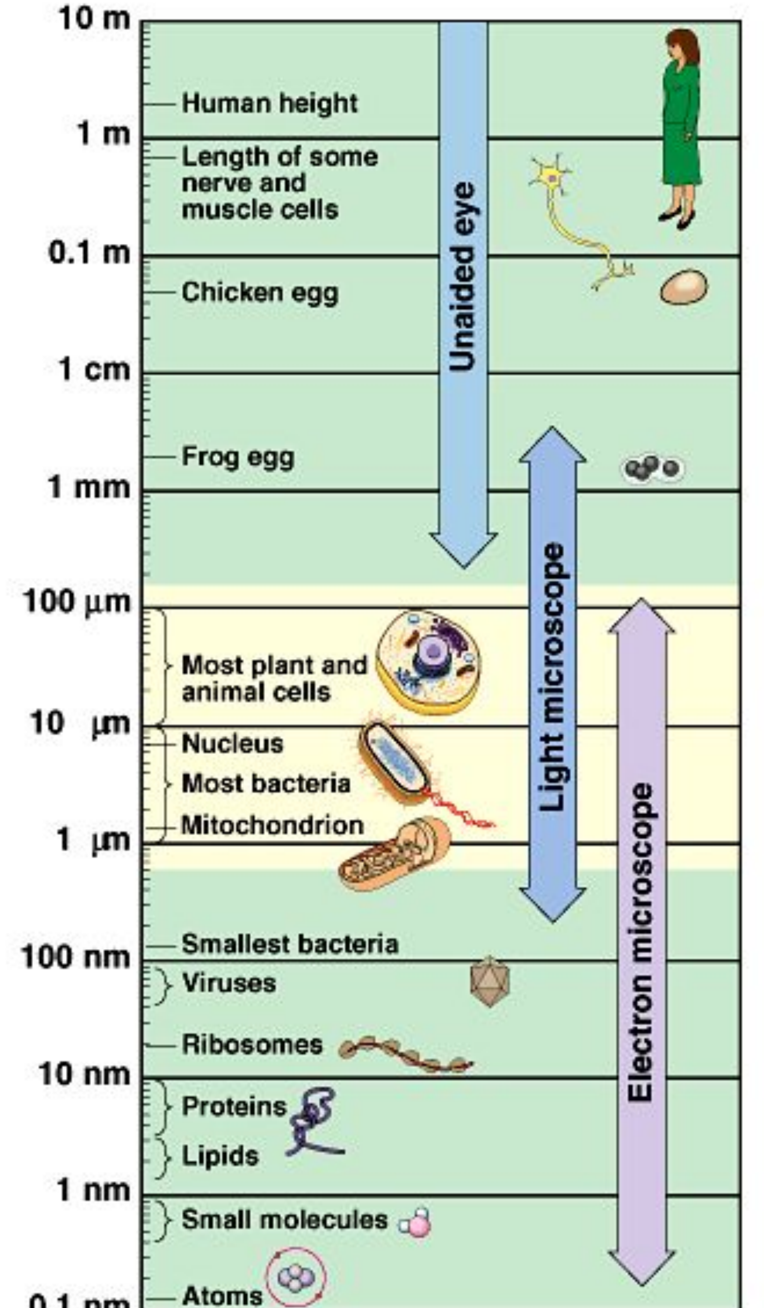
Генно-инженерные и белковые технологии в физиологии растений и сельском хозяйстве

Структурно-функциональная организация генов и белков. Экспрессия генов и биосинтез белка, клеточный контроль этих процессов. Гены продуктивности растений.

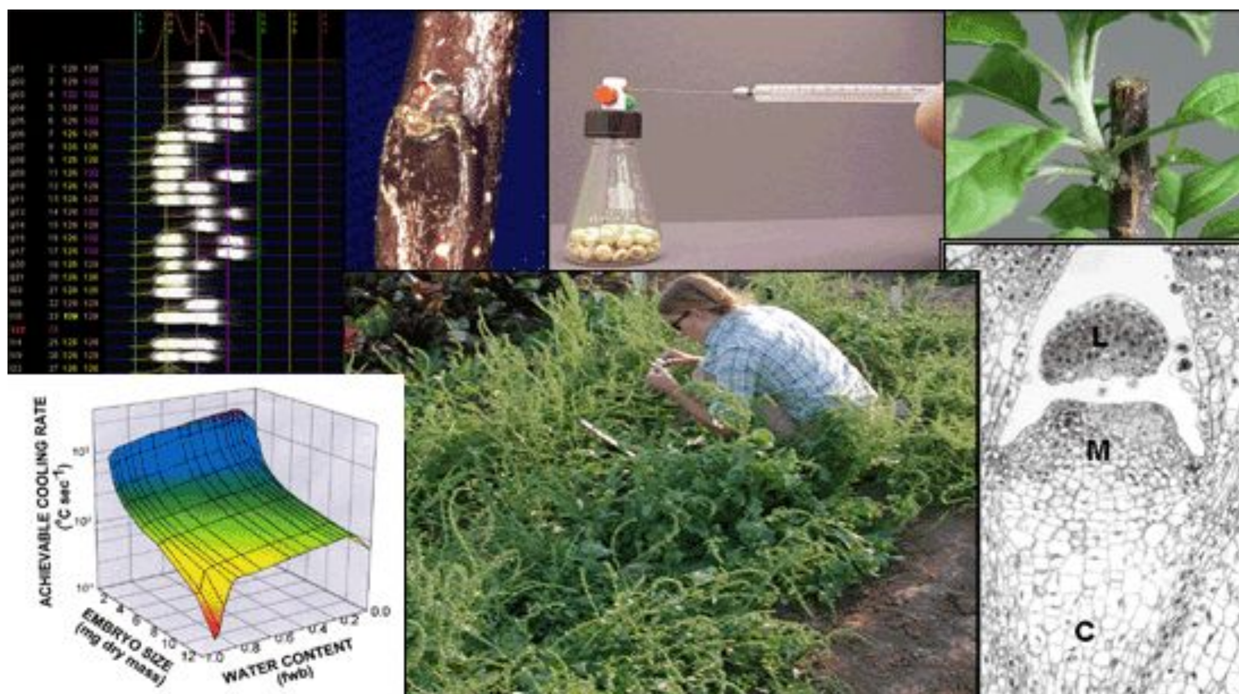


Измерения:

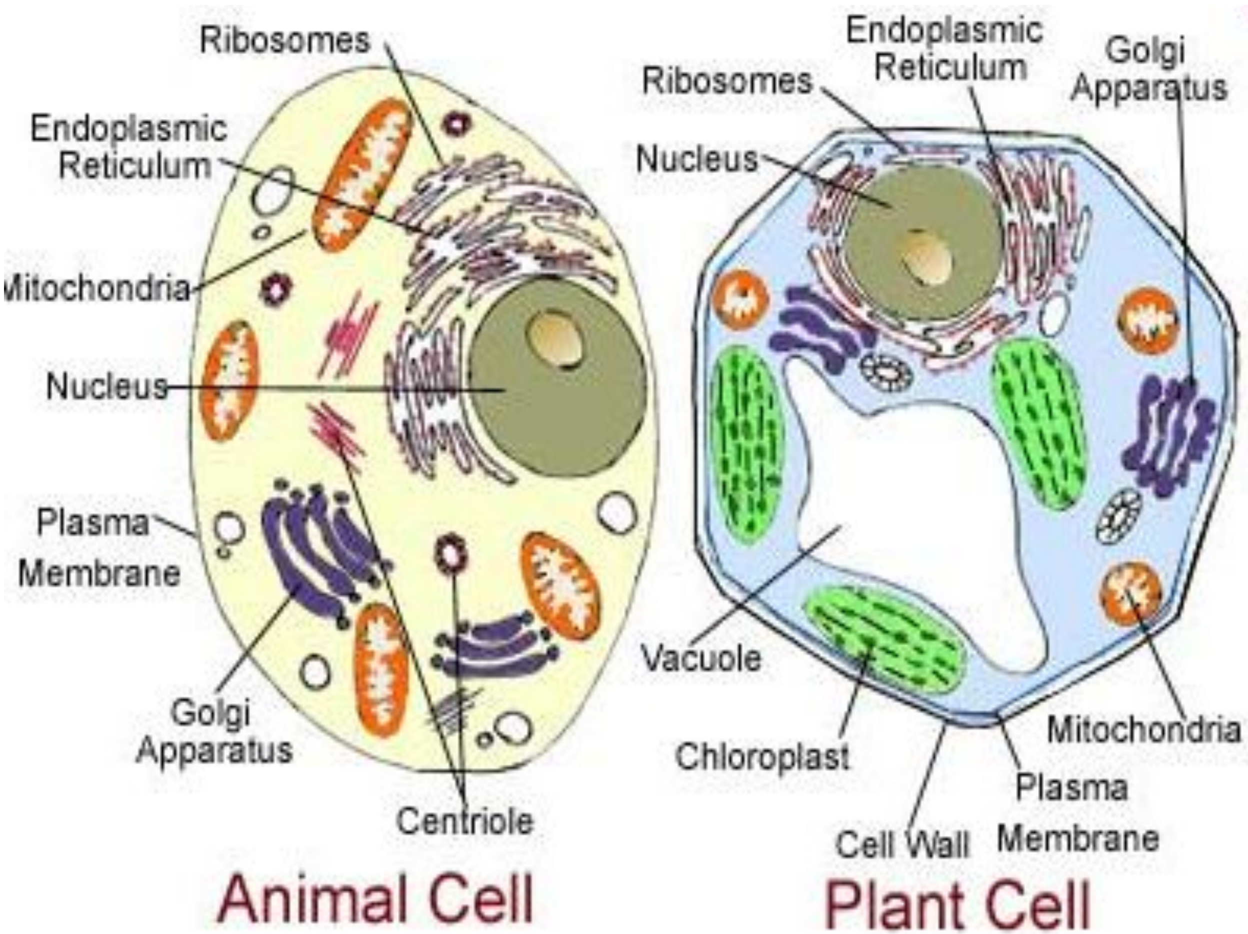
1 сантиметр (см) = 10^{-2} метра (м)
1 миллиметр (мм) = 10^{-3} м
1 микрометр (µм) = 10^{-3} мм = 10^{-6} м
1 нанометр (нм) = 10^{-3} µм = 10^{-9} м

Уровни организации (международная классификация, 2011 год):

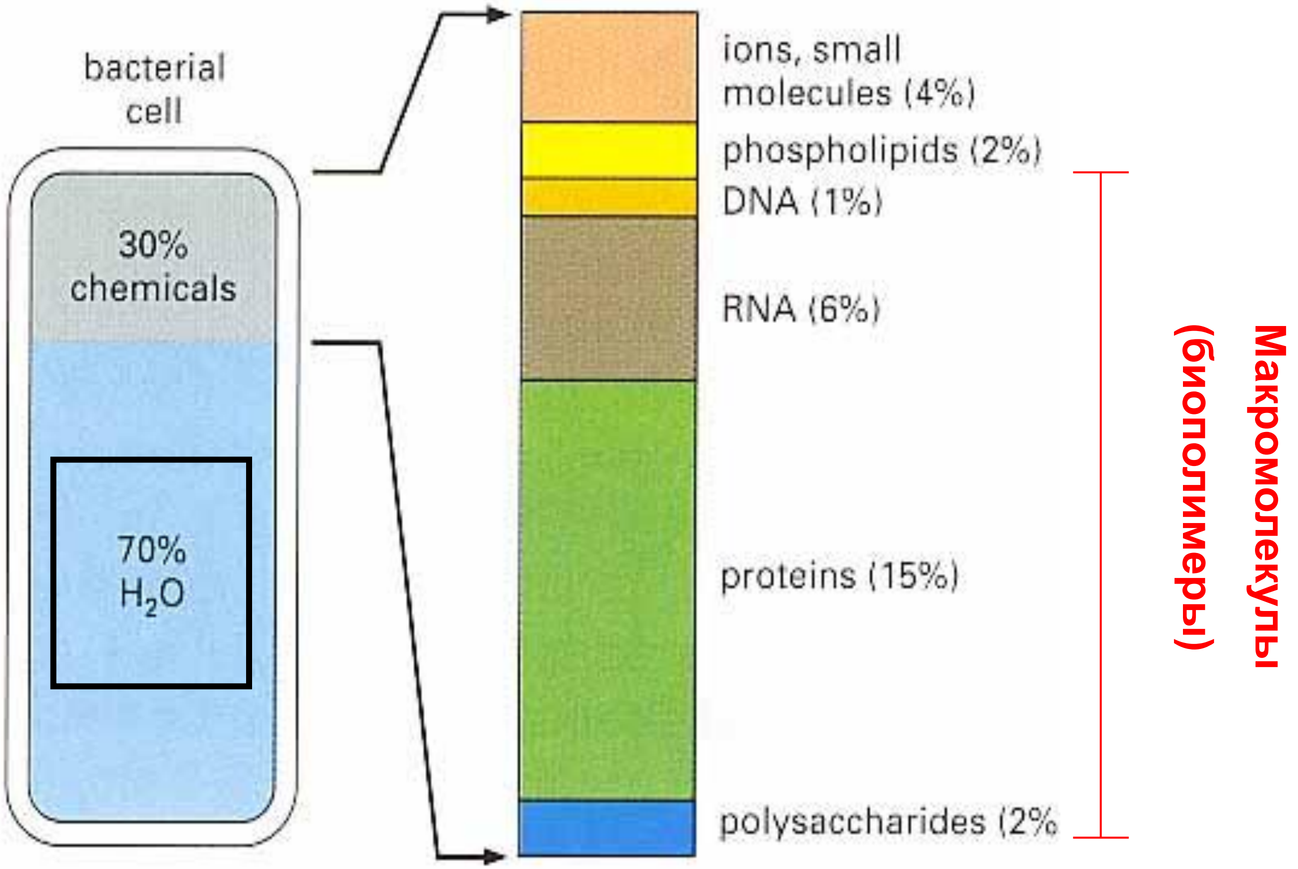
- Atoms
- Molecules
- Assemblies
- Cells
- Tissue
- Organ
- Organ system
- Organism
- Population



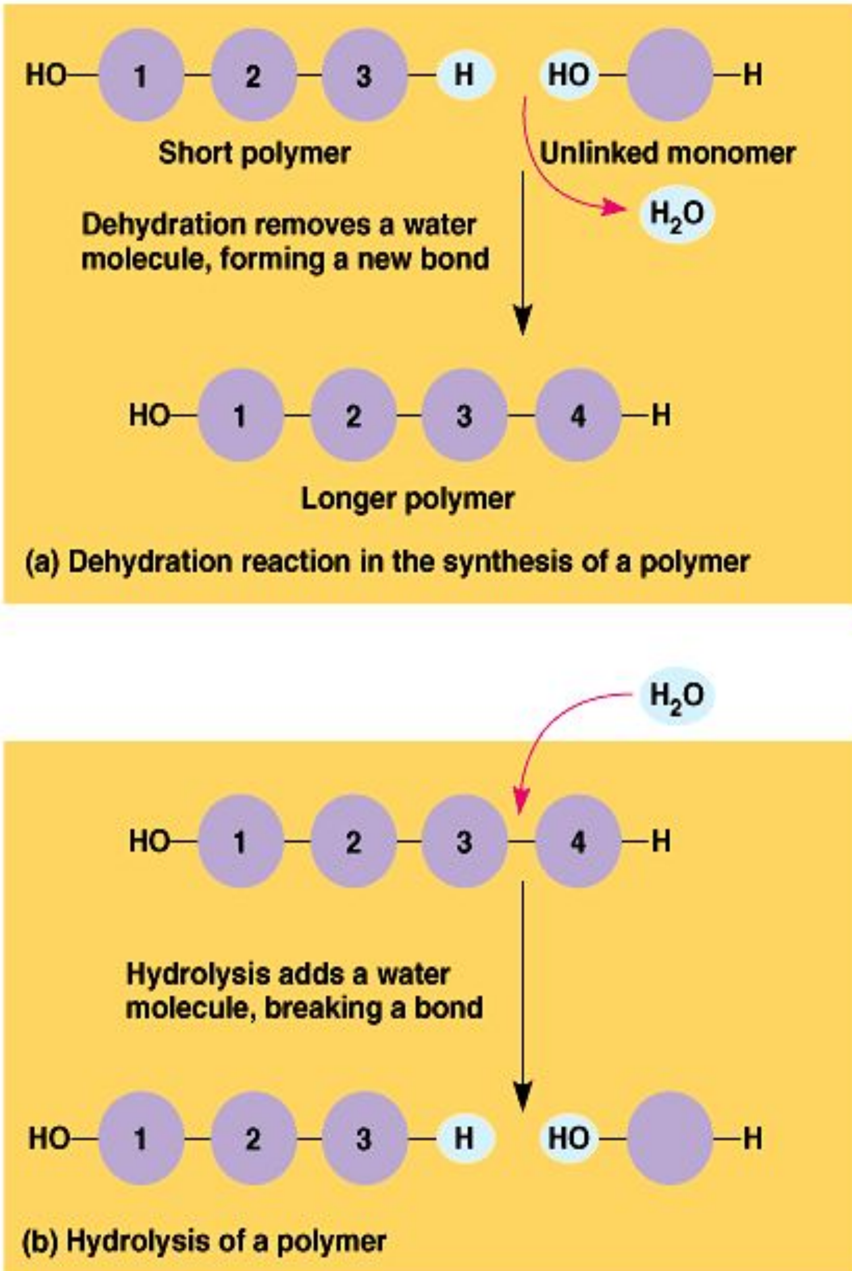
Растительные клетки (большая часть биомассы на планете) пища, топливо, материалы, витамины и т.д.



Химический состав типичной клетки



Общий принцип образования и распада биополимеров



синтез………

распад............

