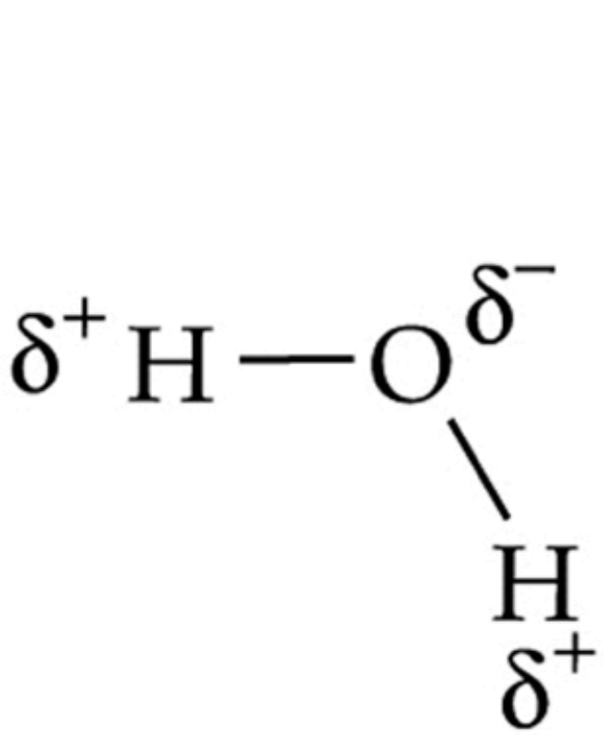
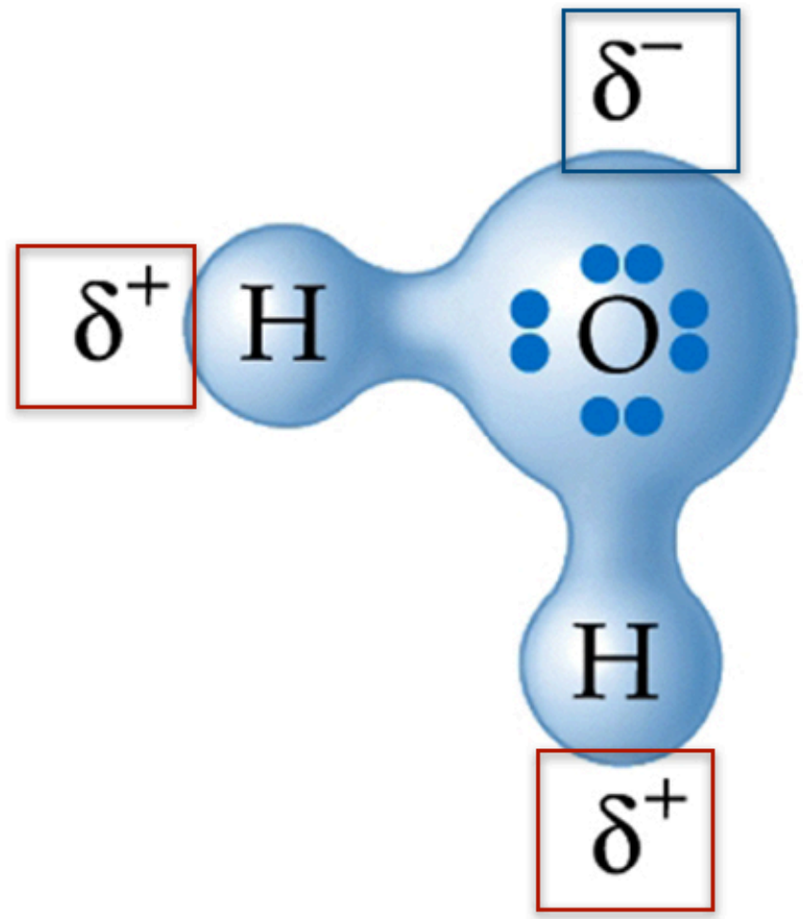
BIOL2107, Fall ’23

Lecture 17





Term Paper:

1. "Evolution is a man-made myth"

2. "An understanding of Genetics is **fundamental** to our understanding of how an organism works."

3. "Virus are alive"

Choose one of the statements above, and provide **two arguments** for me**;** one **for** and one **opposed** to the statement that you chose.

Minimally, each of your arguments should be **half a page** of **11pt**, single-spaced writing (450 words).

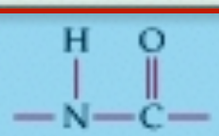
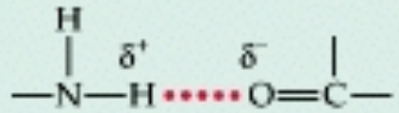
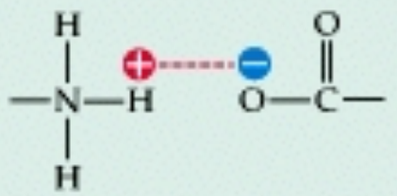
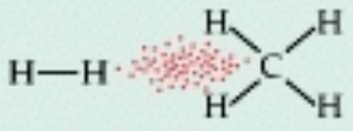
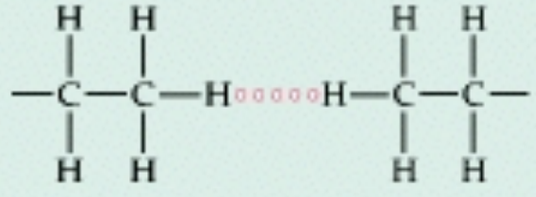
Maximally, each of your arguments should be no more than **one page** of **11pt**, single-spaced writing (900 words).

In addition: you will need to put down references for all the sources of information that you cite.

You will submit your paper as a typed document (E-MAIL)... by **NOV 18th**!!

When you do e-mail me your paper, please ensure that you give the title **"BIO2107 Term Paper"** in the subject line of the email.

2.1 Chemical Bonds and Interactions

NAME	BASIS OF INTERACTION	STRUCTURE	BOND ENERGY[a] (KCAL/MOL)
Covalent bond	Sharing of electron pairs		50–110
Hydrogen bond	Sharing of H atom		3–7
Ionic interaction	Attraction of opposite charges		3–7
van der Waals interaction	Interaction of electron clouds		1
Hydrophobic interaction	Interaction of nonpolar substances		1–2

[a]*Bond energy* is the amount of energy needed to separate two bonded or interacting atoms under physiological conditions.

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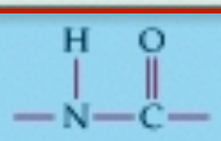
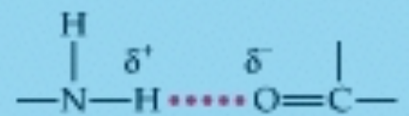
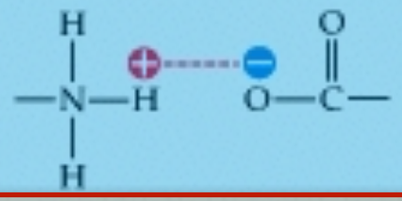
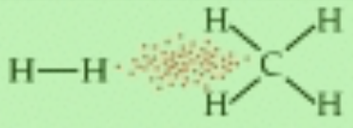
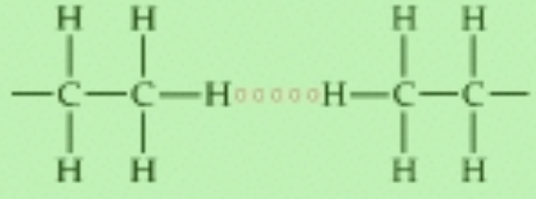
Covalent bond	Sharing of electron pairs		50–110
Hydrogen bond	Sharing of H atom		3–7
Ionic interaction	Attraction of opposite charges		3–7
van der Waals interaction	Interaction of electron clouds		1
Hydrophobic interaction	Interaction of nonpolar substances		1–2

[a]*Bond energy* is the amount of energy needed to separate two bonded or interacting atoms under physiological conditions.

Van der Waals and Hydrophobic Interactions

More Information Online WWW.DIFFERENCEBETWEEN.COM

	Van der Waals Interactions	Hydrophobic Interactions
DEFINITION	Van der Waals interactions are chemical bonds between non-polar molecules	Hydrophobic interactions are repulsion forces between water molecules and other substances
MOLECULES	Between non-polar molecules	Between water molecules and non-polar molecules
CHARGE SEPARATION	One molecule gets an induced positive charge while other molecule gets an induced negative charge	No charge separation

Macromolecules: Giant Polymers

There are four major types of biological macromolecules:

Proteins, Carbohydrates, Lipids (?), and **Nucleic acids.**

These macromolecules are made the same way in all living things, and they are present in all organisms in roughly the same proportions.

