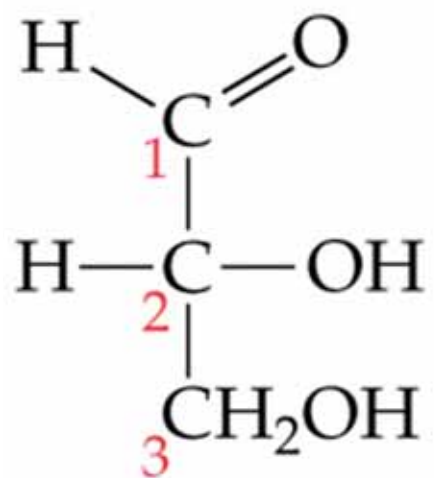


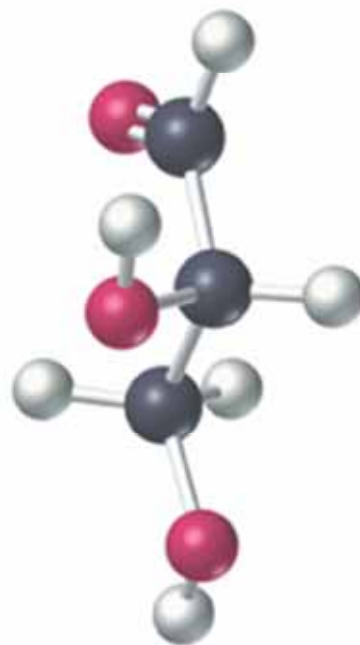
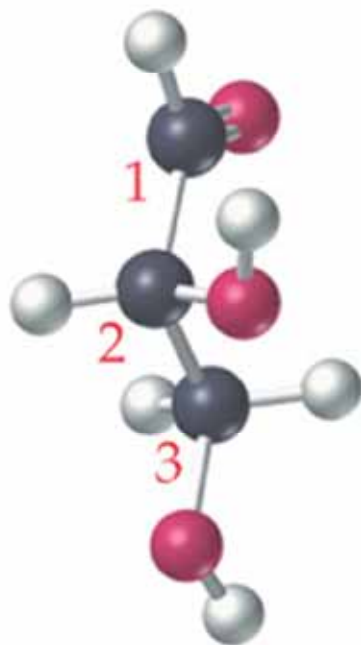
# An Introduction to Carbohydrates

- *Carbohydrates* are a large class of naturally occurring polyhydroxy aldehydes and ketones.
- Monosaccharides also known as simple sugars, are the simplest carbohydrates containing 3-7 carbon atoms.
- sugar containing an aldehydes is known as an aldose.
- sugar containing a ketones is known as a ketose.

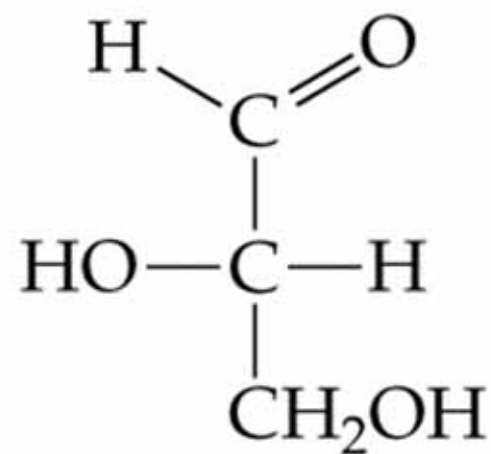
- The number of carbon atoms in an aldose or ketose may be specified as by tri, tetr, pent, hex, or hept. For example, glucose is aldohexose and fructose is ketohexose.
- Monosaccharides react with each other to form disaccharides and polysaccharides.
- Monosaccharides are chiral molecules and exist mainly in cyclic forms rather than the straight chain.

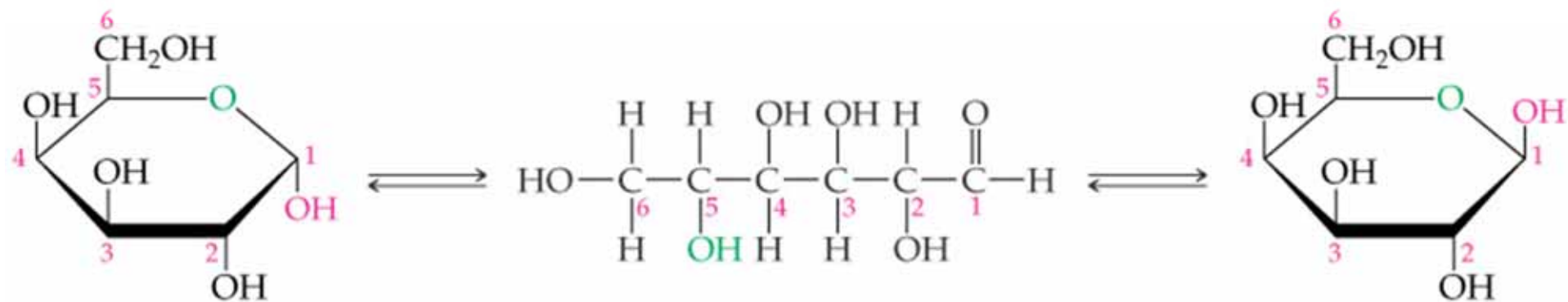


D-Glyceraldehyde  
Right-handed



L-Glyceraldehyde  
Left-handed





$\alpha$ -D-Galactose

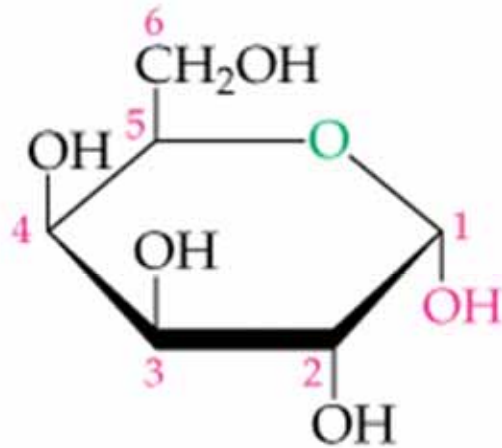


Open-chain galactose

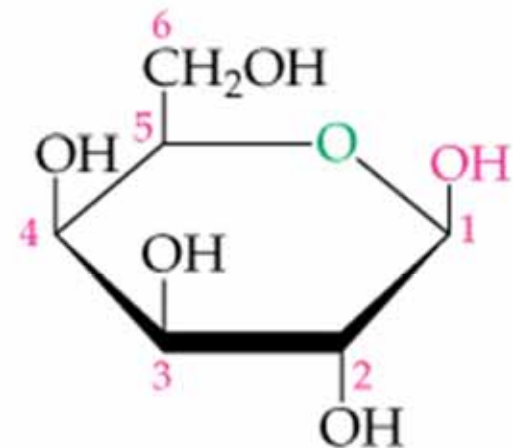


$\beta$ -D-Galactose

- *Anomers:* Cyclic sugars that differ only in positions of substituents at the hemiacetal carbon; the  $\alpha$ -form has the  $\text{--OH}$  group on the opposite side from the  $\text{--CH}_2\text{OH}$ ; the  $\beta$ -form has the  $\text{--OH}$  group on the same side as the  $\text{--CH}_2\text{OH}$  group.



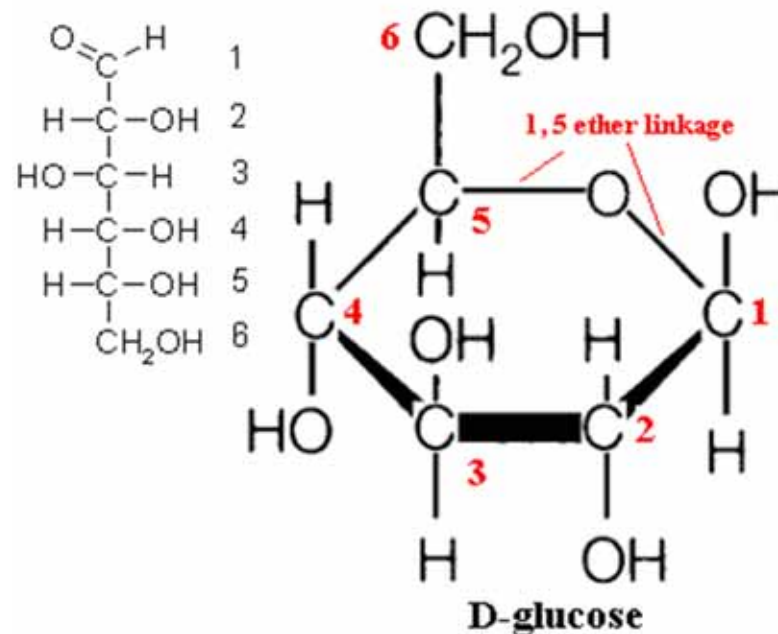
$\alpha$ -D-Galactose

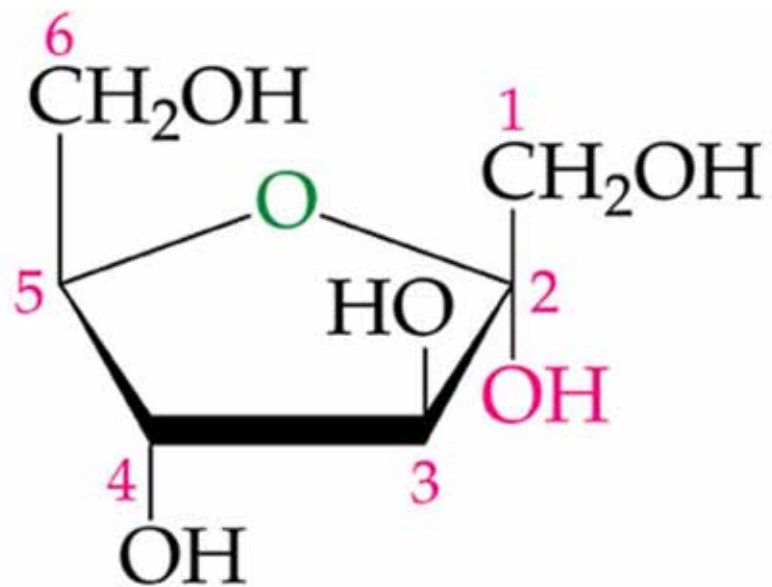


$\beta$ -D-Galactose

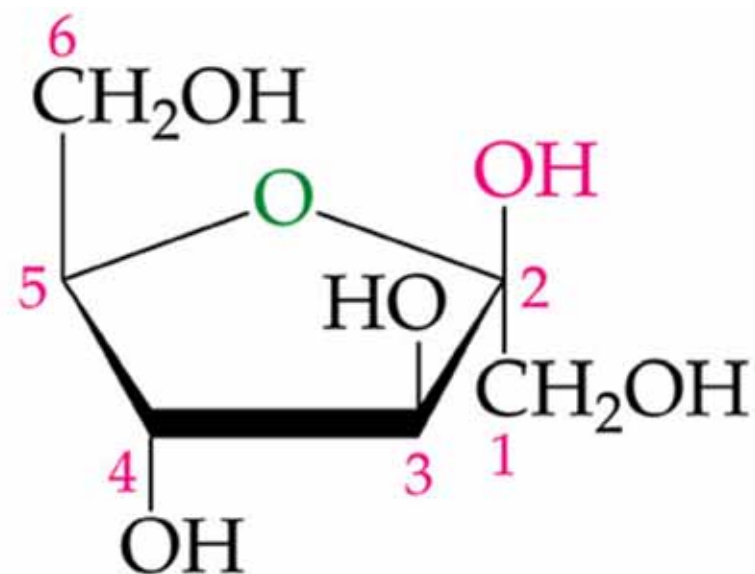
# Some Important Monosaccharides

Monosaccharides are generally high-melting, white, crystalline solids that are soluble in water and insoluble in nonpolar solvents. Most monosaccharides are sweet tasting, digestible, and nontoxic.

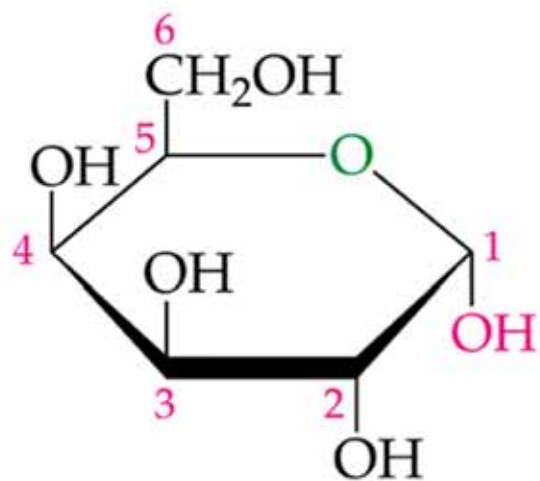




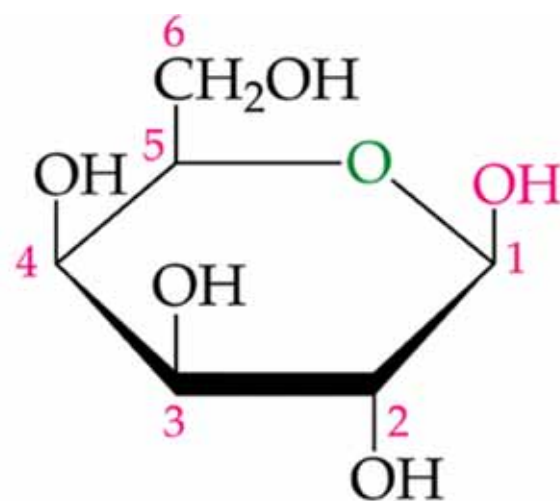
$\alpha$ -D-Fructose



$\beta$ -D-Fructose

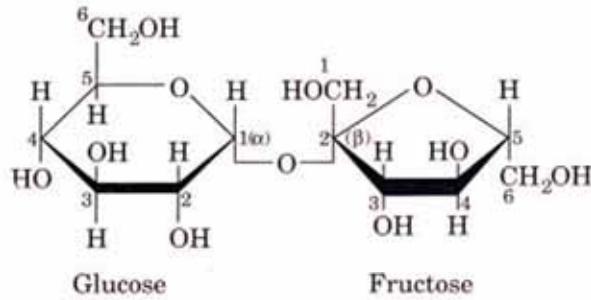


$\alpha$ -D-Galactose

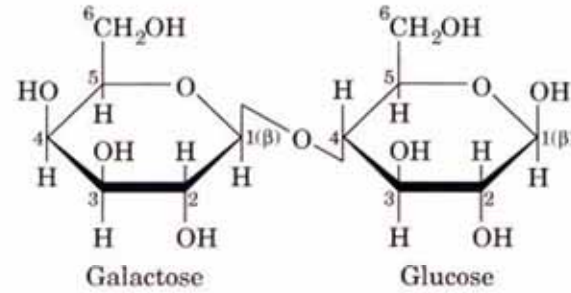


$\beta$ -D-Galactose

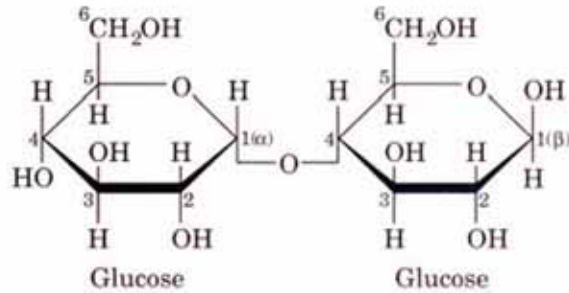
# Some Common Disaccharides



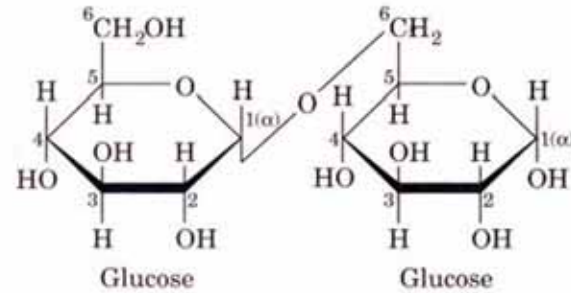
**Sucrose**



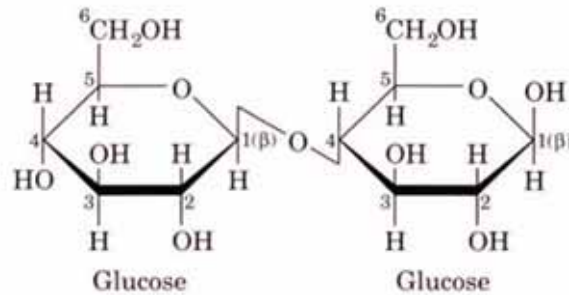
**Lactose**



**Maltose**



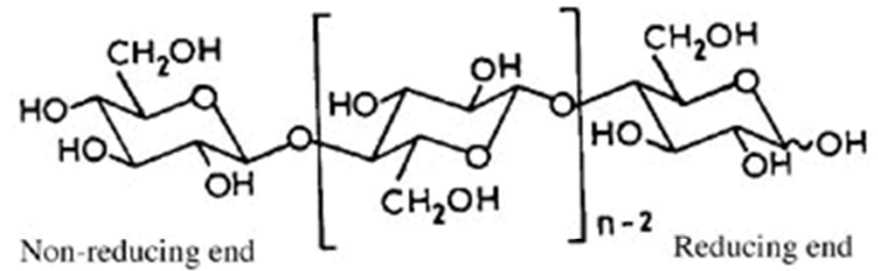
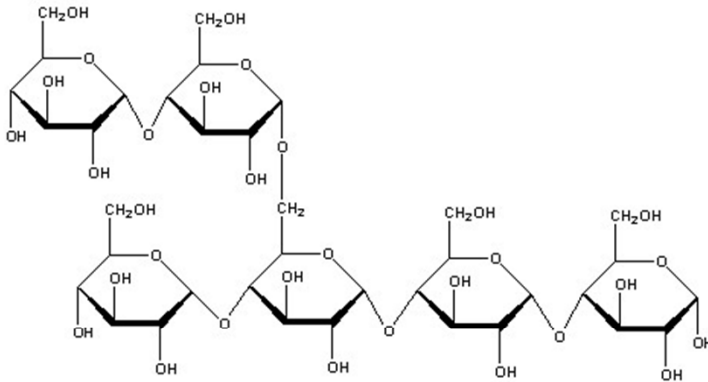
**Isomaltose**



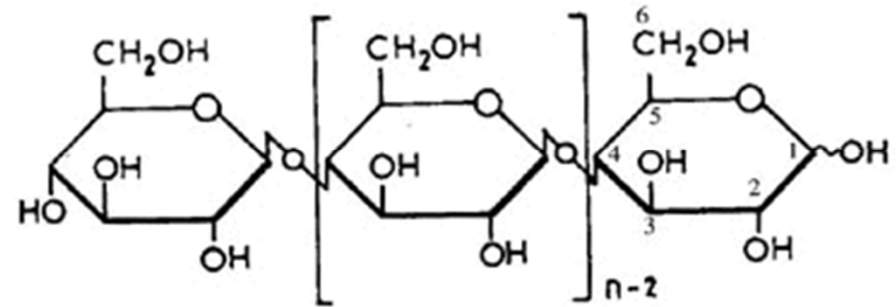
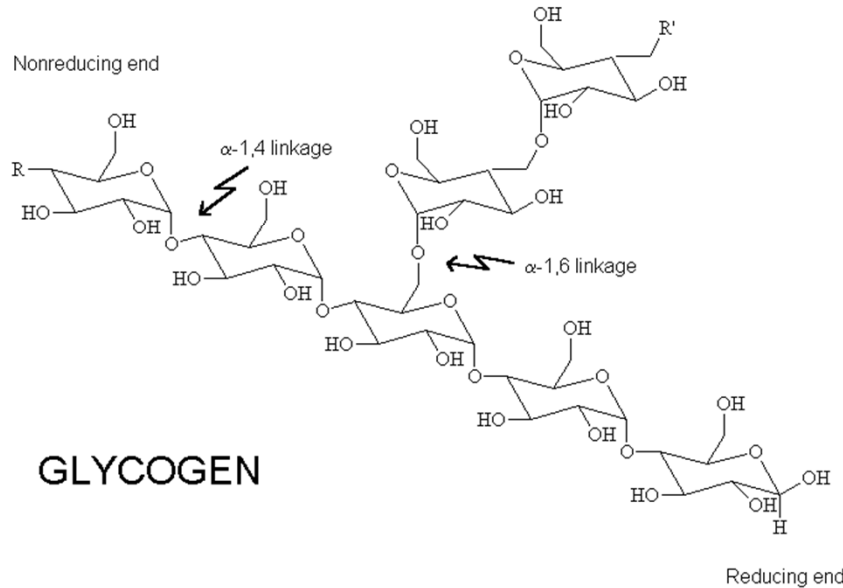
**Cellobiose**



# Polysaccharides

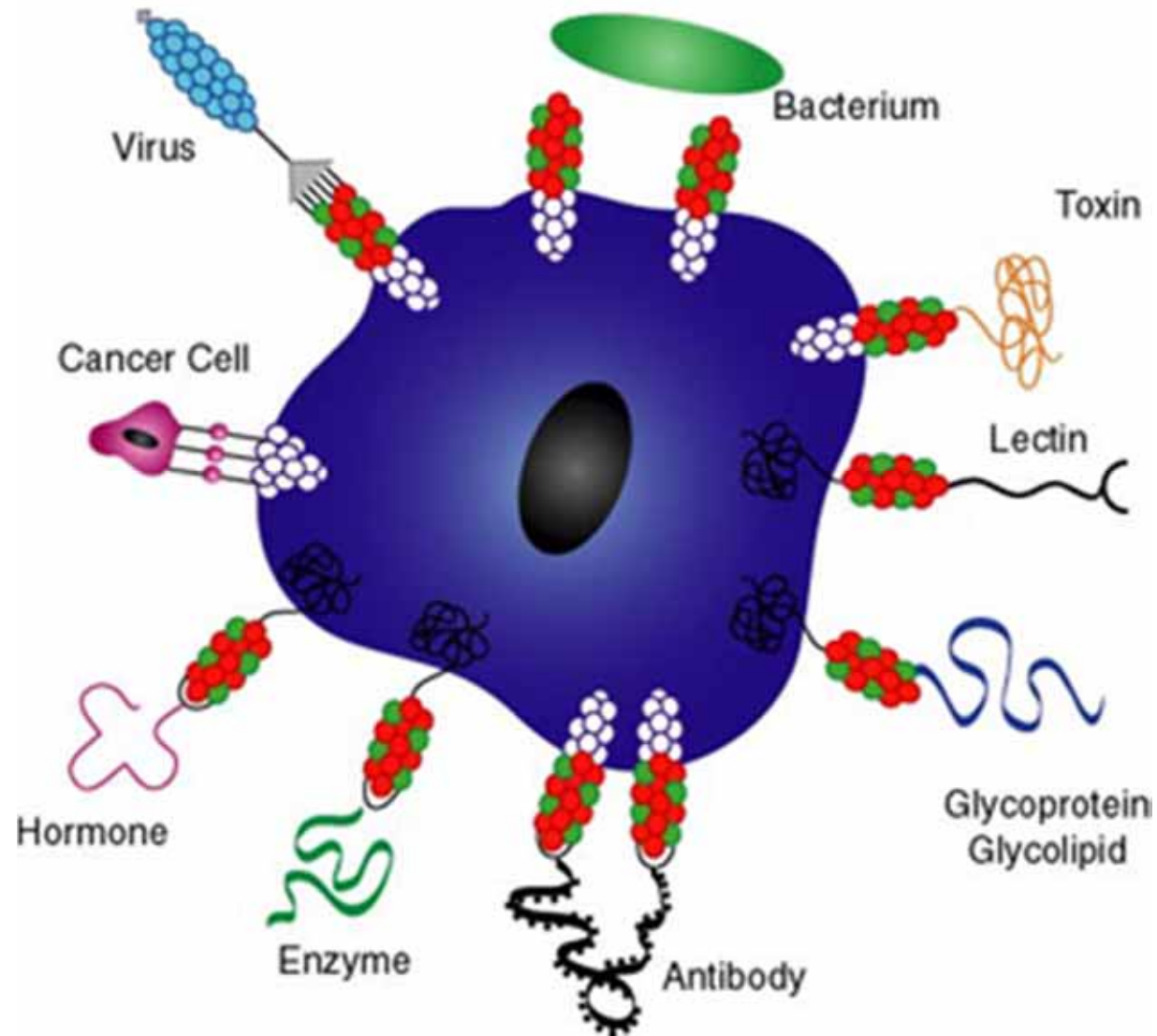


Sometimes shown as



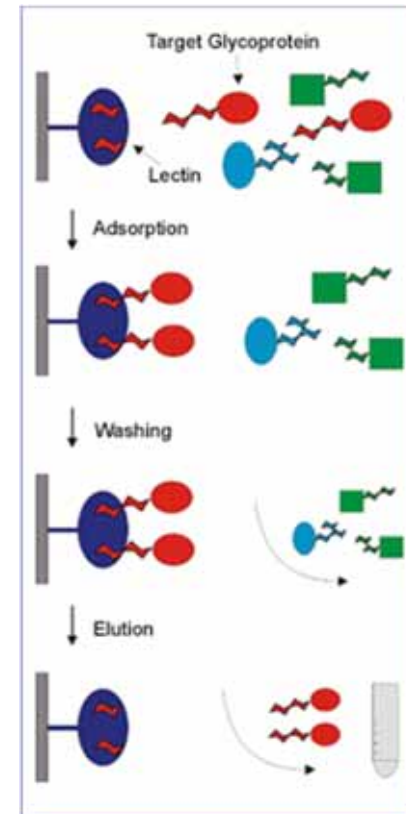
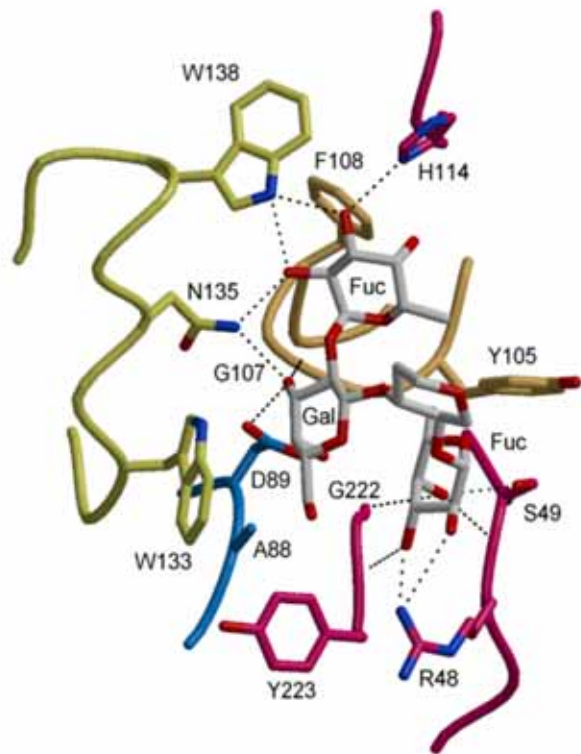
**Cellulose**