Всего 20 аминокислот участвует в образовании белков и других реакциях
(международные названия и классификация):

AMINO ACID			SIDE CHAIN
Aspartic acid	Asp	D	negative
Glutamic acid	Glu	E	negative
Arginine	Arg	R	positive
Lysine	Lys	K	positive
Histidine	His	H	positive
Asparagine	Asn	N	uncharged polar
Glutamine	Gln	Q	uncharged polar
Serine	Ser	S	uncharged polar
Threonine	Thr	T	uncharged polar
Tyrosine	Tyr	Y	uncharged polar

POLAR AMINO ACIDS

AMINO ACID			SIDE CHAIN
Alanine	Ala	A	nonpolar
Glycine	Gly	G	nonpolar
Valine	Val	V	nonpolar
Leucine	Leu	L	nonpolar
Isoleucine	Ile	I	nonpolar
Proline	Pro	P	nonpolar
Phenylalanine	Phe	F	nonpolar
Methionine	Met	M	nonpolar
Tryptophan	Trp	W	nonpolar
Cysteine	Cys	C	nonpolar

NONPOLAR AMINO ACIDS

Figure 4–3 **Twenty different amino acids are found in proteins.** Both three-letter and one-letter abbreviations are presented. As shown, there are an equal number of polar and nonpolar side chains. For atomic structures, see Panel 2–5 (pp. 74–75).

Аденозинтрифосфат - АТФ

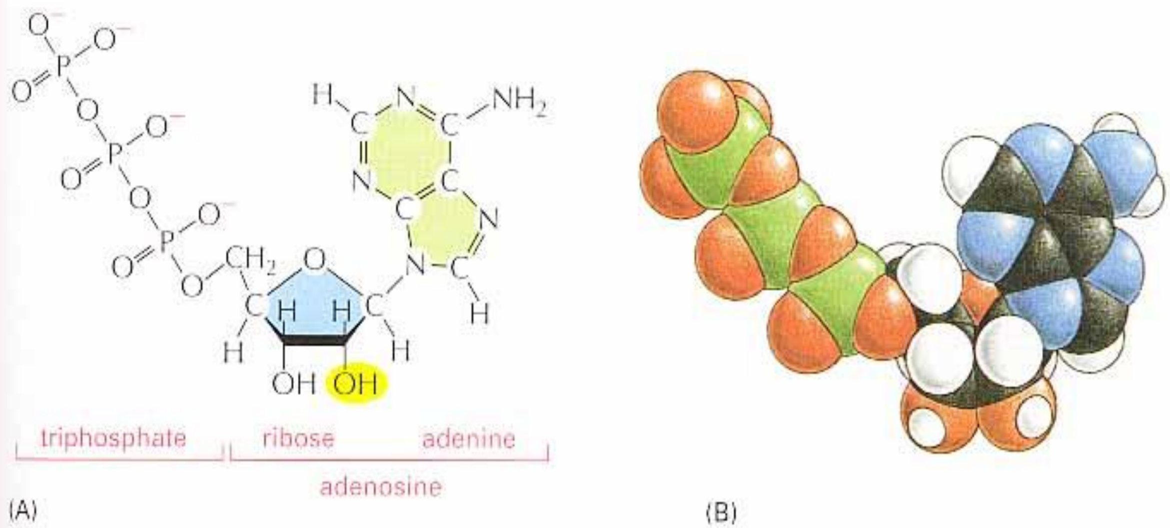
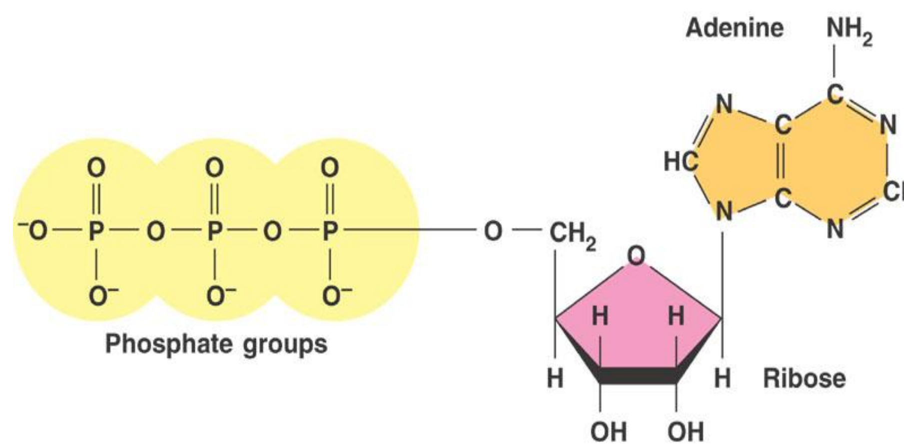
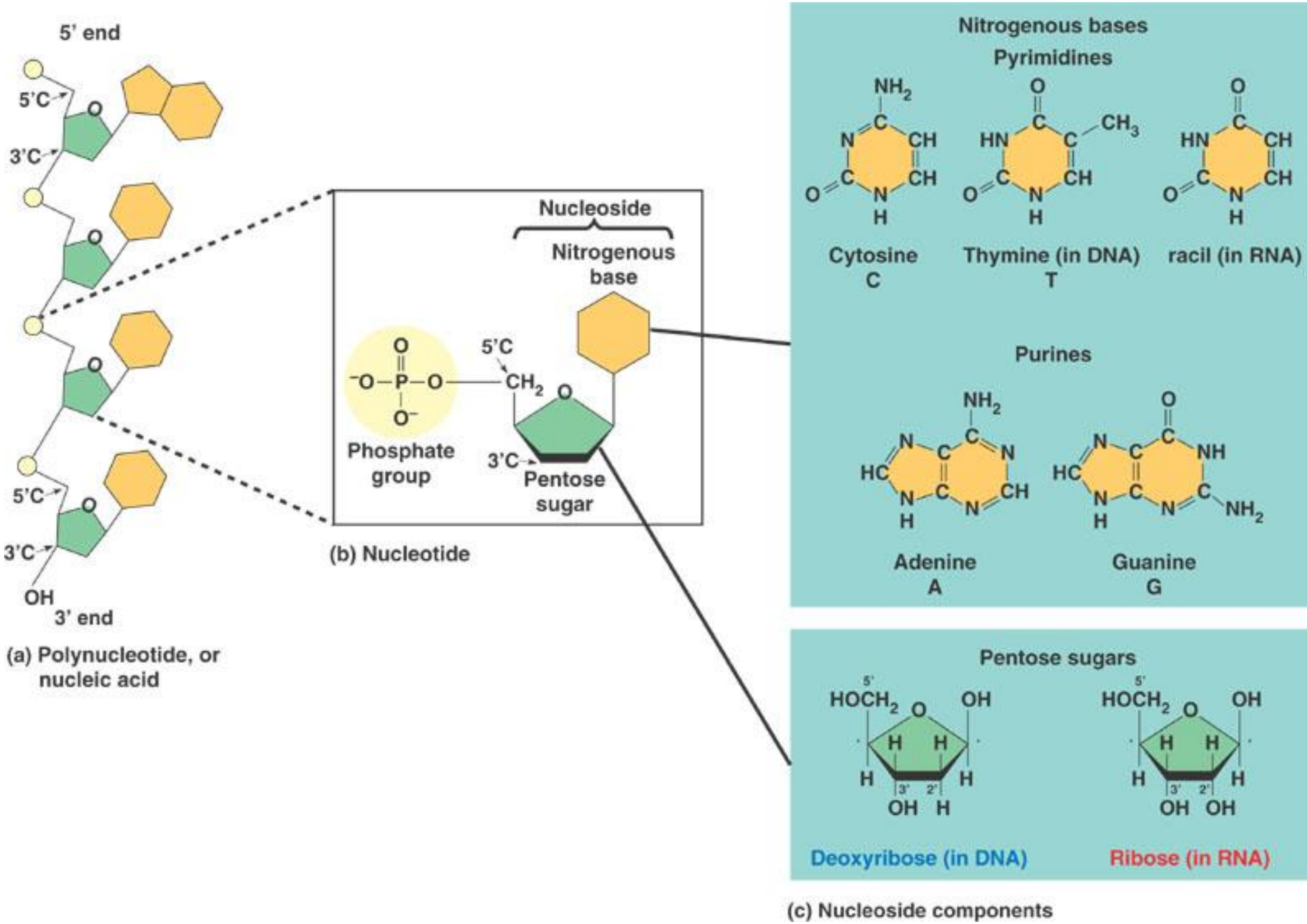


Figure 2–23 Adenosine triphosphate (ATP) is a nucleotide whose reactivity resides in its terminal phosphate groups. (A) Structural formula. (B) Space-filling model. In (B) the colors of the atoms are C, *black;* H, *white;* N, *blue;* O, *red;* and P, *green.* The deoxyribonucleotide version of adenosine triphosphate (dATP) differs only in that a hydrogen atom replaces the hydroxyl group shaded in *yellow* in (A).

- **АТФ – нуклеотид**
- **предшественник биосинтеза нуклеиновых кислот**
- **источник энергии**
- **медиатор, нейротрансмиттер, регулятор**



Строение нуклеиновых кислот:



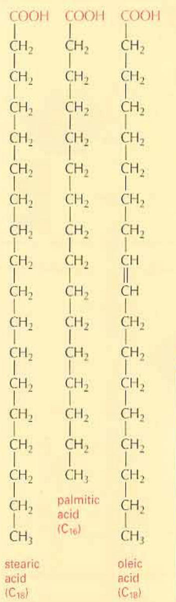
Строение липидов:

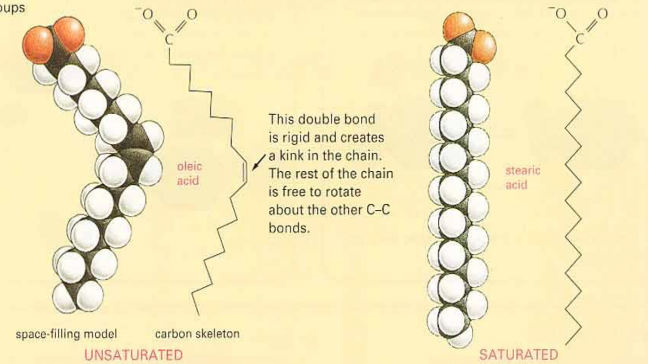
Panel 2–4 Fatty acids and other lipids

FATTY ACIDS

All fatty acids have carboxyl groups with long hydrocarbon tails.

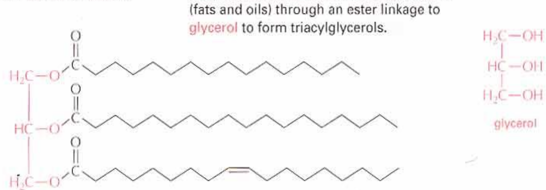
Hundreds of different kinds of fatty acids exist. Some have one or more double bonds in their hydrocarbon tail and are said to be unsaturated. Fatty acids with no double bonds are saturated.





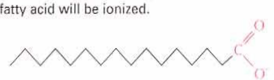
TRIACYLGLYCEROLS

Fatty acids are stored as an energy reserve (fats and oils) through an ester linkage to glycerol to form triacylglycerols.

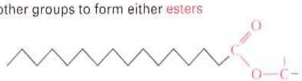


CARBOXYL GROUP

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



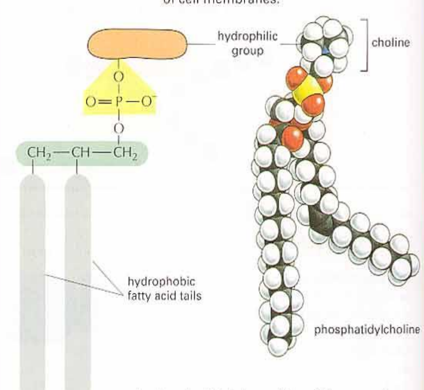
But more often it is linked to other groups to form either esters



or amides.

PHOSPHOLIPIDS

Phospholipids are the major constituents of cell membranes.

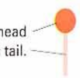


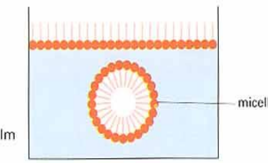
general structure of a phospholipid

In phospholipids two of the –OH groups in glycerol are linked to fatty acids, while the third –OH group is linked to phosphoric acid. The phosphate is further linked to one of a variety of small polar groups (alcohols).

LIPID AGGREGATES

Fatty acids have a hydrophilic head and a hydrophobic tail.

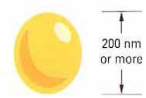




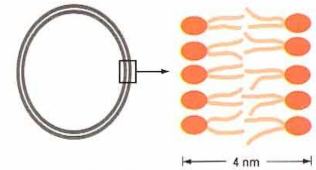
In water they can form a surface film or form small micelles.

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

Triglycerides form large spherical fat droplets in the cell cytoplasm.

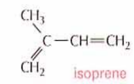


Phospholipids and glycolipids form self-sealing lipid bilayers that are the basis for all cellular membranes.



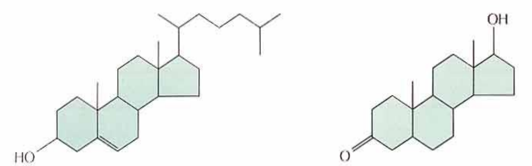
OTHER LIPIDS

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.



STEROIDS

Steroids have a common multiple-ring structure.

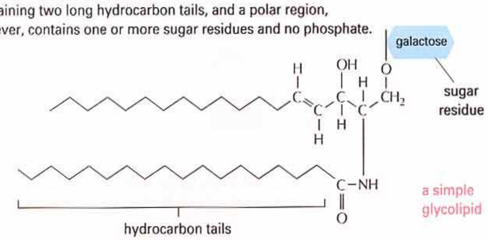


cholesterol—found in many membranes

testosterone—male steroid hormone

GLYCOLIPIDS

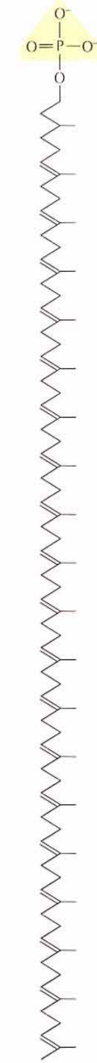
Like phospholipids, these compounds are composed of a hydrophobic region, containing two long hydrocarbon tails, and a polar region, which, however, contains one or more sugar residues and no phosphate.



a simple glycolipid

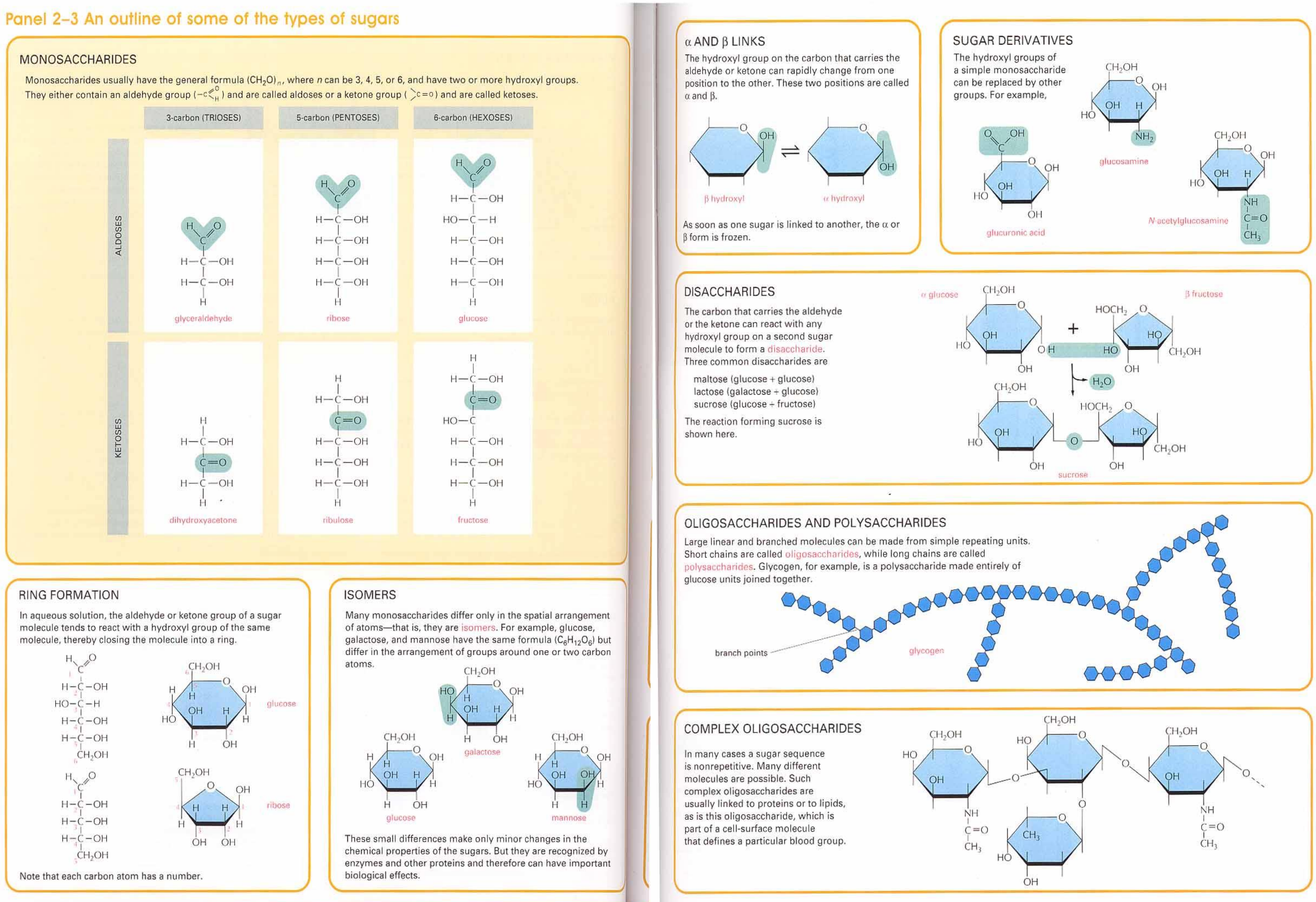
POLYISOPRENOIDS

long-chain polymers of isoprene



dolichol phosphate—used to carry activated sugars in the membrane-associated synthesis of glycoproteins and some polysaccharides

Строение липидов:



Panel 2–3 An outline of some of the types of sugars

MONOSACCHARIDES

Monosaccharides usually have the general formula $(CH_2O)_n$, where n can be 3, 4, 5, or 6, and have two or more hydroxyl groups. They either contain an aldehyde group ($-C\overset{O}{\underset{H}{\lessdot}}$) and are called aldoses or a ketone group ($>C{=}O$) and are called ketoses.