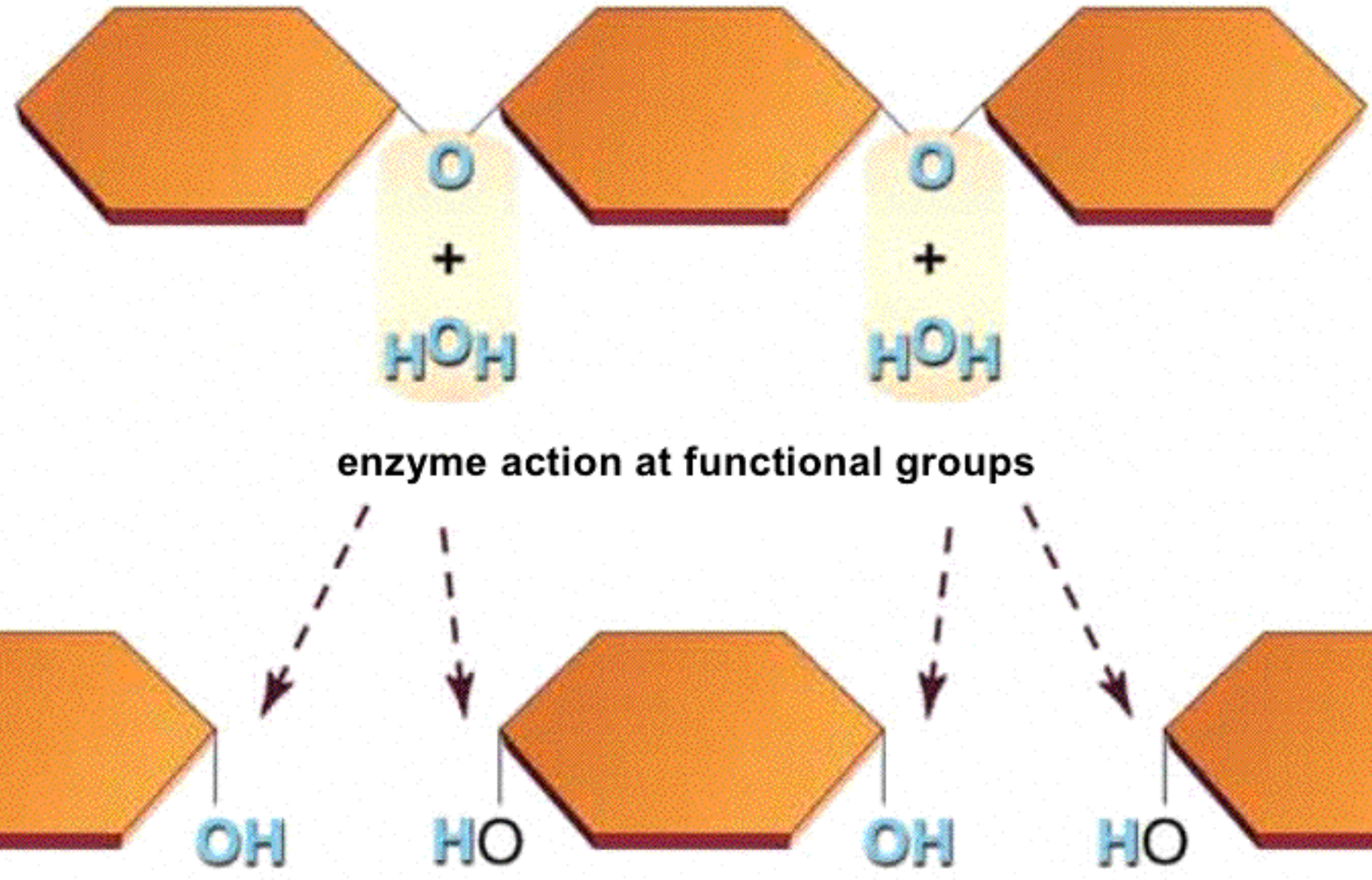
Macromolecules are essentially giant polymers, which are formed by **covalent linkages** of smaller units called monomers.

Molecules with molecular weights greater than **1,000 Daltons** (atomic mass units) are usually classified as “**macromolecules**".

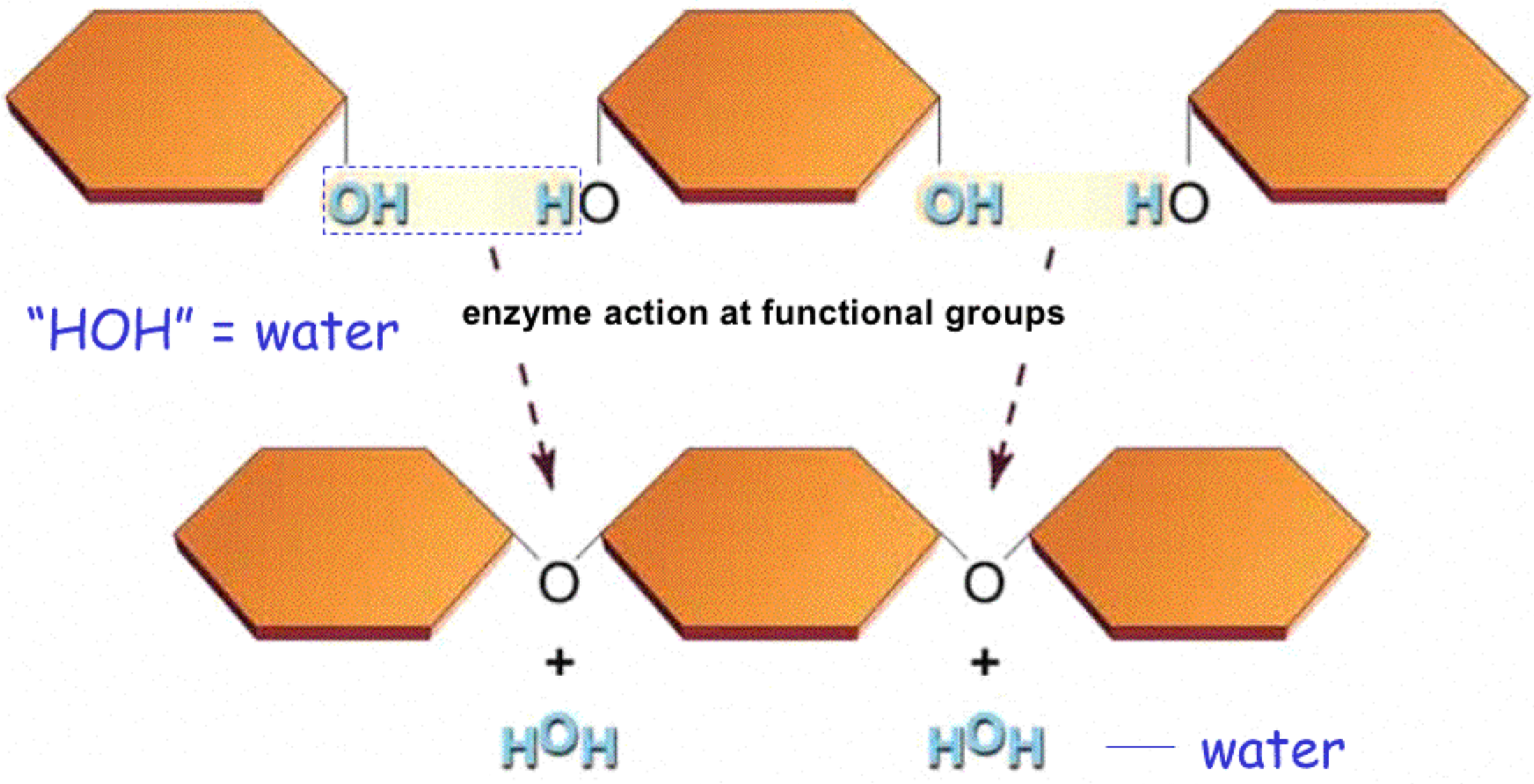
Some of the many roles of **macromolecules** include:

Energy source
Energy storage
Structural support
Catalysis
Transport
Protection and defense
Regulation of metabolic activities
Maintenance of homeostasis
Means for movement, growth, and development
Heredity