## Cell-Surface Carbohydrates Involved in Molecular Recognition













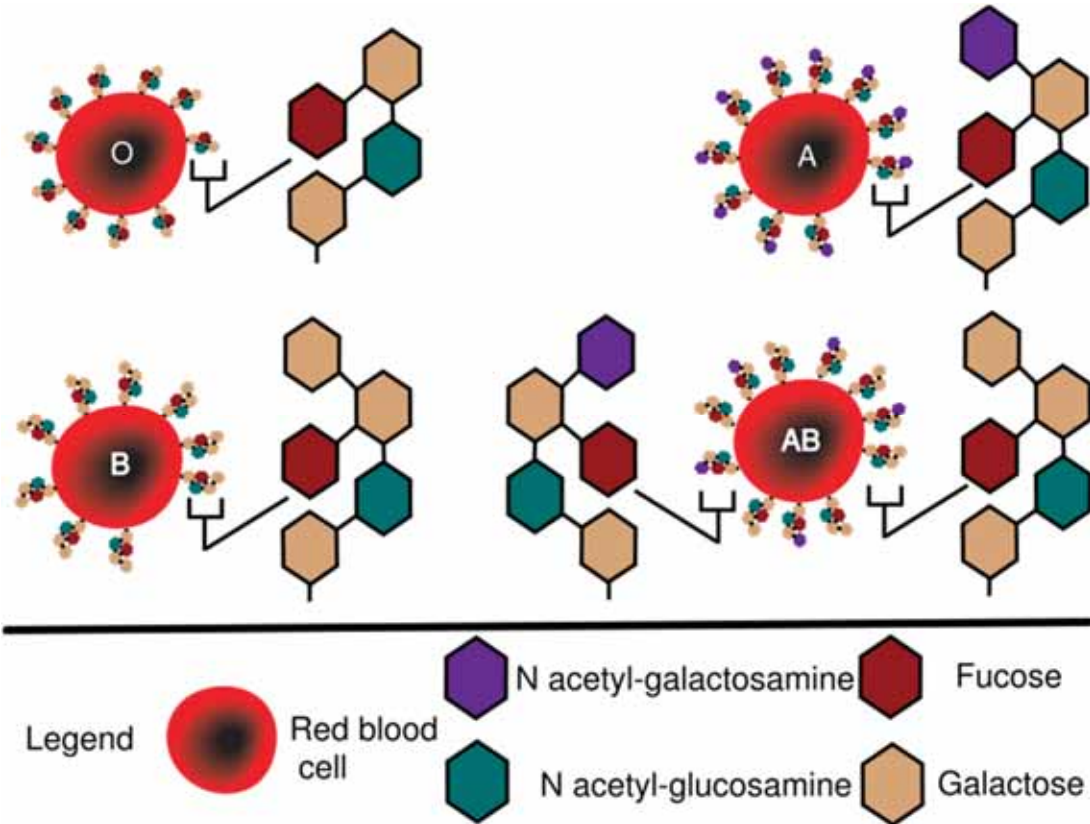
# Lectin

**Lectins** are sugar-binding proteins which are highly specific for their sugar moieties. They typically play a role in biological recognition phenomena involving cells and proteins. For example, some bacteria use lectins to attach themselves to the cells of the host organism during infection.

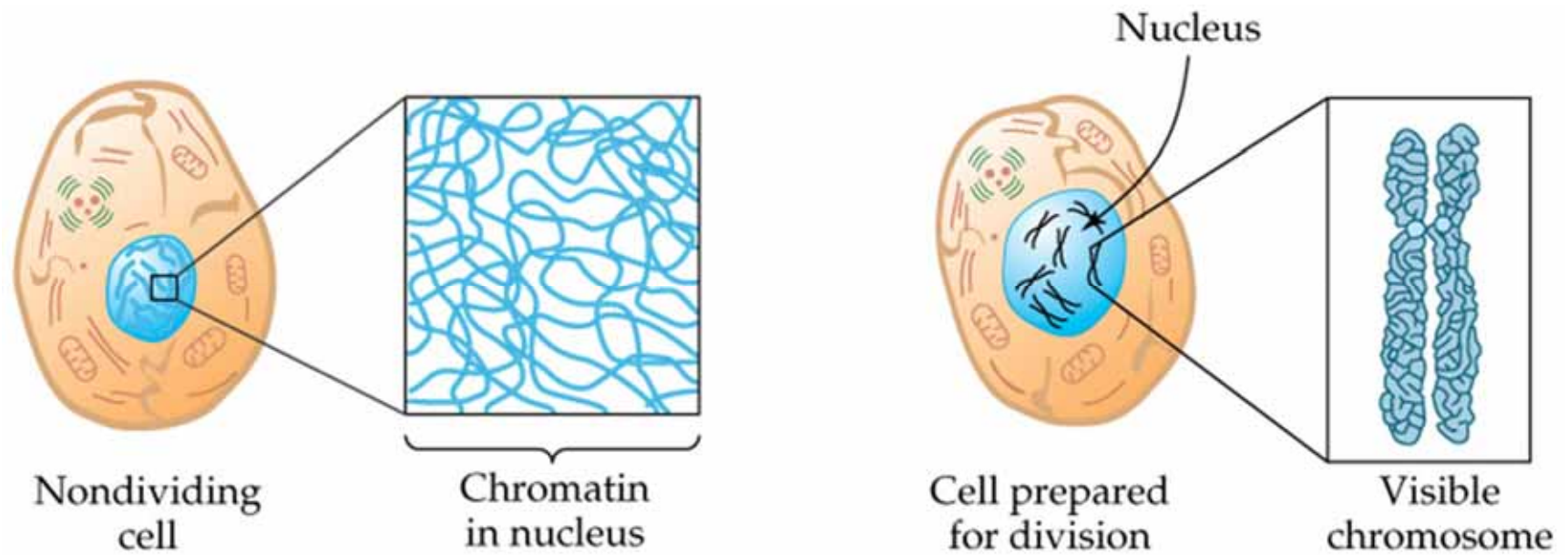


# Blood Type

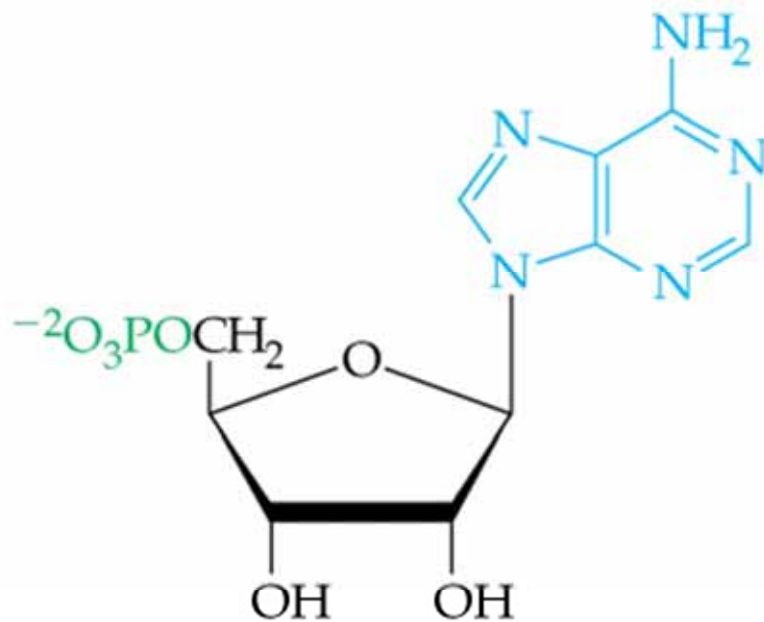
	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies present	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens present	A antigen 	B antigen 	A and B antigens 	No antigens



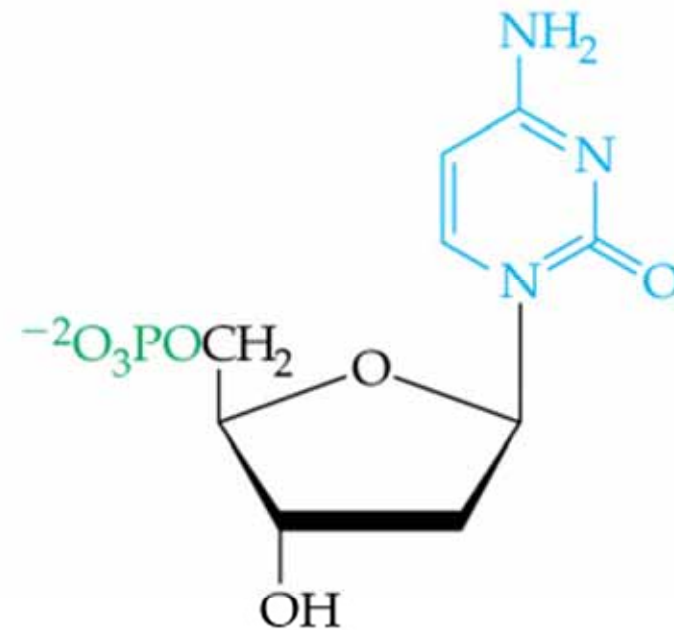
# DNA



- In RNA, the sugar is ribose.
- In DNA, the sugar is deoxyribose.



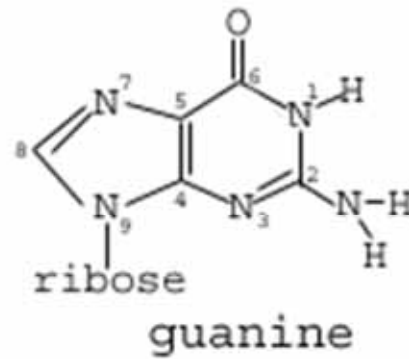
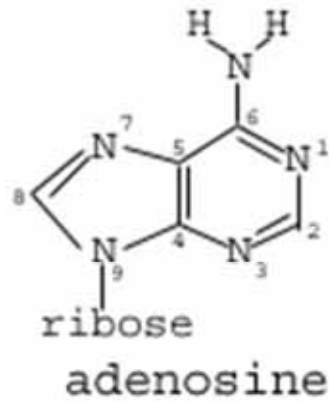
Adenosine 5'-monophosphate (AMP)  
(a ribonucleotide)



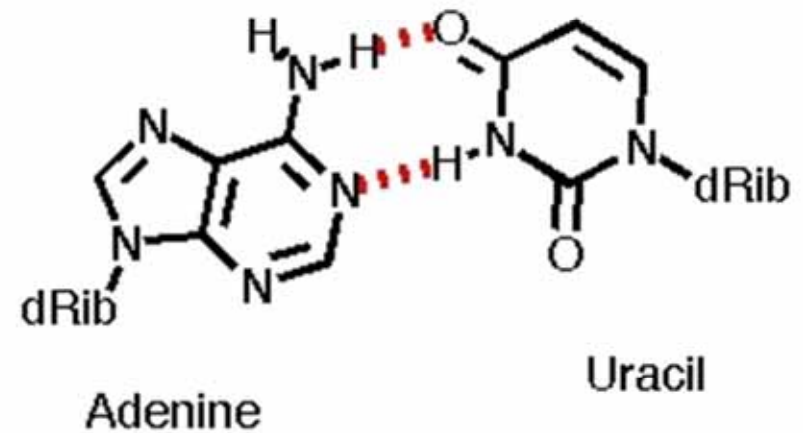
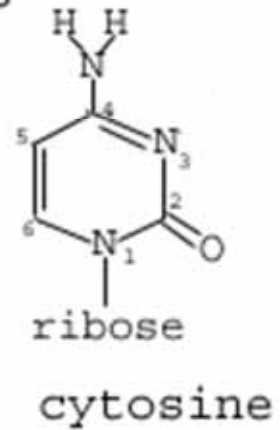
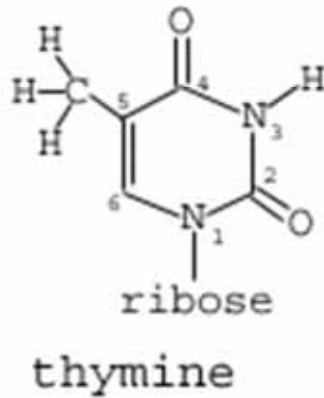
Deoxycytidine 5'-monophosphate (dCMP)  
(a deoxyribonucleotide)

# Base

## Purines

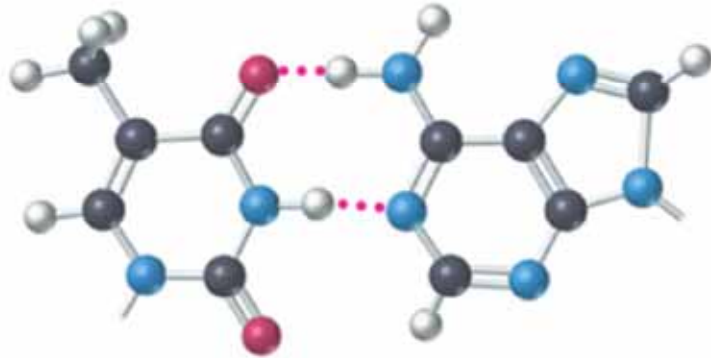


## Pyrimidines

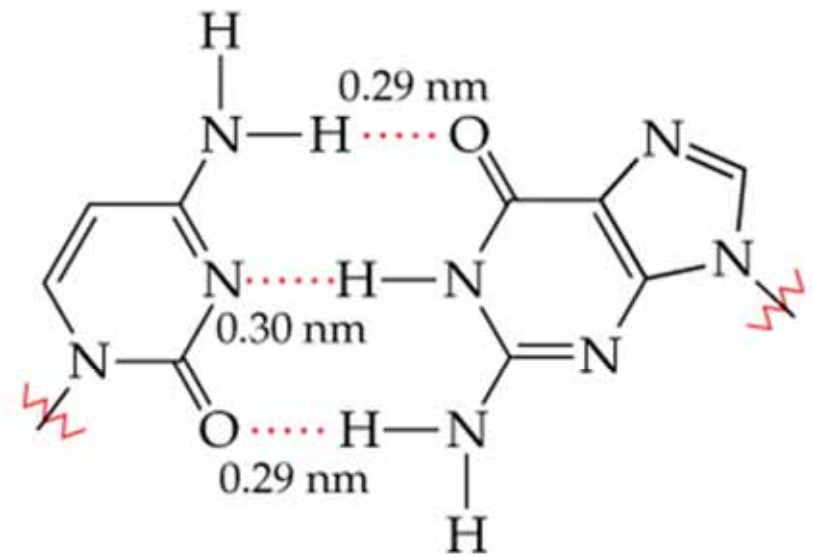
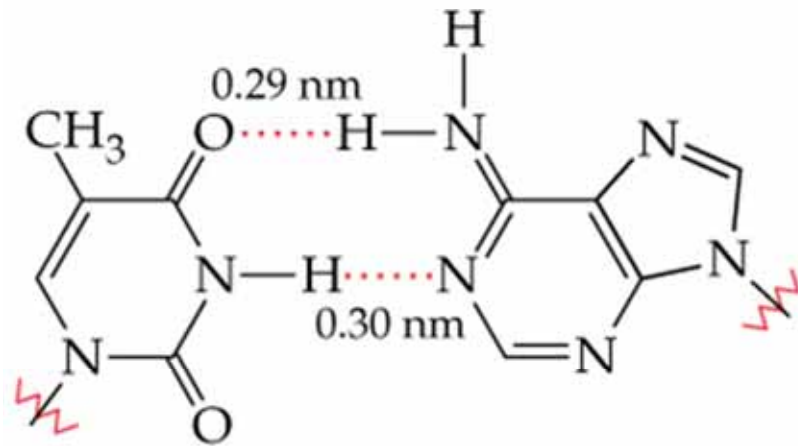
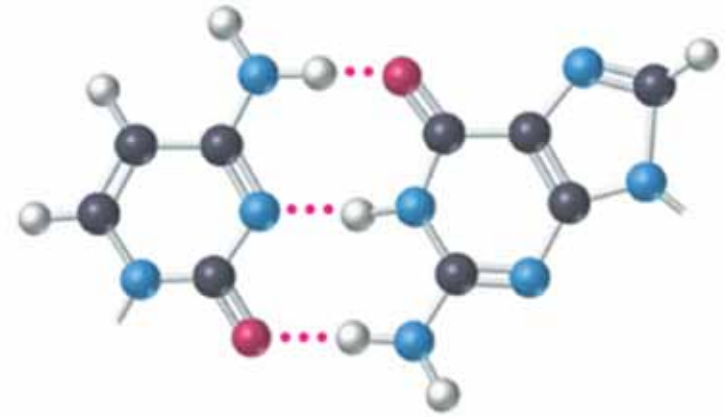