RING FORMATION

In aqueous solution, the aldehyde or ketone group of a sugar molecule tends to react with a hydroxyl group of the same molecule, thereby closing the molecule into a ring.

Note that each carbon atom has a number.

ISOMERS

Many monosaccharides differ only in the spatial arrangement of atoms—that is, they are isomers. For example, glucose, galactose, and mannose have the same formula ($C_6H_{12}O_6$) but differ in the arrangement of groups around one or two carbon atoms.

These small differences make only minor changes in the chemical properties of the sugars. But they are recognized by enzymes and other proteins and therefore can have important biological effects.

α AND β LINKS

The hydroxyl group on the carbon that carries the aldehyde or ketone can rapidly change from one position to the other. These two positions are called α and β.

As soon as one sugar is linked to another, the α or β form is frozen.

SUGAR DERIVATIVES

The hydroxyl groups of a simple monosaccharide can be replaced by other groups. For example,

DISACCHARIDES

The carbon that carries the aldehyde or the ketone can react with any hydroxyl group on a second sugar molecule to form a disaccharide. Three common disaccharides are

maltose (glucose + glucose)
lactose (galactose + glucose)
sucrose (glucose + fructose)

The reaction forming sucrose is shown here.

OLIGOSACCHARIDES AND POLYSACCHARIDES

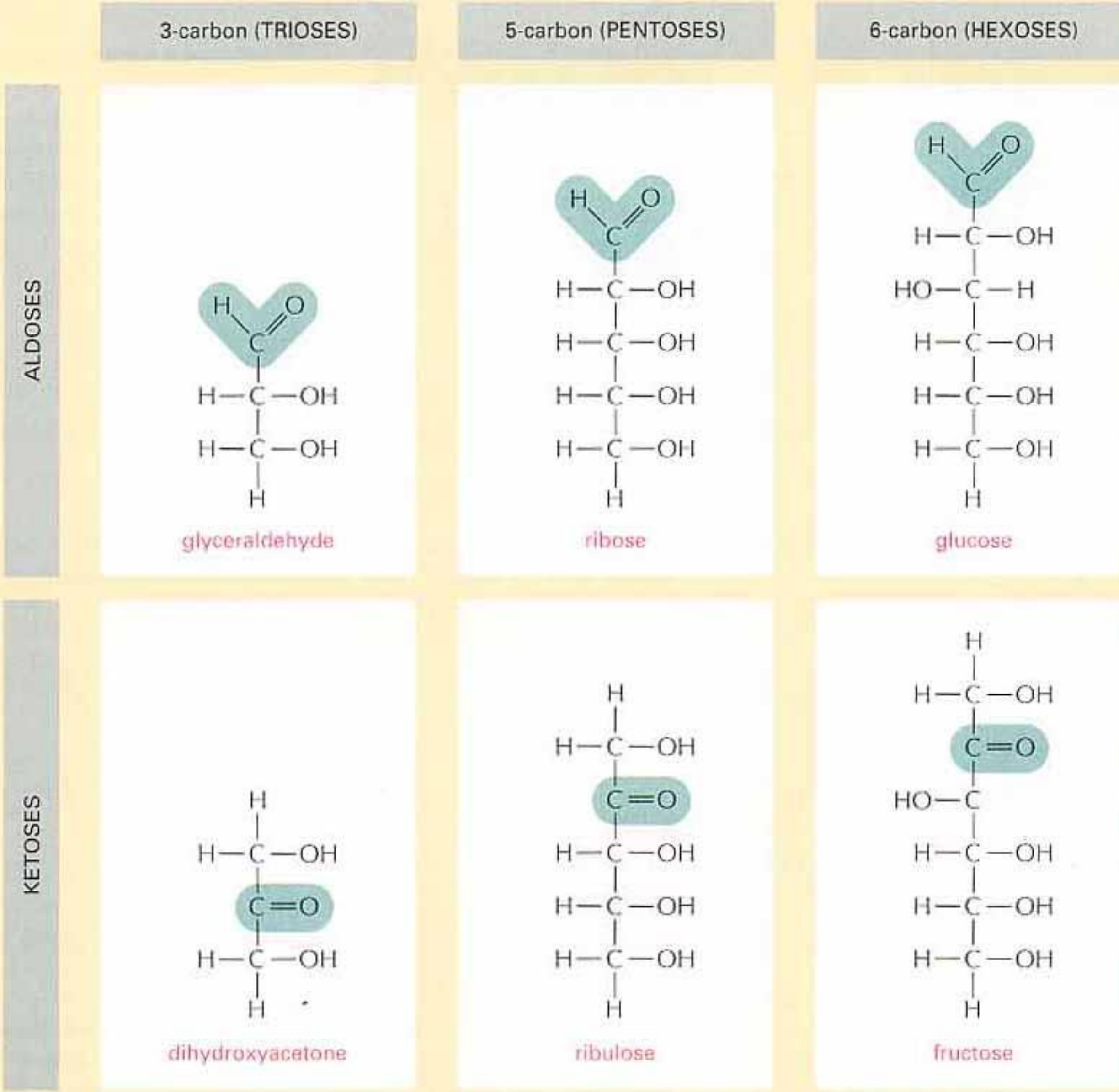
Large linear and branched molecules can be made from simple repeating units. Short chains are called oligosaccharides, while long chains are called polysaccharides. Glycogen, for example, is a polysaccharide made entirely of glucose units joined together.

COMPLEX OLIGOSACCHARIDES

In many cases a sugar sequence is nonrepetitive. Many different molecules are possible. Such complex oligosaccharides are usually linked to proteins or to lipids, as is this oligosaccharide, which is part of a cell-surface molecule that defines a particular blood group.

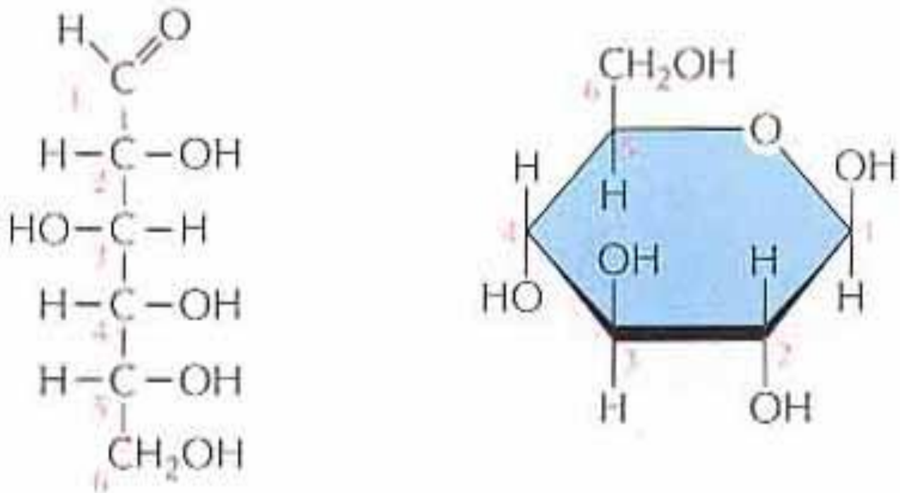
MONOSACCHARIDES

Monosaccharides usually have the general formula $(CH_2O)_n$, where n can be 3, 4, 5, or 6, and have two or more hydroxyl groups. They either contain an aldehyde group ($-\mathrm{C}\begin{smallmatrix}\mathrm{O}\\ \mathrm{H}\end{smallmatrix}$) and are called aldoses or a ketone group ($>\mathrm{C}=\mathrm{O}$) and are called ketoses.

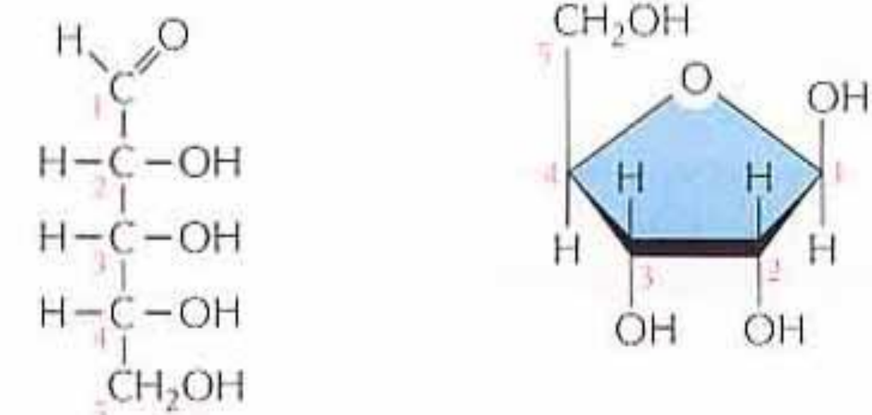


RING FORMATION

In aqueous solution, the aldehyde or ketone group of a sugar molecule tends to react with a hydroxyl group of the same molecule, thereby closing the molecule into a ring.



glucose



ribose

Note that each carbon atom has a number.

OLIGOSACCHARIDES AND POLYSACCHARIDES

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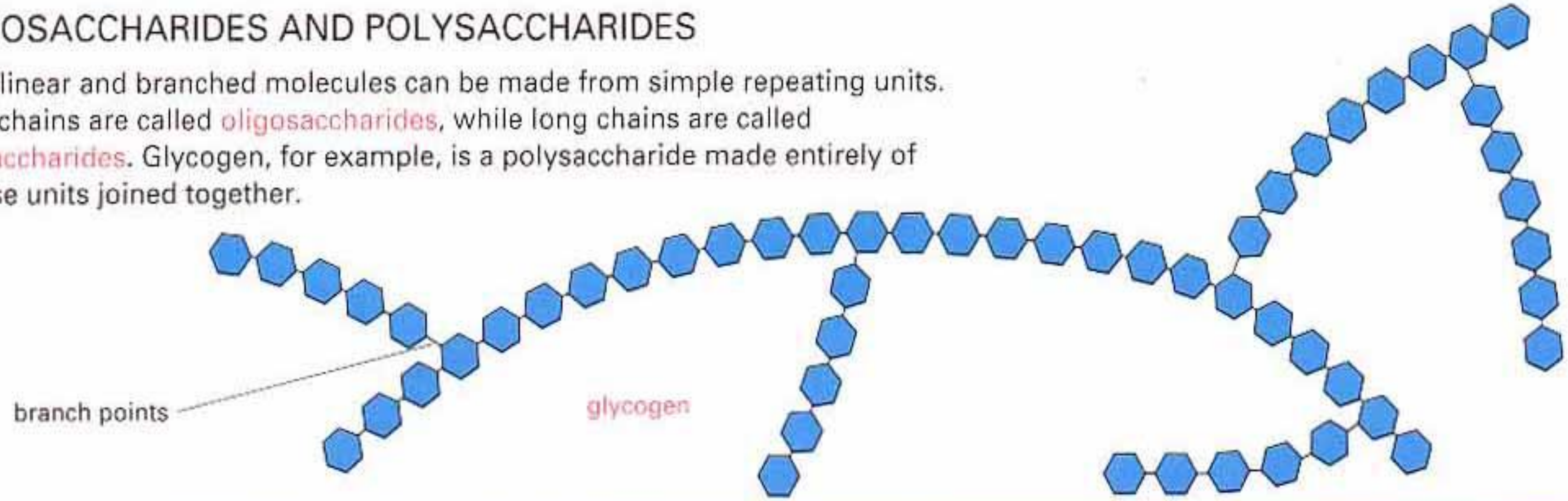

COMPLEX OLIGOSACCHARIDES

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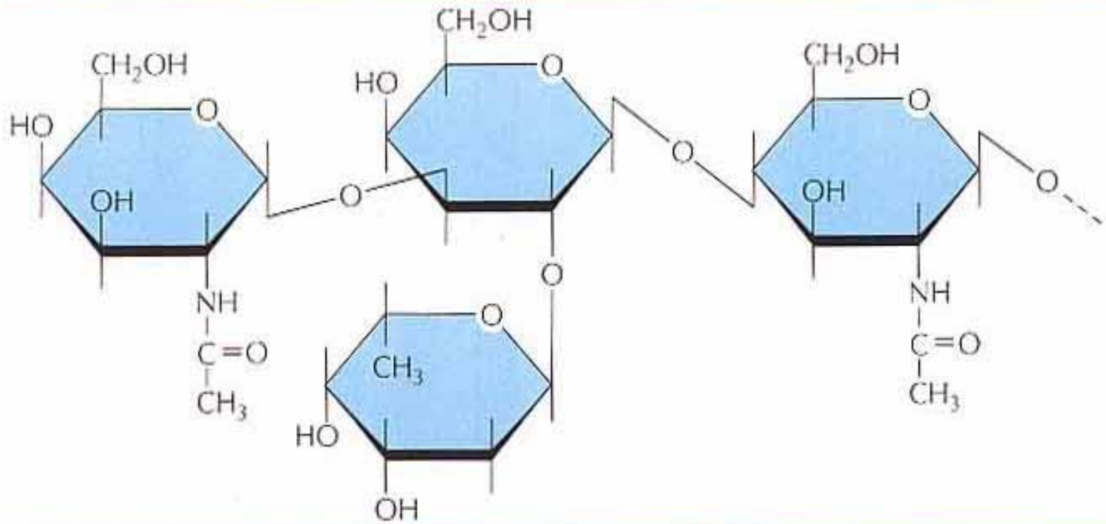
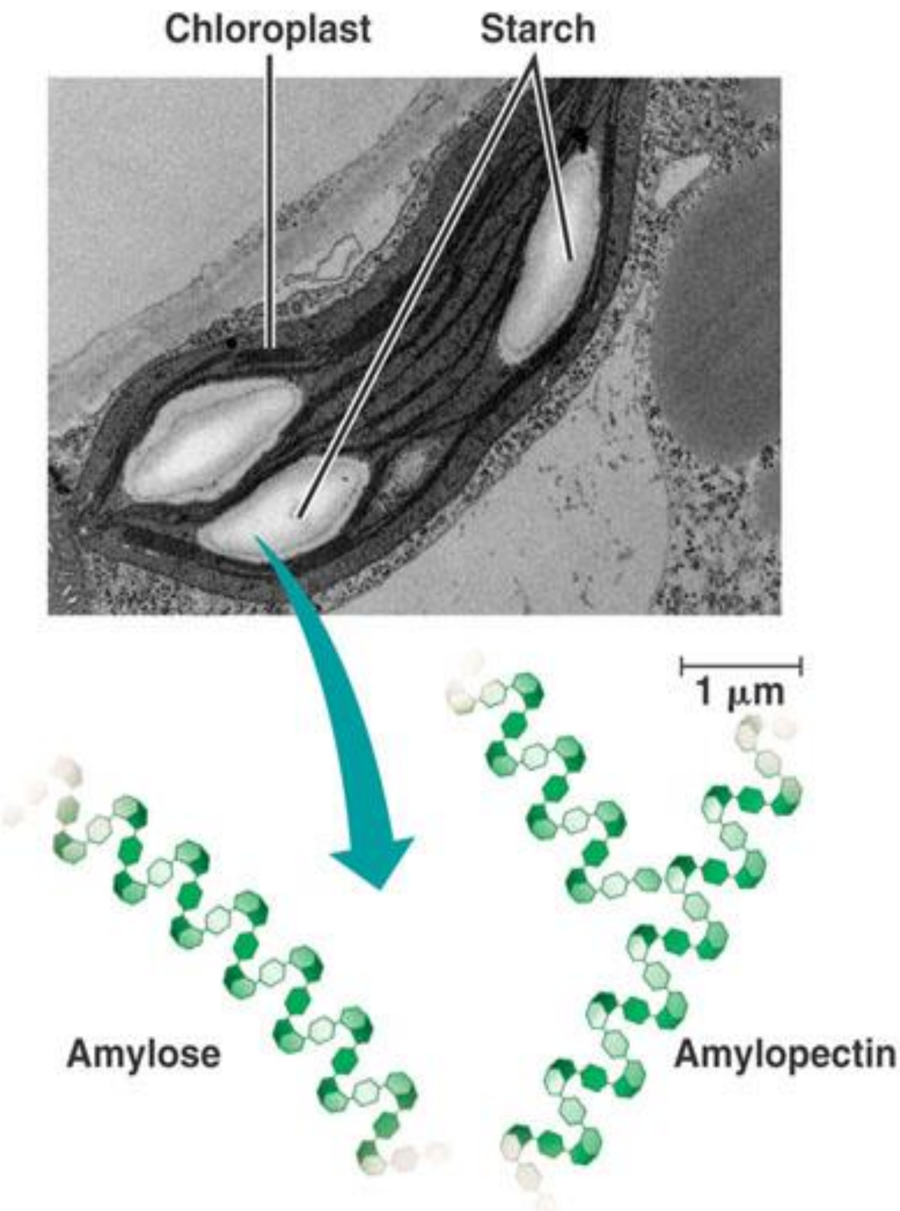
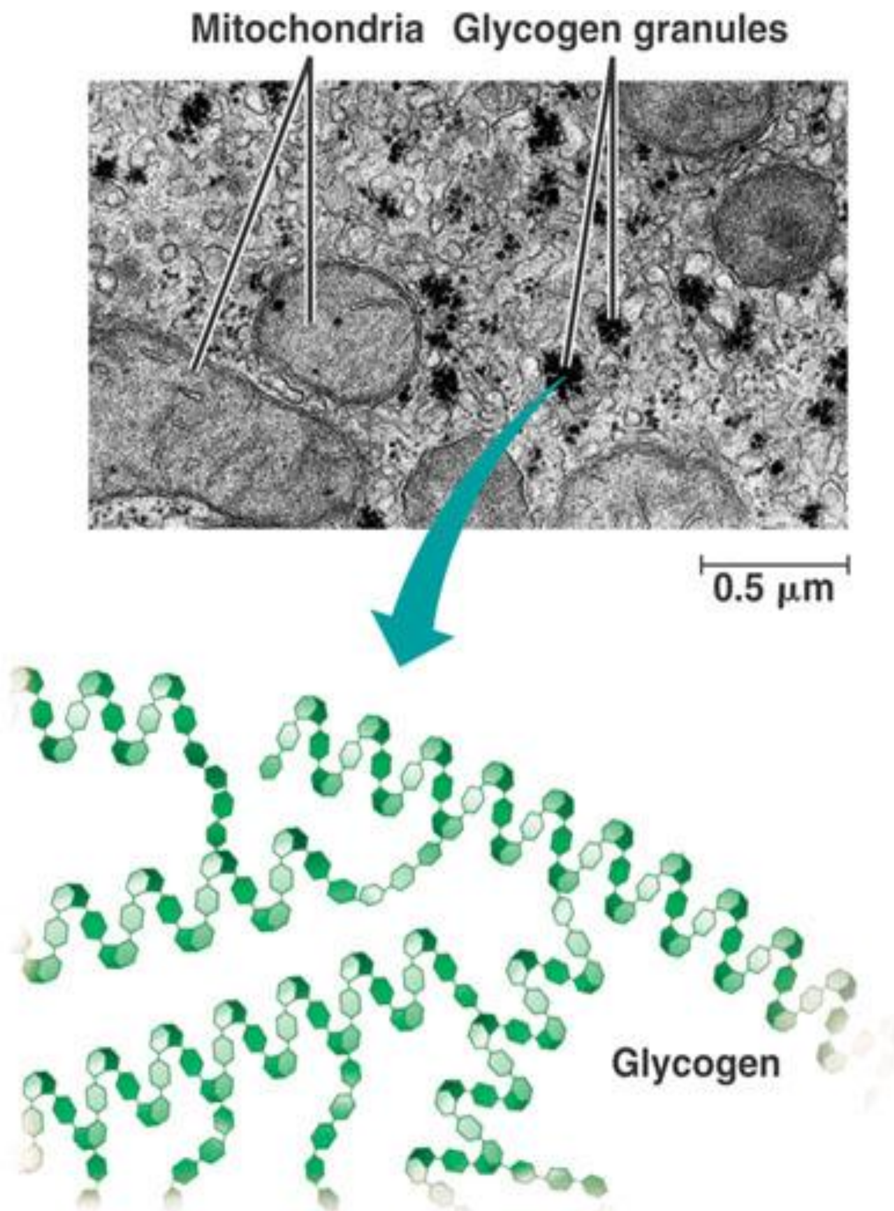
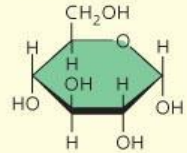
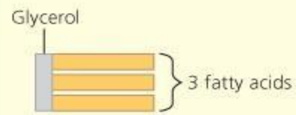
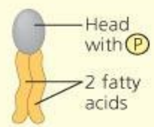
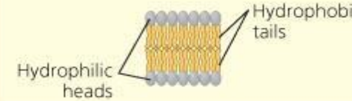
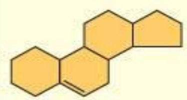
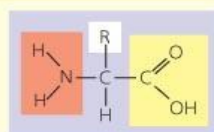
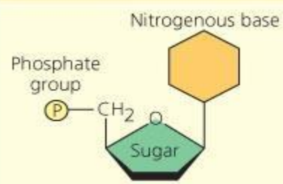