Hydrolysis



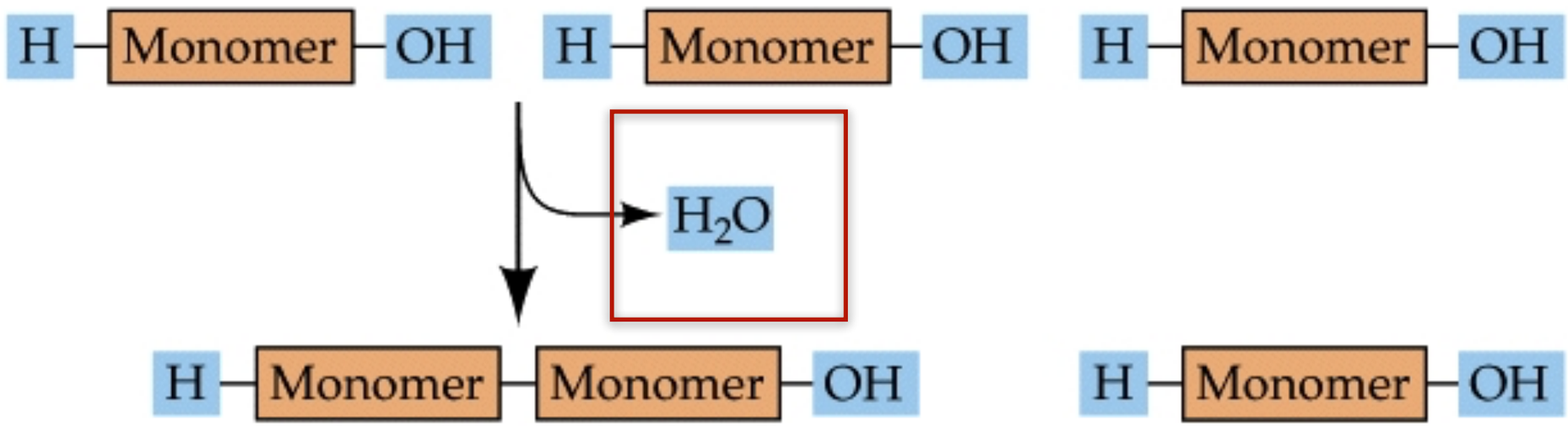
Condensation

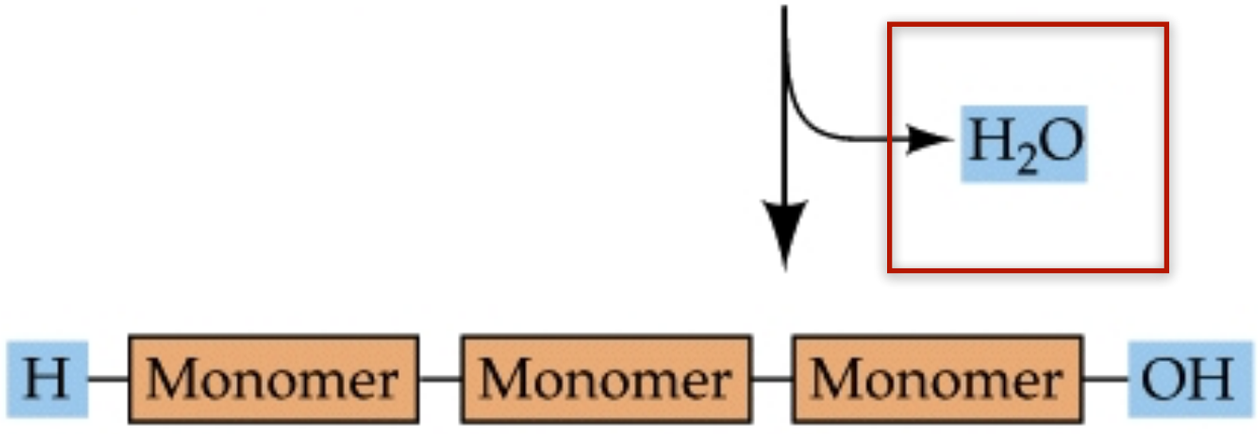


"HOH" = water

enzyme action at functional groups

(*a*) **Condensation**

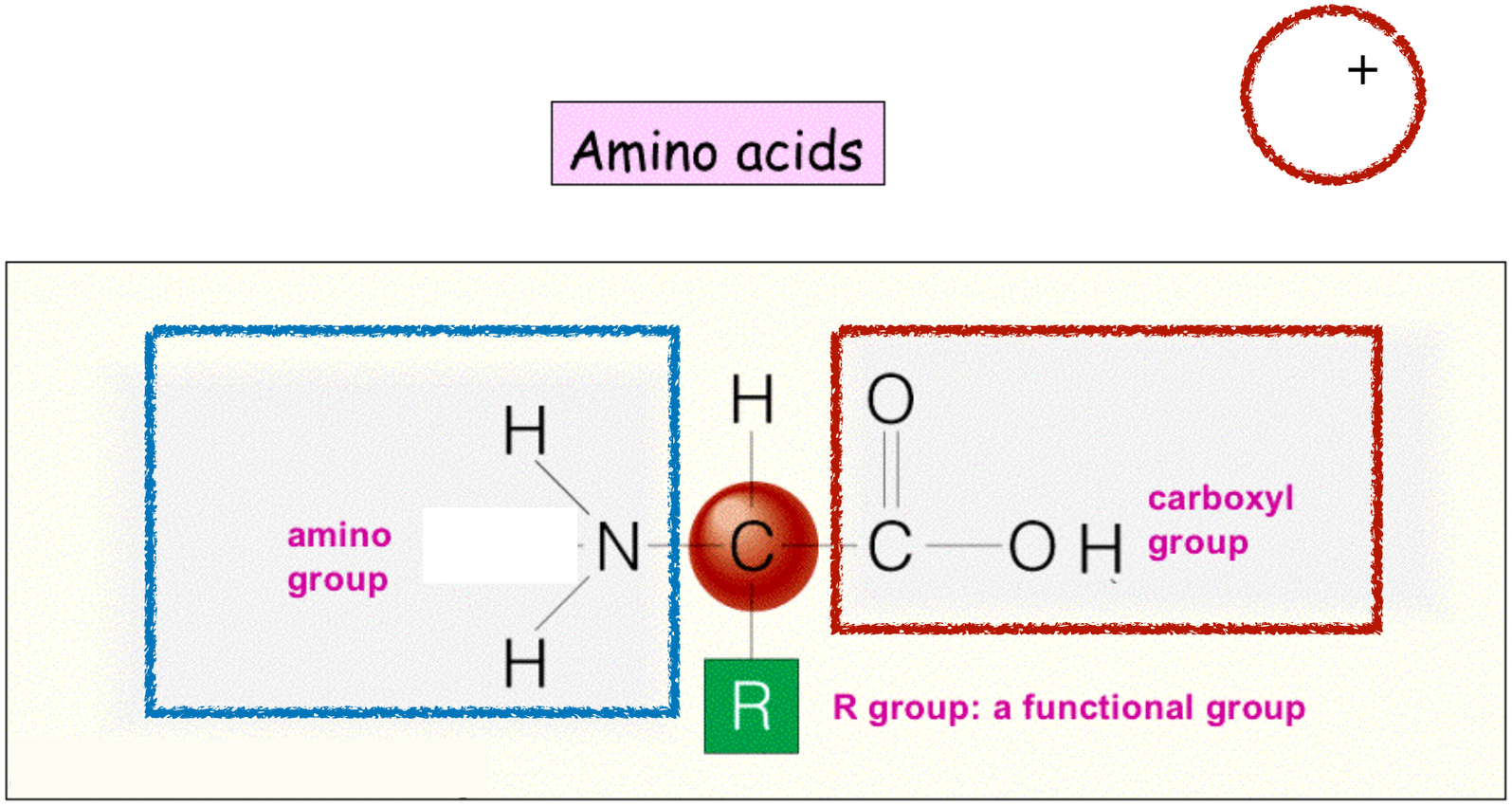


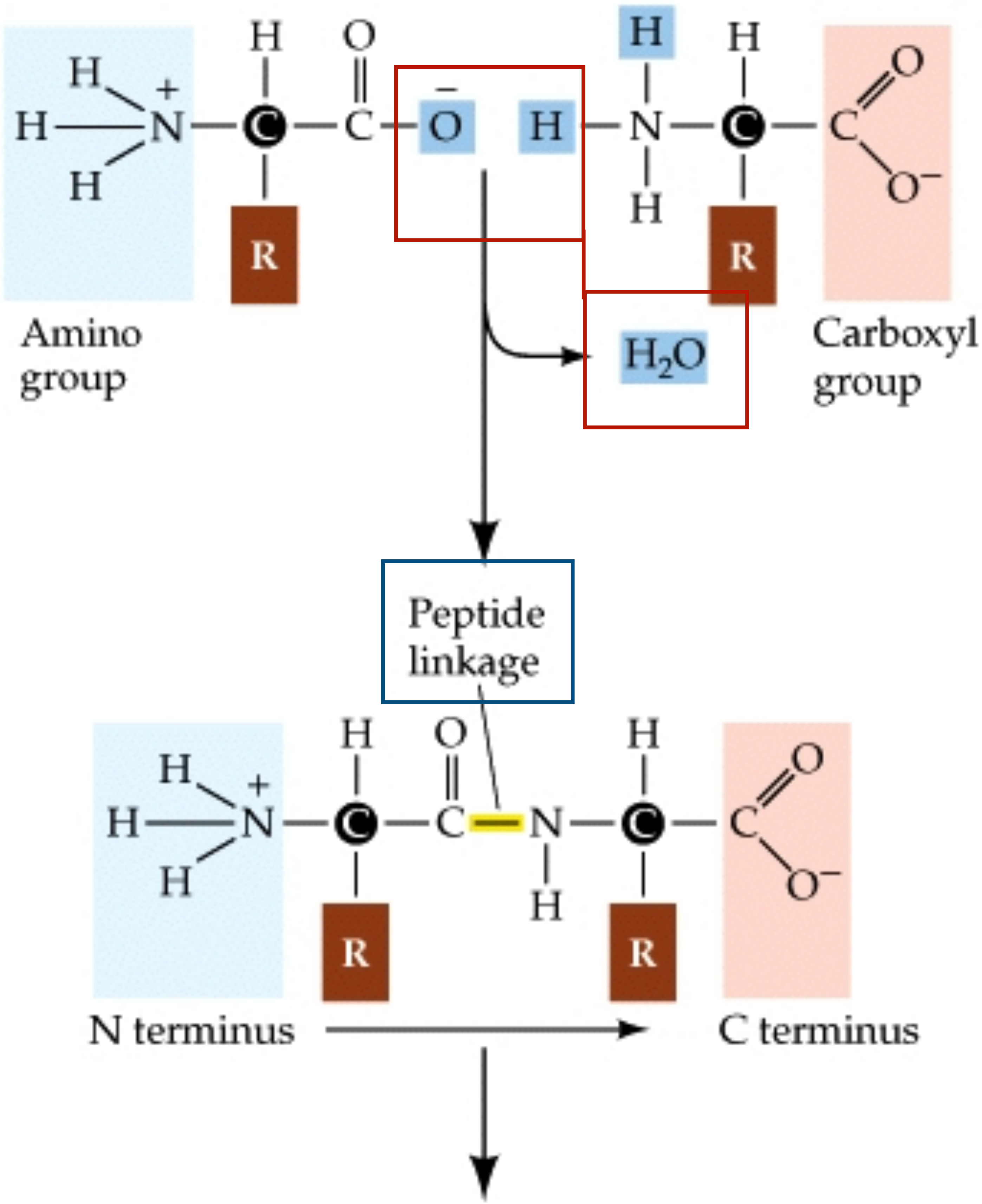


Acids, Bases, and the pH Scale

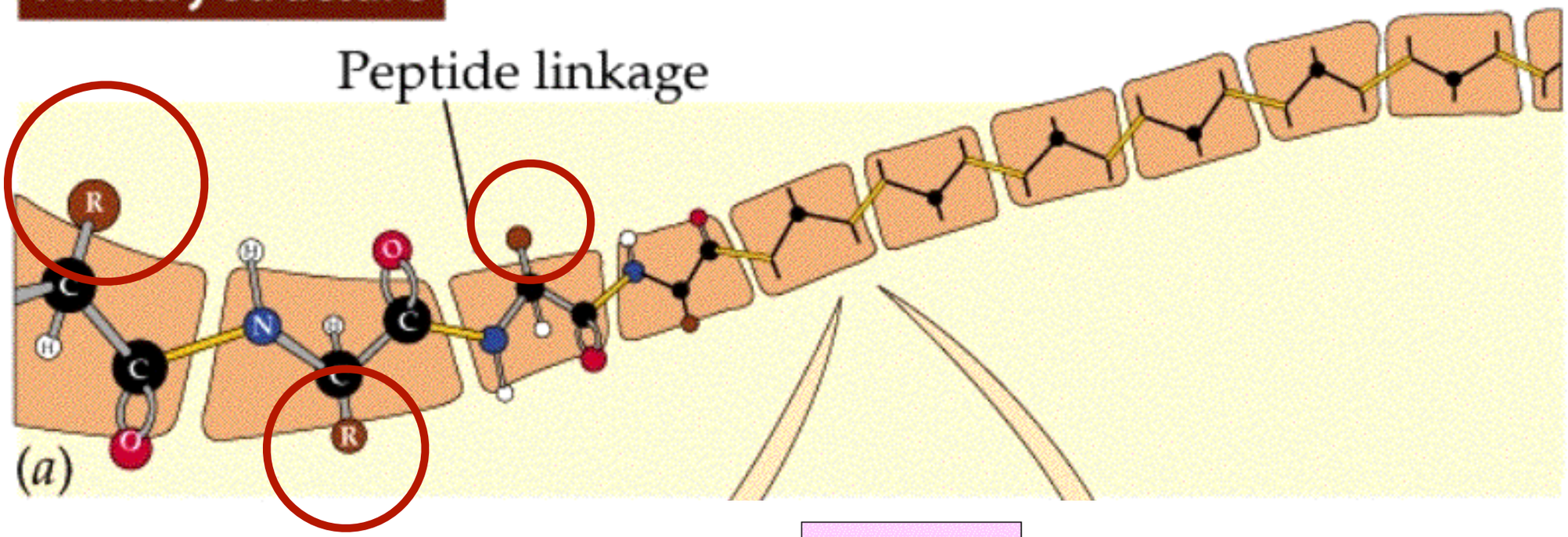
Acids donate H^+; bases accept H^+.

Amino acids: the very building blocks of proteins, contain both **carboxyl groups** and **amino groups**, so they are **simultaneously acids and bases**.