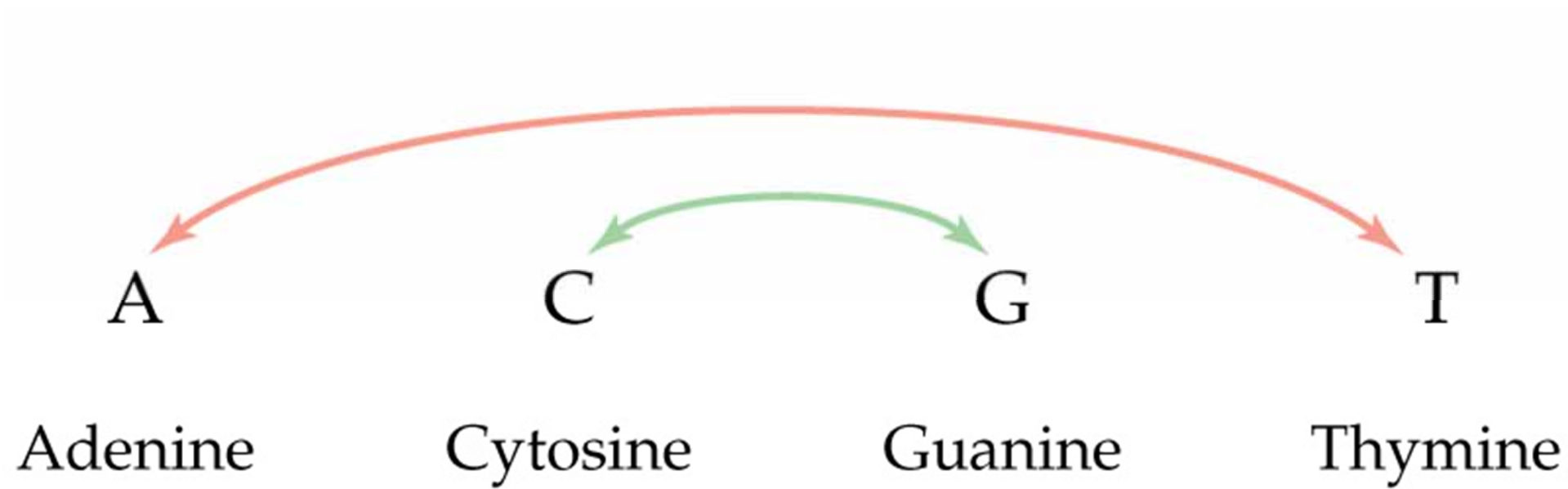
Thymine-Adenine

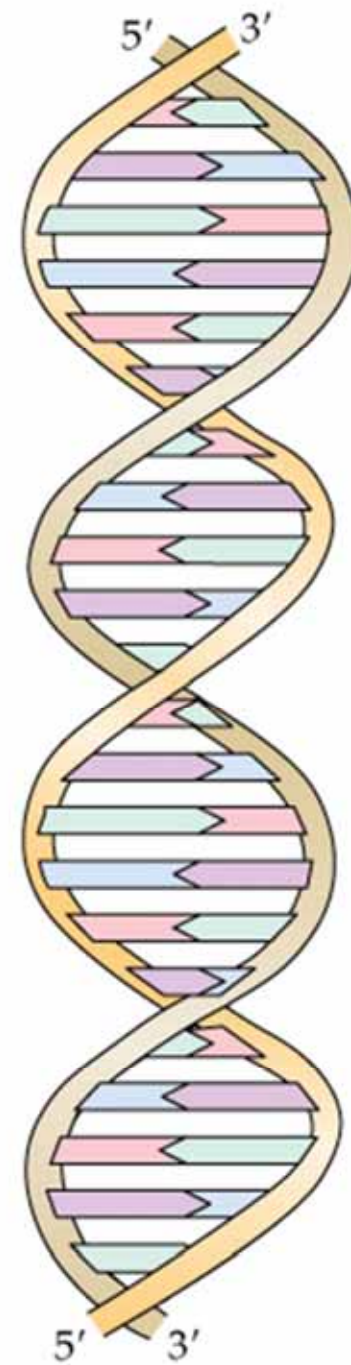
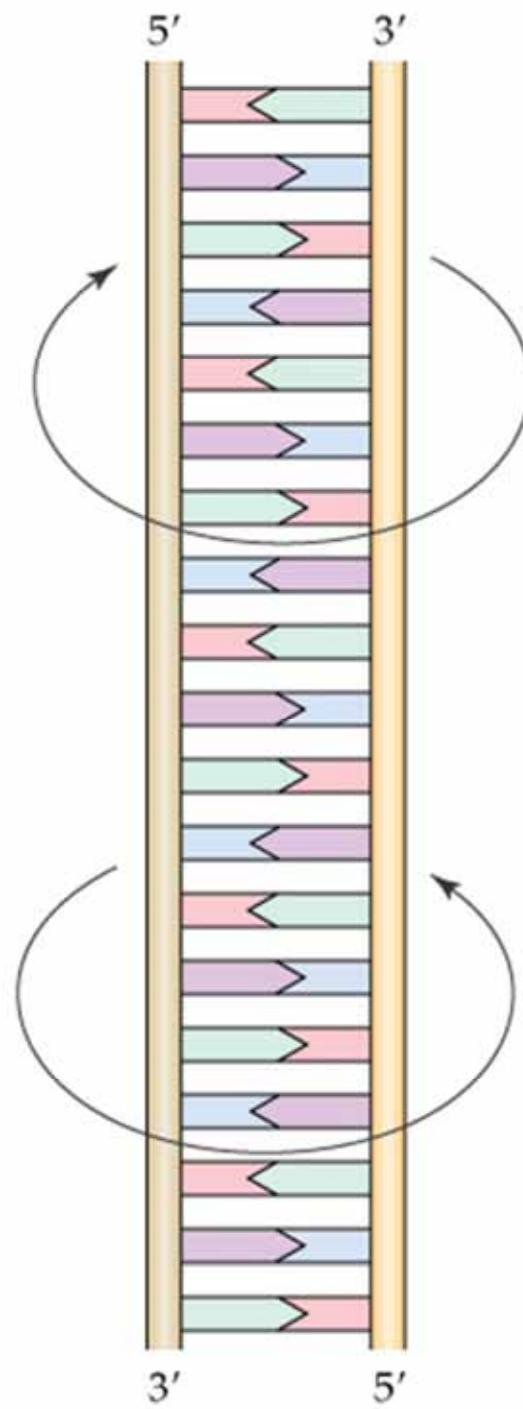
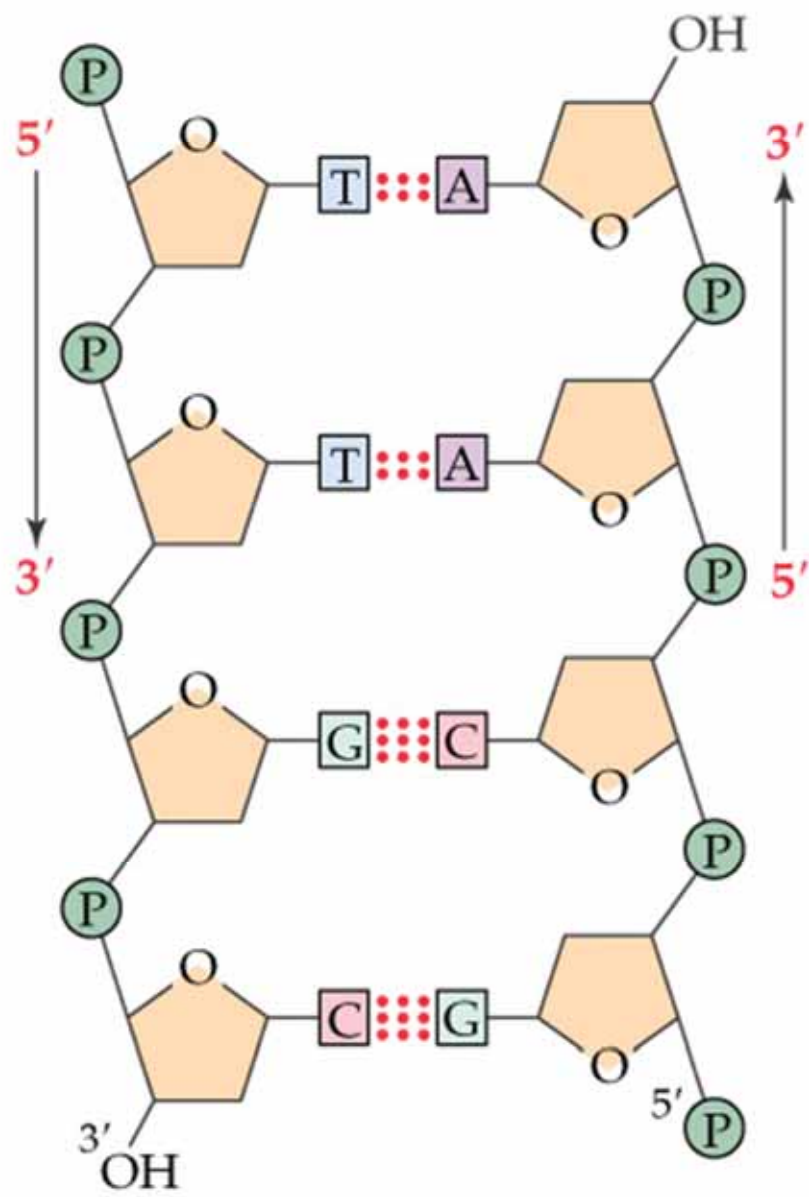


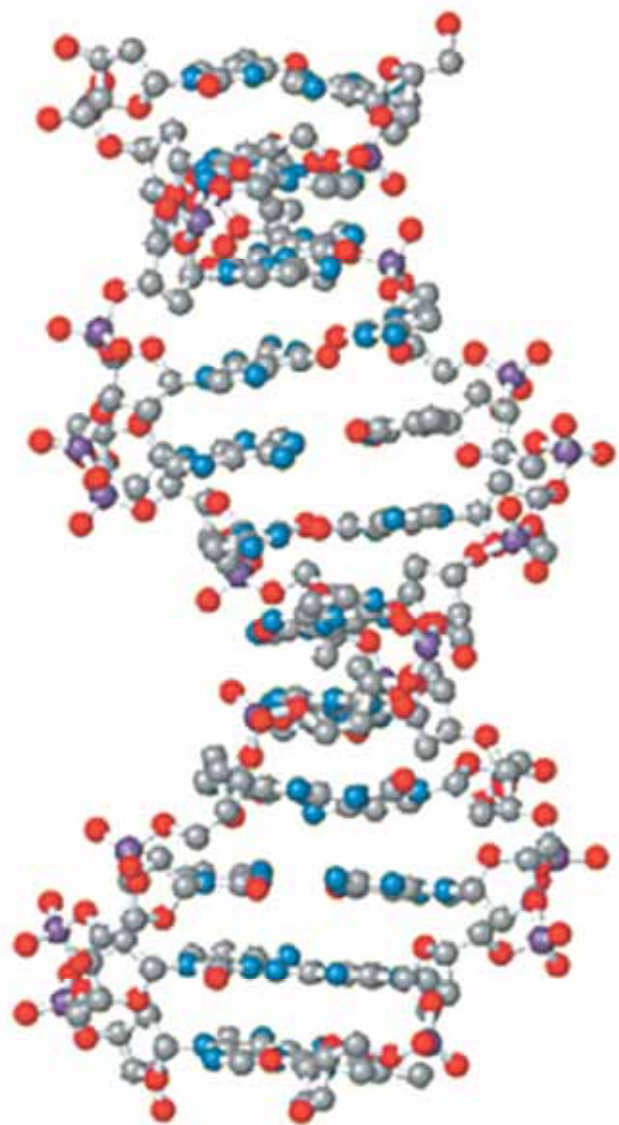
Cytosine-Guanine



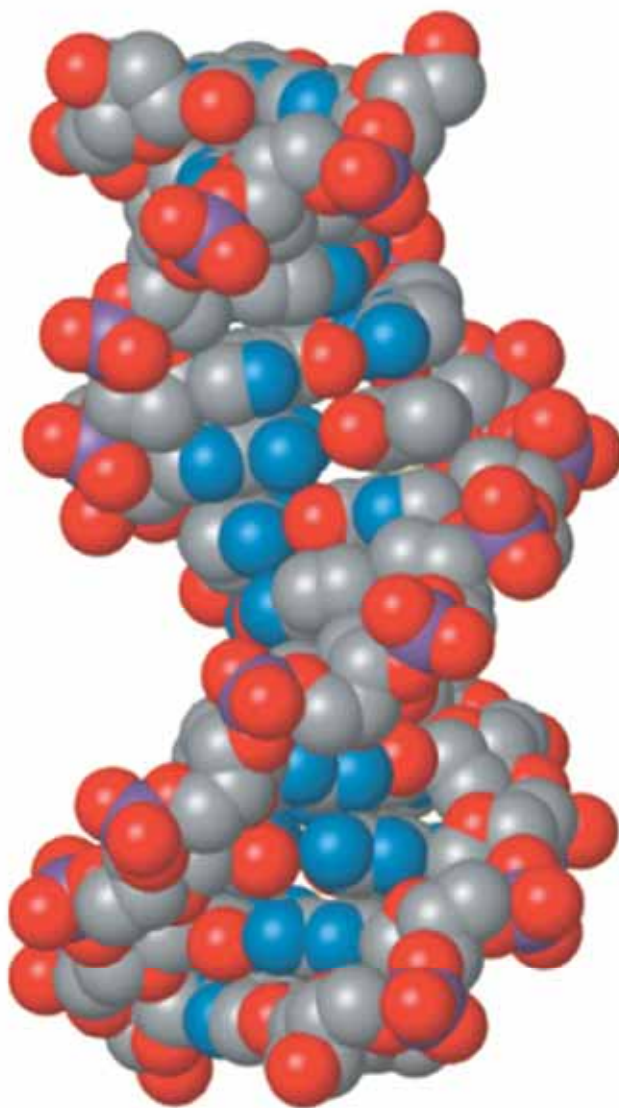








(a)

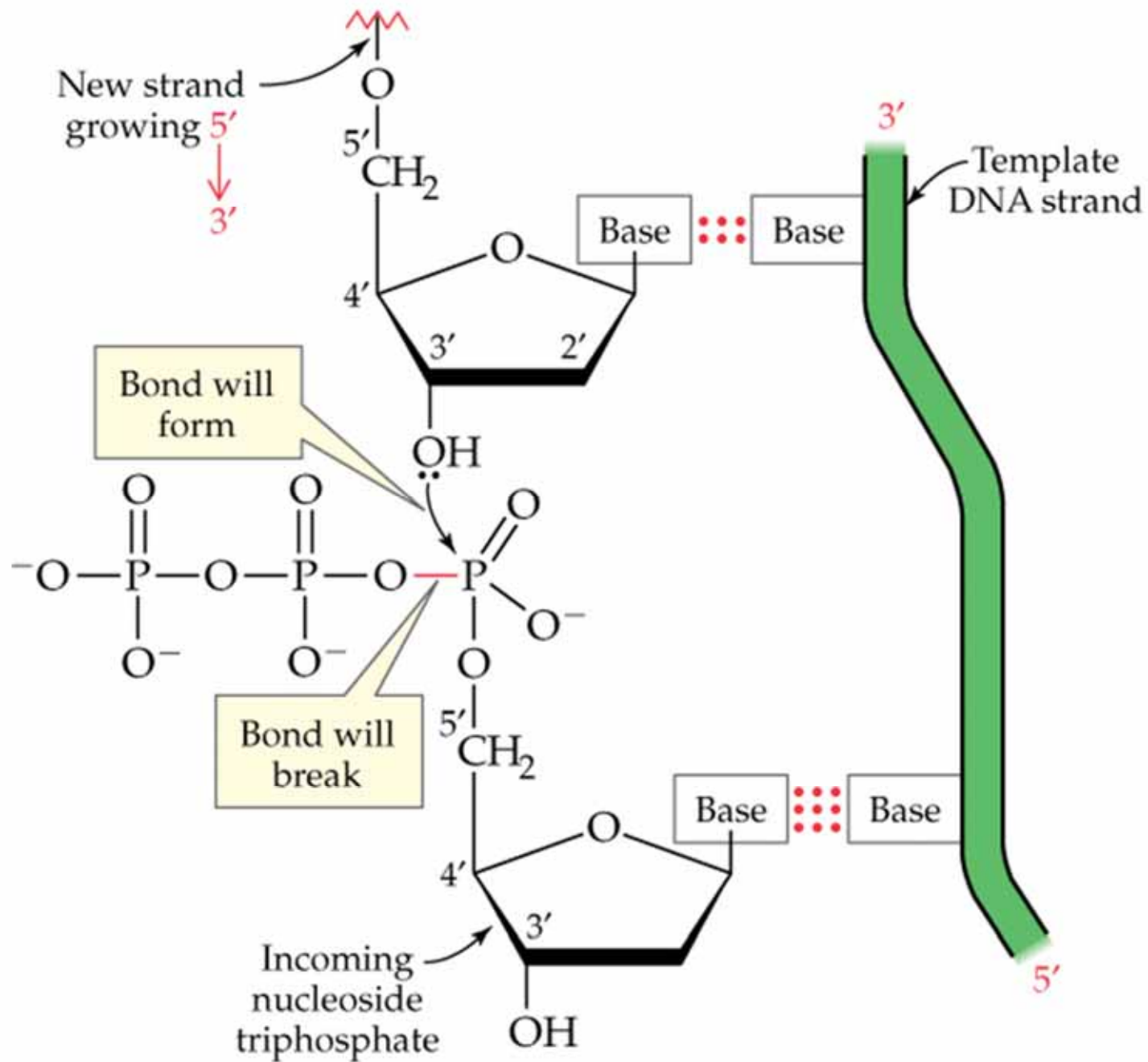


(b)

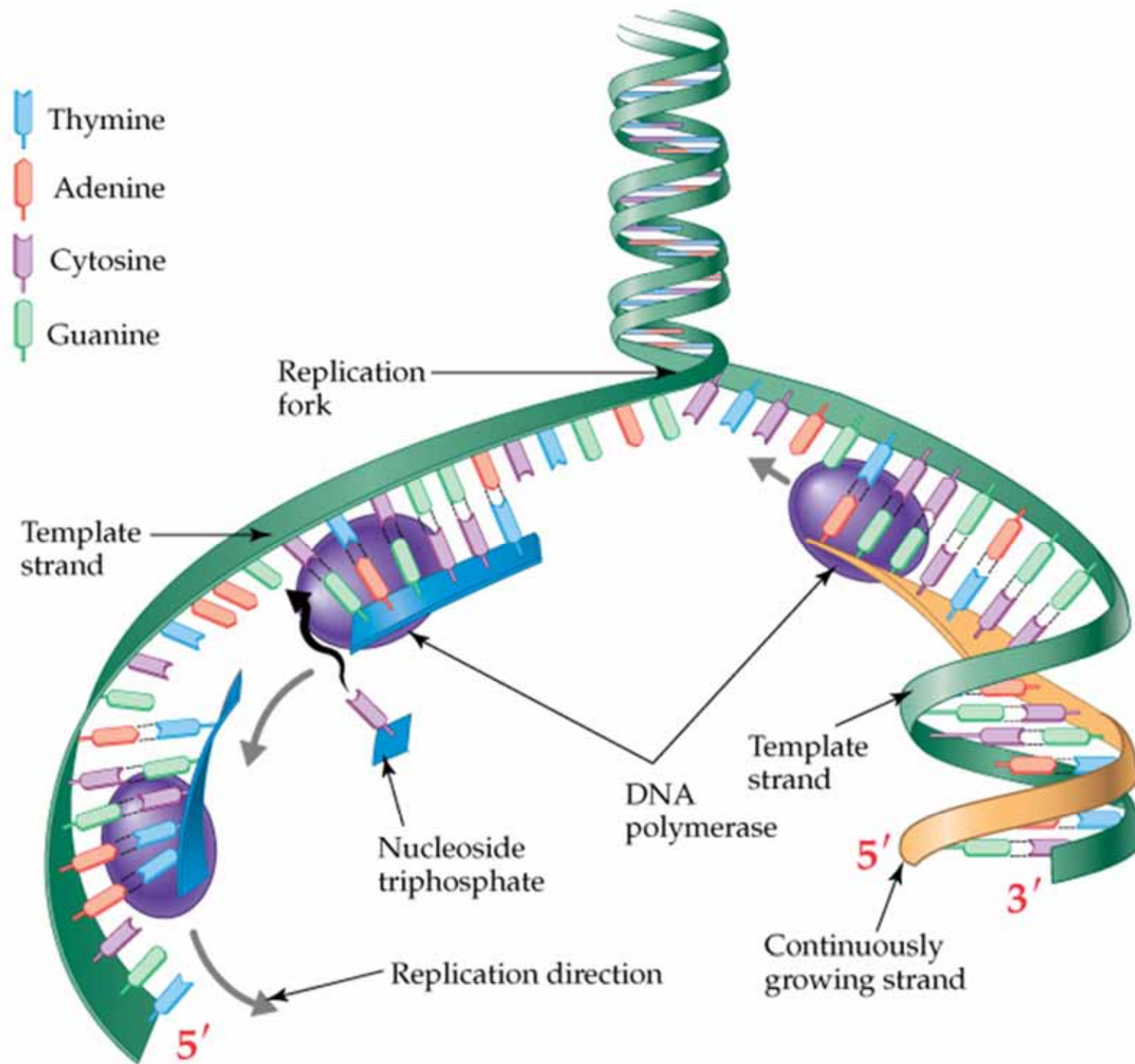


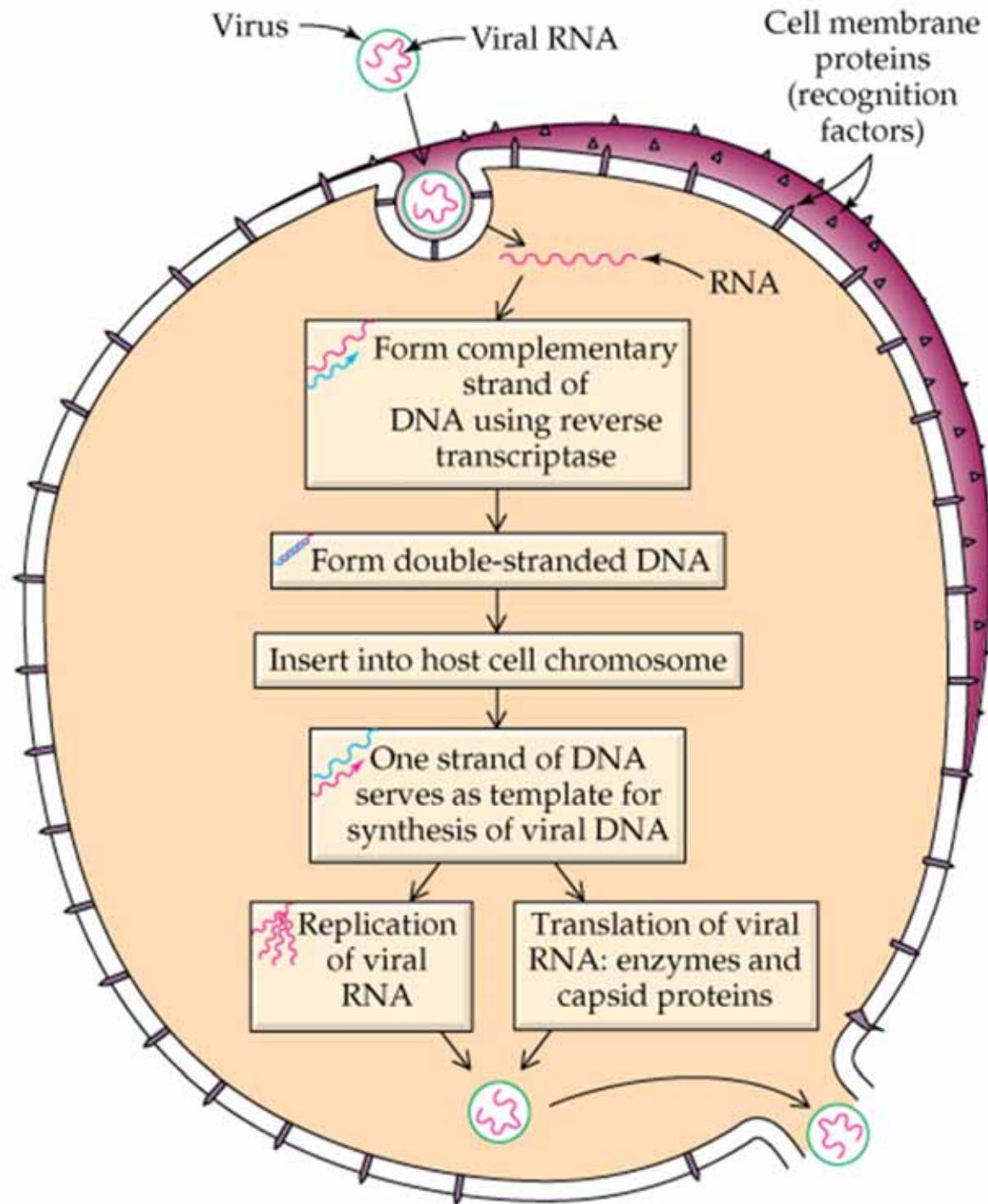
(c)

## *Bond formation in DNA replication*

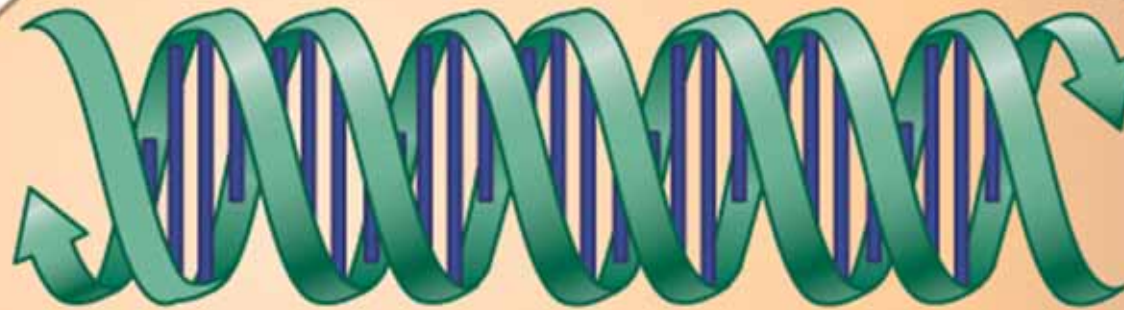






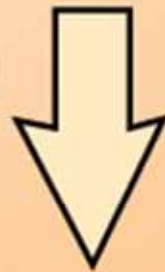


Cell nucleus



DNA

Transcription



mRNA

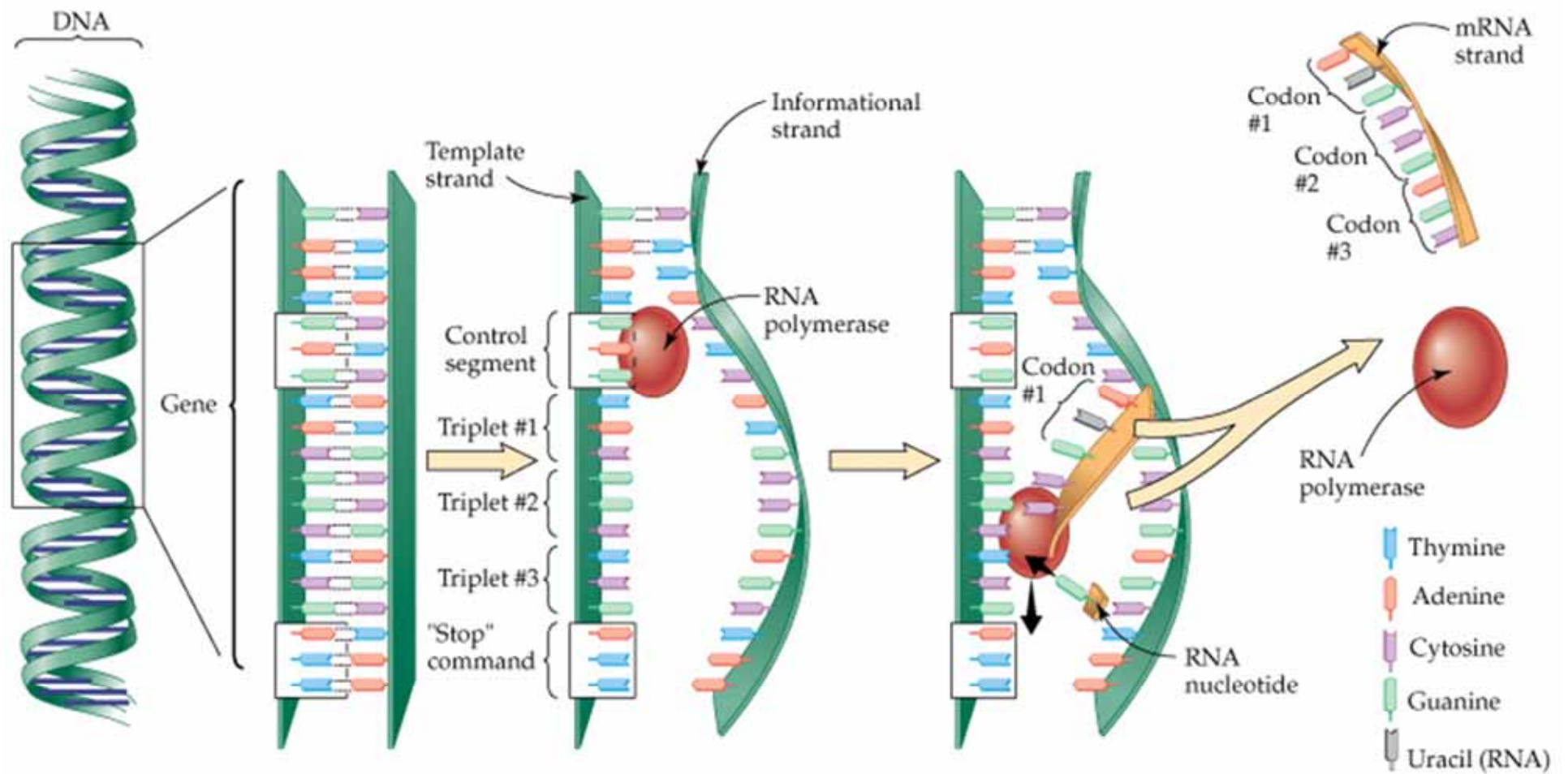
- The following three RNA make it possible for the encoded information carried by the DNA to be put to use in the synthesis of proteins.

