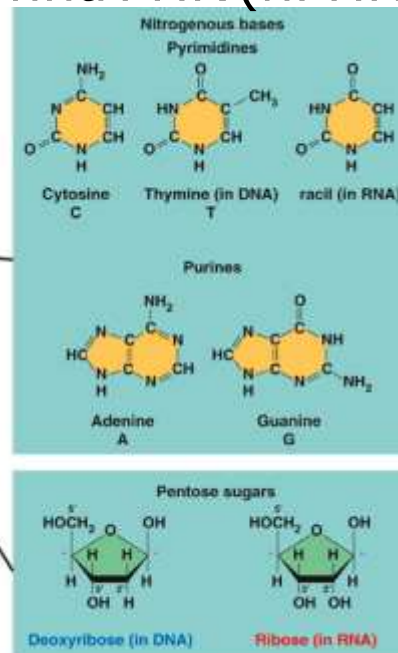
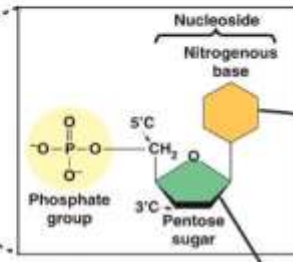
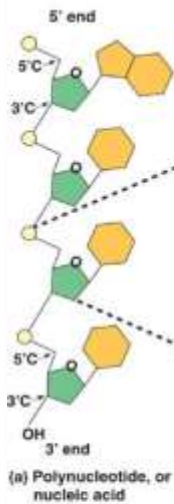


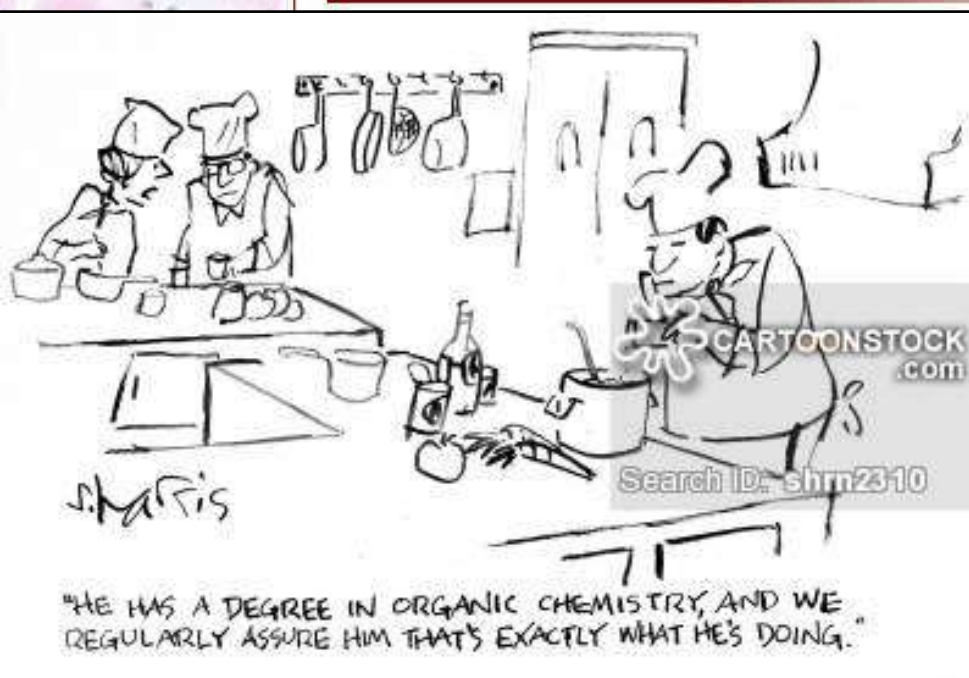
# Клетка – органични съединения

## ■ Нуклеинови киселини:

- ✓ ДНК
- ✓ РНК

- рибозомна РНК (рРНК)
- транспортна РНК (тРНК)
- информационна РНК (иРНК)





"HE HAS A DEGREE IN ORGANIC CHEMISTRY, AND WE REGULARLY ASSURE HIM THAT'S EXACTLY WHAT HE'S DOING."



"Apparently your DNA is composed of battery acids instead of nucleic acids."



**Благодаря ...**