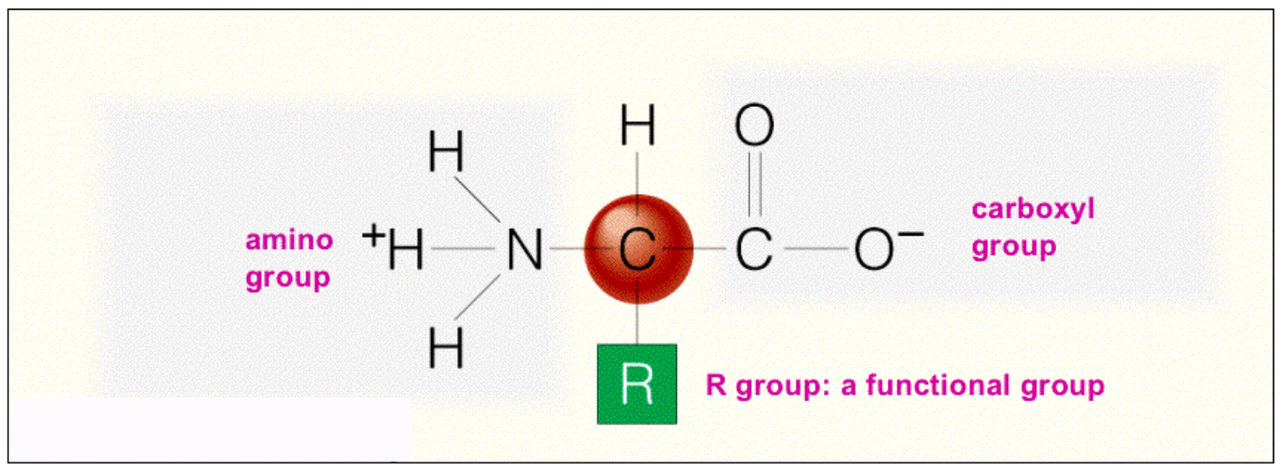



Amino group
Carboxyl group
H_2O
Peptide linkage
N terminus
C terminus

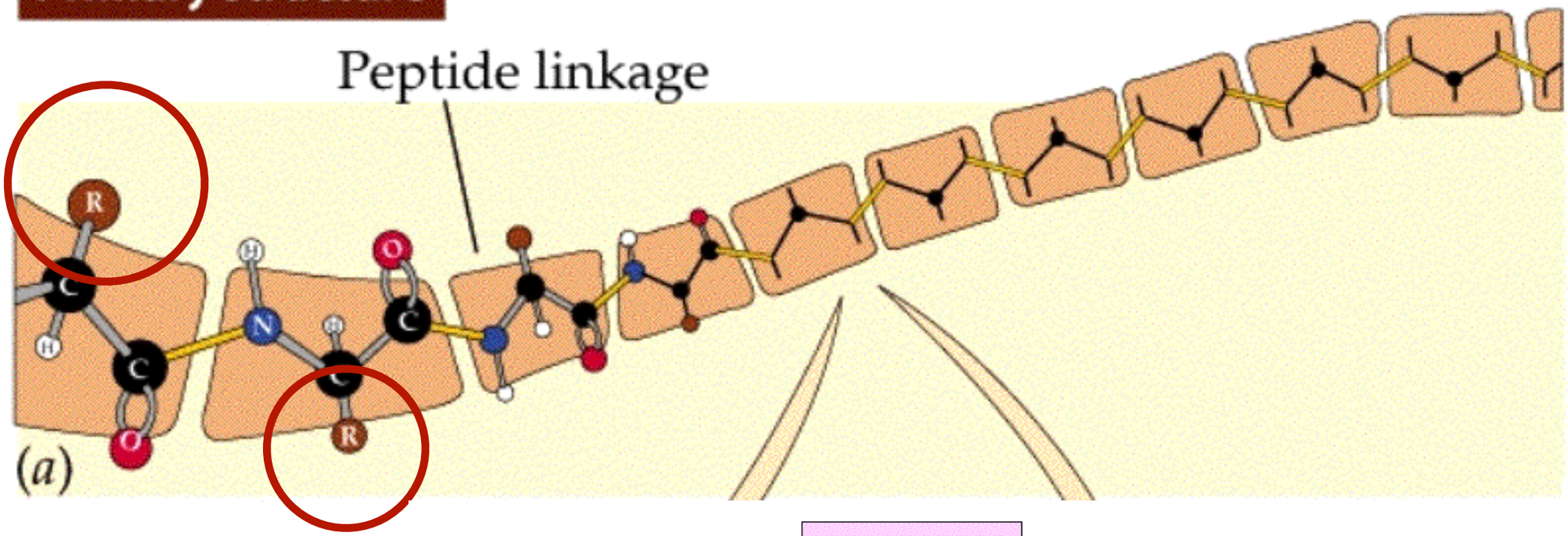
Primary structure



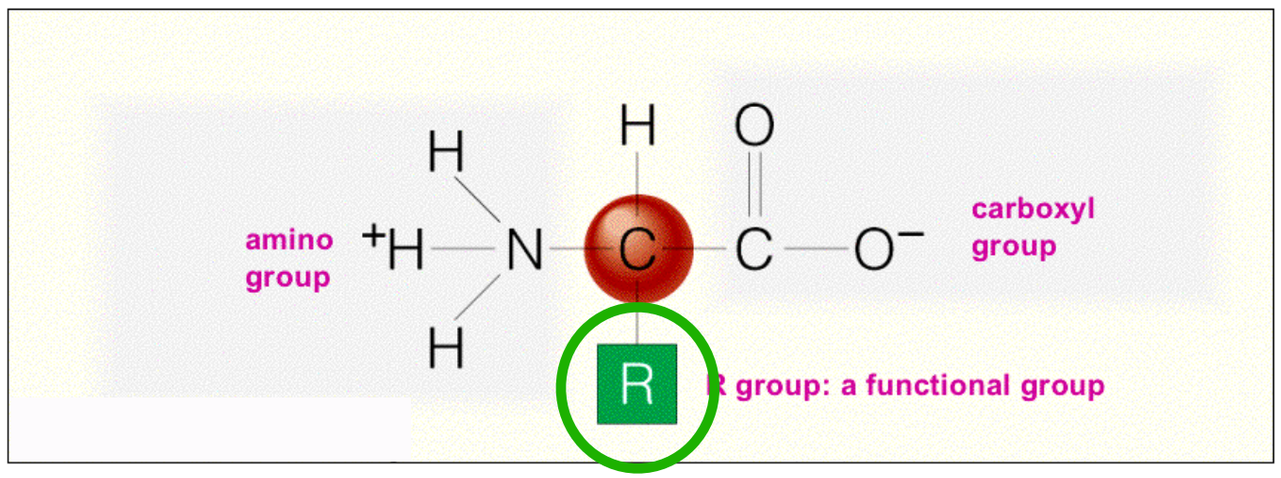
Amino acids



Primary structure

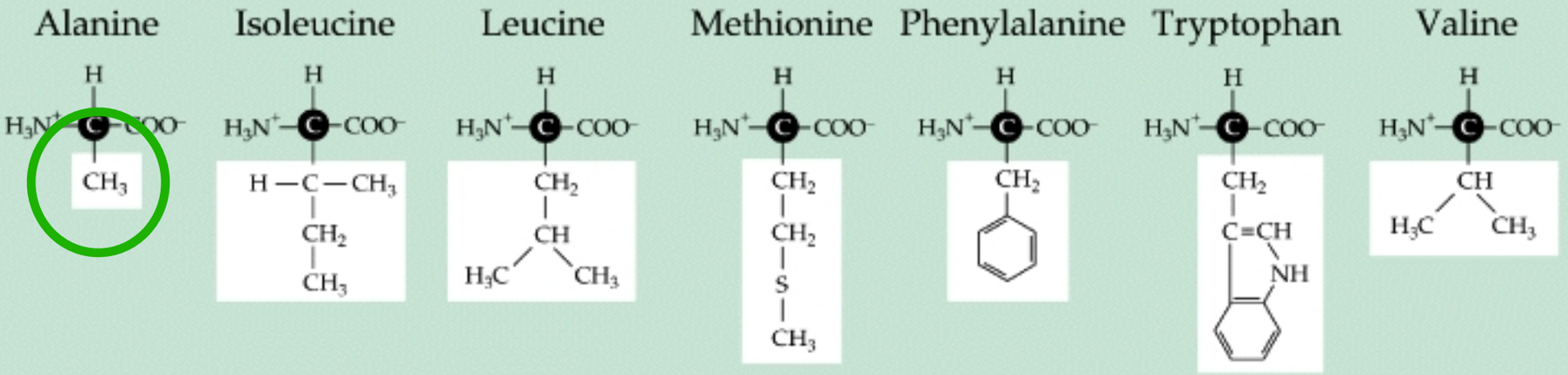


Amino acids

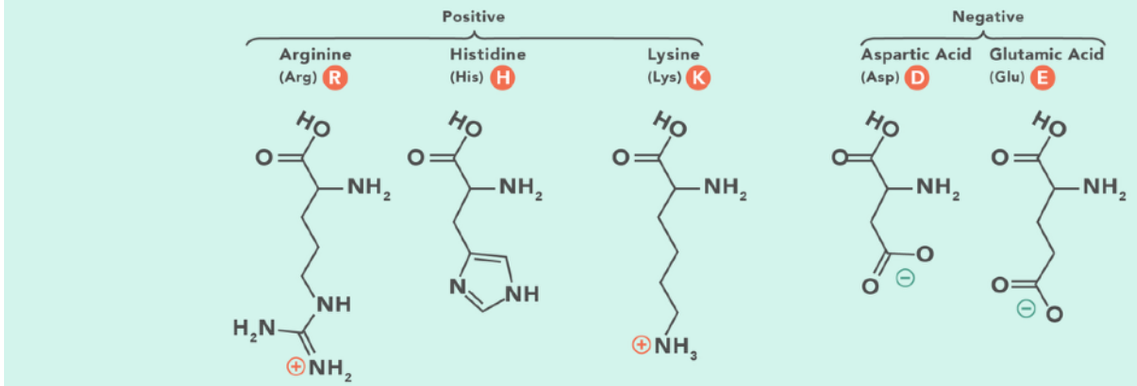


3.2 Twenty Amino Acids Found in Proteins

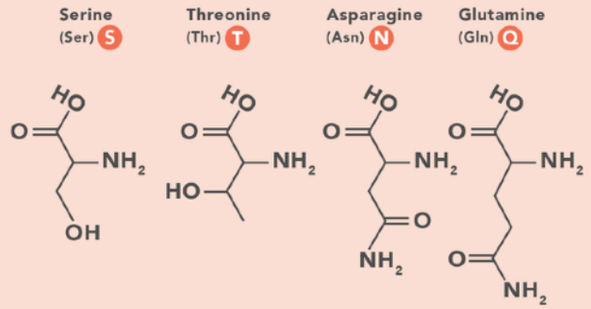
D. *Amino acids with hydrophobic side chains*