- Ribosome RNA***: The granular organelles in the cell where protein synthesis takes place. These organelles are composed of protein and ribosomal RNA (rRNA).

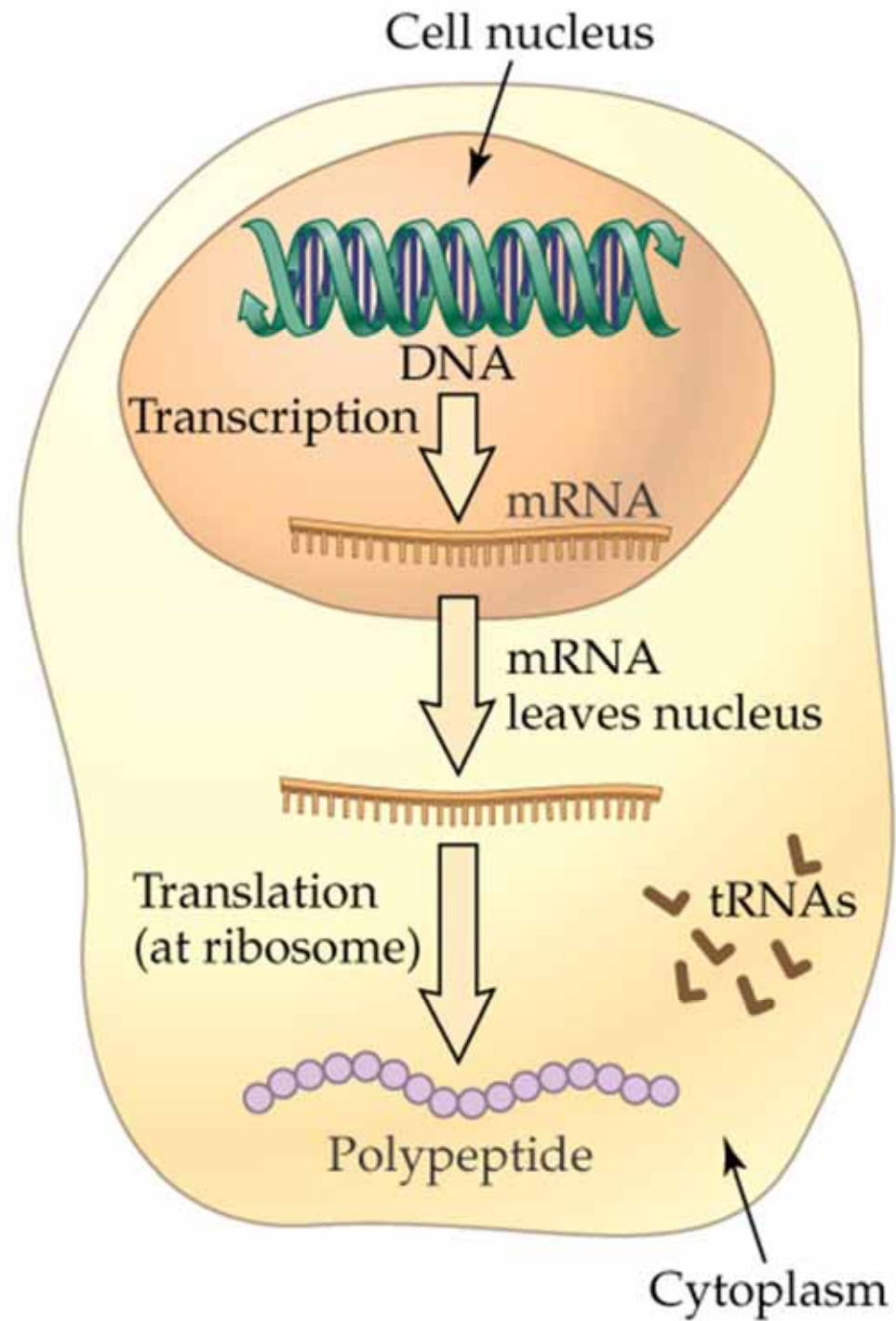
- Messenger RNA (mRNA)***: The RNA that carries the code transcribed from DNA and directs protein synthesis.

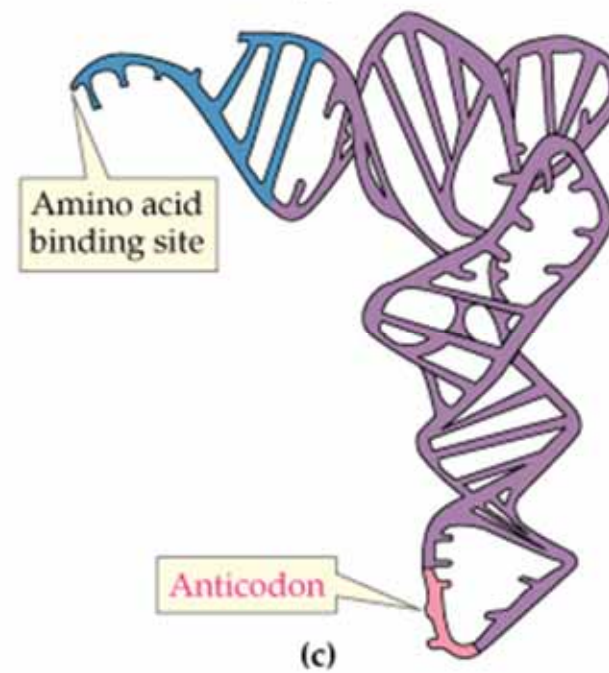
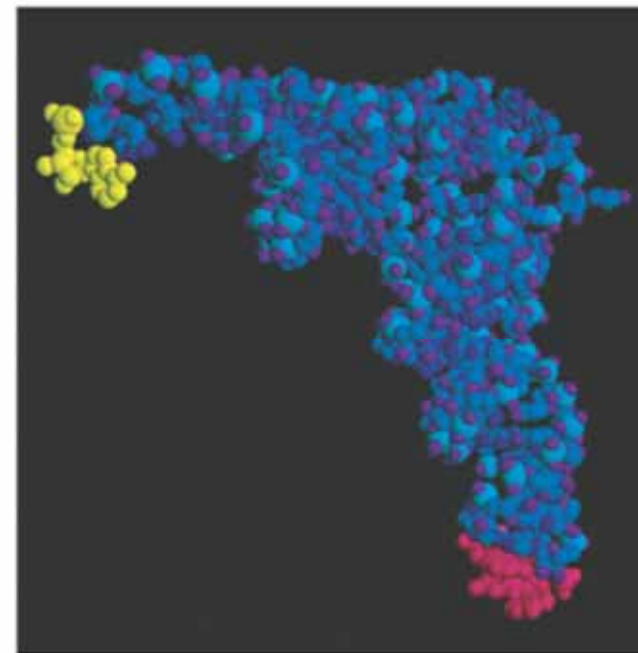
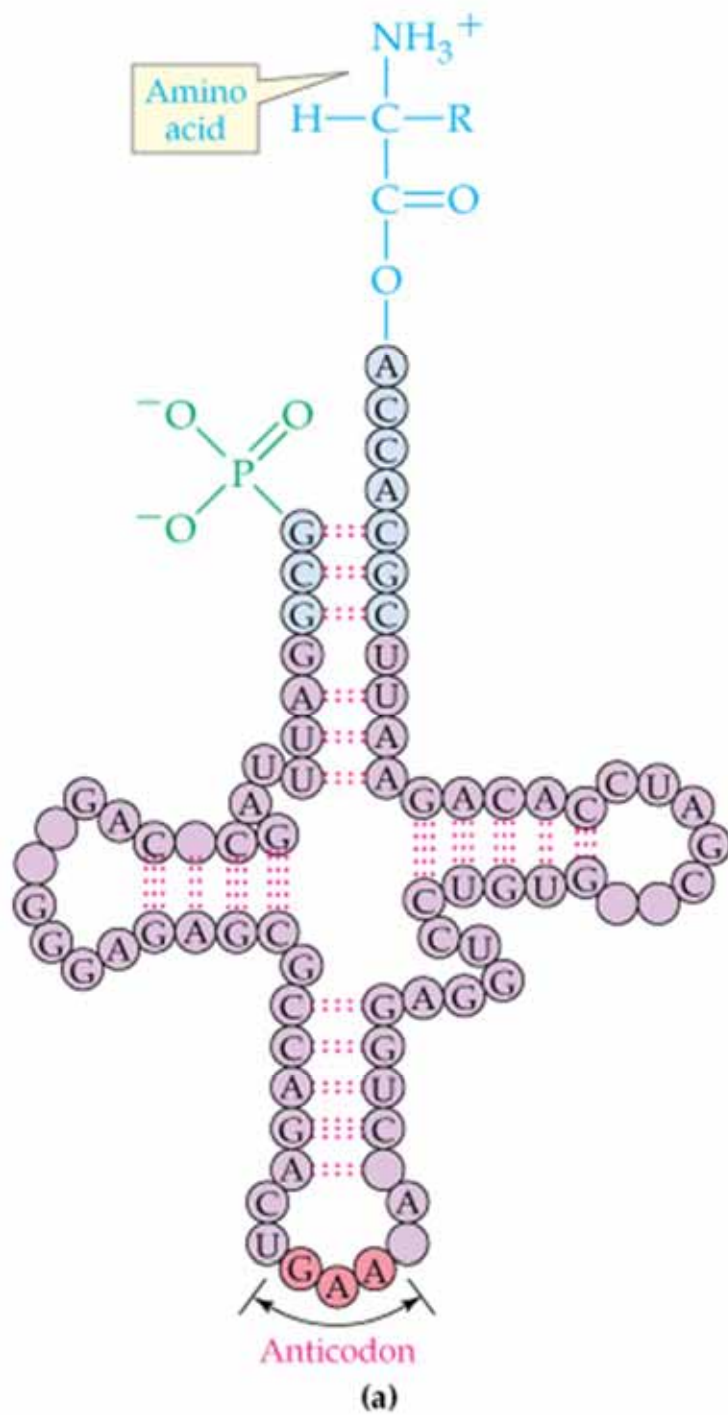
- Transfer RNA (tRNA)***: The smaller RNA that delivers amino acids one by one to protein chains growing at ribosomes. Each tRNA recognizes and carries only one amino acid.

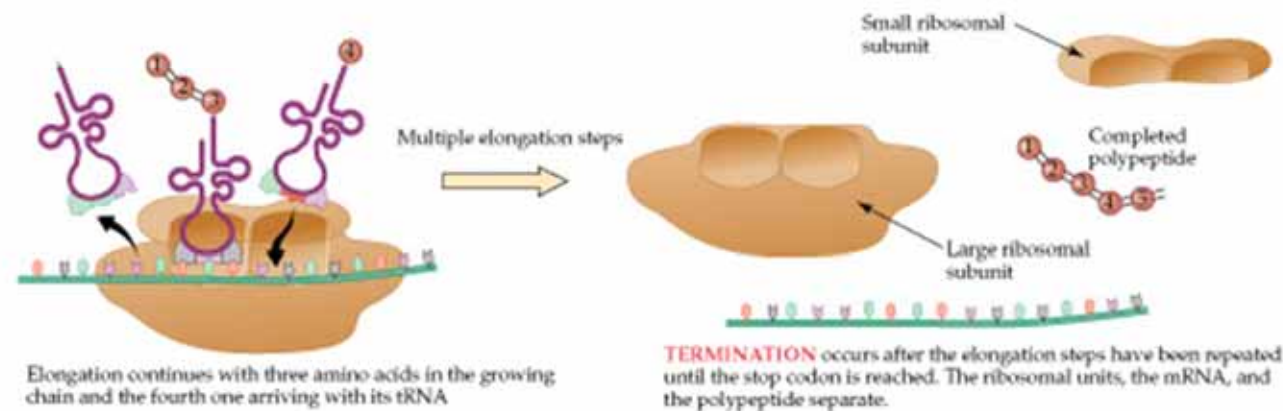
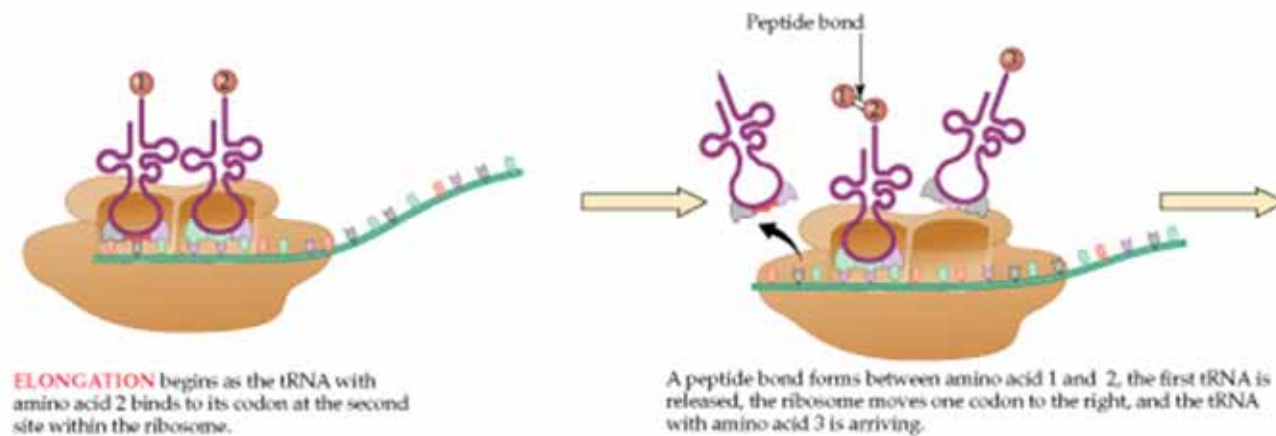
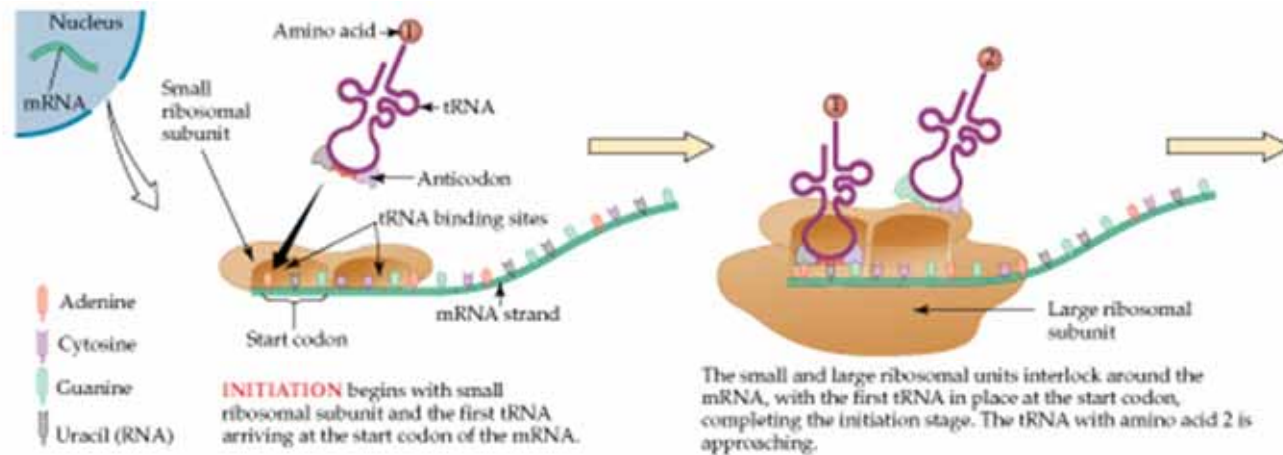




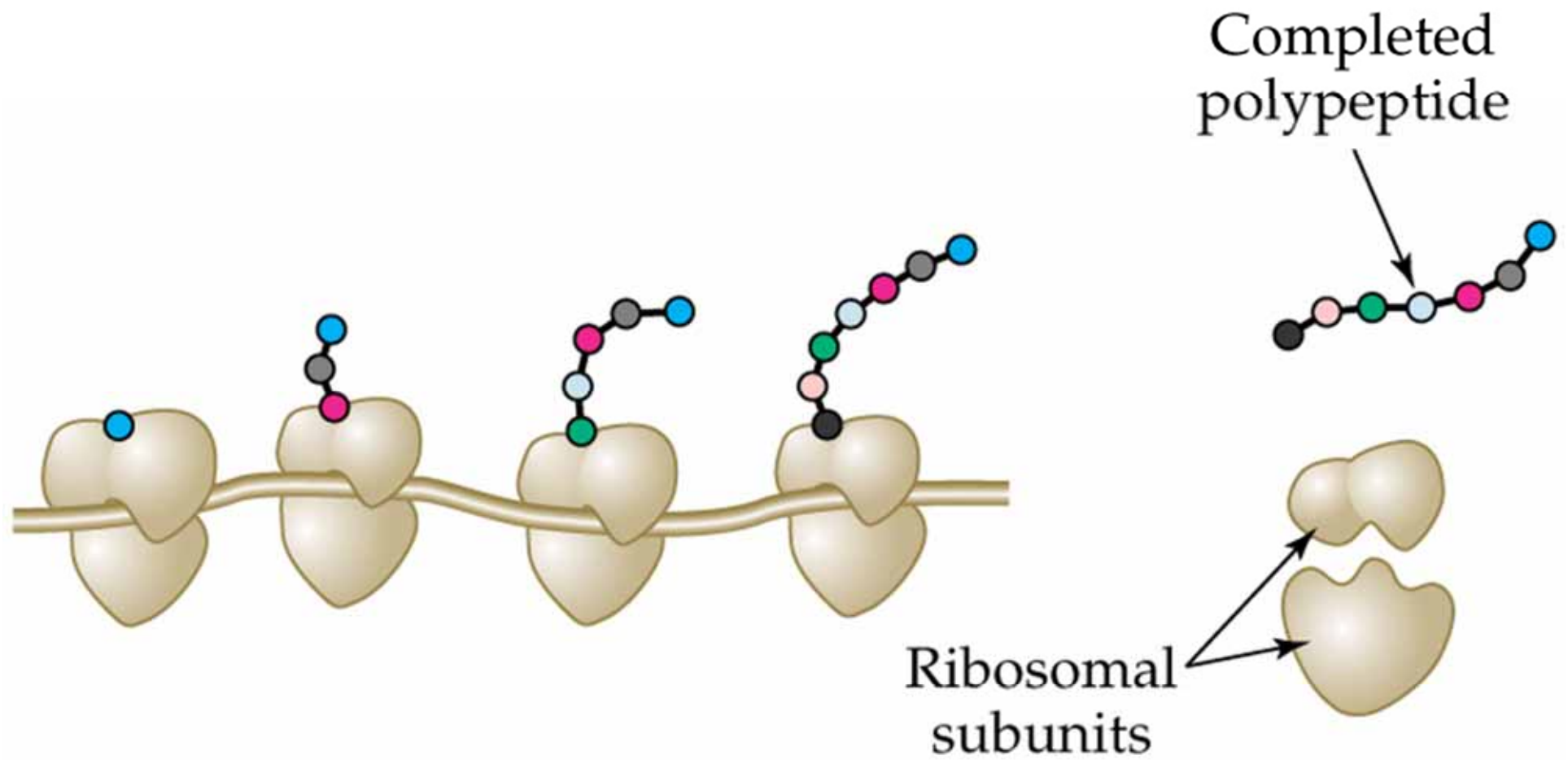




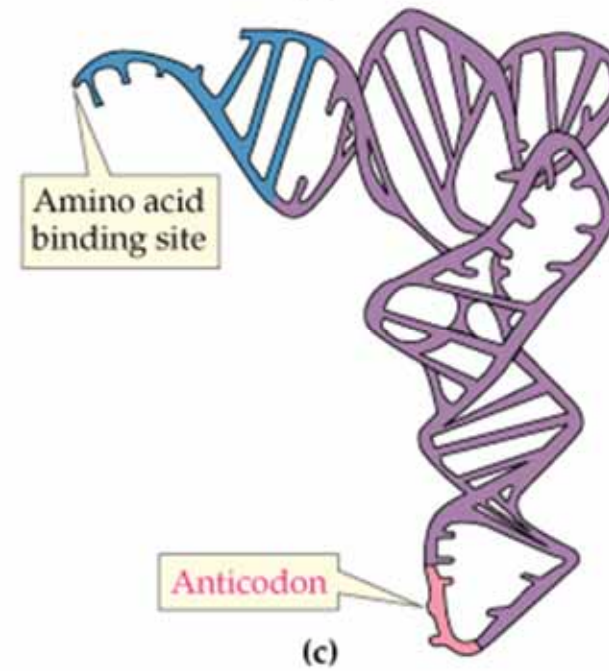
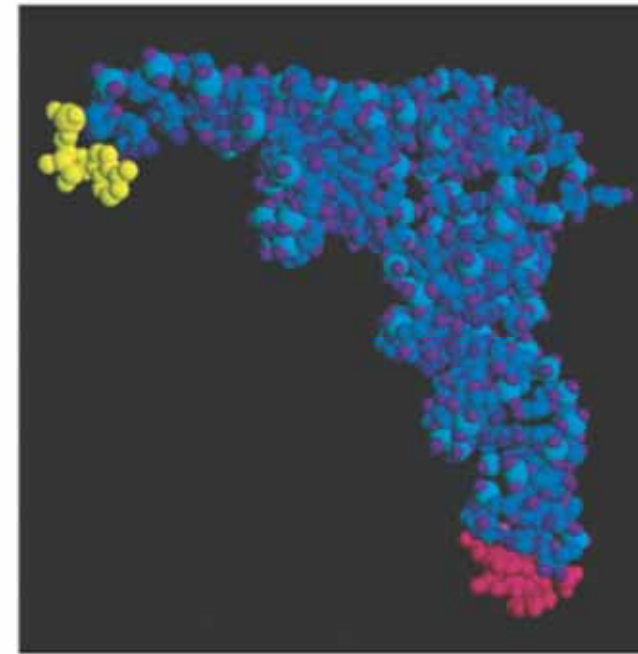
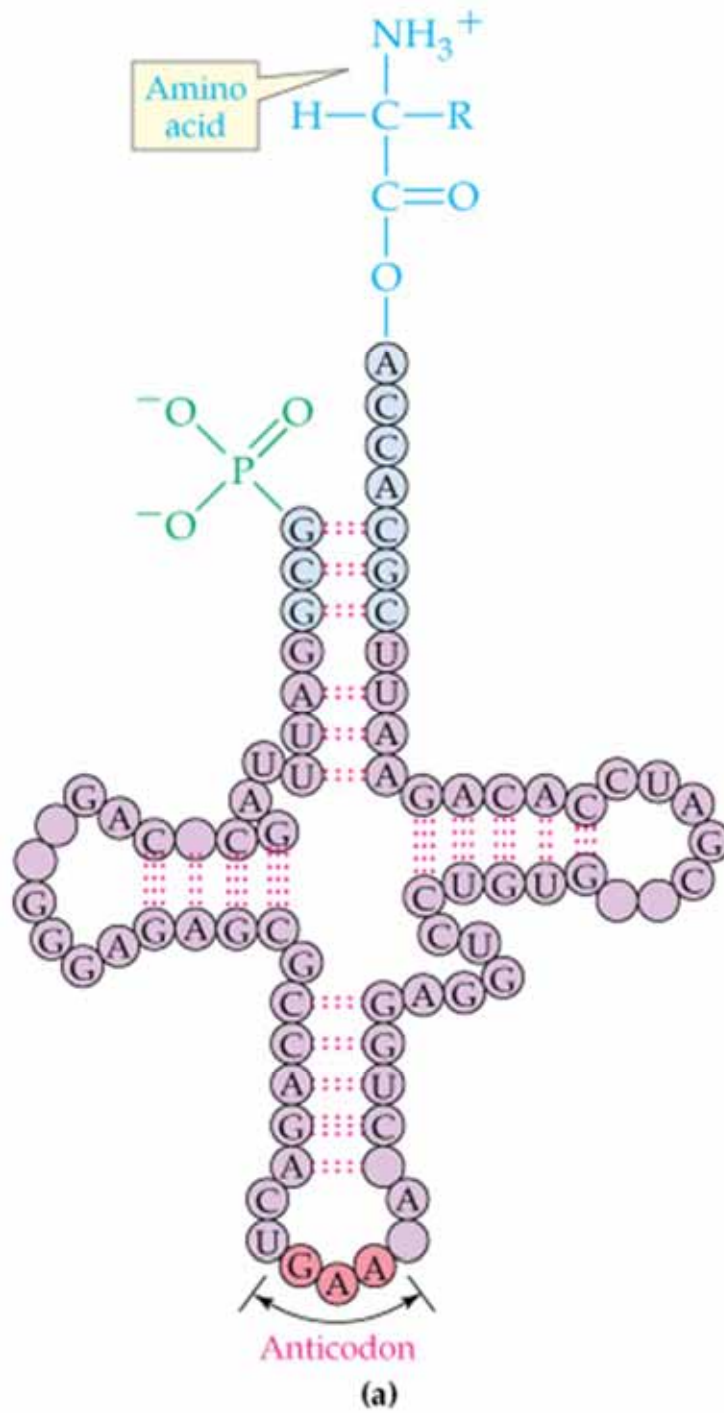