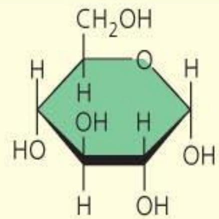
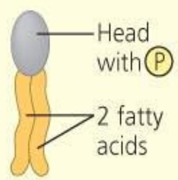
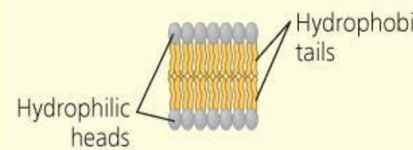
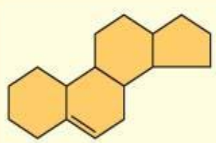


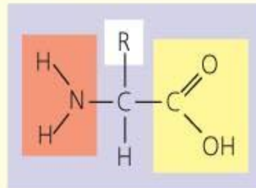
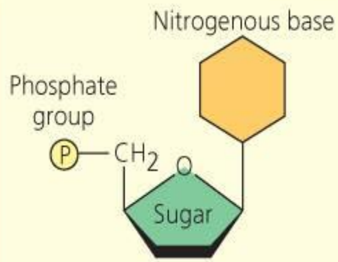
(a) Starch: a plant polysaccharide



(b) Glycogen: an animal polysaccharide

Large Biological Molecules	Components	Examples	Functions
Concept 5.2 **Carbohydrates** serve as fuel and building material	 Monosaccharide monomer	Monosaccharides: glucose, fructose	Fuel; carbon sources that can be converted to other molecules or combined into polymers
		Disaccharides: lactose, sucrose	
		Polysaccharides: • Cellulose (plants) • Starch (plants) • Glycogen (animals) • Chitin (animals and fungi)	• Strengthens plant cell walls • Stores glucose for energy • Stores glucose for energy • Strengthens exoskeletons and fungal cell walls
Concept 5.3 **Lipids** are a diverse group of hydrophobic molecules and are not macromolecules		Triacylglycerols (fats or oils): glycerol + 3 fatty acids	Important energy source 
		Phospholipids: phosphate group + 2 fatty acids	Lipid bilayers of membranes 
	 Steroid backbone	Steroids: four fused rings with attached chemical groups	• Component of cell membranes (cholesterol) • Signals that travel through the body (hormones)
Concept 5.4 **Proteins** have many structures, resulting in a wide range of functions	 Amino acid monomer (20 types)	• Enzymes • Structural proteins • Storage proteins • Transport proteins • Hormones • Receptor proteins • Motor proteins • Defensive proteins	• Catalyze chemical reactions • Provide structural support • Store amino acids • Transport substances • Coordinate organismal responses • Receive signals from outside cell • Function in cell movement • Protect against disease
Concept 5.5 Nucleic acids store and transmit hereditary information	 Nucleotide monomer	DNA:  • Sugar = deoxyribose • Nitrogenous bases = C, G, A, T • Usually double-stranded	Stores all hereditary information
		RNA:  • Sugar = ribose • Nitrogenous bases = C, G, A, U • Usually single-stranded	Carries protein-coding instructions from DNA to protein-synthesizing machinery

Large Biological Molecules	Components	Examples	Functions
Concept 5.2 **Carbohydrates** serve as fuel and building material	 Monosaccharide monomer	Monosaccharides: glucose, fructose	Fuel; carbon sources that can be converted to other molecules or combined into polymers
		Disaccharides: lactose, sucrose	
		Polysaccharides: • Cellulose (plants) • Starch (plants) • Glycogen (animals) • Chitin (animals and fungi)	• Strengthens plant cell walls • Stores glucose for energy • Stores glucose for energy • Strengthens exoskeletons and fungal cell walls
Concept 5.3 **Lipids** are a diverse group of hydrophobic molecules and are not macromolecules		Triacylglycerols (fats or oils): glycerol + 3 fatty acids	Important energy source 
		Phospholipids: phosphate group + 2 fatty acids	Lipid bilayers of membranes 
	 Steroid backbone	Steroids: four fused rings with attached chemical groups	• Component of cell membranes (cholesterol) • Signals that travel through the body (hormones)

Large Biological Molecules	Components	Examples	Functions
Concept 5.4 **Proteins** have many structures, resulting in a wide range of functions	 Amino acid monomer (20 types)	• Enzymes • Structural proteins • Storage proteins • Transport proteins • Hormones • Receptor proteins • Motor proteins • Defensive proteins	• Catalyze chemical reactions • Provide structural support • Store amino acids • Transport substances • Coordinate organismal responses • Receive signals from outside cell • Function in cell movement • Protect against disease
Concept 5.5 Nucleic acids store and transmit hereditary information	 Nucleotide monomer	DNA:  • Sugar = deoxyribose • Nitrogenous bases = C, G, A, T • Usually double-stranded	Stores all hereditary information
		RNA:  • Sugar = ribose • Nitrogenous bases = C, G, A, U • Usually single-stranded	Carries protein-coding instructions from DNA to protein-synthesizing machinery

- Разнообразие комбинаций трех полимеров определяет разнообразие живого на планете. Растения, животные и грибы имеют одинаковые «мономеры» и принципы их соединения в макромолекулы, но благодаря отличиям в молекулярной структуре и организации, они могут сильно отличаться на клеточной и организменном уровне.

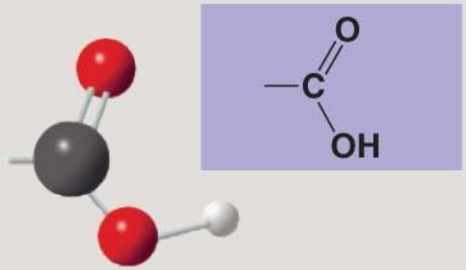
Семь функциональных групп, которые наиболее важны в биохимических процессах:

- Гидроксильная
- Карбонильная
- Карбоксильная
- Амино
- Сульфгидрильная
- Фосфатная
- Метильная

Fig. 4-10c

Carboxyl

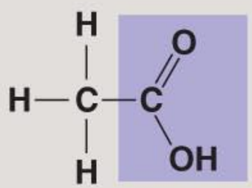
STRUCTURE



NAME OF COMPOUND

Carboxylic acids, or organic acids

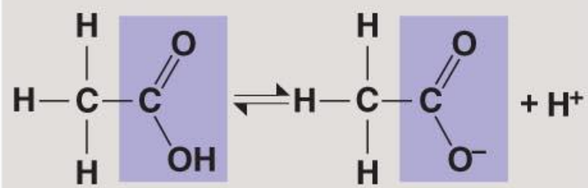
EXAMPLE



Acetic acid, which gives vinegar its sour taste

FUNCTIONAL PROPERTIES

- Has acidic properties because the covalent bond between oxygen and hydrogen is so polar; for example,



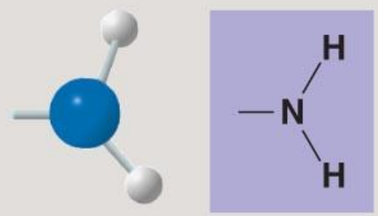
Acetic acid　　Acetate ion

- Found in cells in the ionized form with a charge of 1– and called a carboxylate ion (here, specifically, the acetate ion).

Fig. 4-10d

Amino

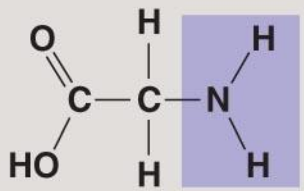
STRUCTURE



NAME OF COMPOUND

Amines

EXAMPLE

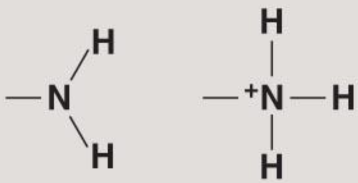


Glycine

Because it also has a carboxyl group, glycine is both an amine and a carboxylic acid; compounds with both groups are called amino acids.

FUNCTIONAL PROPERTIES

- Acts as a base; can pick up an H^+ from the surrounding solution (water, in living organisms).



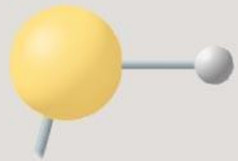
(nonionized) (ionized)

- Ionized, with a charge of 1+, under cellular conditions.

Fig. 4-10e

Sulfhydryl

STRUCTURE



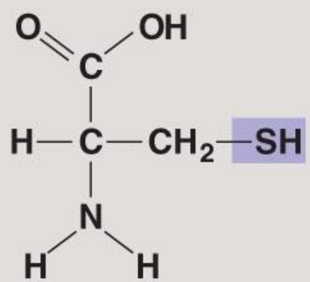
—SH

(may be written HS—)

NAME OF COMPOUND

Thiols

EXAMPLE



Cysteine

Cysteine is an important sulfur-containing amino acid.

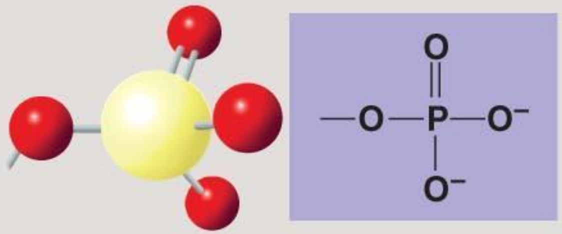
FUNCTIONAL PROPERTIES

- Two sulfhydryl groups can react, forming a covalent bond. This “cross-linking” helps stabilize protein structure.
- Cross-linking of cysteines in hair proteins maintains the curliness or straightness of hair. Straight hair can be “permanently” curled by shaping it around curlers, then breaking and re-forming the cross-linking bonds.

Fig. 4-10f

Phosphate

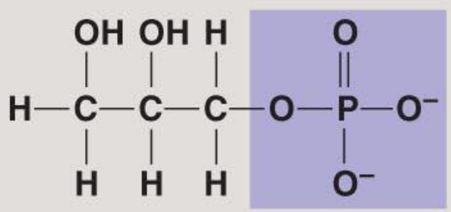
STRUCTURE



NAME OF COMPOUND

Organic phosphates

EXAMPLE



Glycerol phosphate

In addition to taking part in many important chemical reactions in cells, glycerol phosphate provides the backbone for phospholipids, the most prevalent molecules in cell membranes.

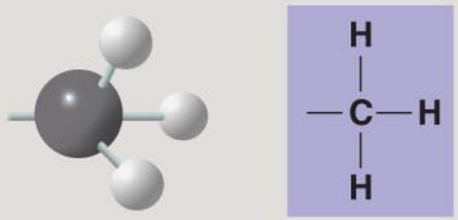
FUNCTIONAL PROPERTIES

- Contributes negative charge to the molecule of which it is a part (2– when at the end of a molecule; 1– when located internally in a chain of phosphates).
- Has the potential to react with water, releasing energy.

Fig. 4-10g

Methyl

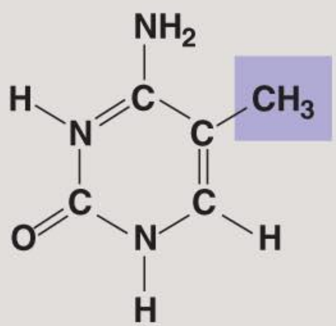
STRUCTURE



NAME OF COMPOUND

Methylated compounds

EXAMPLE

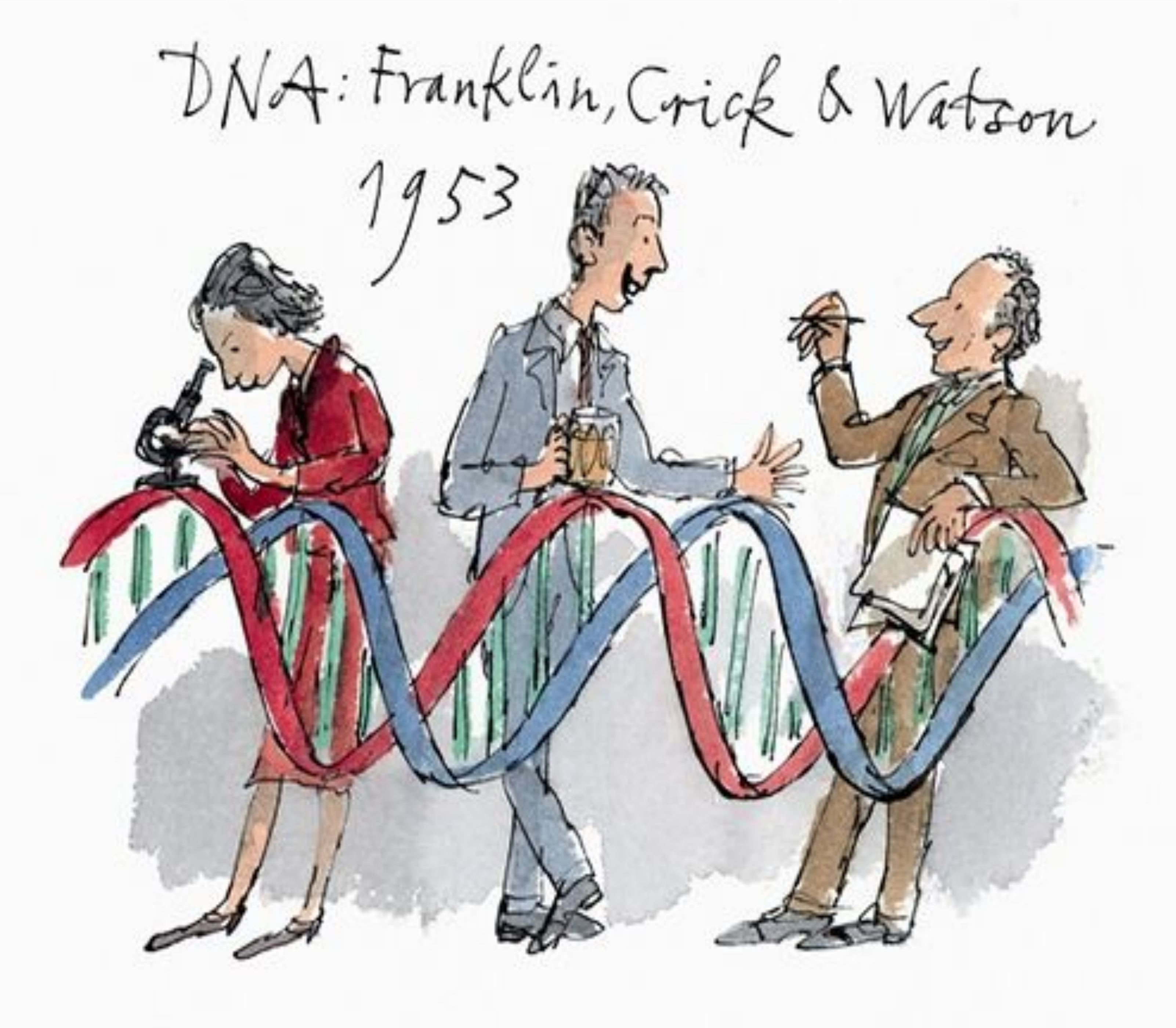


5-Methyl cytidine

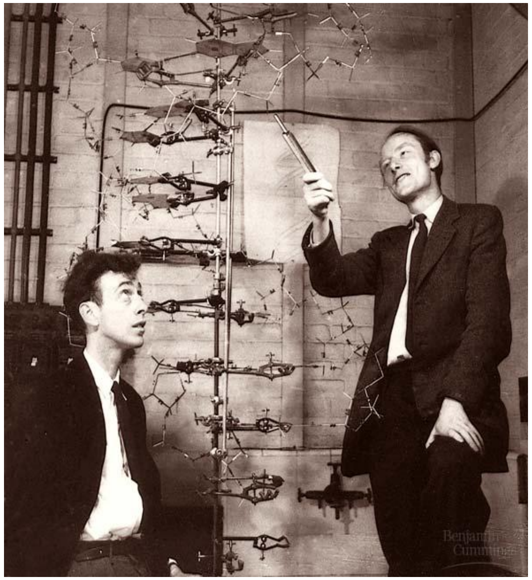
5-Methyl cytidine is a component of DNA that has been modified by addition of the methyl group.