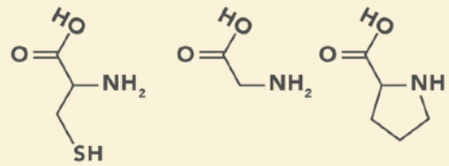
A. Amino Acids with Electrically Charged Side Chains



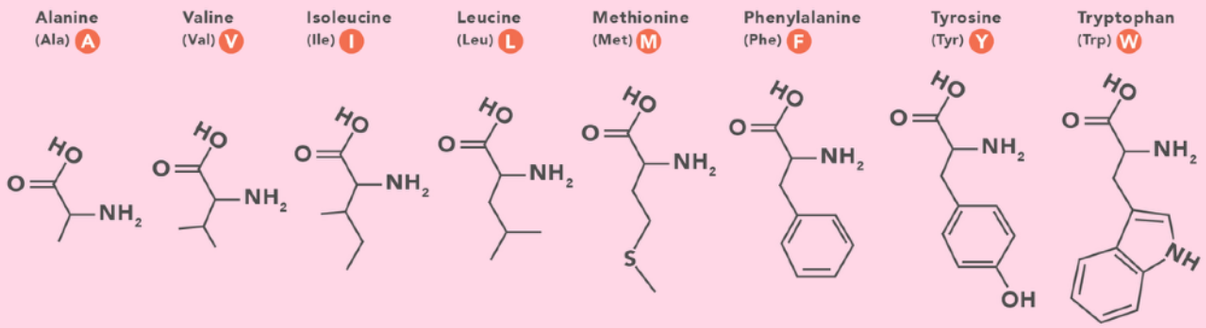
B. Amino Acids with Polar Uncharged Side Chains



C. Special Cases



D. Amino Acids with Hydrophobic Side Chains



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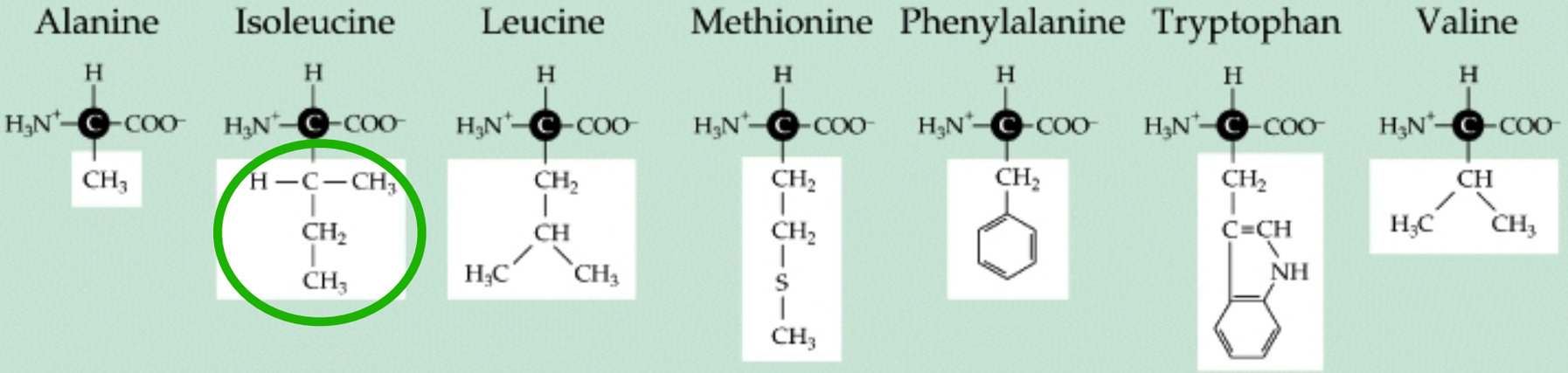
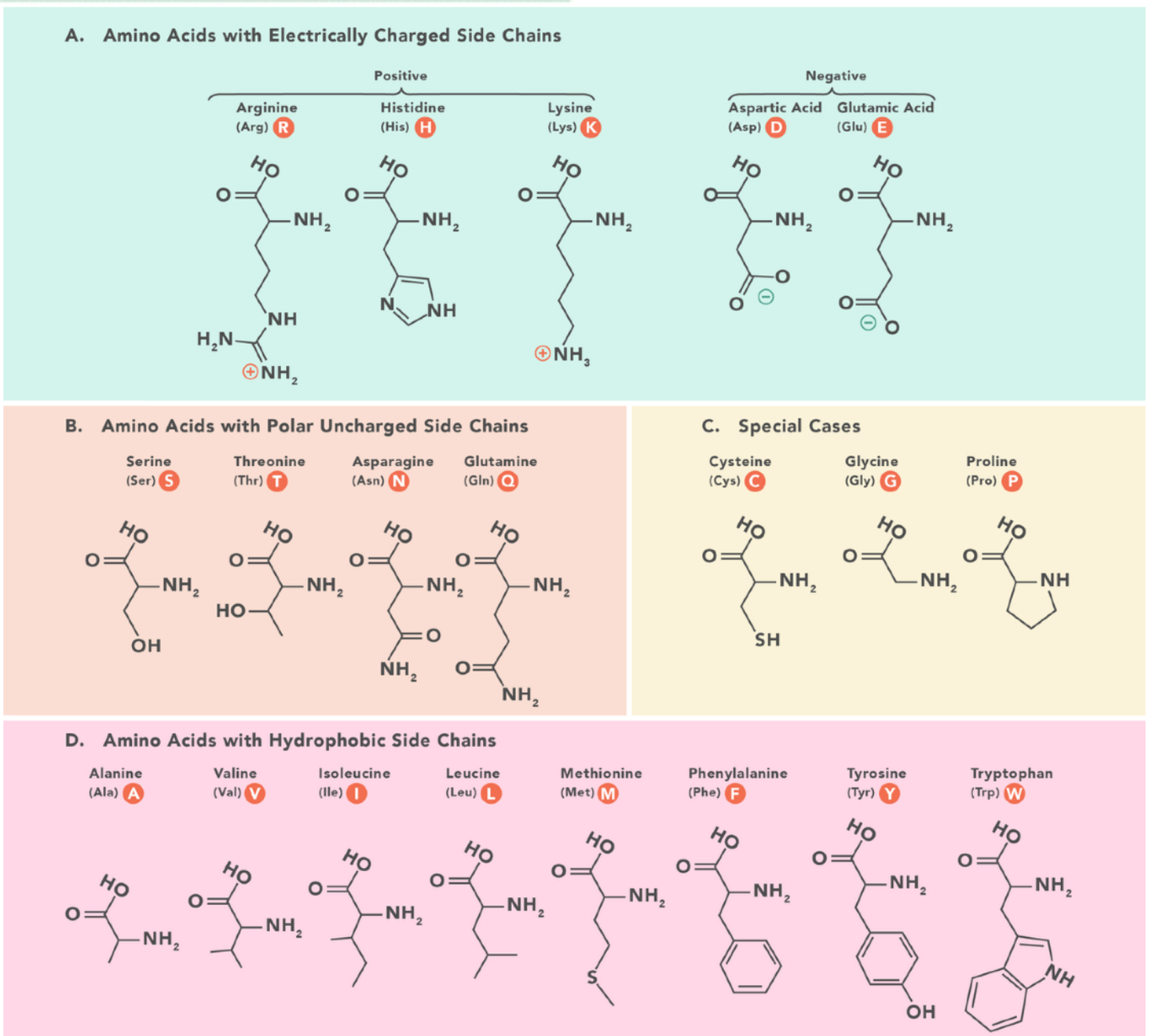
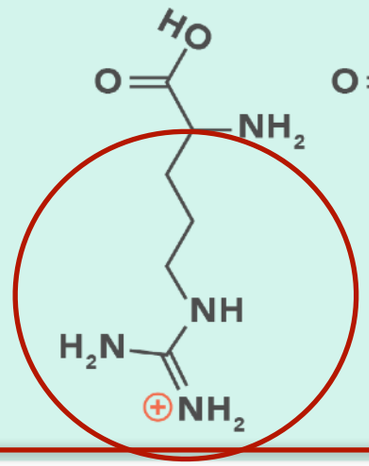