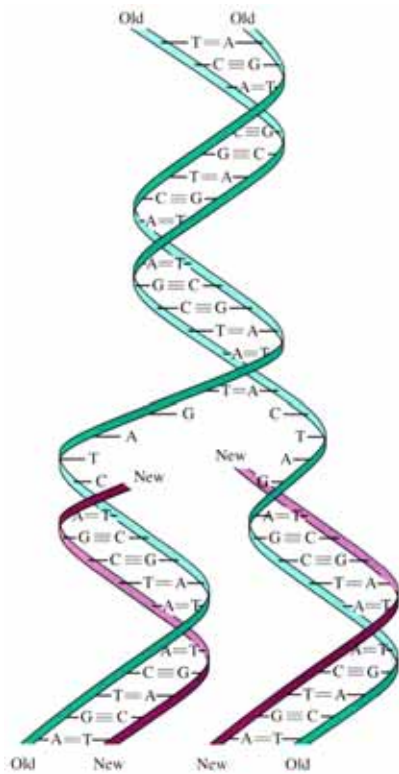


		Second letter				
		U	C	A	G	
First letter	U	UUU } Phe UUC } UUA } Leu UUG }	UCU } UCC } Ser UCA } UCG }	UAU } Tyr UAC } UAA Stop UAG Stop	UGU } Cys UGC } UGA Stop UGG Trp	U C A G
	C	CUU } CUC } Leu CUA } CUG }	CCU } CCC } Pro CCA } CCG }	CAU } His CAC } CAA } Gln CAG }	CGU } CGC } Arg CGA } CGG }	U C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



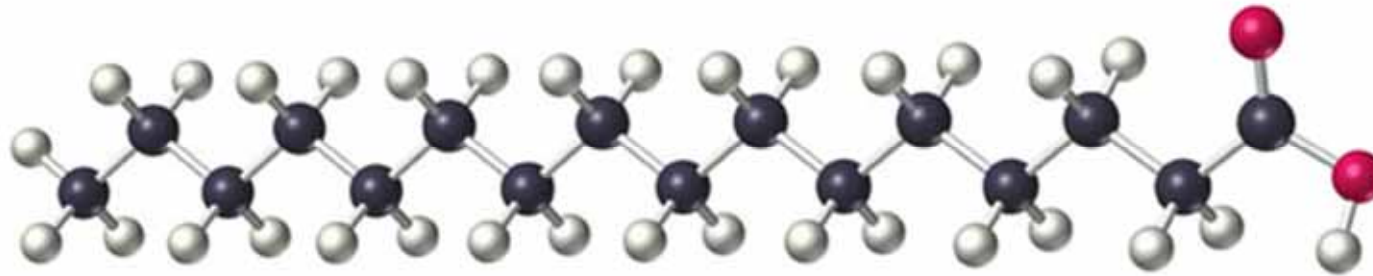


# Self-Assembly Process in Nature

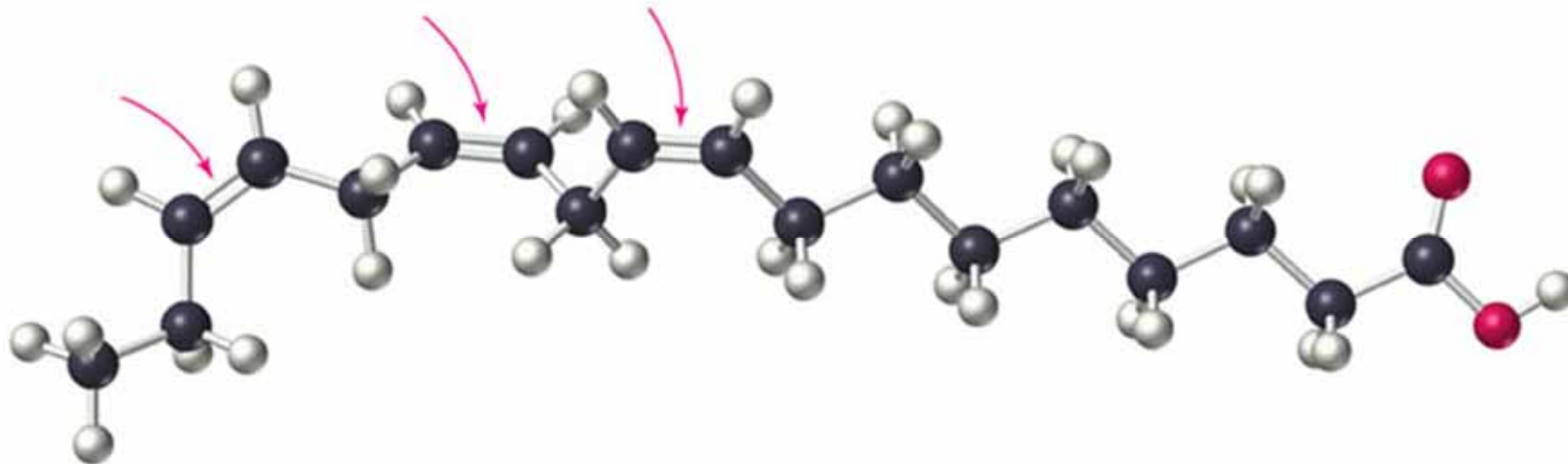
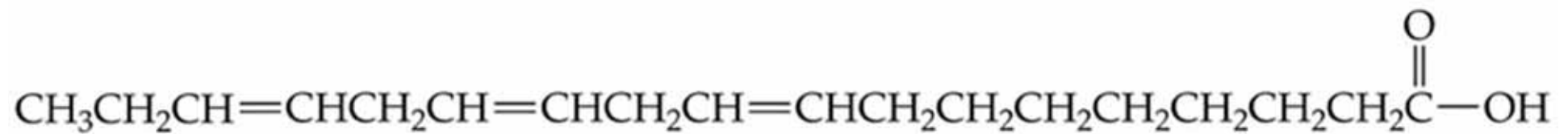


# Lipid

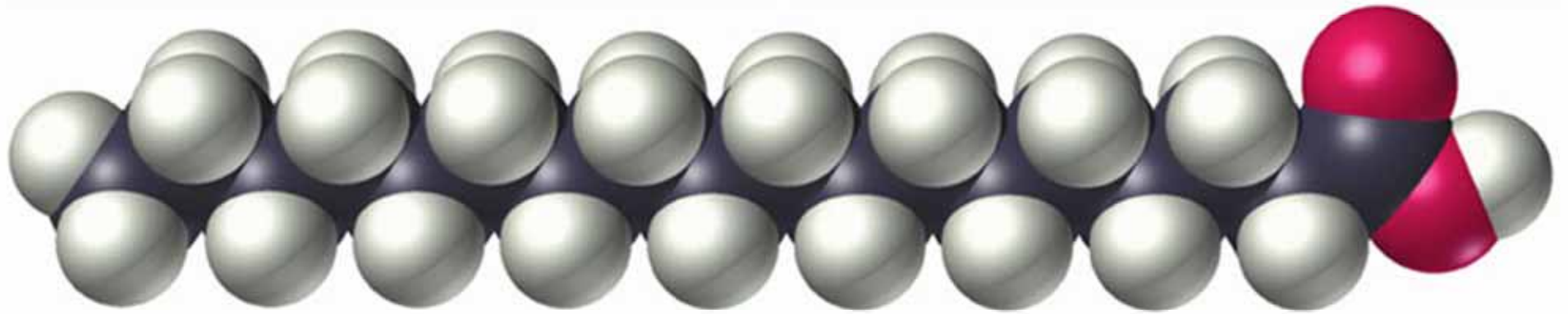
- ***Lipids*** are naturally occurring molecules from plants or animals that are soluble in nonpolar organic solvents.
- Lipid molecules contain large hydrocarbon portion and not many polar functional group, which accounts for their solubility behavior.



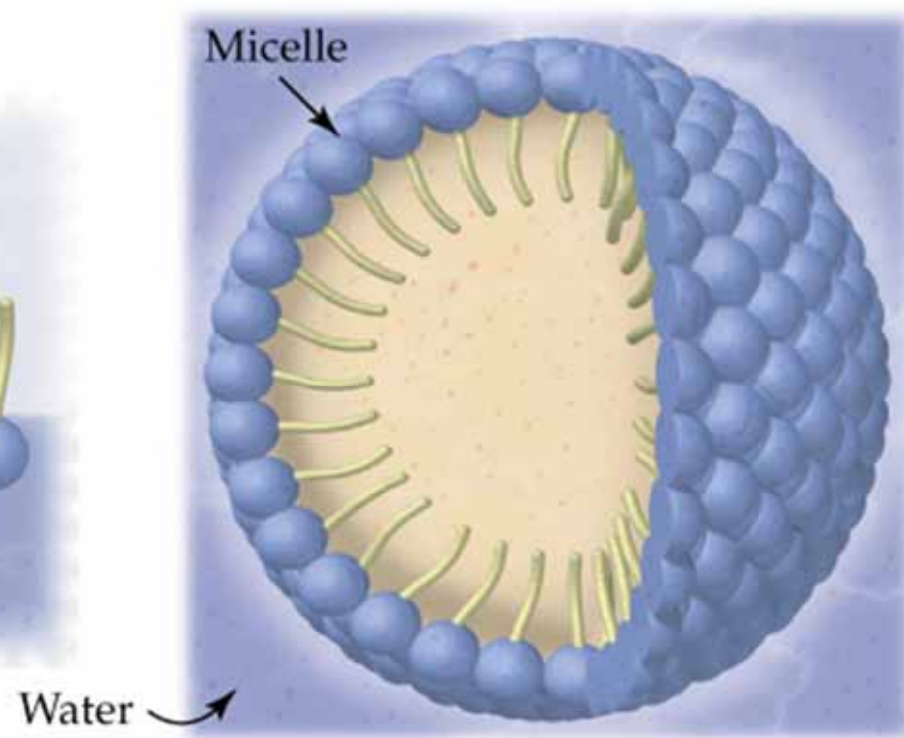
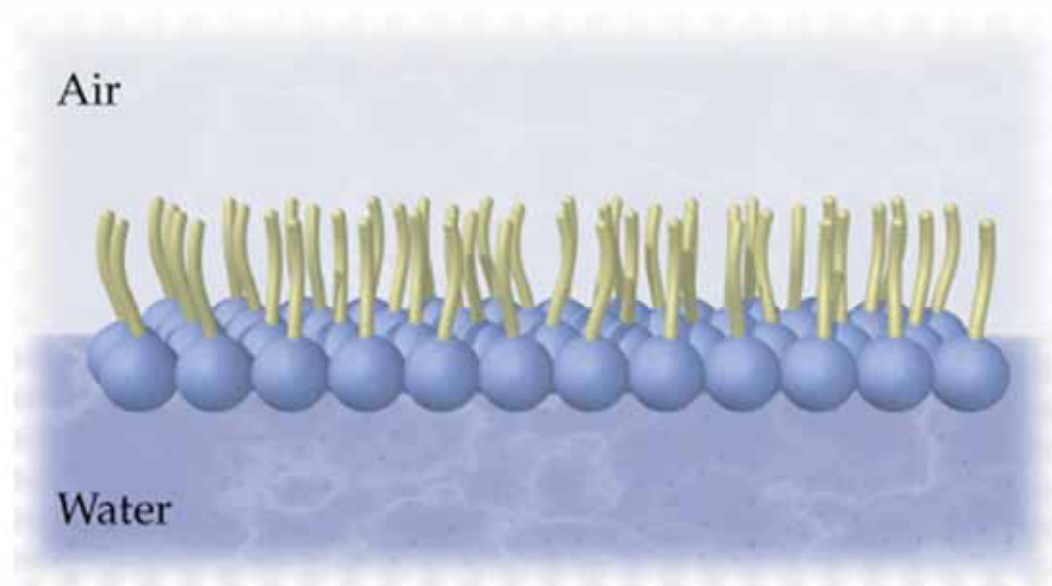
A saturated fatty acid  
(palmitic acid)

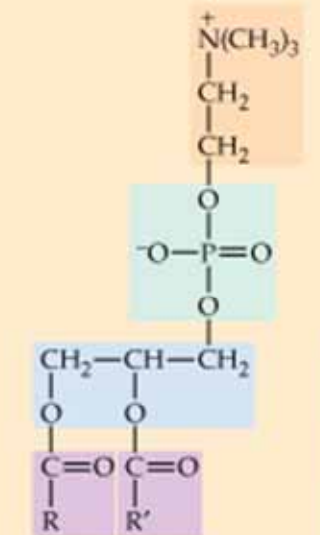
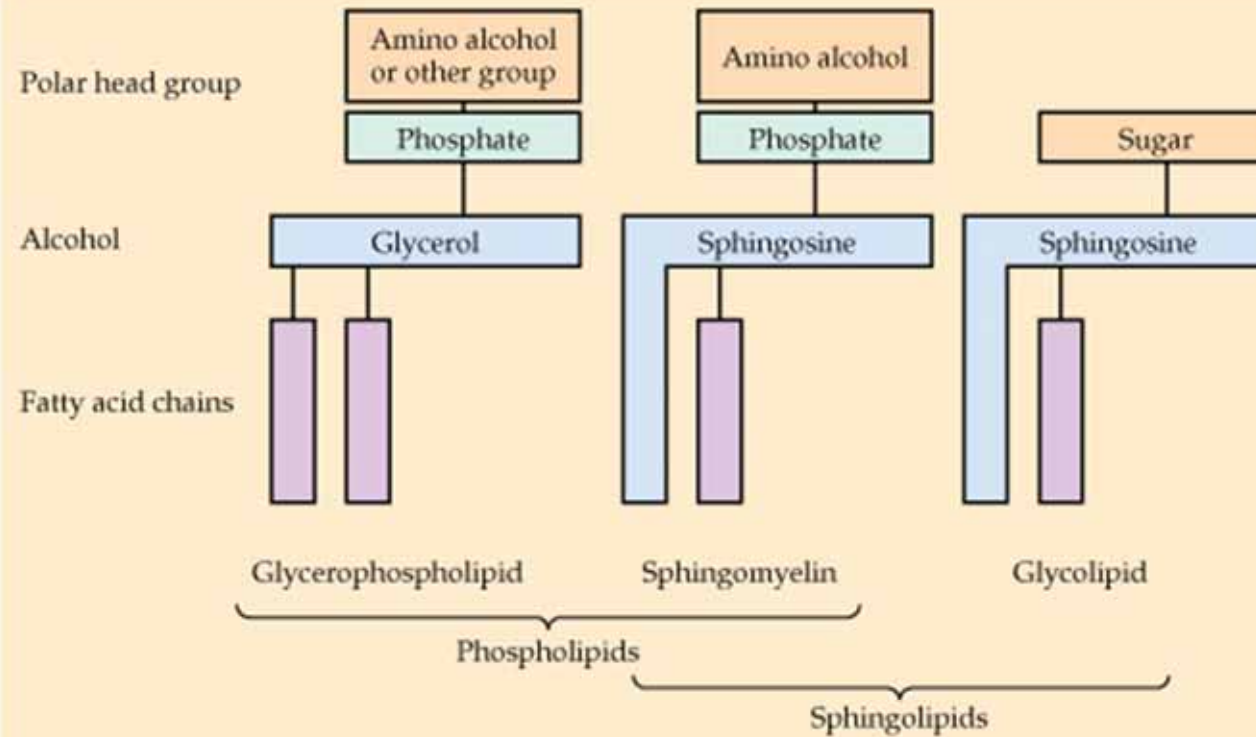


A *cis* unsaturated fatty acid  
(linolenic acid)

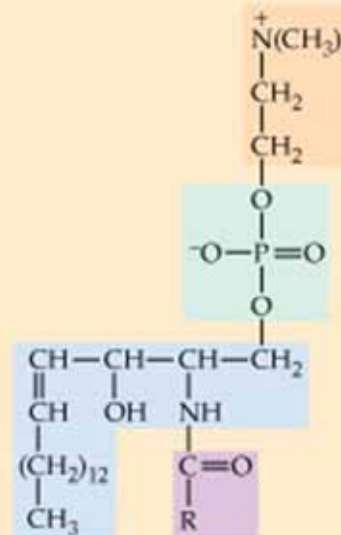


Stearic acid, an 18-carbon saturated fatty acid

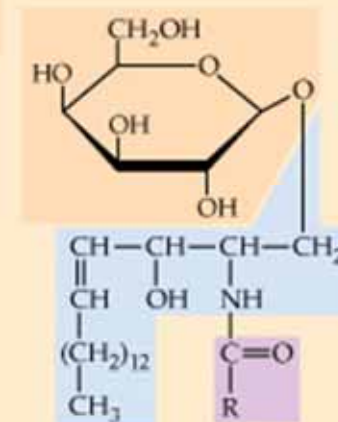




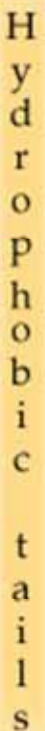
A glycerophospholipid  
(a phosphatidylcholine)