FUNCTIONAL PROPERTIES

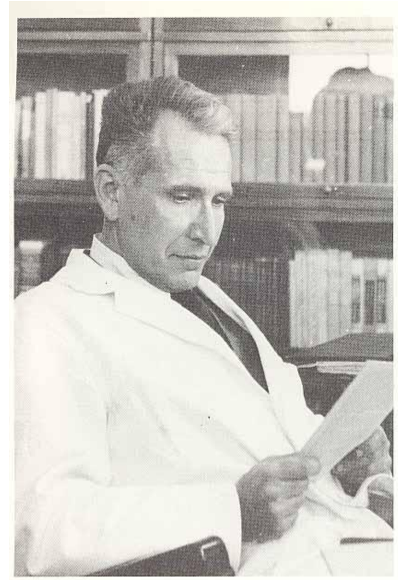
- Addition of a methyl group to DNA, or to molecules bound to DNA, affects expression of genes.
- Arrangement of methyl groups in male and female sex hormones affects their shape and function.


DNA: Franklin, Crick & Watson
1953

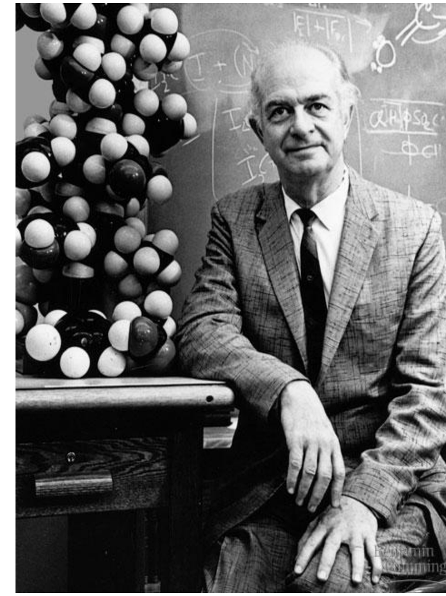
Ученые, которые участвовали в открытии структуры ДНК



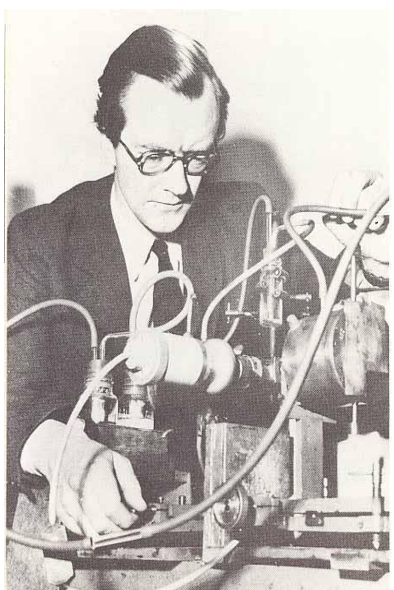
James Watson and Francis Crick, UK



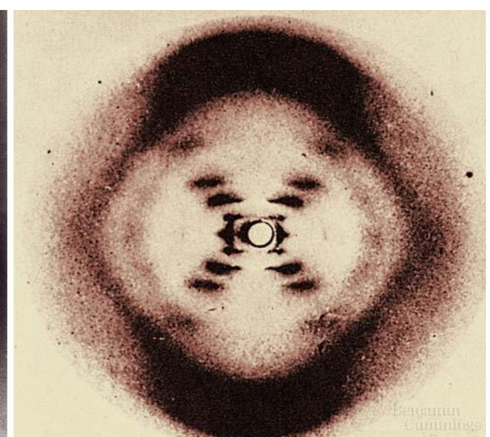
Erwin Chargaff, Ukraine



Linus Pauling, USA



Maurice Wilkins, NZ

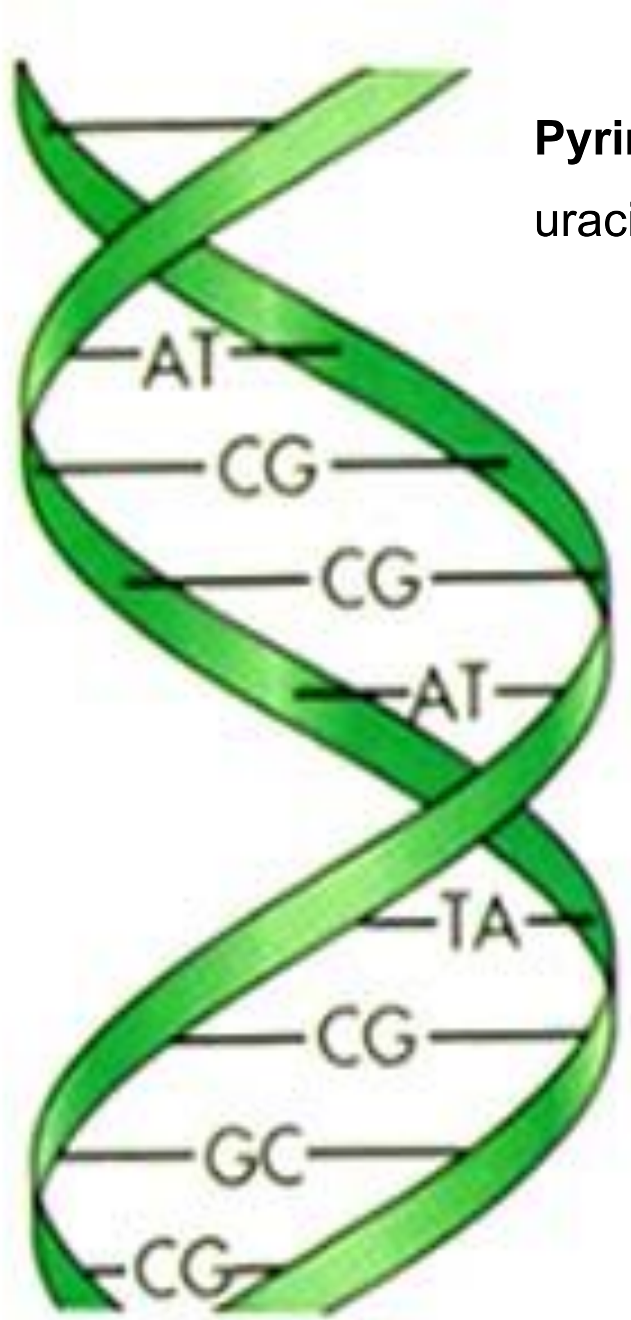


Rosalind Franklin, UK

Первое правило Чаргафа:

В природной ДНК количество единиц гуанина равно количеству единиц цитозина, тогда как количество единиц аденина равно количеству единиц тимина.

В типичной ДНК эукариот (пример: ДНК человека):
А=30.9%, Т=29.4%;
Г=19.9% Ц=19.8%.

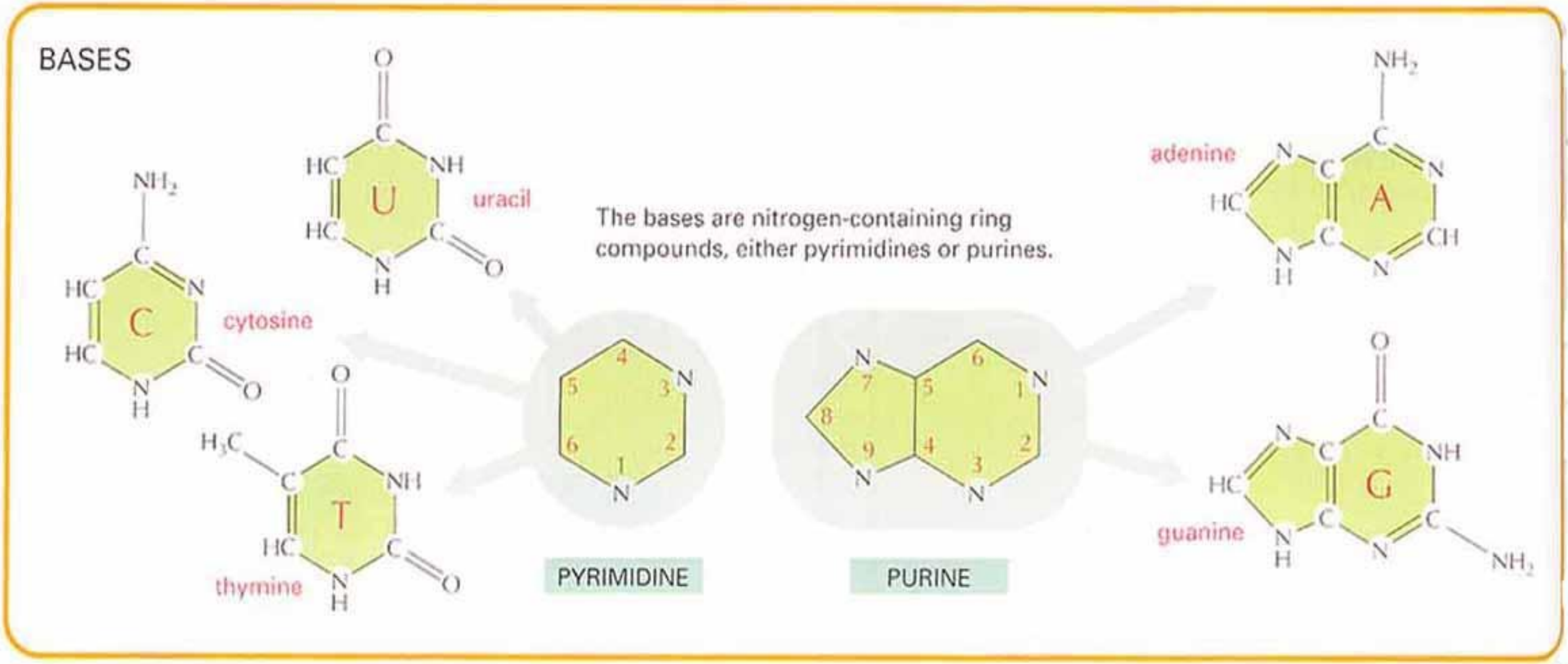


Pyrimidines:

uracil, cytosine, thiamine

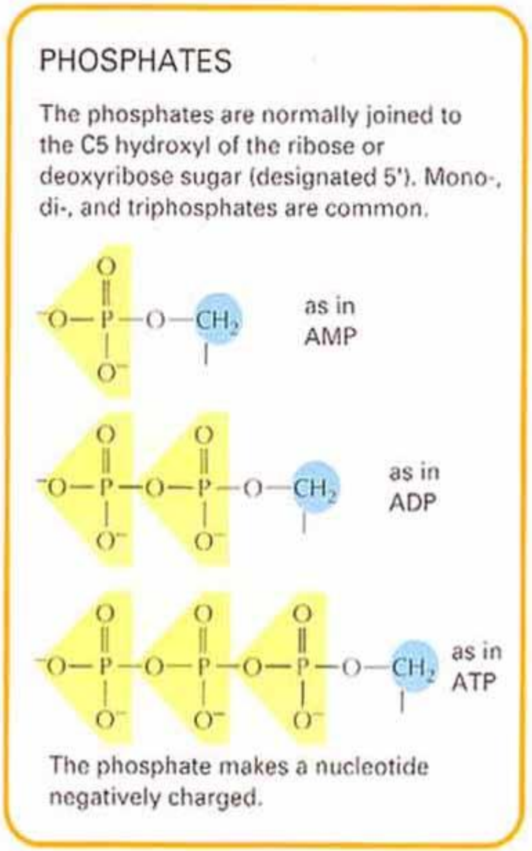
Purines :

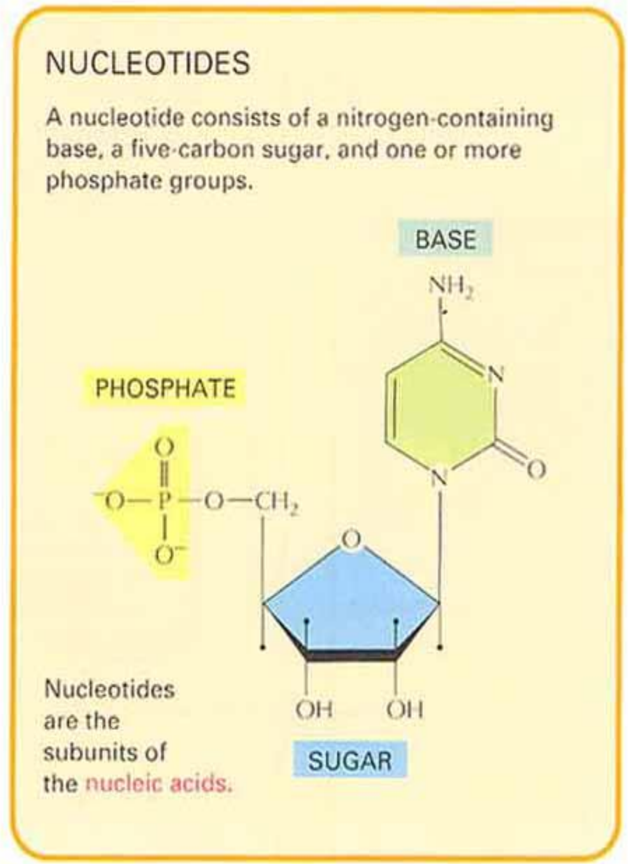
Adenine, guanosine

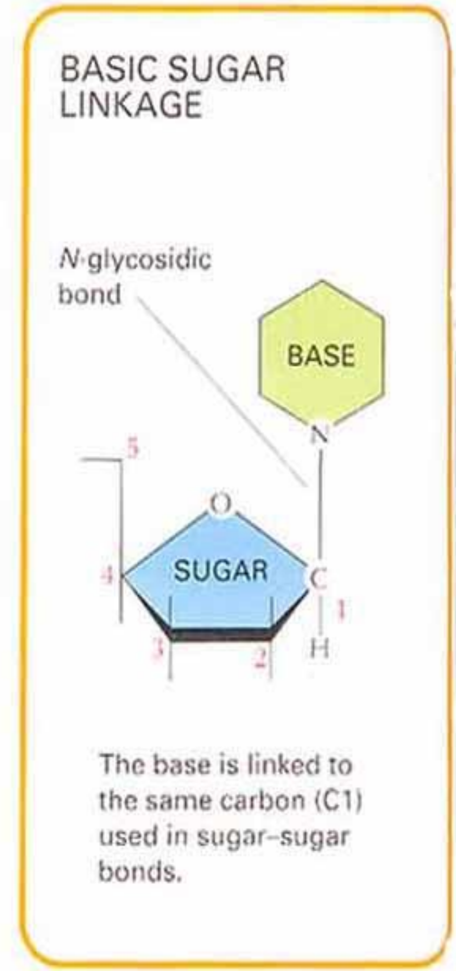


Структура оснований в ДНК и РНК:

пиримидины:	**пурины:**
урацил, цитозин, тиамин	**аденин, гуанозин**







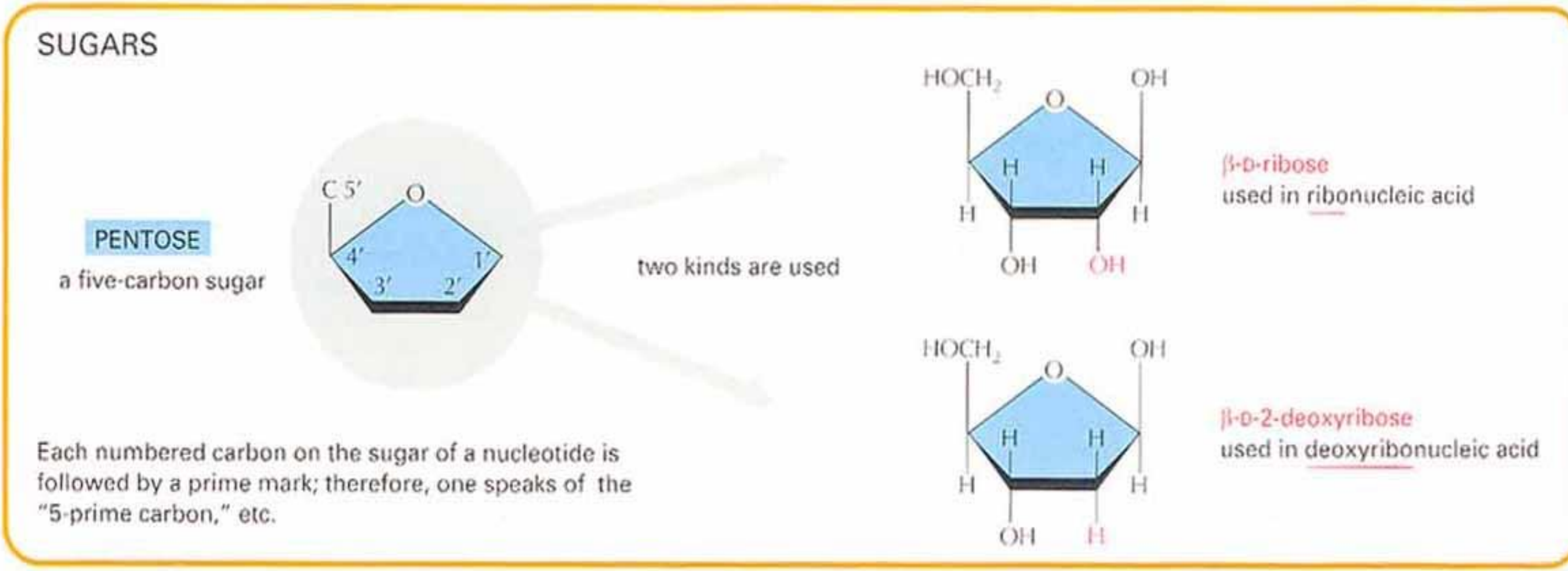
Nucleo***tide***

нуклео***тид***

Nucleo***side***

нуклео***зид***

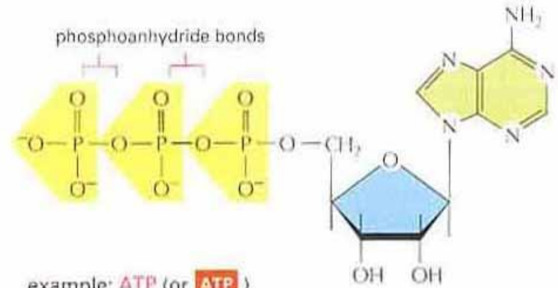
Разница в сахаре в нуклеиновых кислотах:



Другие функции нуклеотидов (помимо генетической):

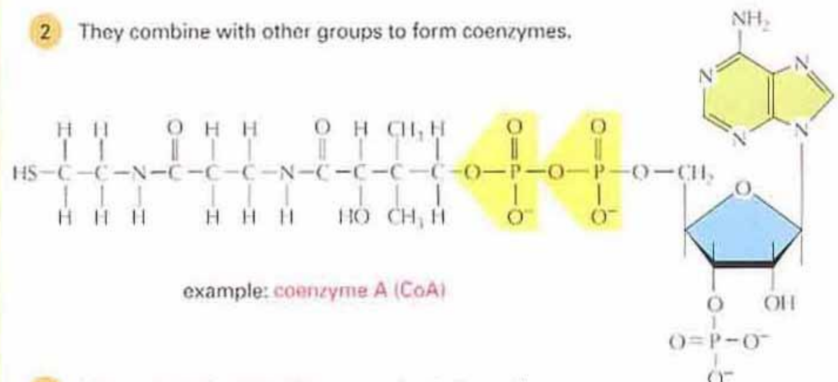
NUCLEOTIDES HAVE MANY OTHER FUNCTIONS

1 They carry chemical energy in their easily hydrolyzed phosphoanhydride bonds.



example: ATP (or ATP)

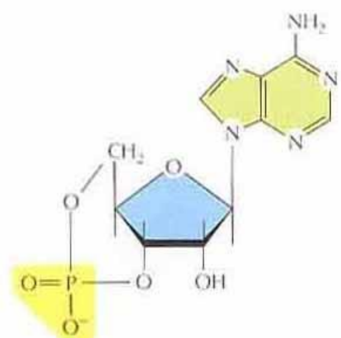
2 They combine with other groups to form coenzymes.



example: coenzyme A (CoA)

3 They are used as signaling molecules in the cell.

example: cyclic AMP



Study this carefully to memorize general structure and nomenclature.