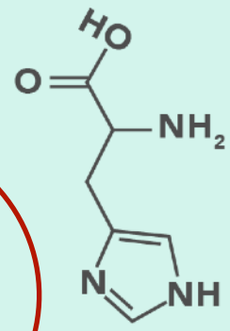
A. Amino Acids with Electrically Charged Side Chains

Positive

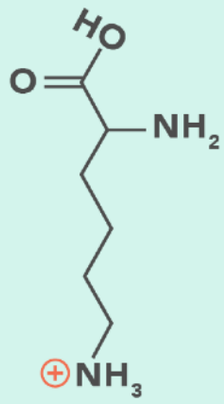
Arginine (Arg) R



Histidine (His) H

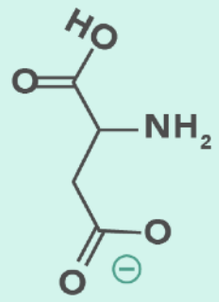


Lysine (Lys) K

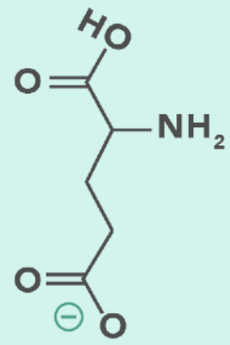


Negative

Aspartic Acid (Asp) D

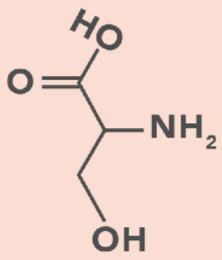


Glutamic Acid (Glu) E

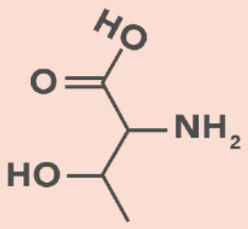


B. Amino Acids with Polar Uncharged Side Chains

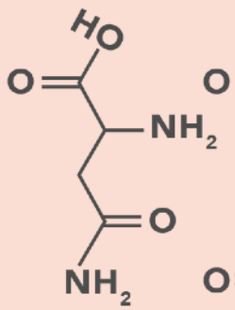
Serine (Ser) S



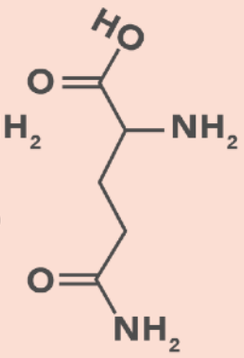
Threonine (Thr) T



Asparagine (Asn) N

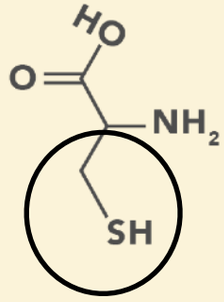


Glutamine (Gln) Q

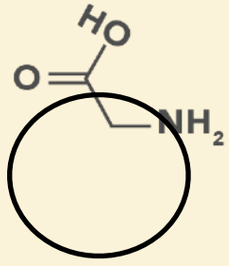


C. Special Cases

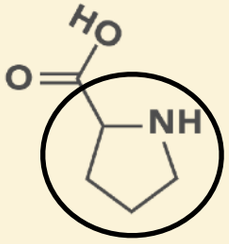
Cysteine (Cys) C



Glycine (Gly) G

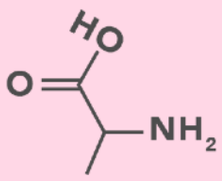


Proline (Pro) P

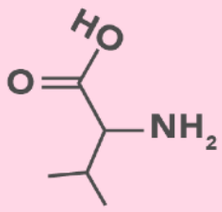