A sphingomyelin

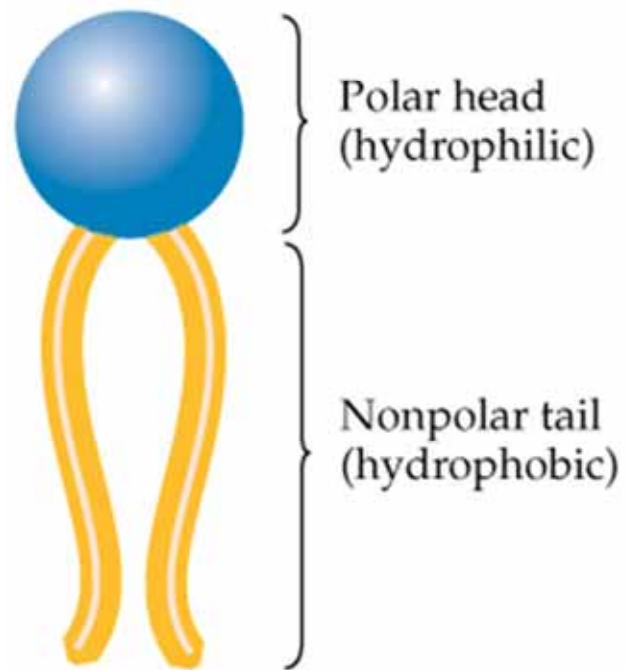


A glycolipid

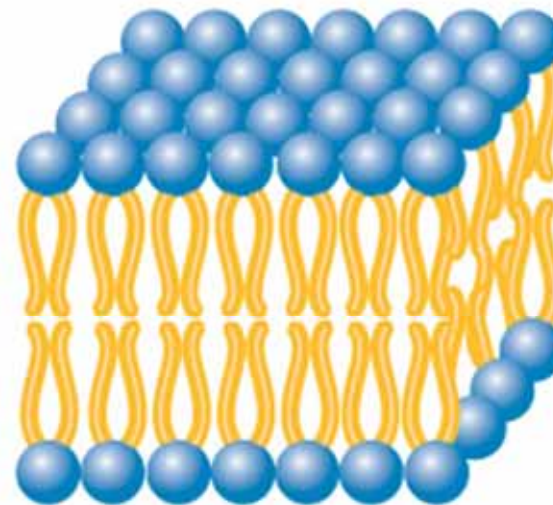


A sphingomyelin

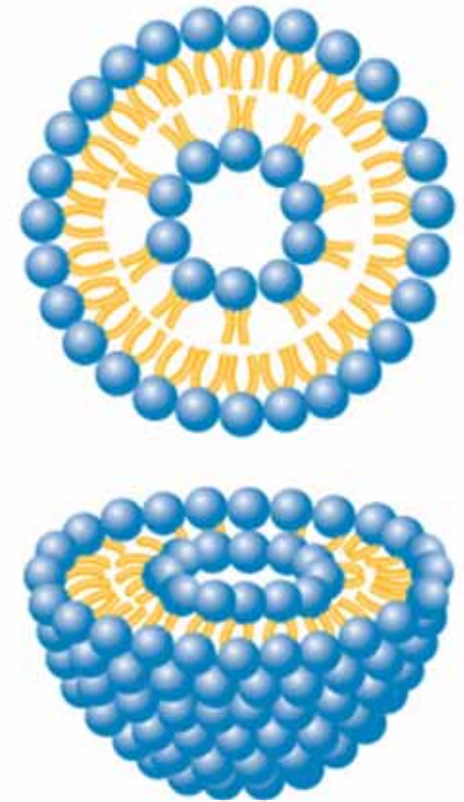




Membrane lipid



Lipid bilayer



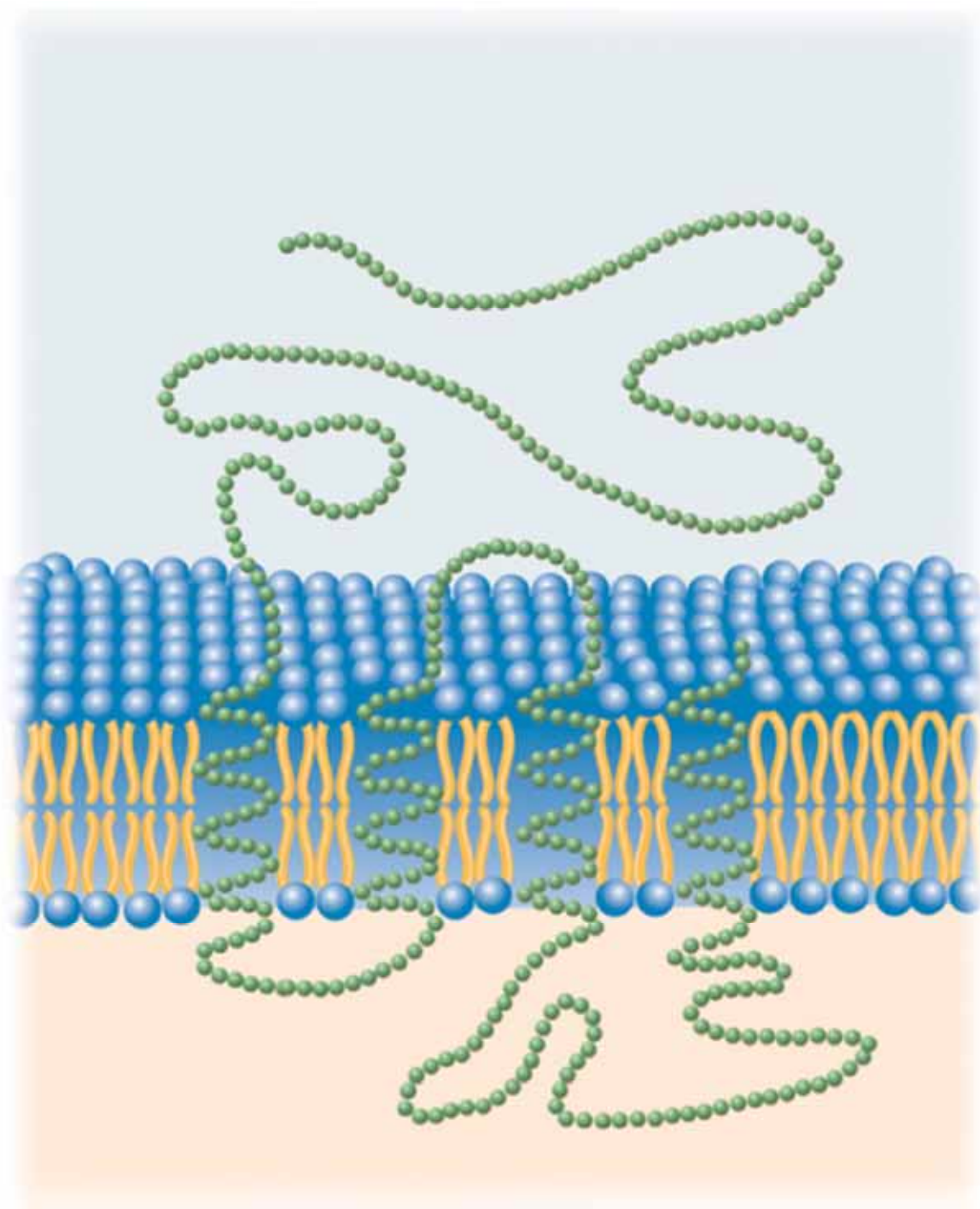
Liposome



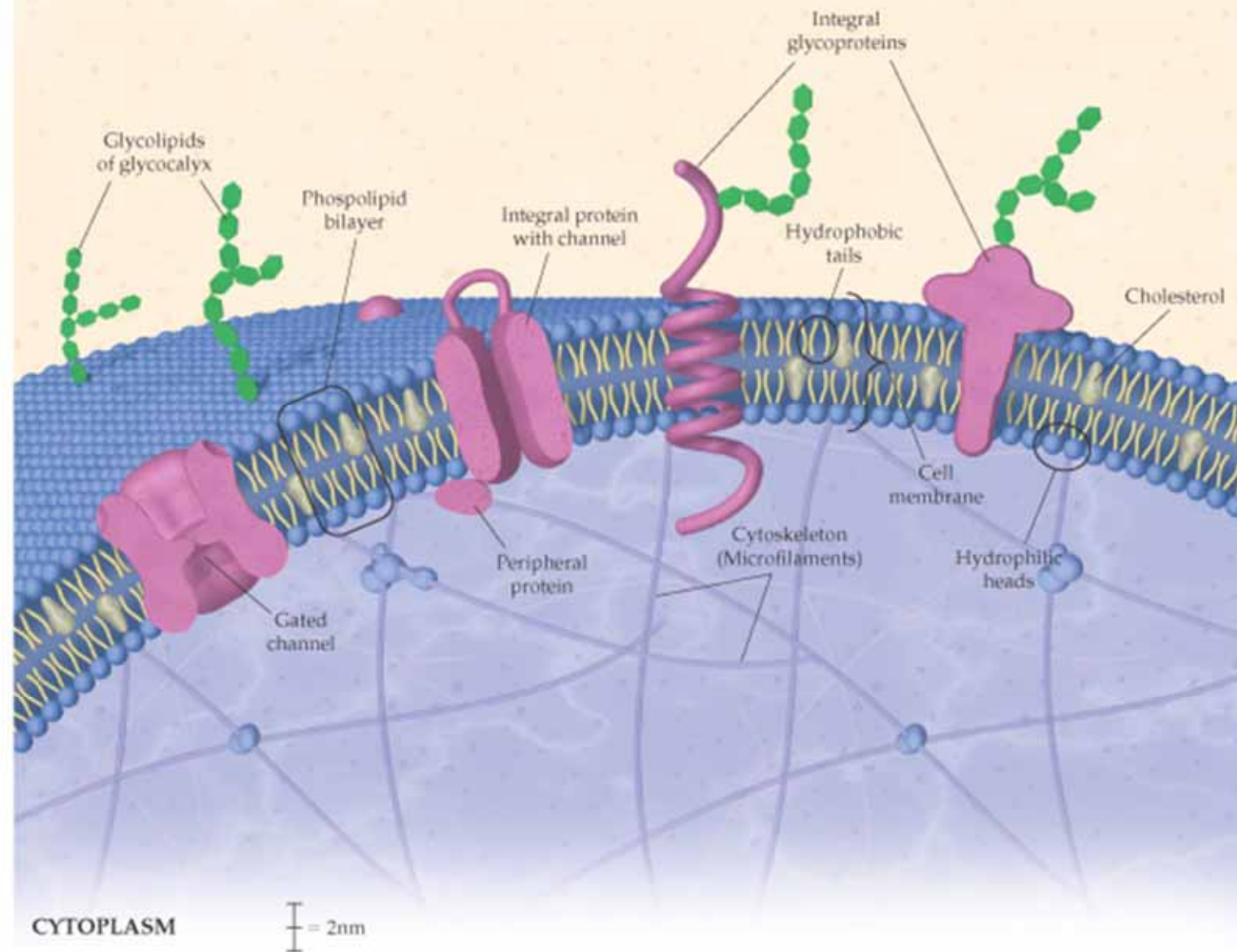
# Properties of cell membranes:

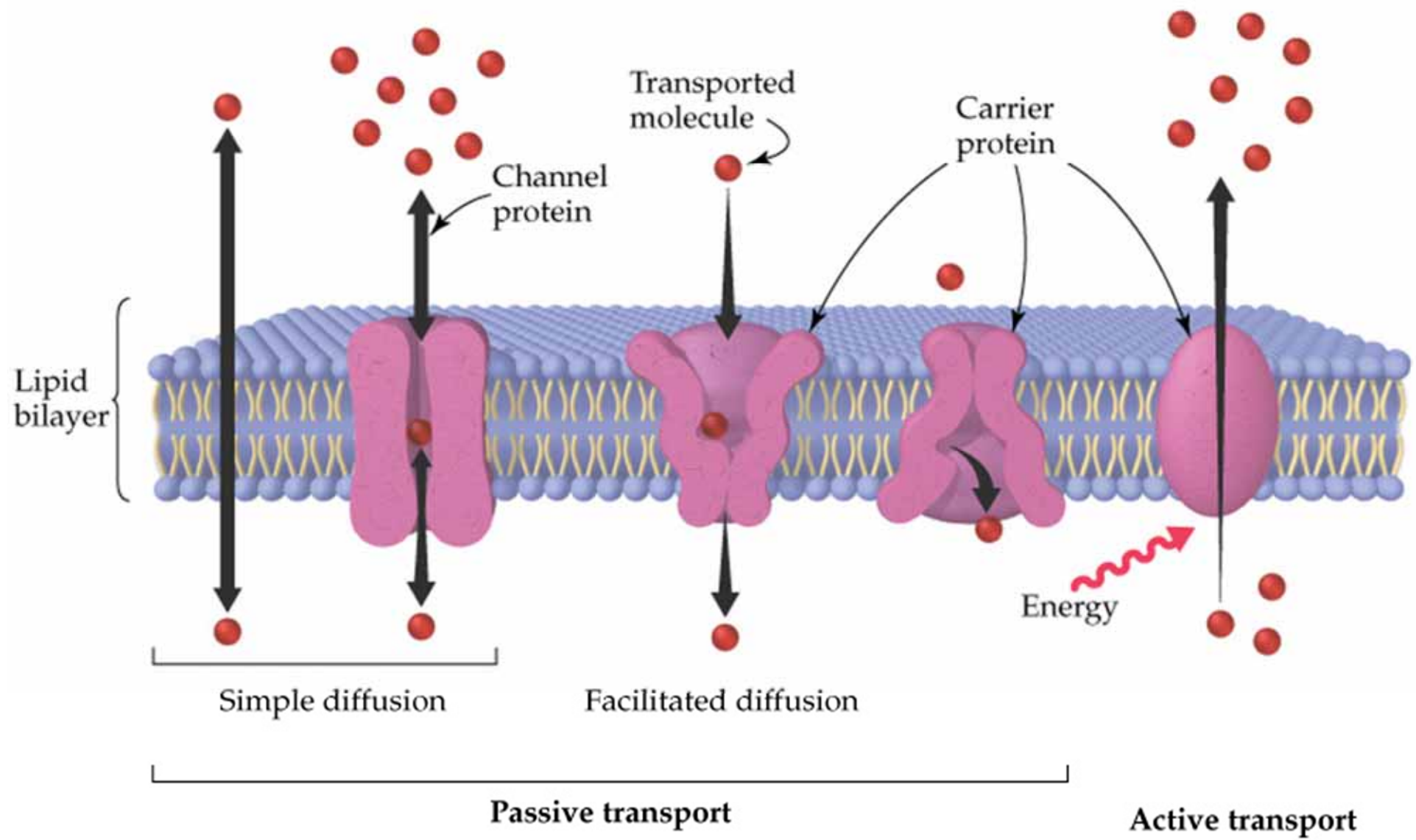
- Cell membranes are composed of a fluid like phospholipid bilayer.
- The bilayer incorporates cholesterol, proteins, and glycolipids.
- Small nonpolar molecules cross by diffusion through the lipid bilayer.
- Small ions and polar molecules diffuse through the aqueous media in protein pores.
- Glucose and certain other substances cross with the aid of proteins without energy input.
- $\text{Na}^+$ ,  $\text{K}^+$ , and other substances that maintain concentration gradients inside and outside the cell cross with expenditure of energy and the aid of proteins.

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- Glucose and certain other substances cross with the aid of proteins without energy input.
- $\text{Na}^+$ ,  $\text{K}^+$ , and other substances that maintain concentration gradients inside and outside the cell cross with expenditure of energy and the aid of proteins.

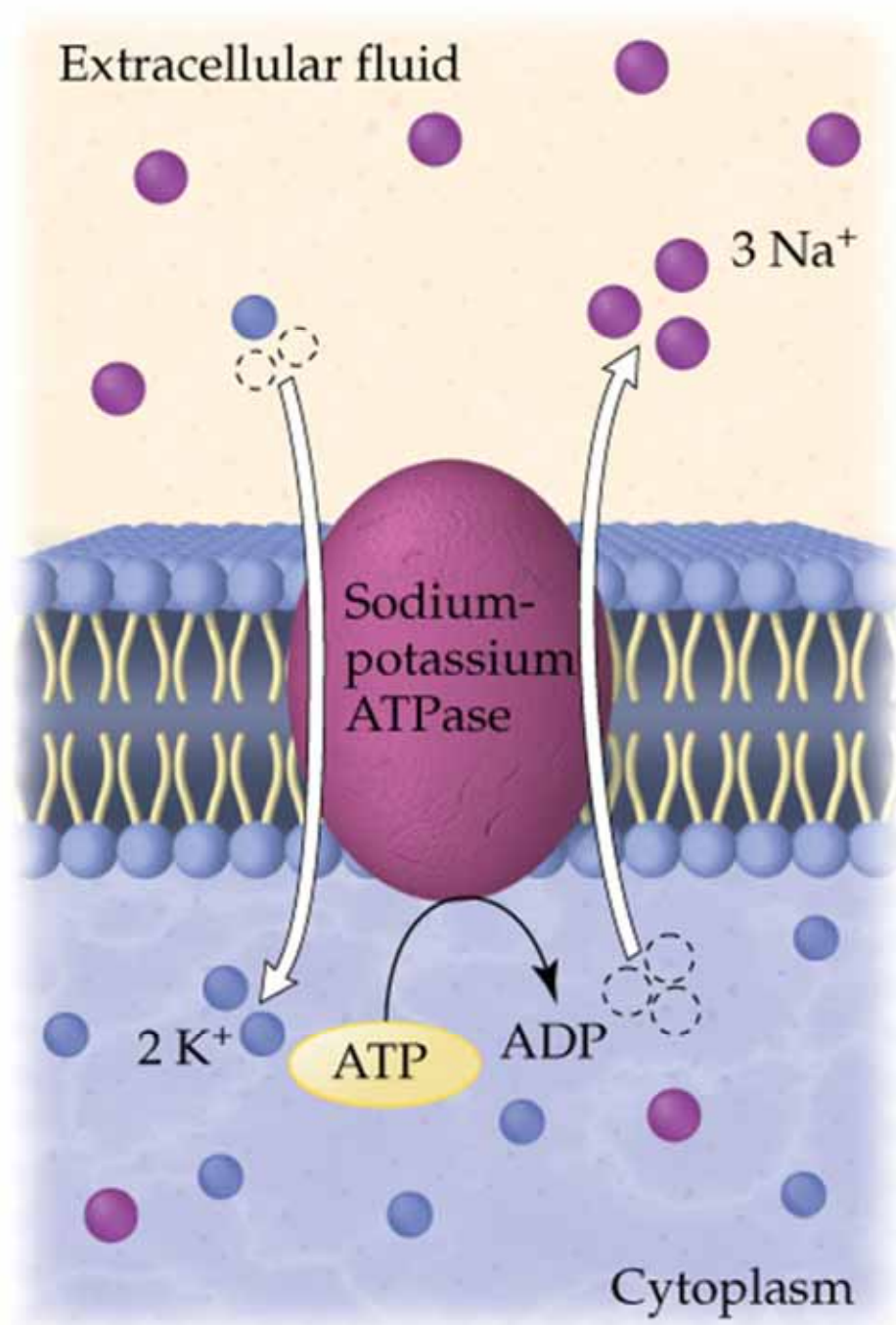


EXTRACELLULAR FLUID

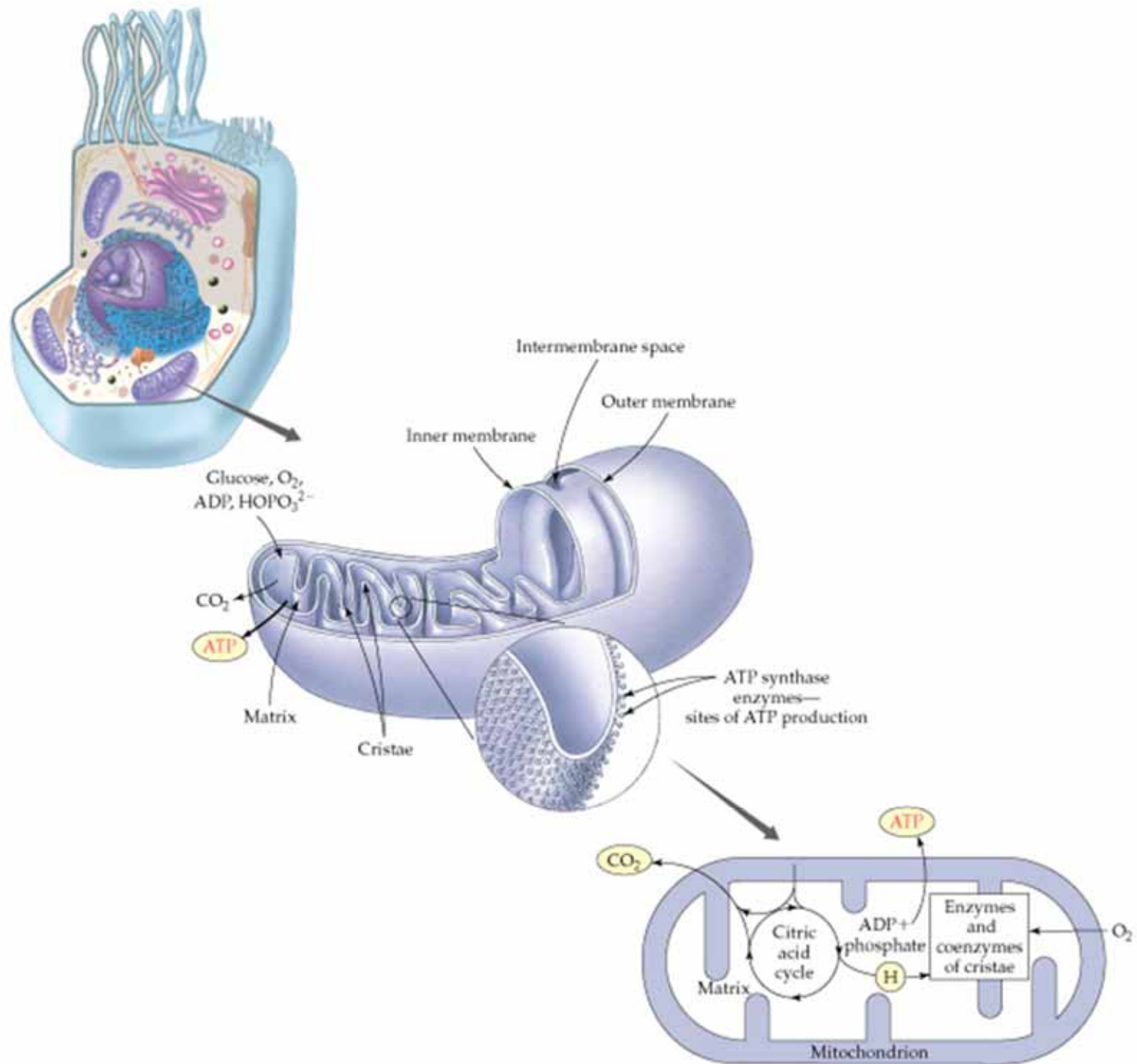








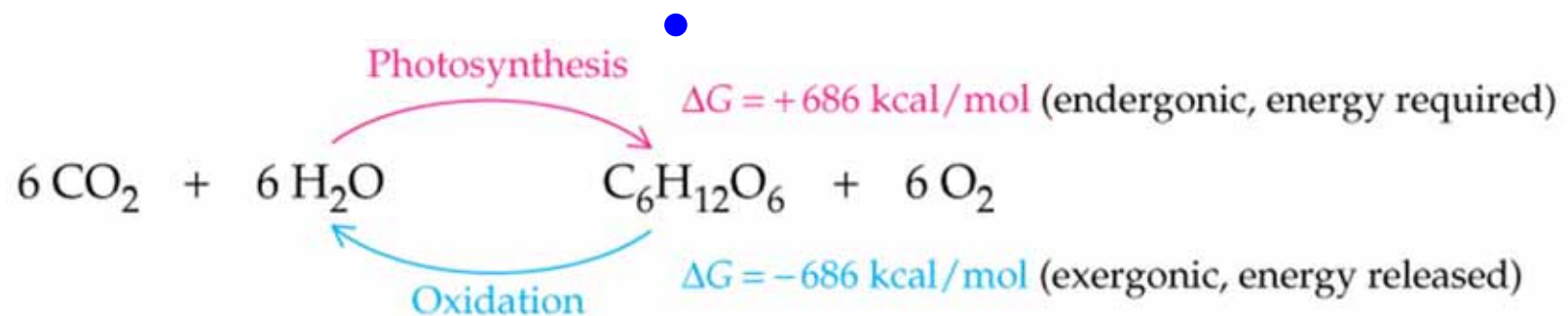




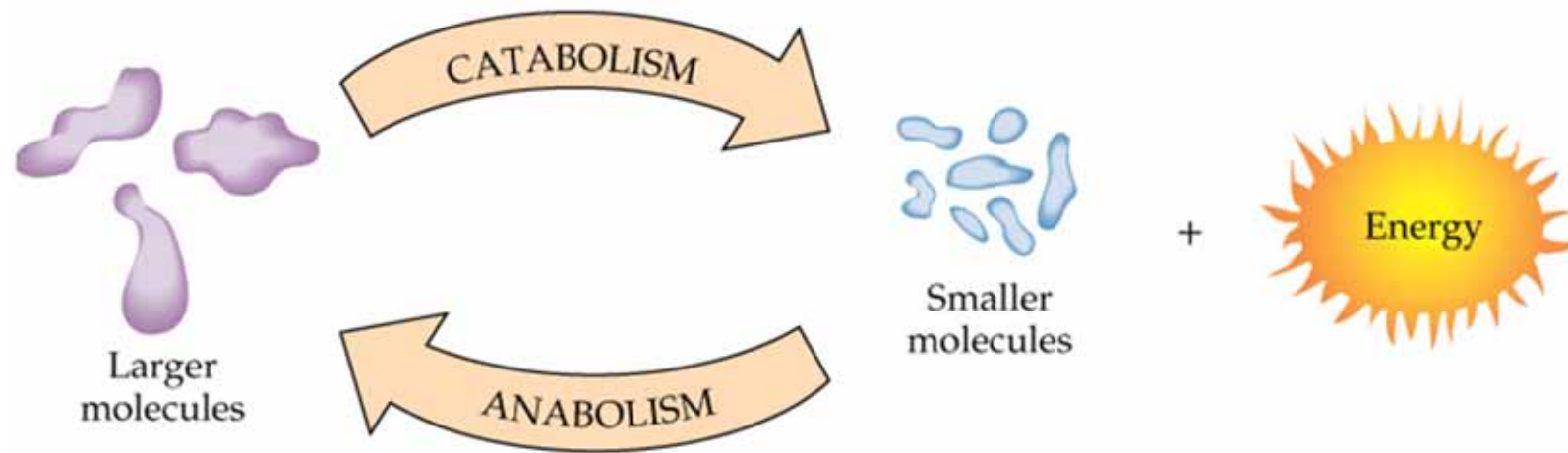
# Energy and Biochemical Reactions

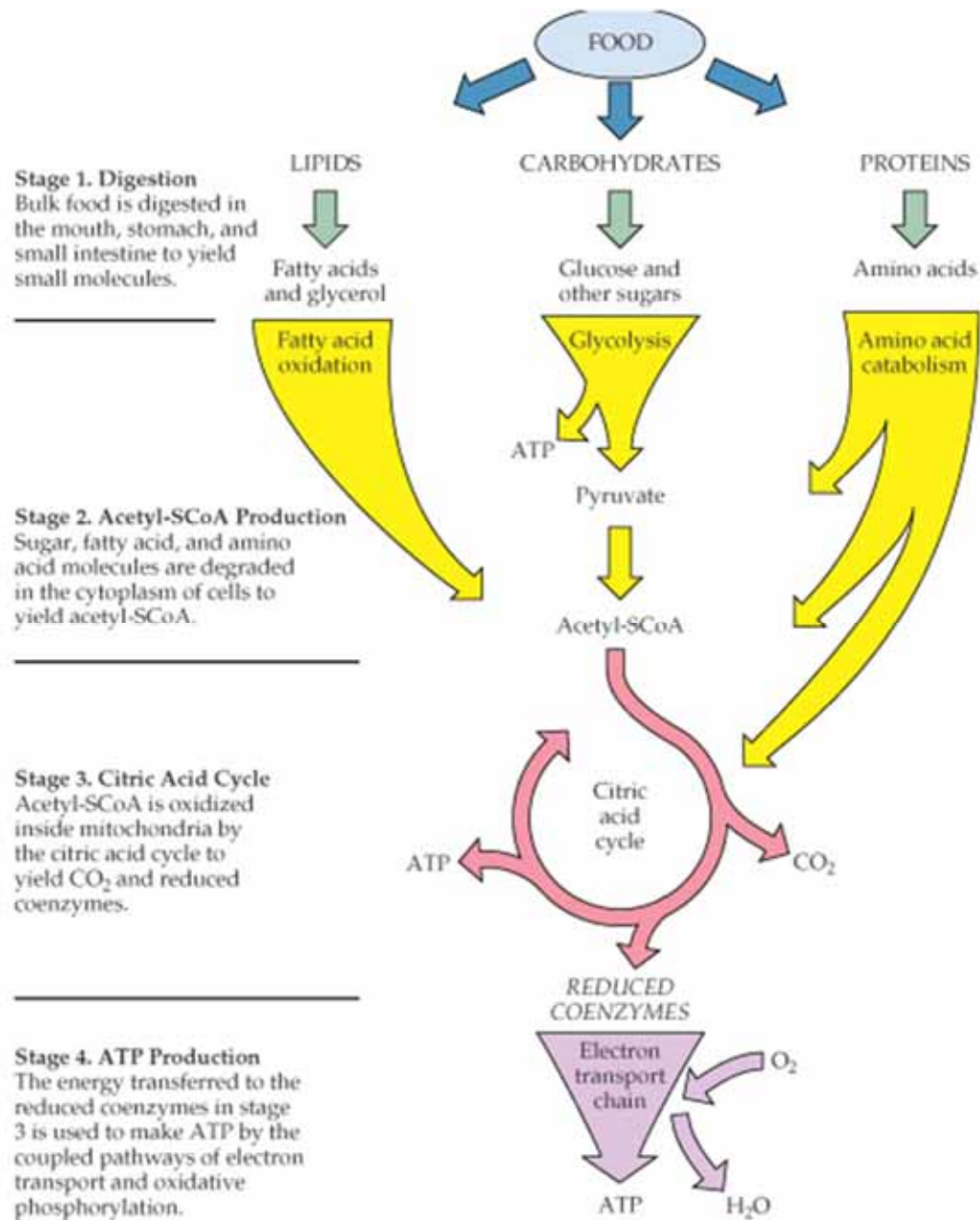
- Reactions in living organisms are similar to reactions in a chemical laboratory.
- Spontaneous reactions, those are favorable in the forward direction, release free energy and the energy released is available to do work.
- Spontaneous reactions , also known as *exergonic* reactions, are the source of our biochemical energy.
- Products of exergonic reactions are more stable than the reactants and the free energy change  $\Delta G$  has a negative value.