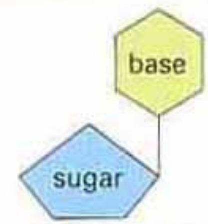
NOMENCLATURE

The names can be confusing, but the abbreviations are clear.

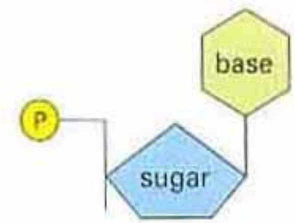
BASE	NUCLEOSIDE	ABBR.
adenine	adenosine	A
guanine	guanosine	G
cytosine	cytidine	C
uracil	uridine	U
thymine	thymidine	T

Nucleotides are abbreviated by three capital letters. Some examples follow:

AMP = adenosine monophosphate
dAMP = deoxyadenosine monophosphate
UDP = uridine diphosphate
ATP = adenosine triphosphate



BASE + SUGAR = NUCLEOSIDE

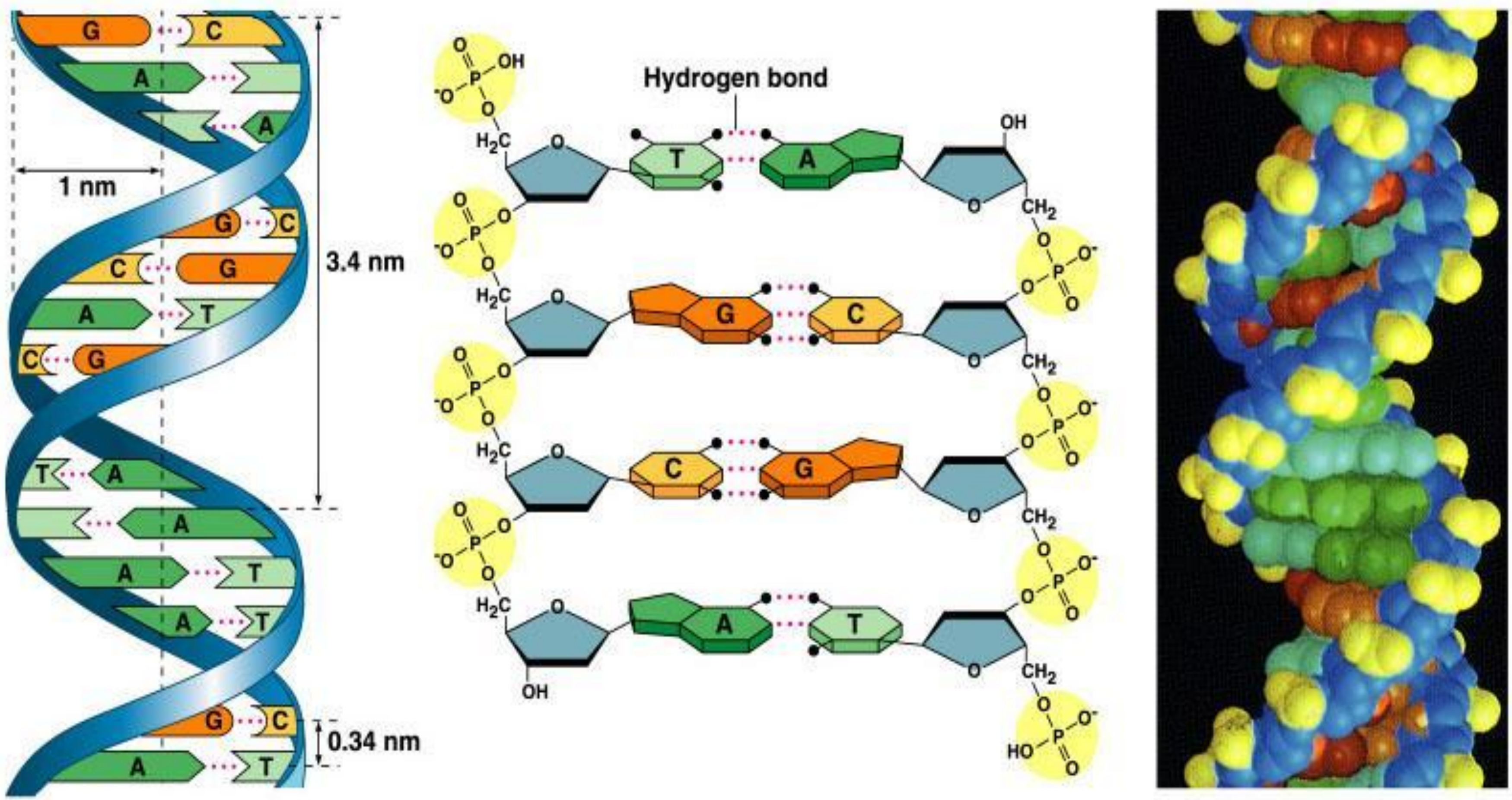


BASE + SUGAR + PHOSPHATE = NUCLEOTIDE

Размеры спирали:

Водородные связи:

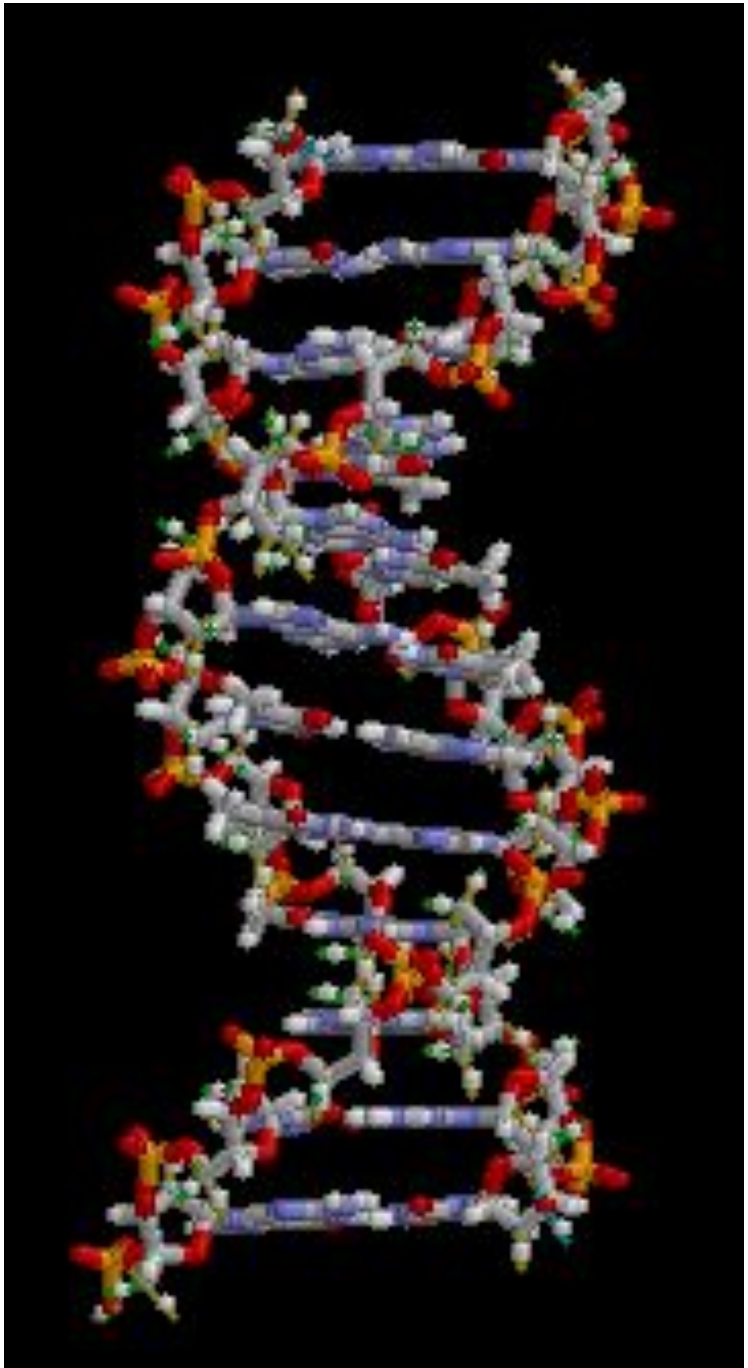
Пространстенное расположение частей (по цветам):



(a) Key features of DNA structure

(b) Partial chemical structure

(c) Space-filling model

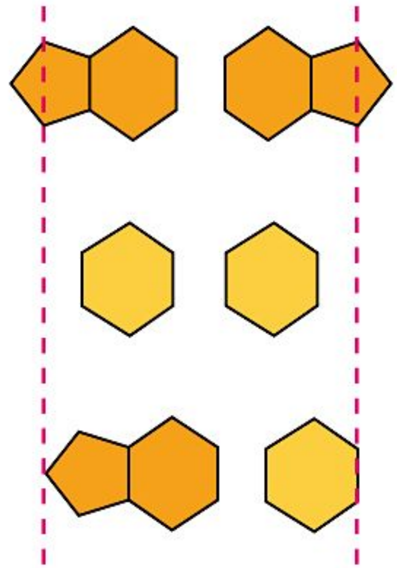


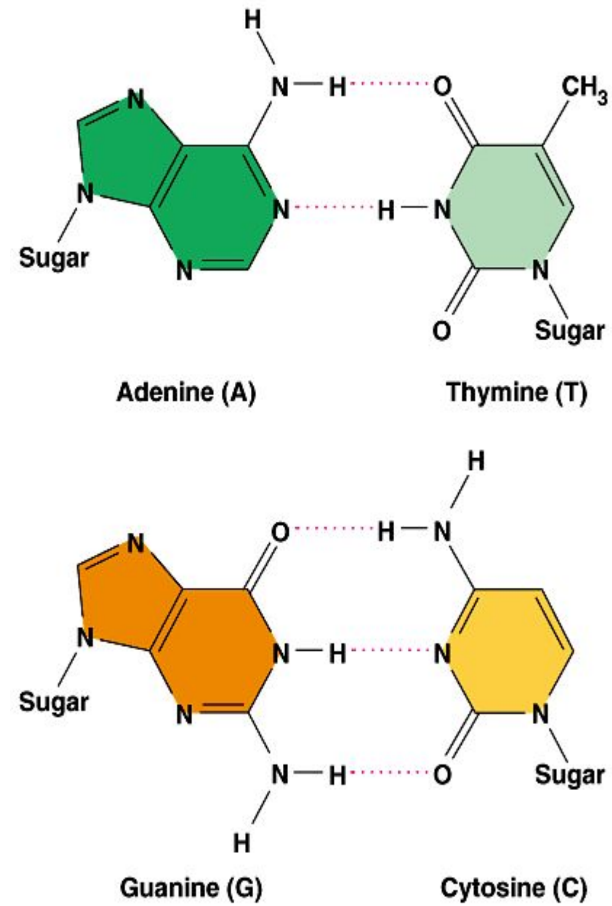
Hydrogen bonding between bases important in double helix. Two between A and T; three between G and C.

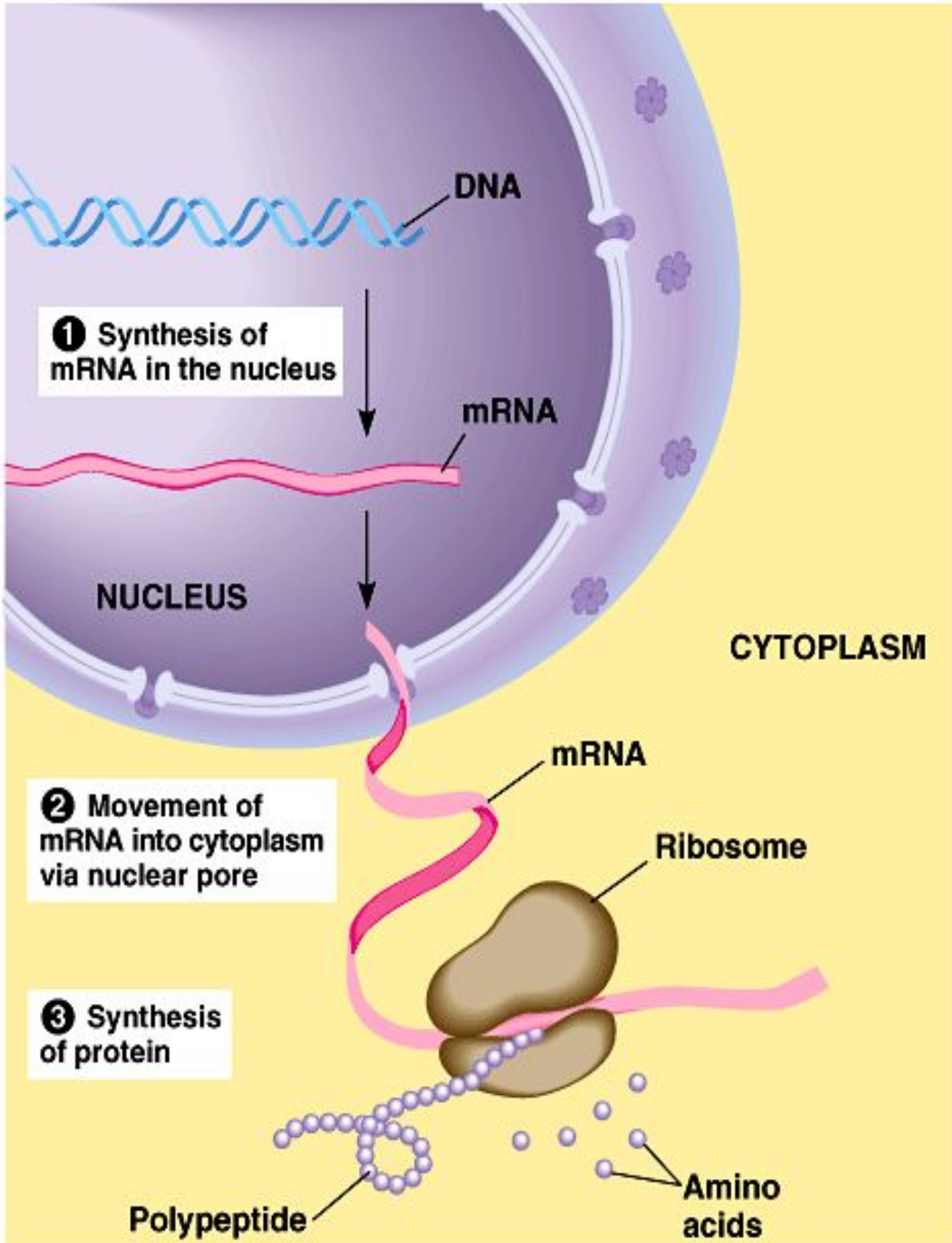
Purine + purine: too wide

Pyrimidine + pyrimidine: too narrow

Purine + pyrimidine: width consistent with X-ray data



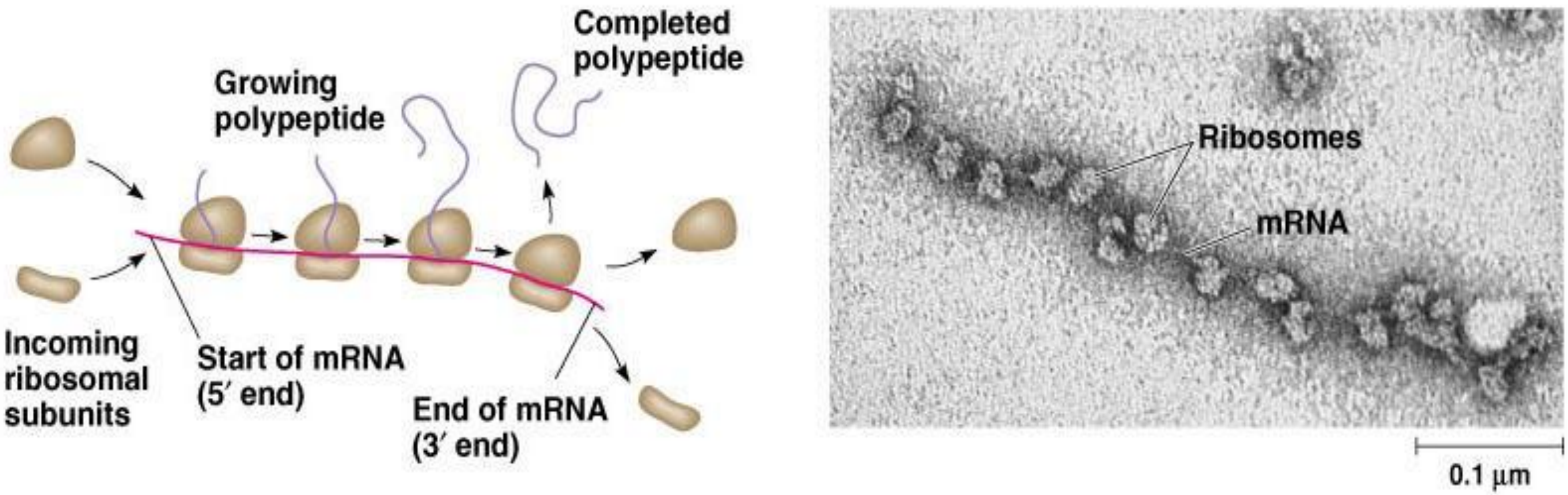




DNA to RNA to protein:

a diagrammatic overview of information flow in a cell.