D. Amino Acids with Hydrophobic Side Chains

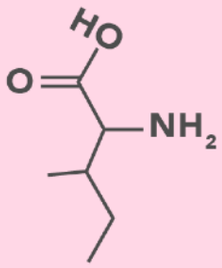
Alanine (Ala) A



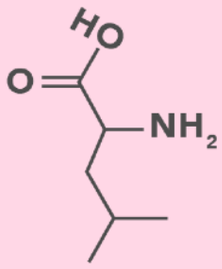
Valine (Val) V



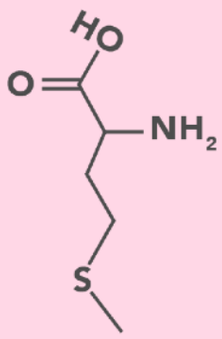
Isoleucine (Ile) I



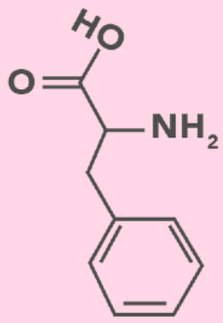
Leucine (Leu) L



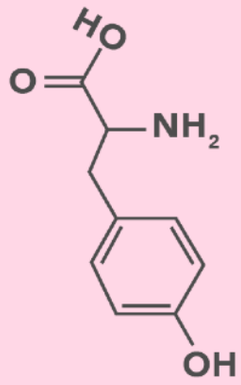
Methionine (Met) M



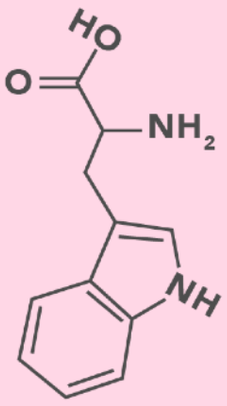
Phenylalanine (Phe) F



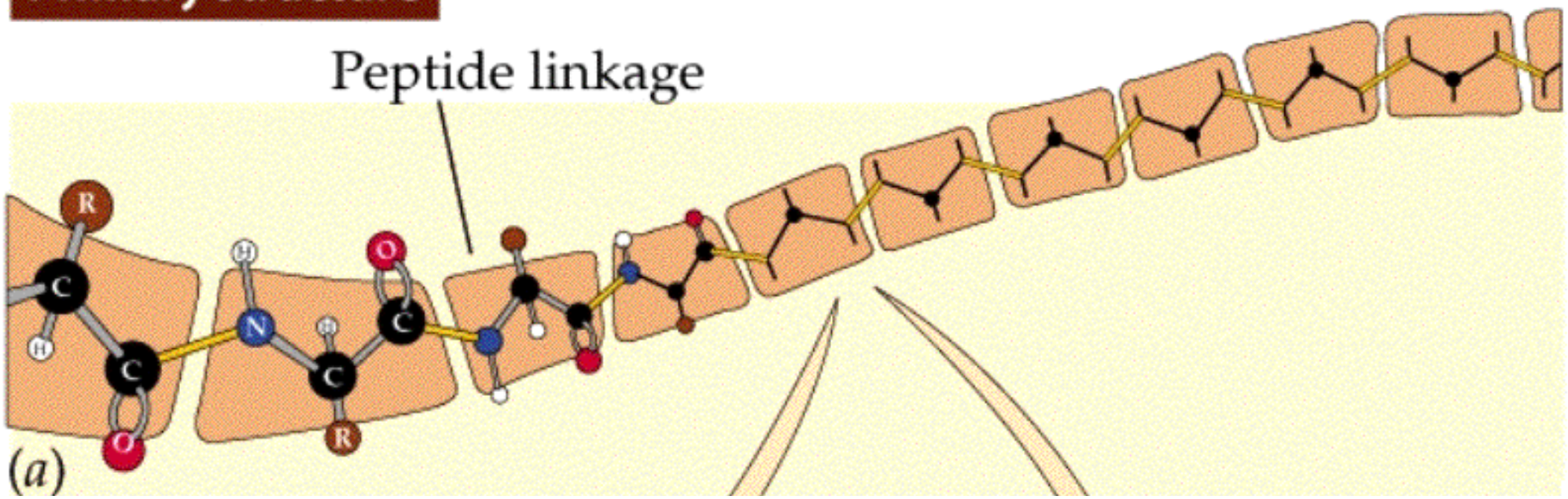
Tyrosine (Tyr) Y



Tryptophan (Trp) W



Primary structure

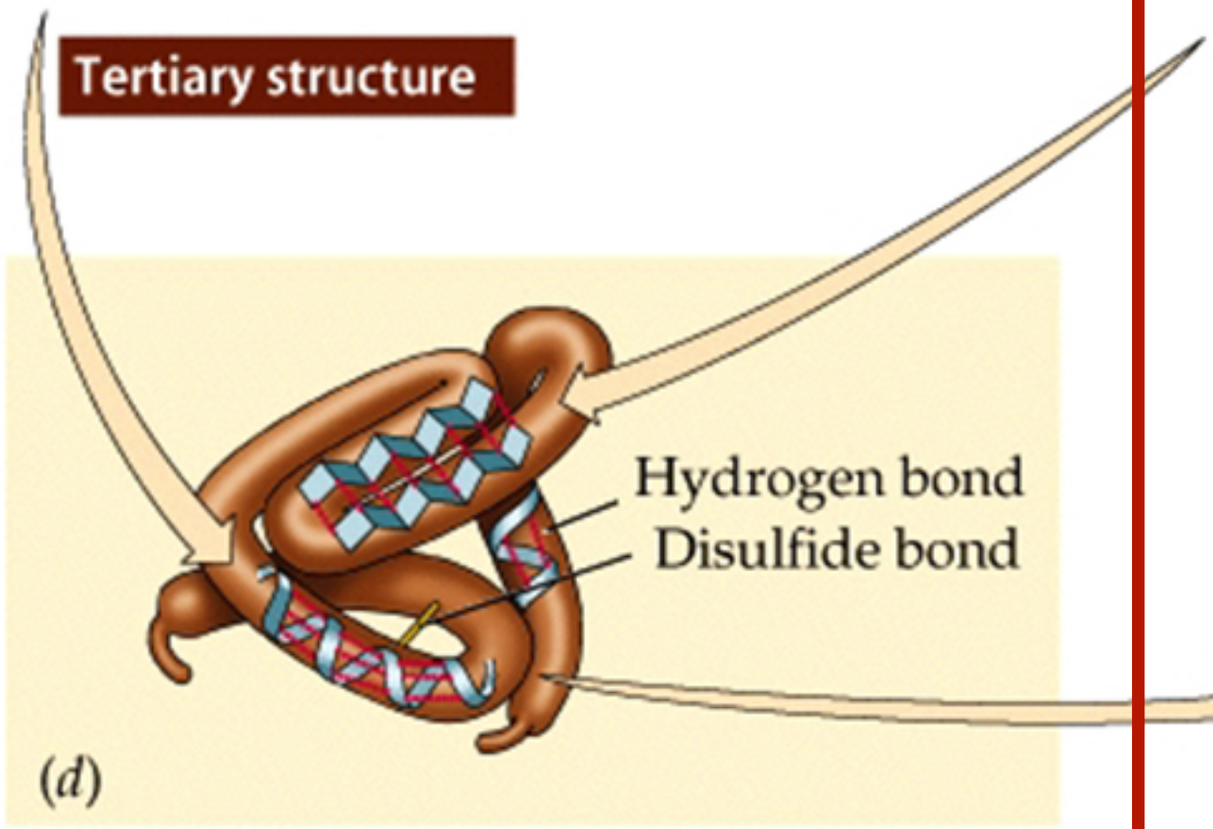


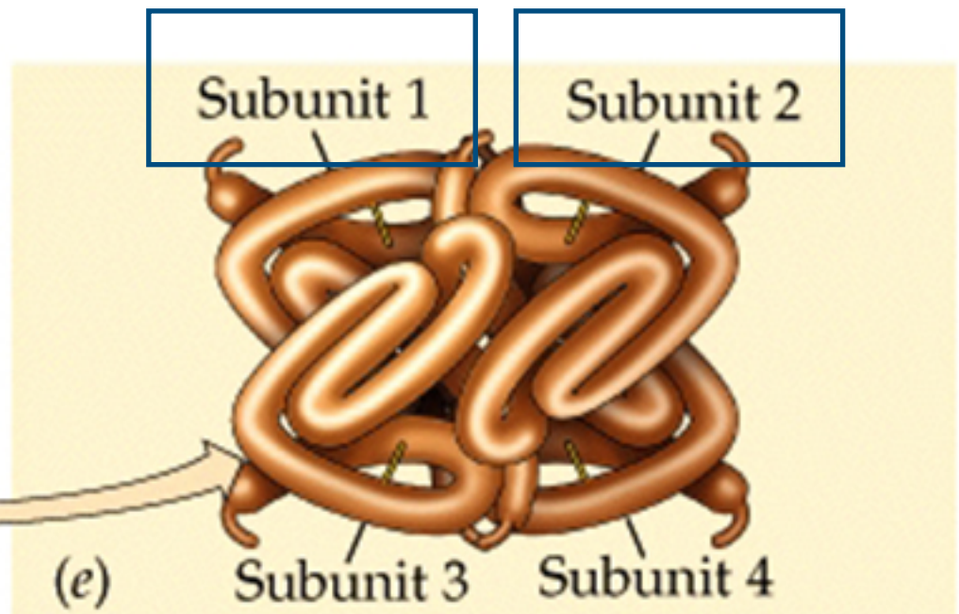
(b) α Helix

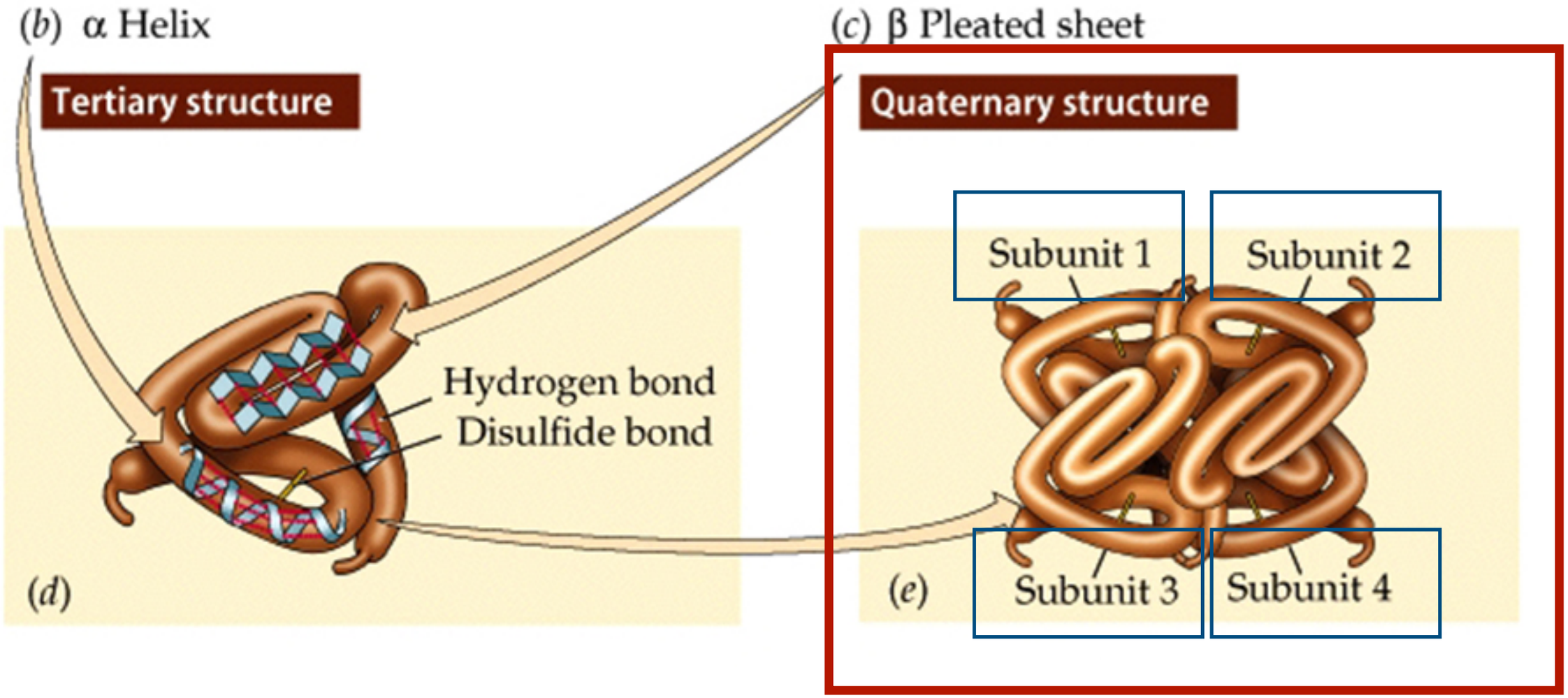
Tertiary structure

(c) β Pleated sheet

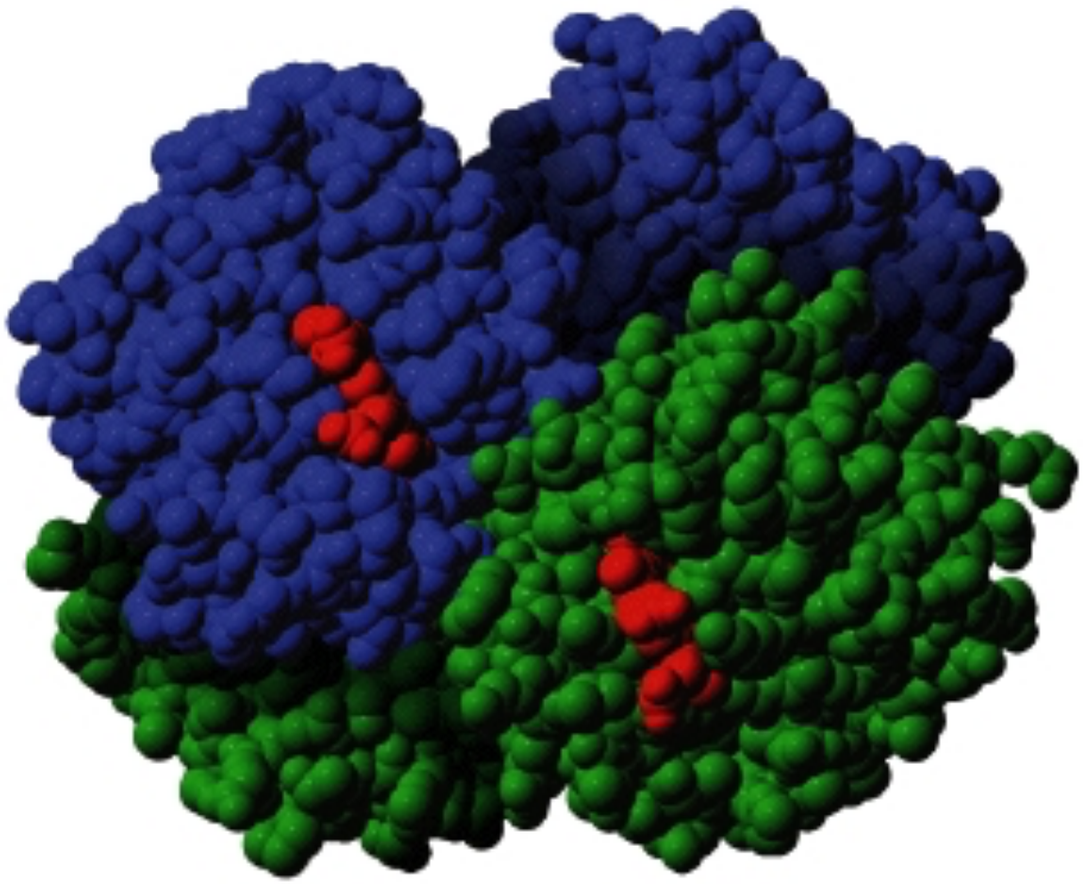
Quaternary structure



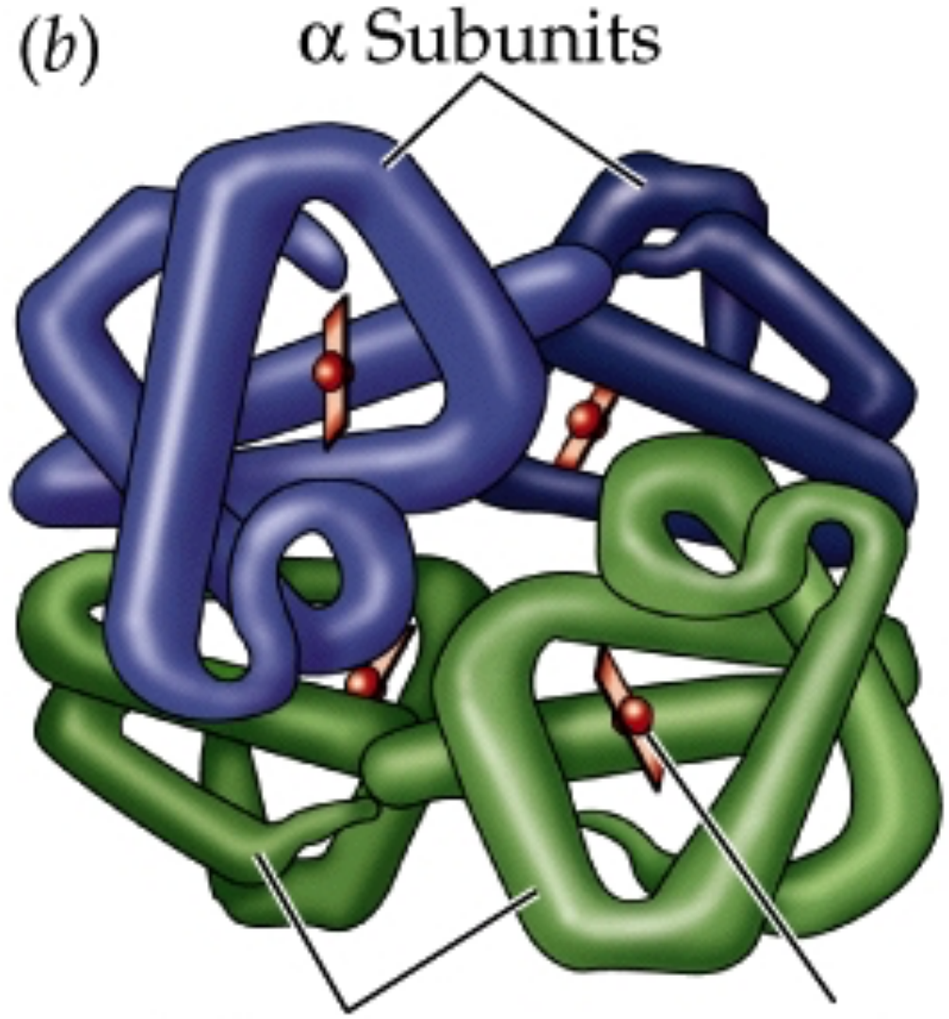



(b) α Helix
Tertiary structure
(c) β Pleated sheet
Quaternary structure
Subunit 1