- *Photosynthesis* in plants, converts  $\text{CO}_2$  and  $\text{H}_2\text{O}$  to glucose plus  $\text{O}_2$  which is the reverse of oxidation of glucose. The sun provides the necessary external energy for photosynthesis (686 kcal of free energy per mole of glucose formed).



- The *mitochondria* is often called the cell's power plants. Within the mitochondria, small molecules are broken down to provide the energy for an organism and also the principle energy carrying molecule adenosine triphosphate (ATP) is produced.



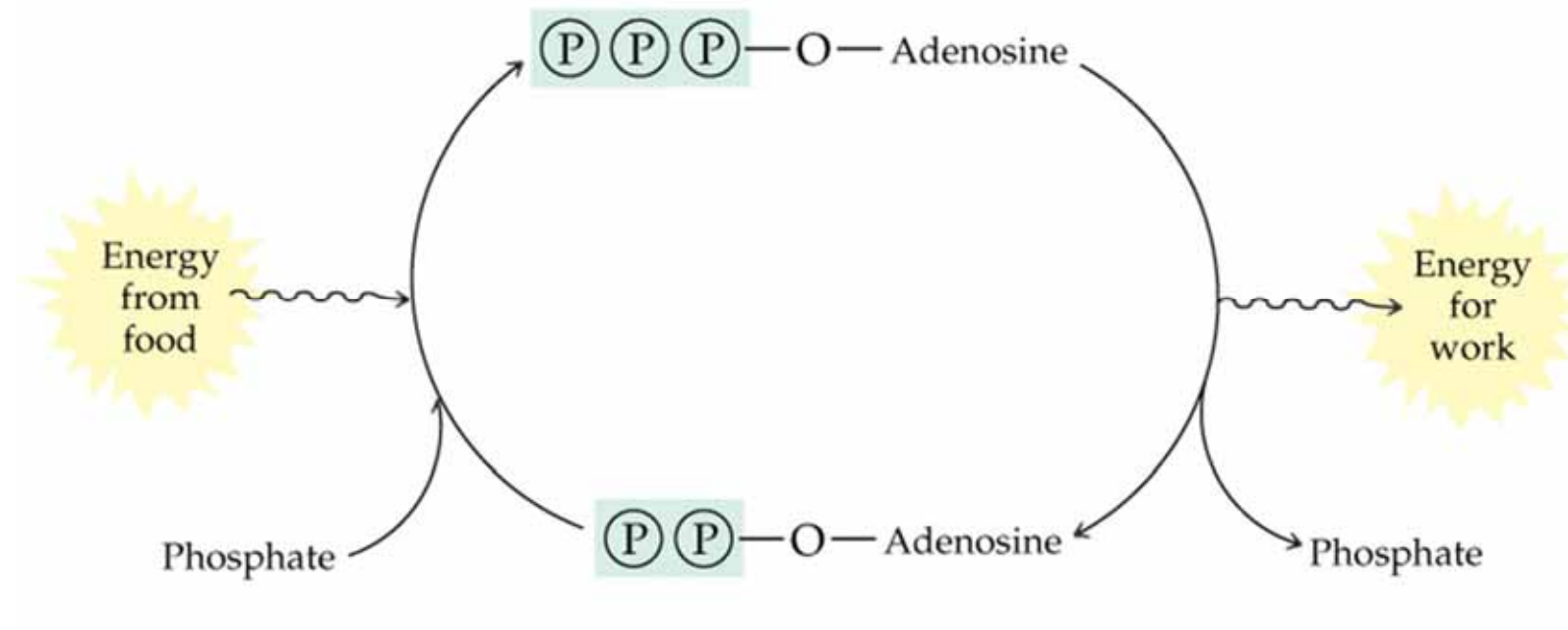




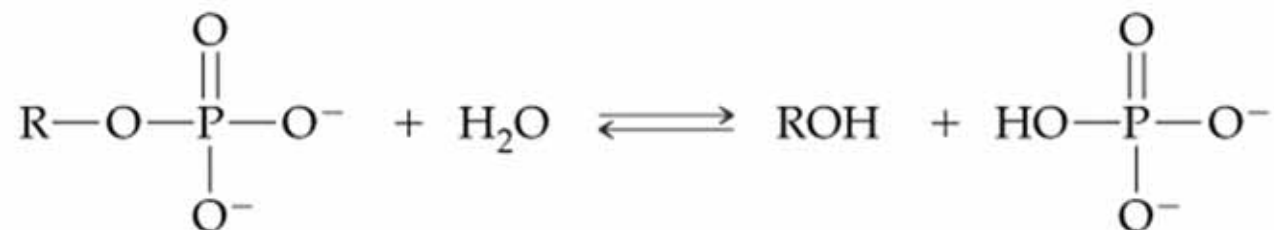
# ATP and Energy Transfer

- Adenosine triphosphate (ATP) transport energy in living organisms.
- ATP has three  $\text{-PO}_3^-$  groups.
- Removal of one of the  $\text{-PO}_3^-$  groups from ATP by hydrolysis produces adenosine diphosphate (ADP). Since this reaction is an exergonic process, it releases energy.
- The reverse of ATP hydrolysis reaction is known as phosphorylation reaction. Phosphorylation reactions are endergonic.

- Biochemical energy production, transport, and use all depends on the  $\text{ATP} \rightleftharpoons \text{ADP}$  interconversions.



**TABLE 21.1** Free Energies of Hydrolysis of Some Phosphates

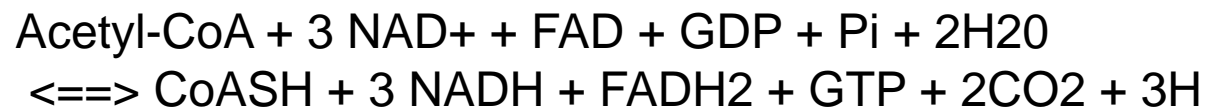
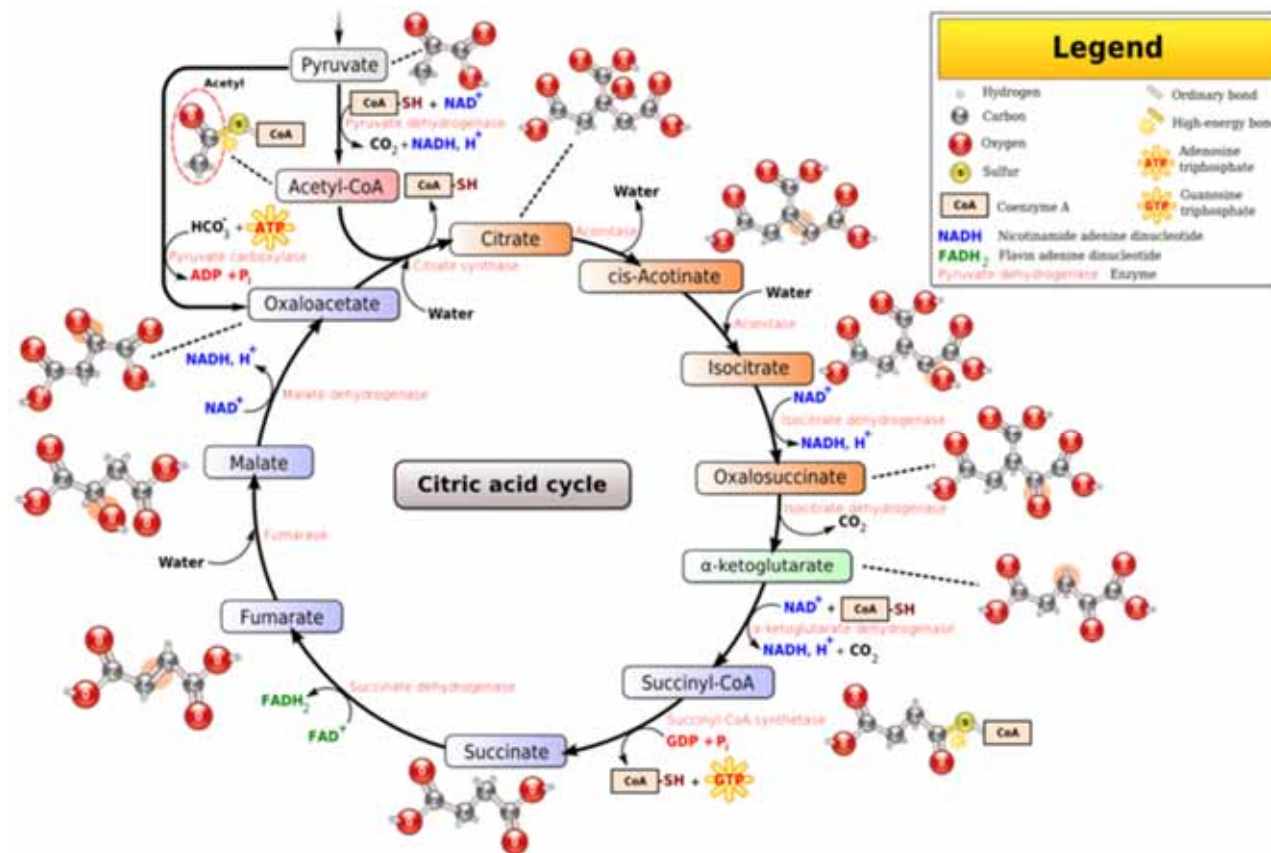


Compound Name	Function	$\Delta G$ (kcal/mol)
Phosphoenol pyruvate	Final intermediate in conversion of glucose to pyruvate (glycolysis)—stage 2, Figure 21.5	−14.8
1, 3-Bisphosphoglycerate	Another intermediate in glycolysis	−11.8
Creatine phosphate	Energy storage in muscle cells	−10.3
ATP (→ ADP)	Principal energy carrier	−7.3
Glucose 1-phosphate	First intermediate in breakdown of carbohydrates stored as starch or glycogen	−5.0
Glucose 6-phosphate	First intermediate in glycolysis	−3.3
Fructose 6-phosphate	Second intermediate in glycolysis	−3.3

- A few enzymes continuously cycle between their oxidized and reduced forms



Coenzyme	As Oxidizing Agent	As Reducing Agent
Nicotinamide adenine dinucleotide	$NAD^+$	$NADH/H^+$
Nicotinamide adenine dinucleotide phosphate	$NADP^+$	$NADPH/H^+$
Flavin adenine dinucleotide	FAD	$FADH_2$
Flavin mononucleotide	FMN	$FMNH_2$

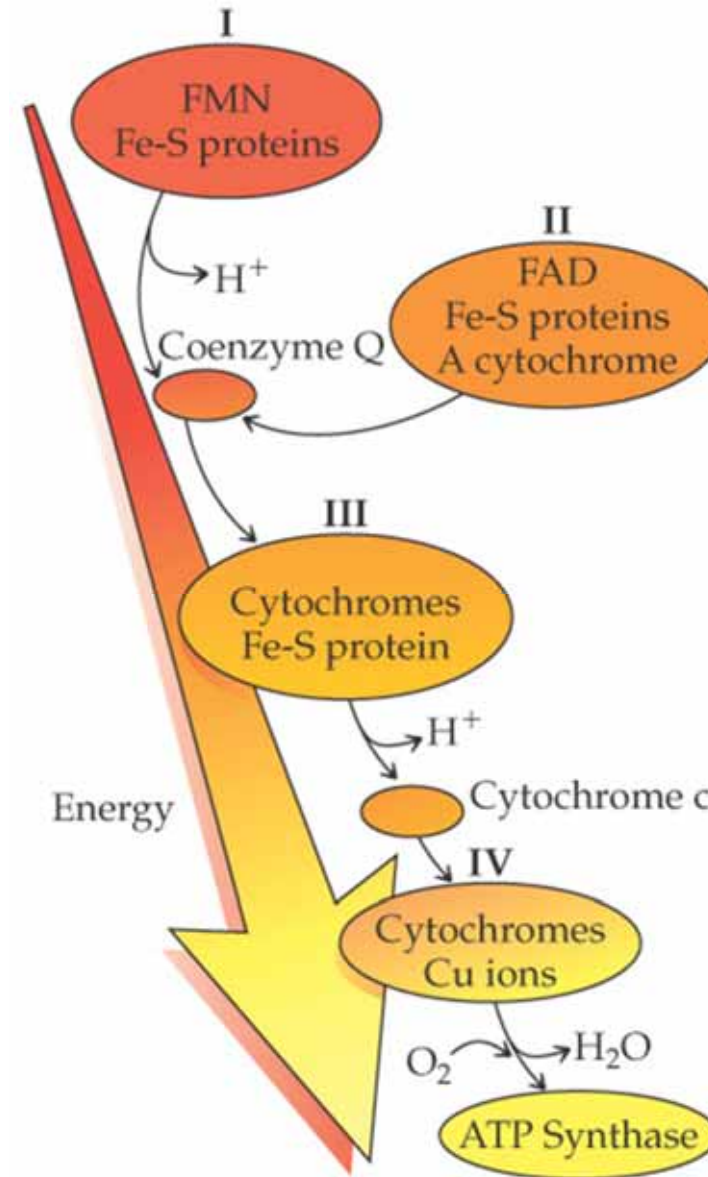
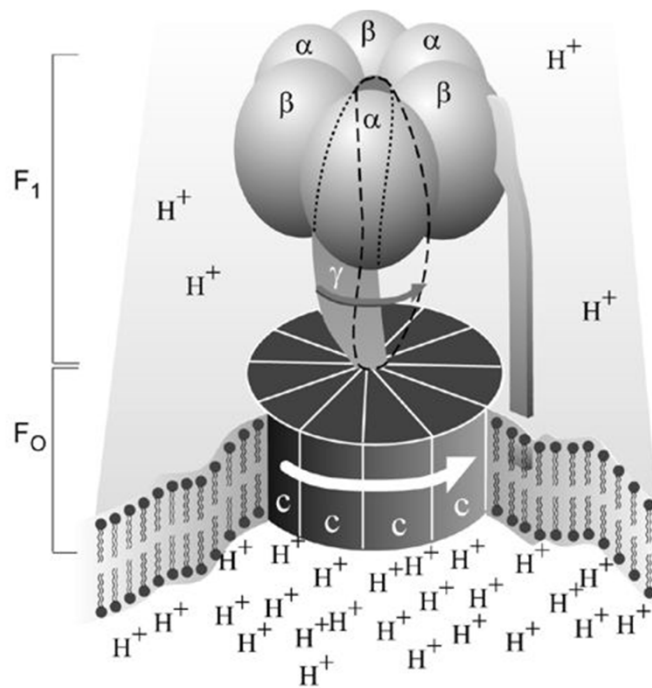
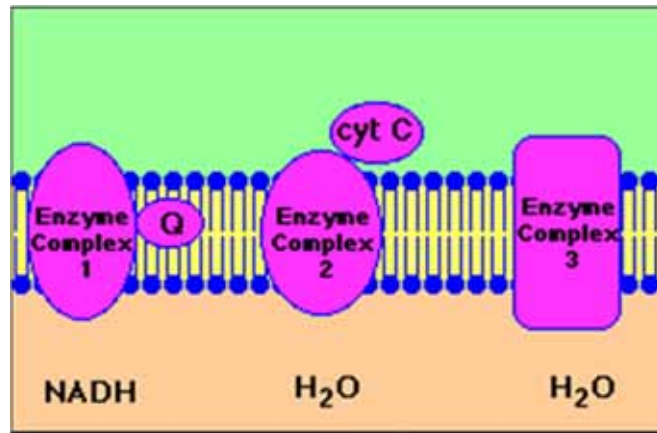


The citric acid cycle

# The Electron-Transport Chain and ATP Production

- Electron transport chain: The series of biochemical reactions that passes electrons from reduced coenzymes to oxygen and is coupled to ATP formation. The electrons combine with the oxygen we breathe and with hydrogen ions from their surrounding to produce water.
- Electron transport involves four enzyme complexes held in fixed positions within the inner membrane of mitochondria and two electron carriers move from one complex to another.



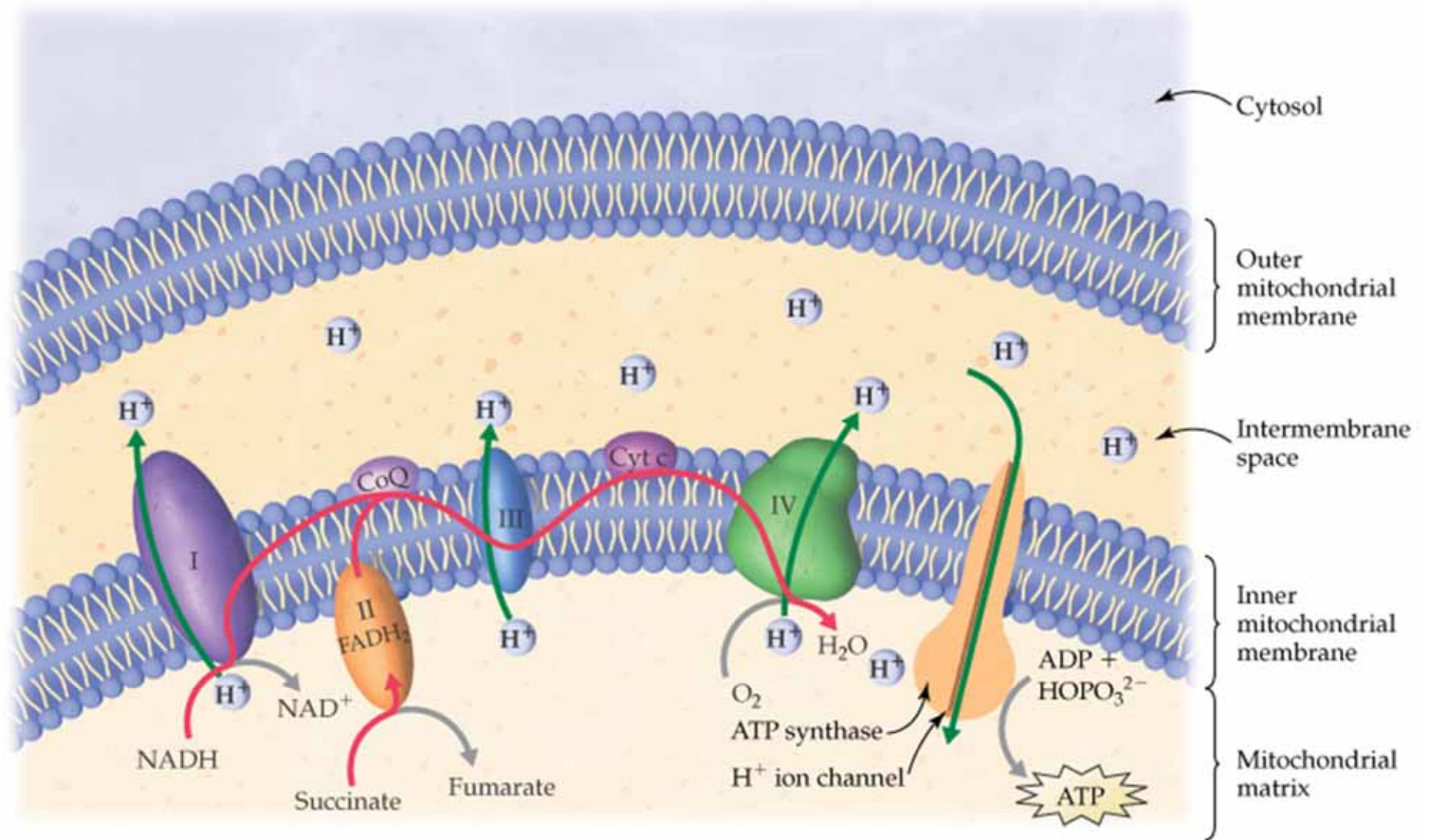


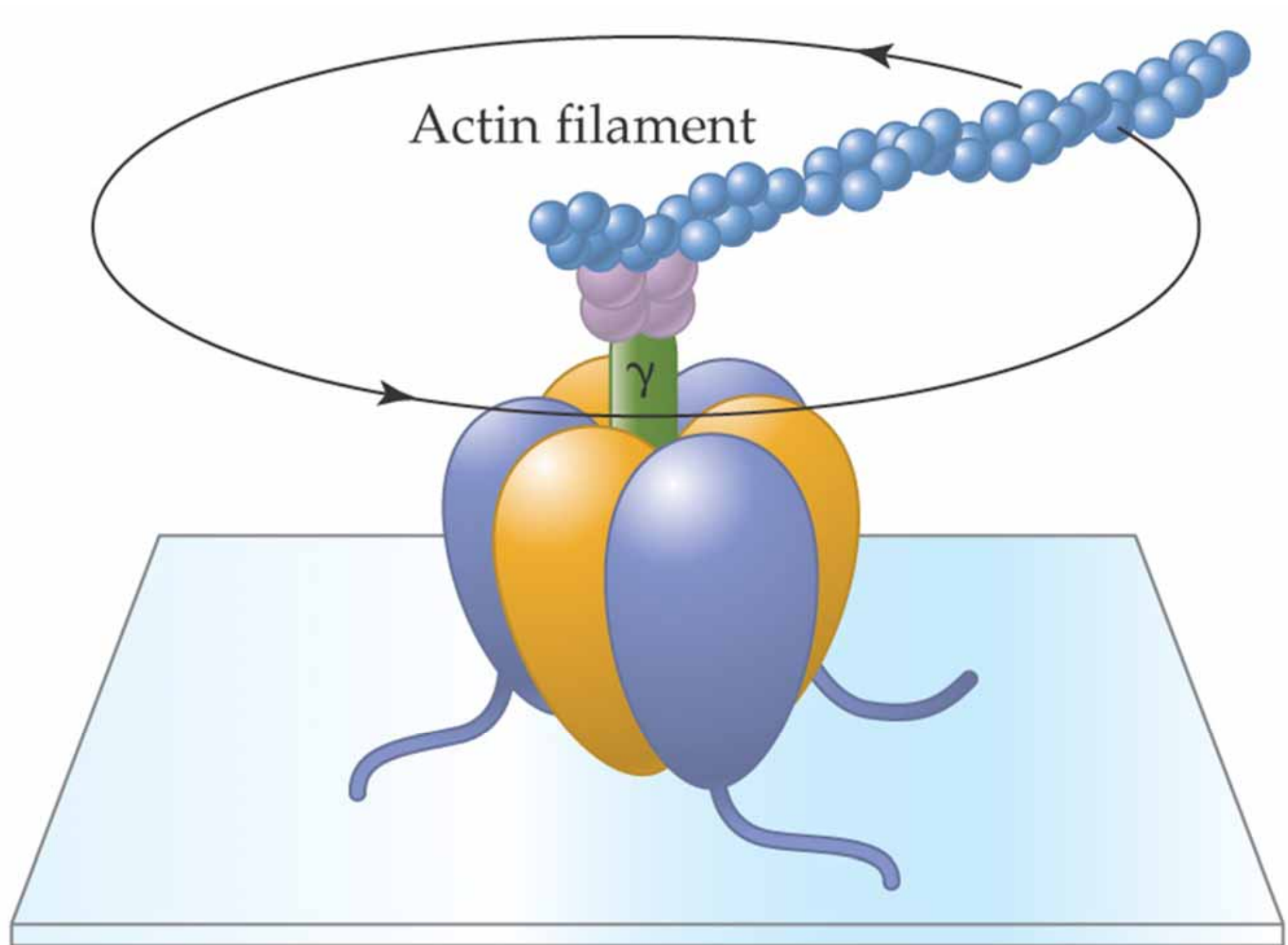
• Pathway of electrons in electron transport