Both DNA and RNA are nucleic acids



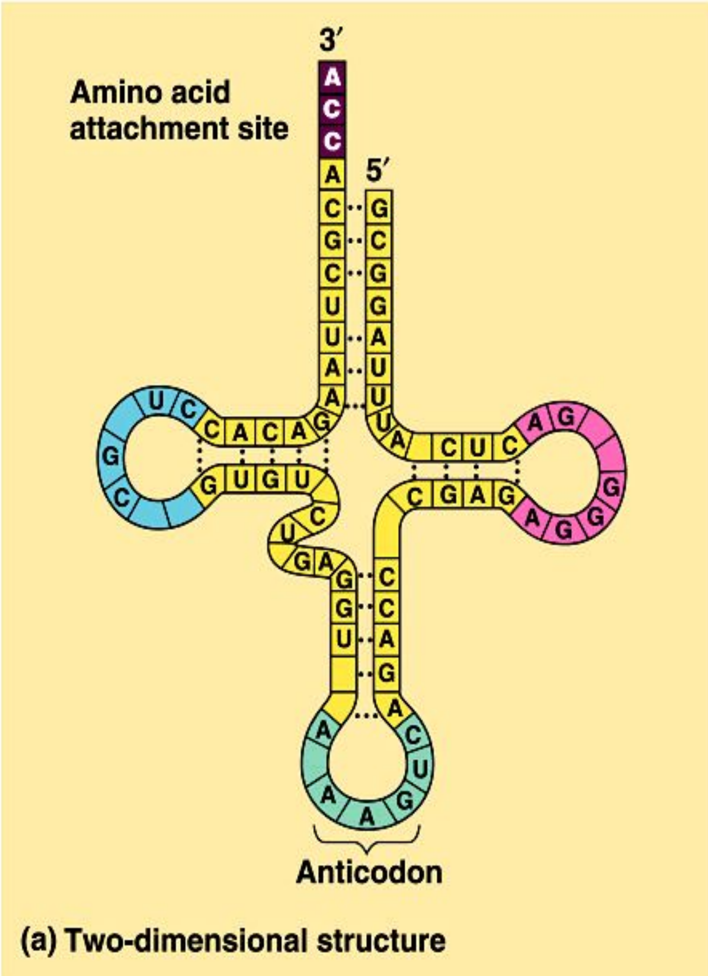
(a) An mRNA molecule is generally translated simultaneously by several ribosomes in clusters called polyribosomes.

(b) This micrograph shows a large polyribosome in a prokaryotic cell (TEM).

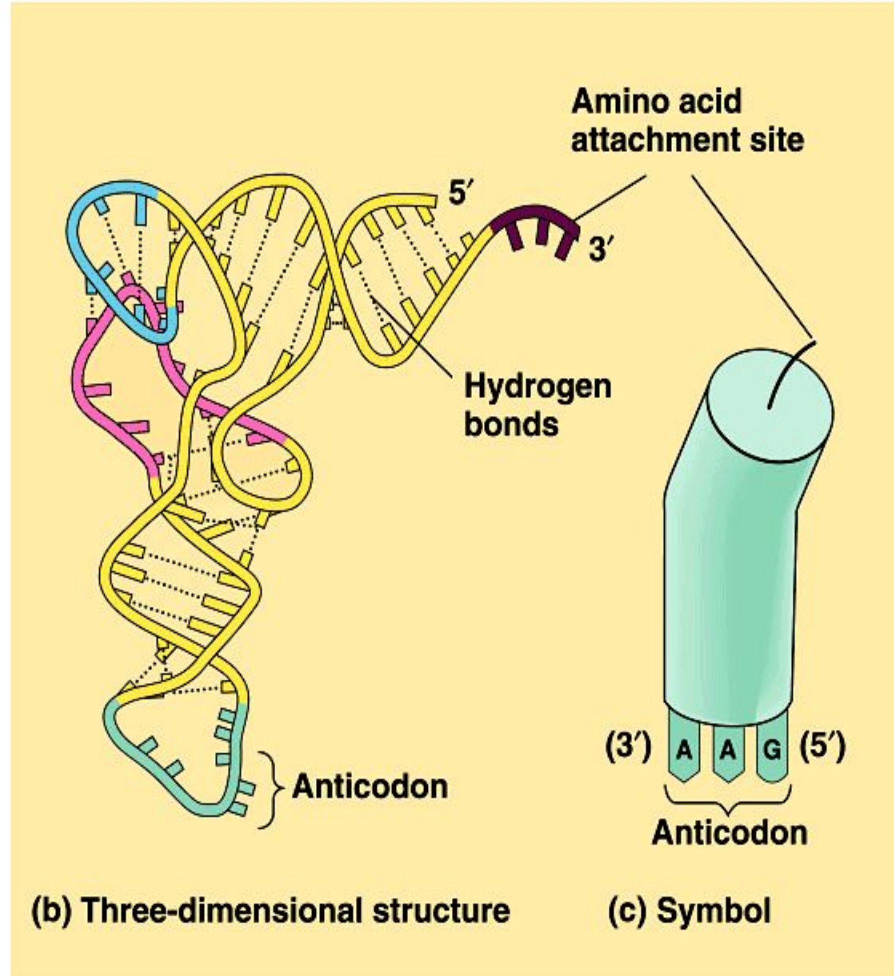
mRNA is translated into a polypeptide/protein in the cytoplasm.

Ribosomes are composed of RNA and protein

Campbell and Reece 8 **Figure 17.20** Polyribosomes



(a) Two-dimensional structure



(b) Three-dimensional structure

(c) Symbol

Transfer RNA is an adaptor molecule bringing in amino acids in the synthesis of protein.

Campbell and Reece **Figure 17.14** The structure of transfer RNA (tRNA).

Table 17.1 Types of RNA in a Eukaryotic Cell	
Type of RNA	**Functions**
Messenger RNA (mRNA)	Carries information specifying amino acid sequences of proteins from DNA to ribosomes.
Transfer RNA (tRNA)	Serves as adapter molecule in protein synthesis; translates mRNA codons into amino acids.
Ribosomal RNA (rRNA)	Plays catalytic (ribozyme) roles and structural roles in ribosomes.
Primary transcript	Serves as a precursor to mRNA, rRNA, or tRNA, before being processed by splicing or cleavage. Some intron RNA acts as a ribozyme, catalyzing its own splicing.
Small nuclear RNA (snRNA)	Plays structural and catalytic roles in spliceosomes, the complexes of protein and RNA that splice pre-mRNA.
SRP RNA	Is a component of the signal-recognition particle (SRP), the protein-RNA complex that recognizes the signal peptides of polypeptides targeted to the ER.
Small nucleolar RNA (snoRNA)	Aids in processing of pre-rRNA transcripts for ribosome subunit formation in the nucleolus.
Small interfering RNA (siRNA) and microRNA (miRNA)	Are involved in regulation of gene expression.

These first three are the types of RNA that you need to know about:

mRNA

tRNA

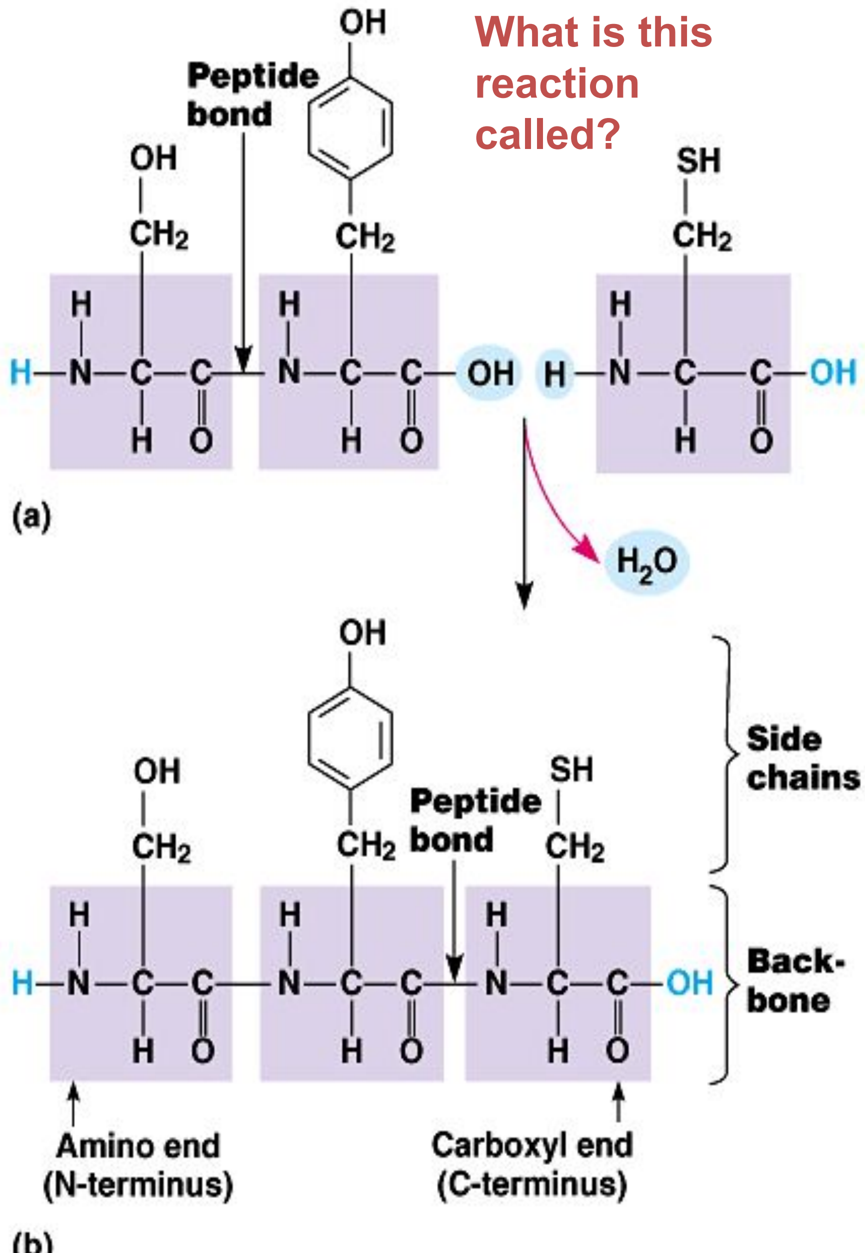
rRNA

Campbell and Reece 8 Chapter 17

Table 17.1 Types of RNA in a Eukaryotic Cell

Type of RNA	Functions
Messenger RNA (mRNA)	Carries information specifying amino acid sequences of proteins from DNA to ribosomes.
Transfer RNA (tRNA)	Serves as adapter molecule in protein synthesis; translates mRNA codons into amino acids.
Ribosomal RNA (rRNA)	Plays catalytic (ribozyme) roles and structural roles in ribosomes.

Proteins

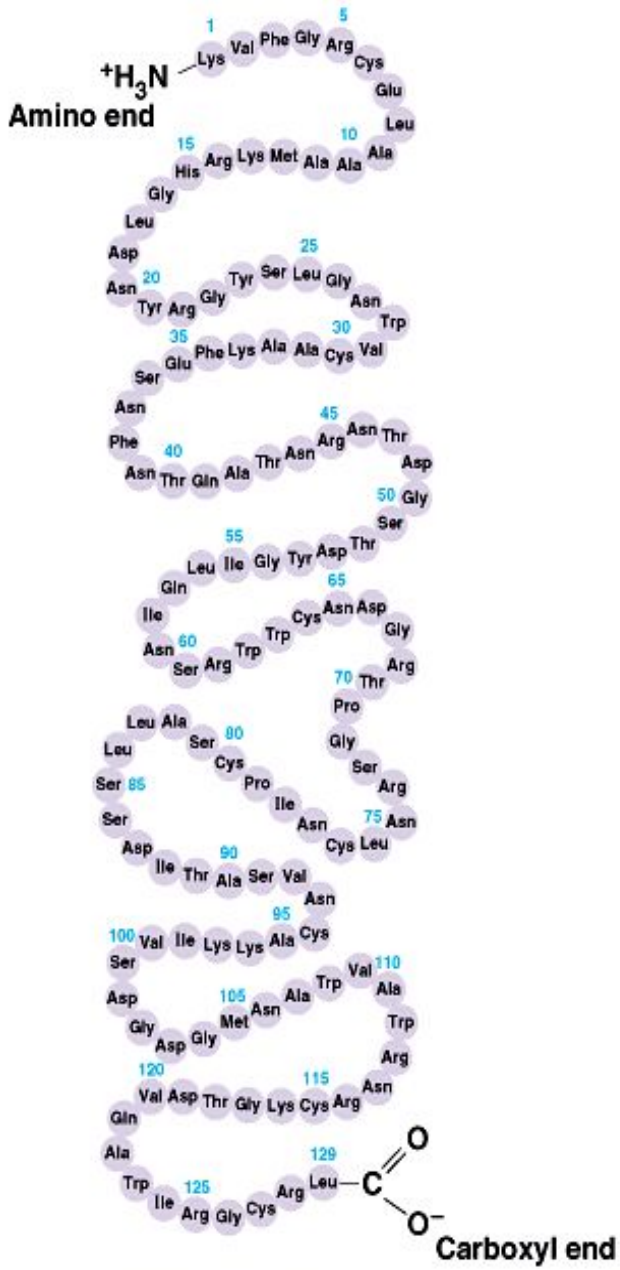


Making a polypeptide chain

Amino acids are linked by the formation of **a peptide bond**

Note the different side chains of the amino acids

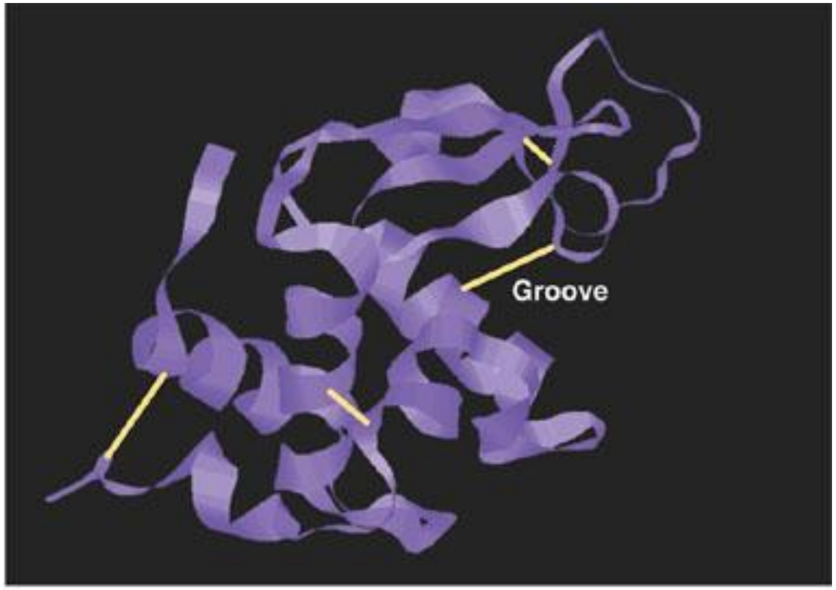
The primary structure of a protein is the sequence of amino acids



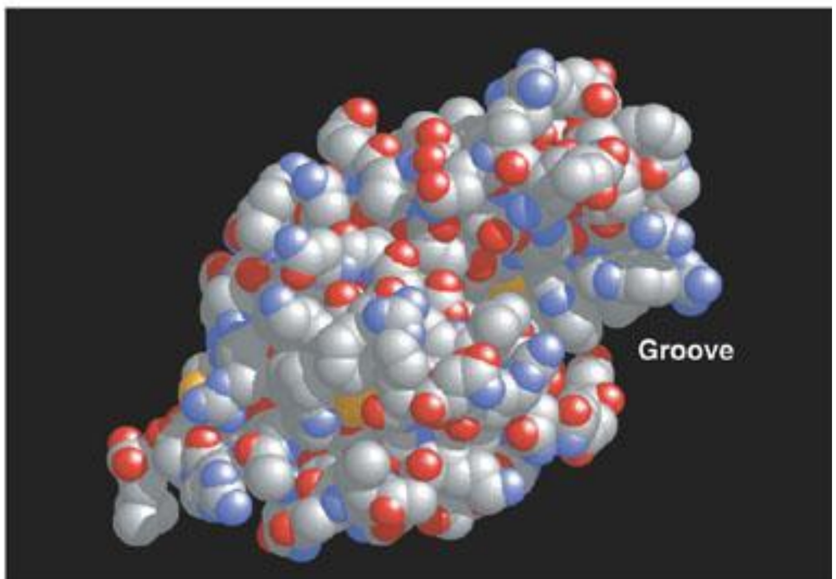
This is the enzyme lysozyme

There is an amino terminal to the protein, which has an amino group.

The end of the protein has a carboxyl group.



(a) A ribbon model

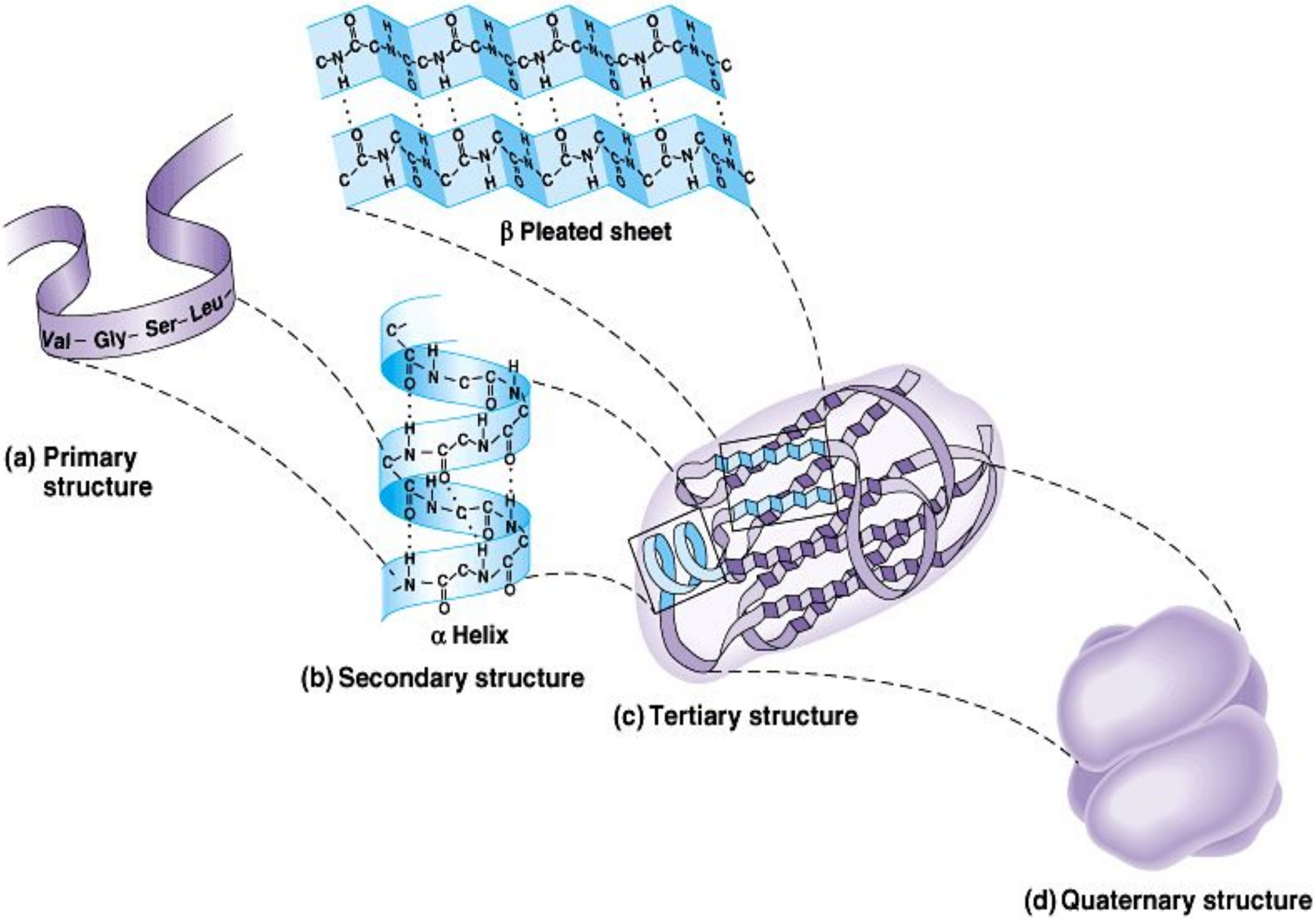


(b) A space-filling model

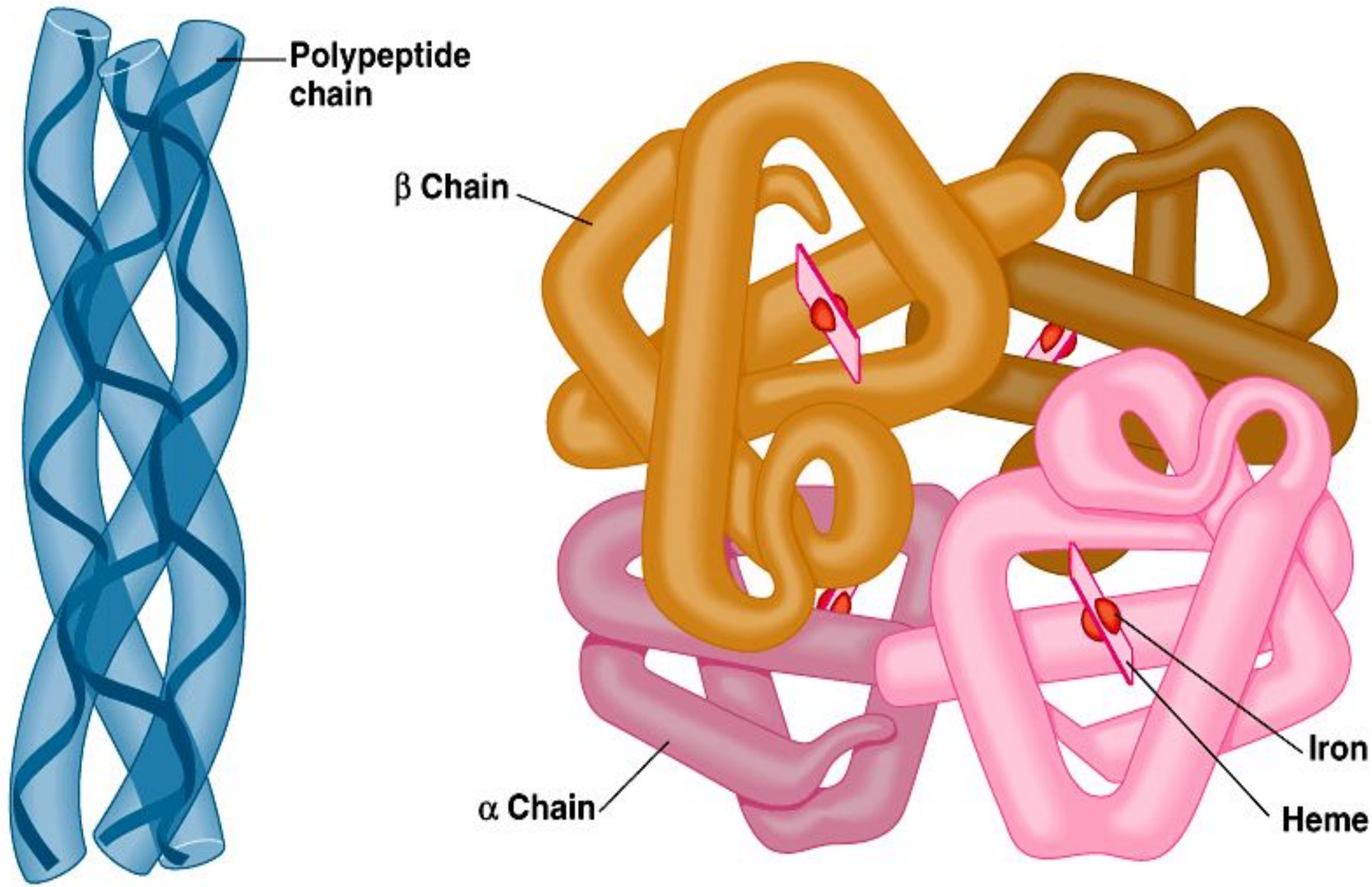
Campbell and Reece
Figure 5.19

Conformation of the enzyme lysozyme. Two types of model, the ribbon model and the space filling model

The substrate molecule in bacterial cell walls binds in the groove



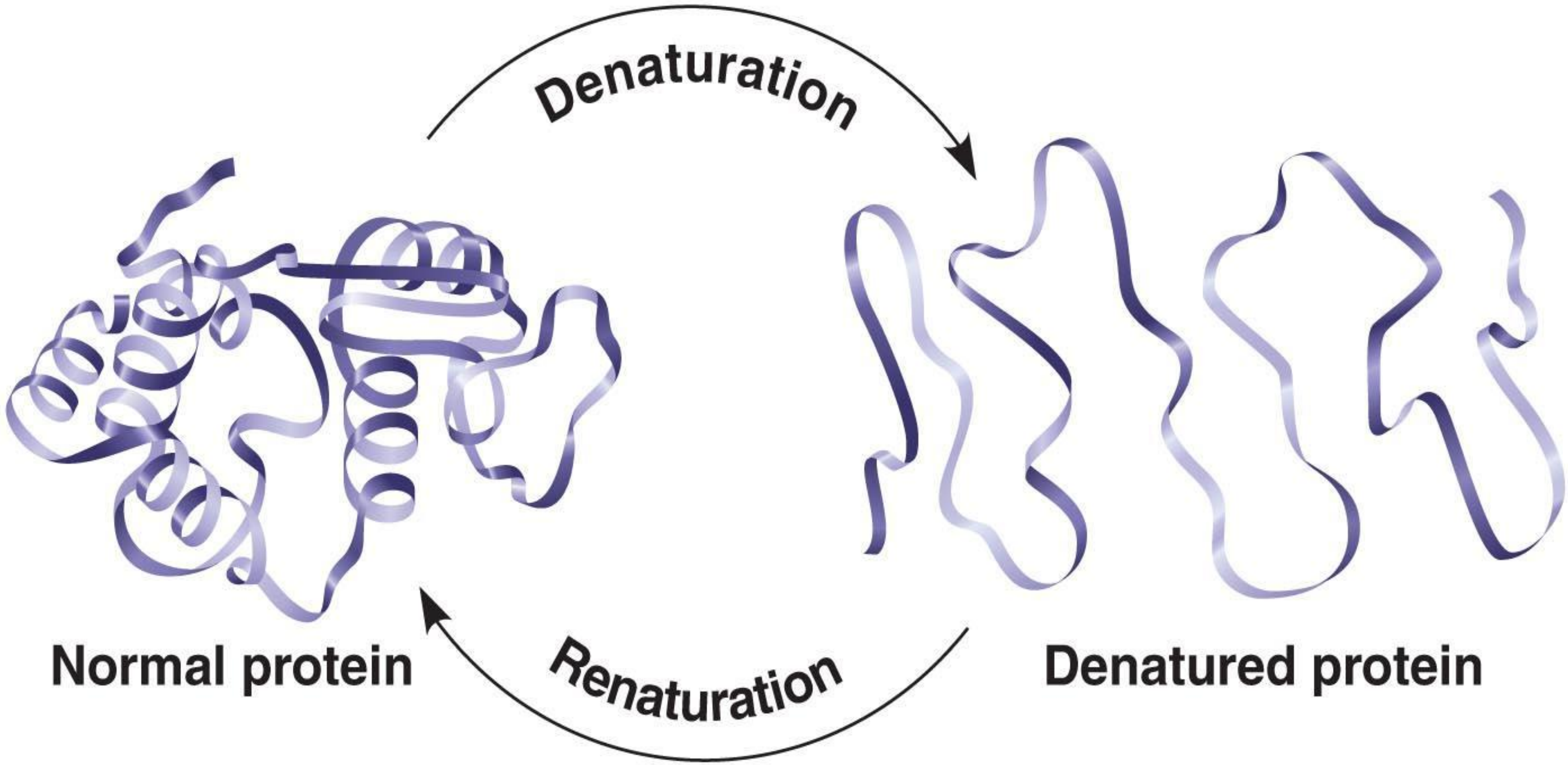
Campbell and Reece 8 **Figure 5.21** Exploring levels of protein structure.



(a) Collagen (b) Hemoglobin

Campbell and Reece 8 **Figure 5.21** The quarternary structure of proteins.

Heat, low/high pH



Campbell and Reece 8 Fig 5.23 Denaturation and renaturation of a protein

Protein structure and protein-protein interactions are important in viral particle structure

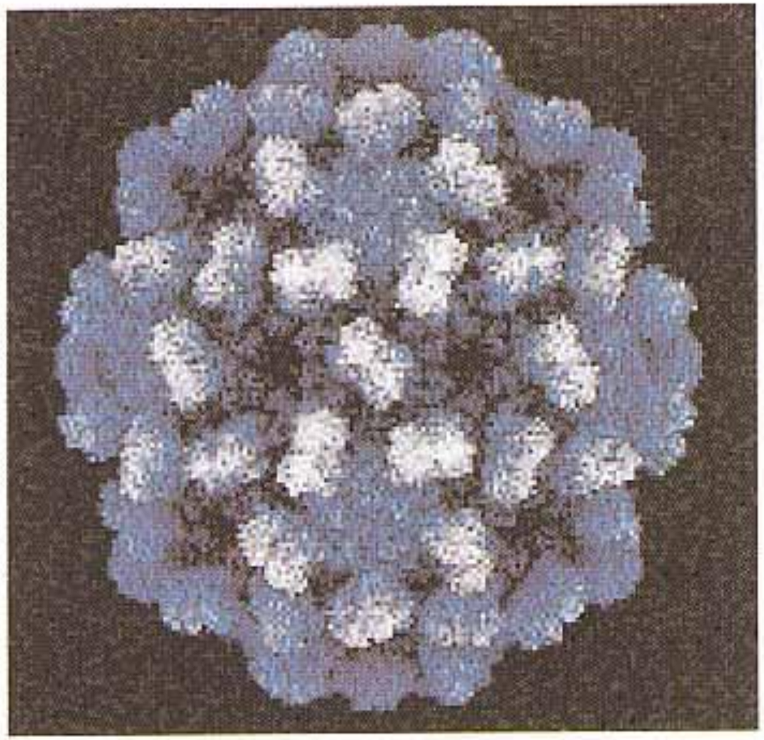


Figure 4–27 **Viral capsids are made of spherical protein assemblies.** The structure of tomato bushy stunt virus, shown here, was determined by X-ray crystallography and is known in atomic detail. (Courtesy of Robert Grant, Stephan Crainic, and James M. Hogle.)

Essential Cell Biology 2

Examples of relative sizes and shapes of different proteins

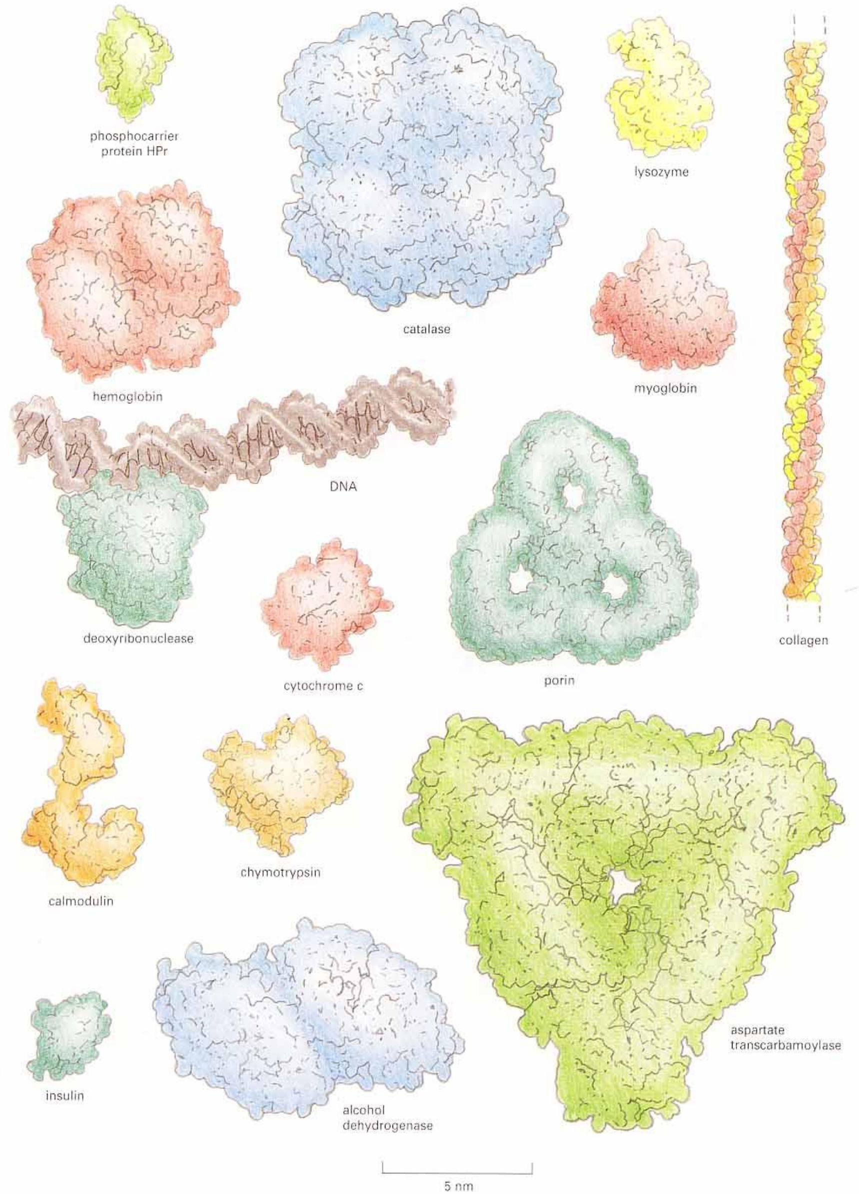


Figure 4–9 Proteins come in a variety of shapes and sizes. Each protein is shown as a space-filling model, represented at the same scale. In the *top left corner* is the phosphocarrier protein HPr, which is featured in greater detail in Panel 4–2 (pp. 132–133). Part of a molecule of DNA *(gray)* is shown for comparison. (After David S. Goodsell, Our Molecular Nature. New York: Springer-Verlag, 1996.)

Compare the size and general shape of:

collagen,

catalase and

chymotrypsin