- **ATP Synthesis**

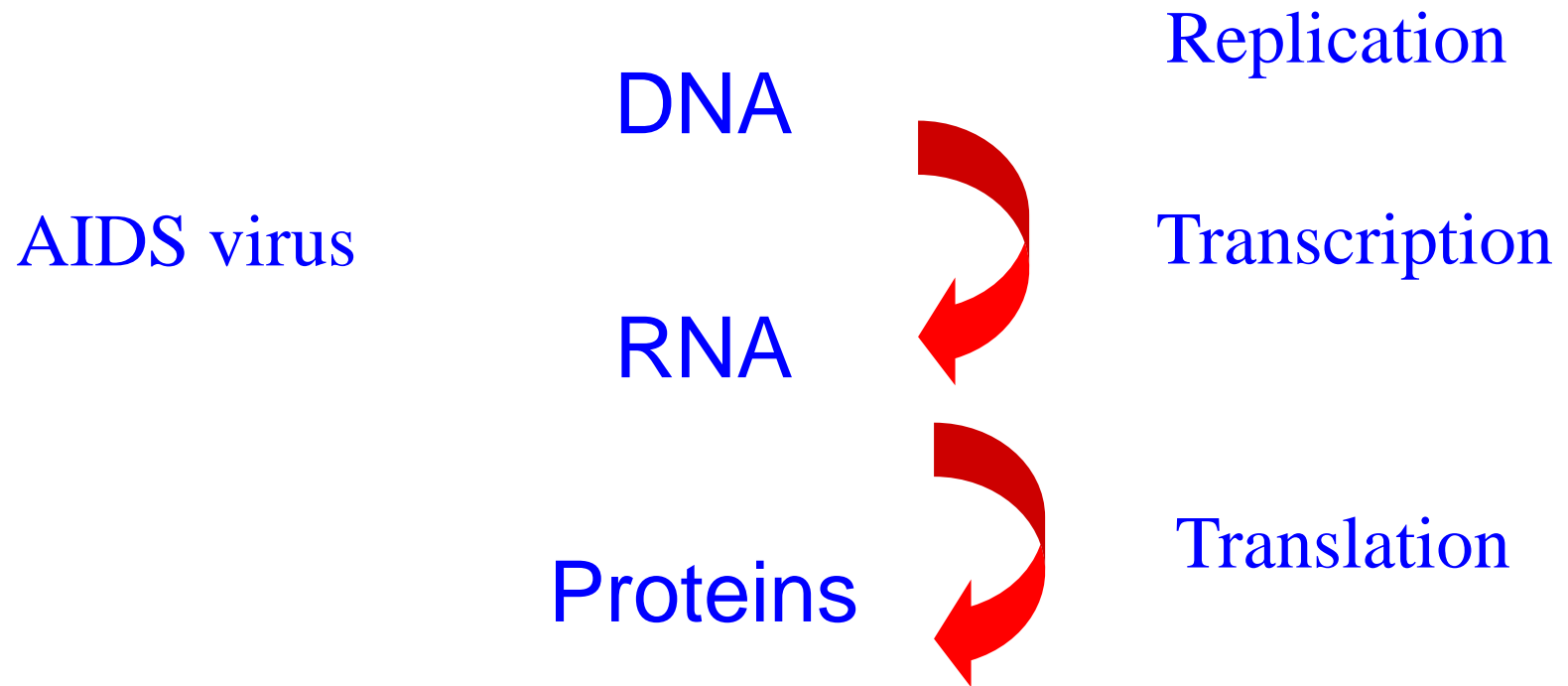
- ADP is converted to ATP by a reaction between ADP and hydrogen phosphate ion. This is both an oxidation and phosphorylation reaction. Energy released in the electron transport chain drives this reaction forward.

Vedio: <http://www.iubmb-nicholson.org/swf/ATPSynthase.swf>

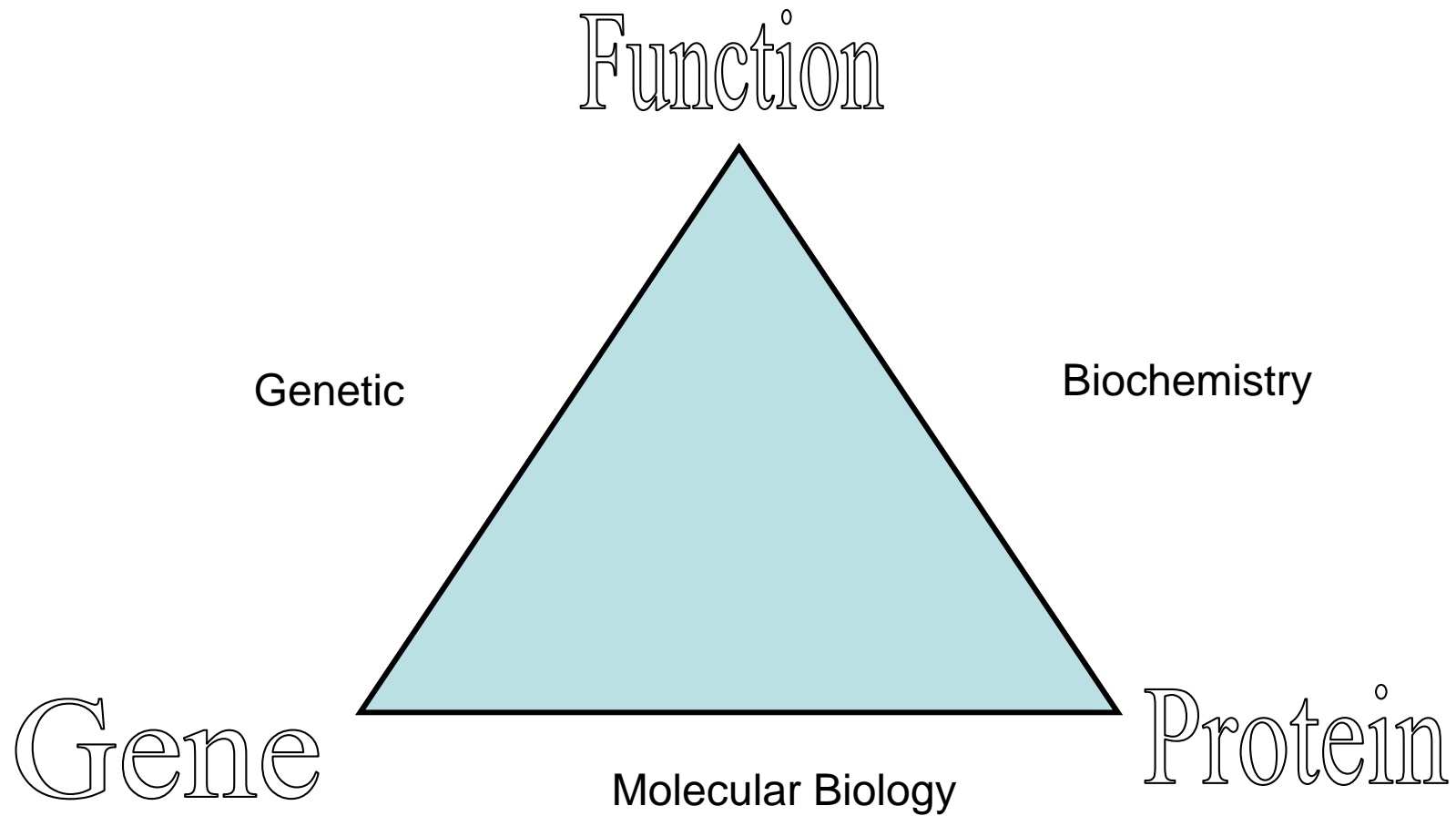




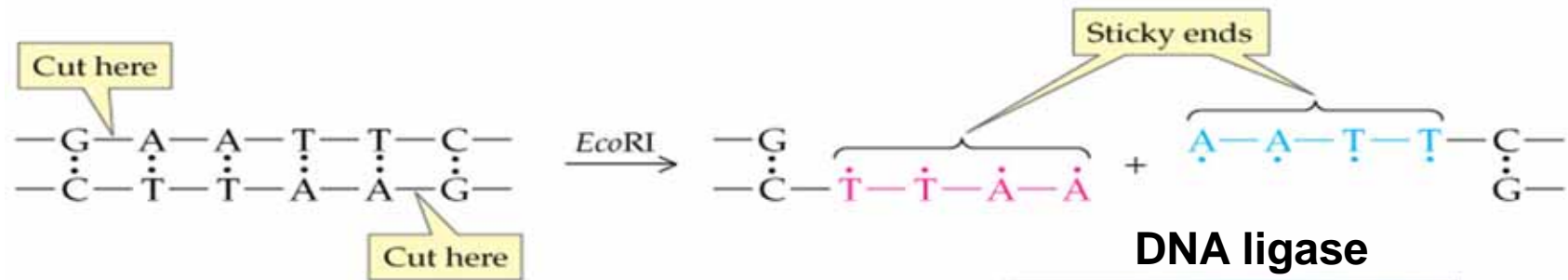
# Central Dogma



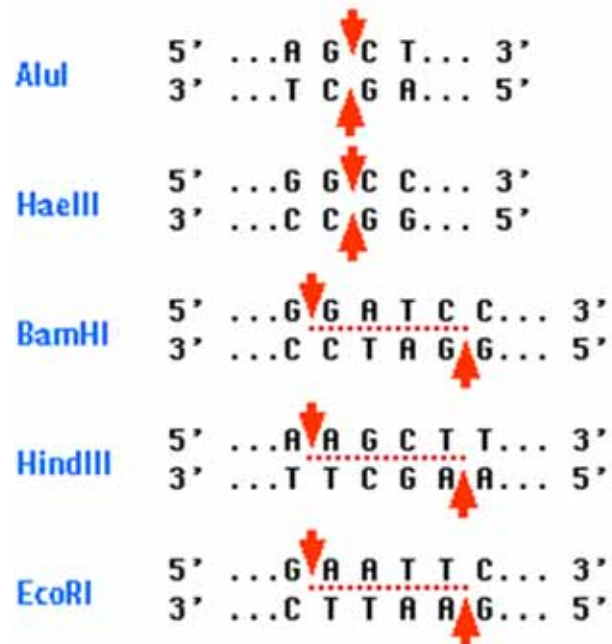
# Recombinant DNA





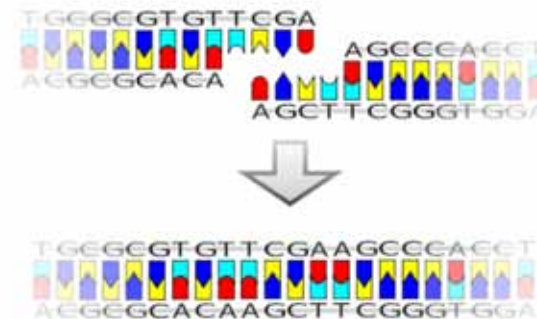
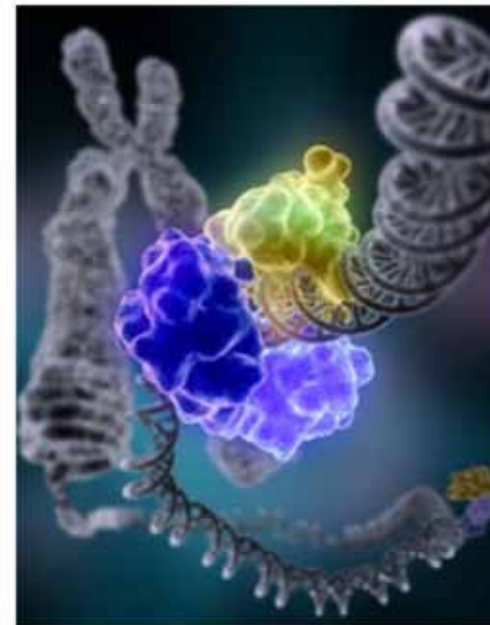


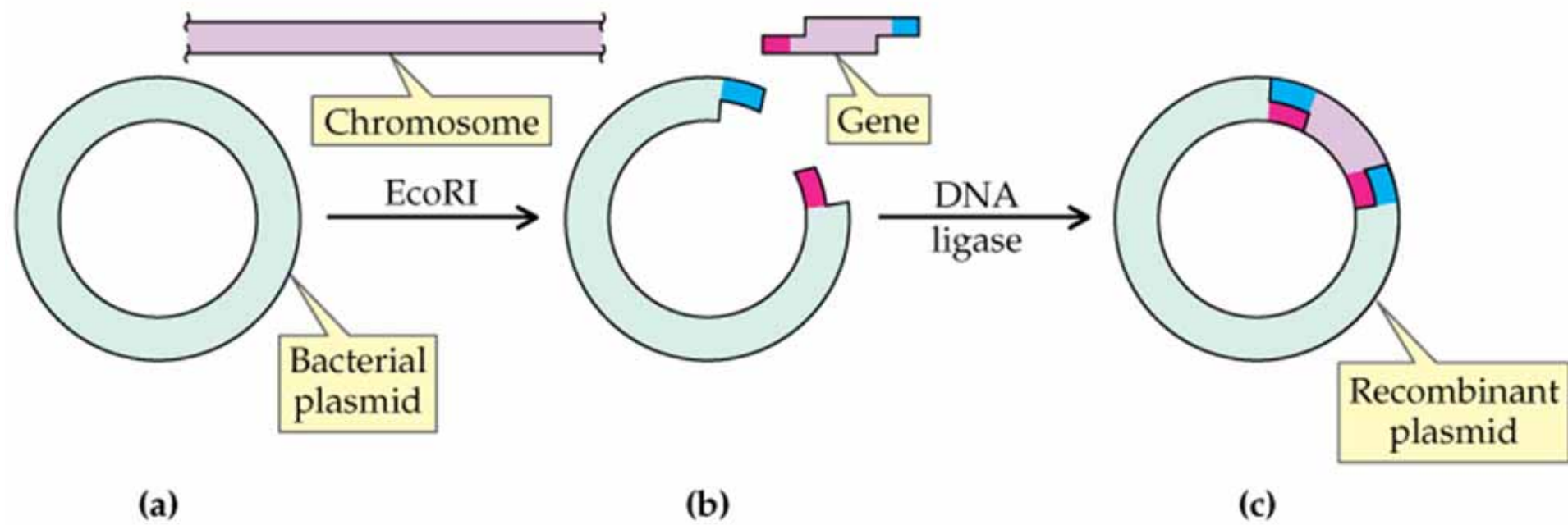
## Restriction Enzyme



**AluI** and **HaeIII** produce blunt ends

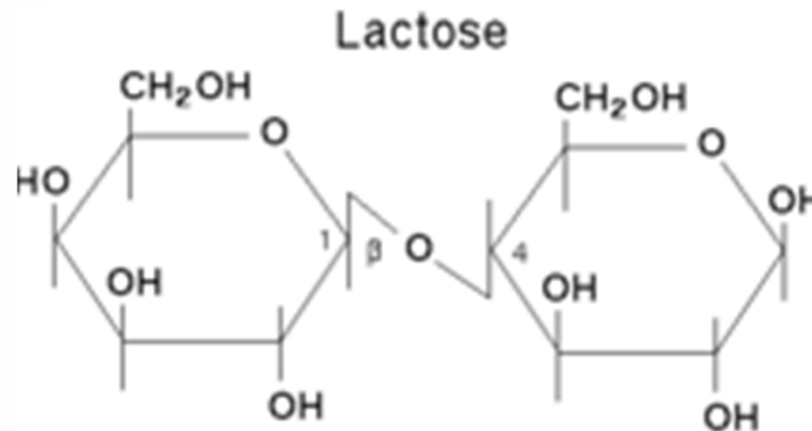
**BamHI** **HindIII** and **EcoRI** produce "sticky" ends





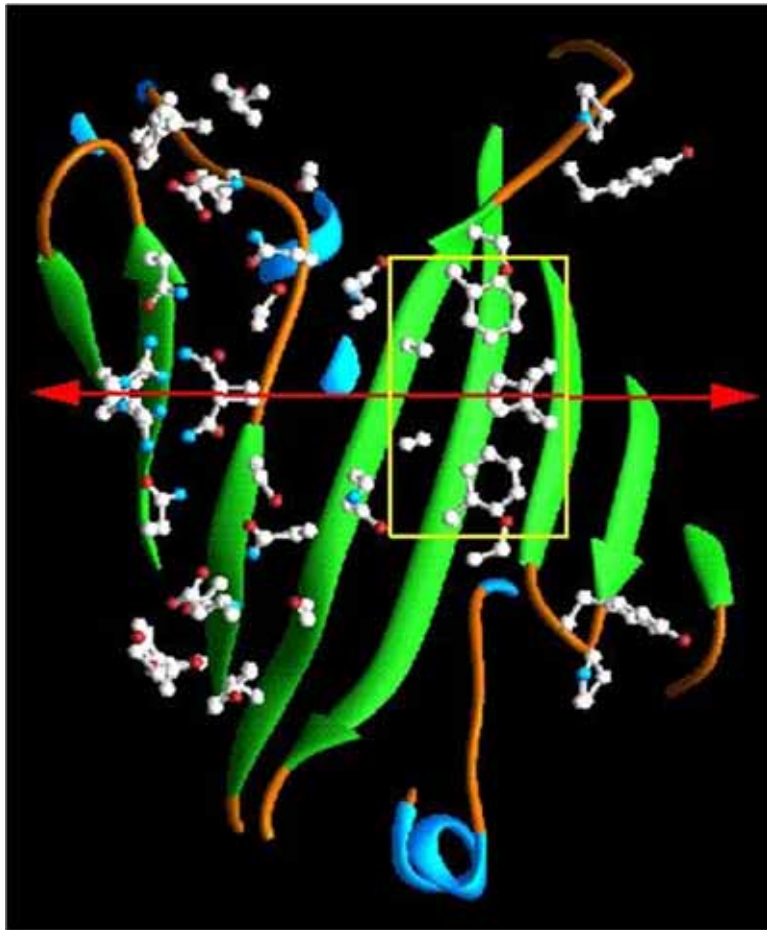
# $\beta$ -Galactosidase

The enzyme that splits lactose into glucose and galactose. Coded by a gene ([lacZ](#)) in the [lac operon](#) of Escherichia coli.

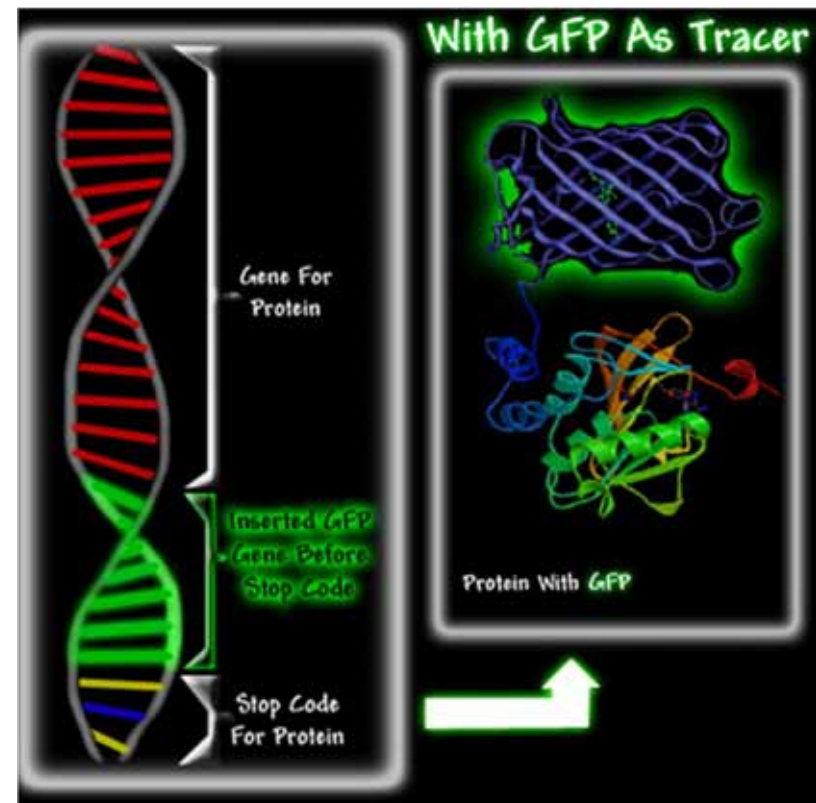


PUC is a family of plasmids that have an ampicillin resistance gene and more importantly a *lacZ* gene. A functional *lacZ* gene will produce the protein  $\beta$  - galactosidase. Bacterial colonies in which  $\beta$  - galactosidase is produced, will form blue colonies in the presence of the substrate 5 - bromo - 4 - chloro - 3 - indolyl -  $\beta$  - D - galactoside or as it is more commonly referred to, X-gal.

# Green Fluorescent Protein (GFP)



The **green fluorescent protein (GFP)** is a protein from the jellyfish *Aequorea victoria* that fluoresces green when exposed to blue light.



# GFP Rats

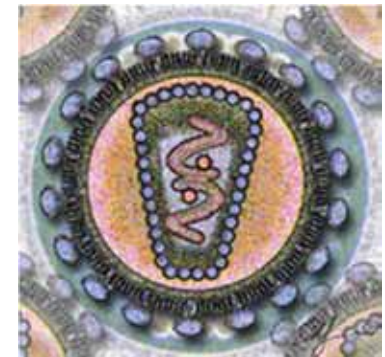
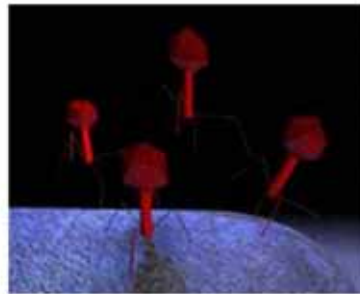
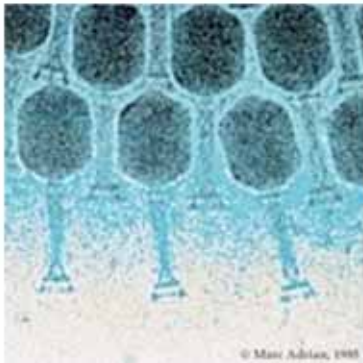
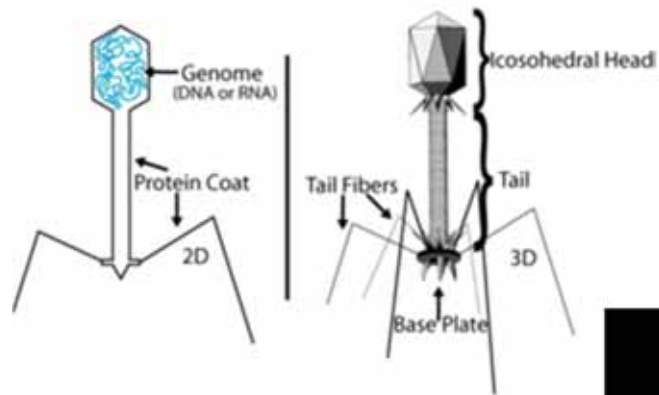


# Life

- Replication: reproduction
- Function: catalytic functions
- RNA world:
- Virus is not alive



# Virus



# Virus Reproduction