Subunit 2
Hydrogen bond
Disulfide bond
(d)
(e)
Subunit 3
Subunit 4

(a)



(b)



Carbohydrates: Sugars and Sugar Polymers

Carbohydrate monomers have molecular weights that approximates **100 Daltons.**

Polymers composed of monomers can have molecular weights of up to hundreds of thousands of Daltons.
There are four major categories of carbohydrates:

Monosaccharides,

Disaccharides, which consist of 2 x **monosaccharides** and

Oligosaccharides, which consist of between **3 and 20 monosaccharides**.

Finally there are

Polysaccharides, which are composed of hundreds to thousands of monosaccharides.

The general formula for a **carbohydrate monomer** is multiples of CH_2O, maintaining a ratio of 1 carbon to every 2 hydrogens and 1 oxygen.

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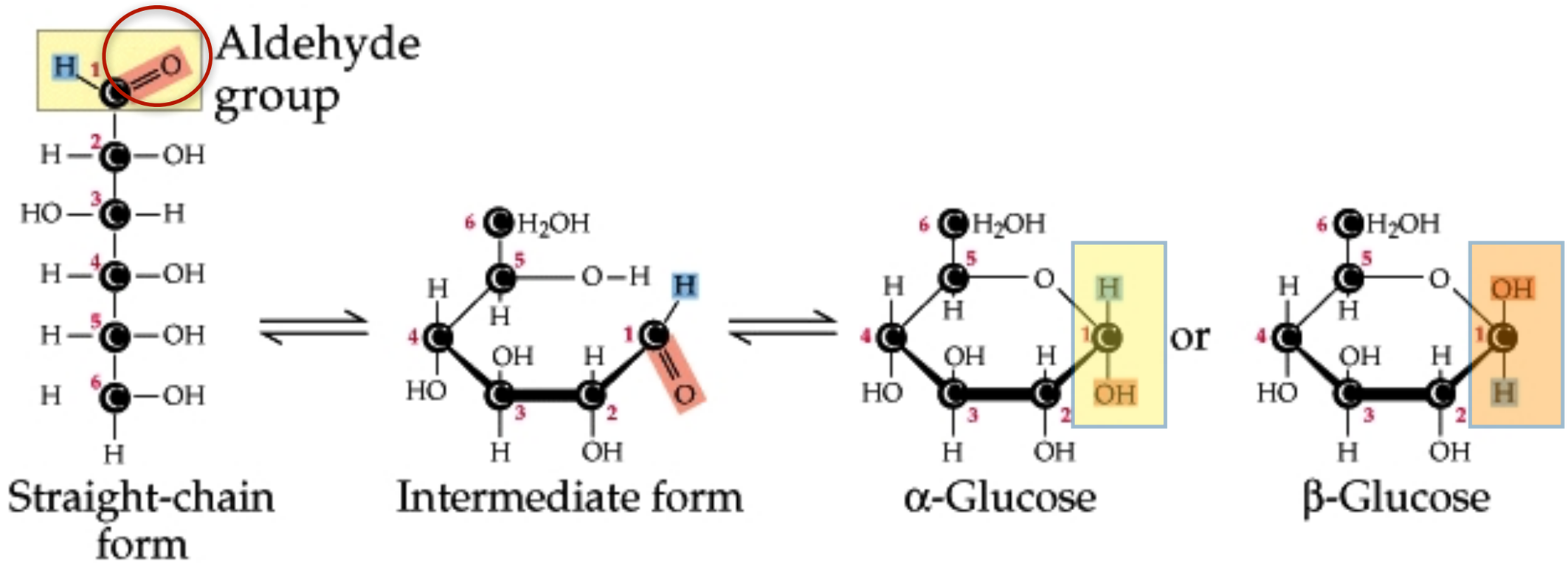

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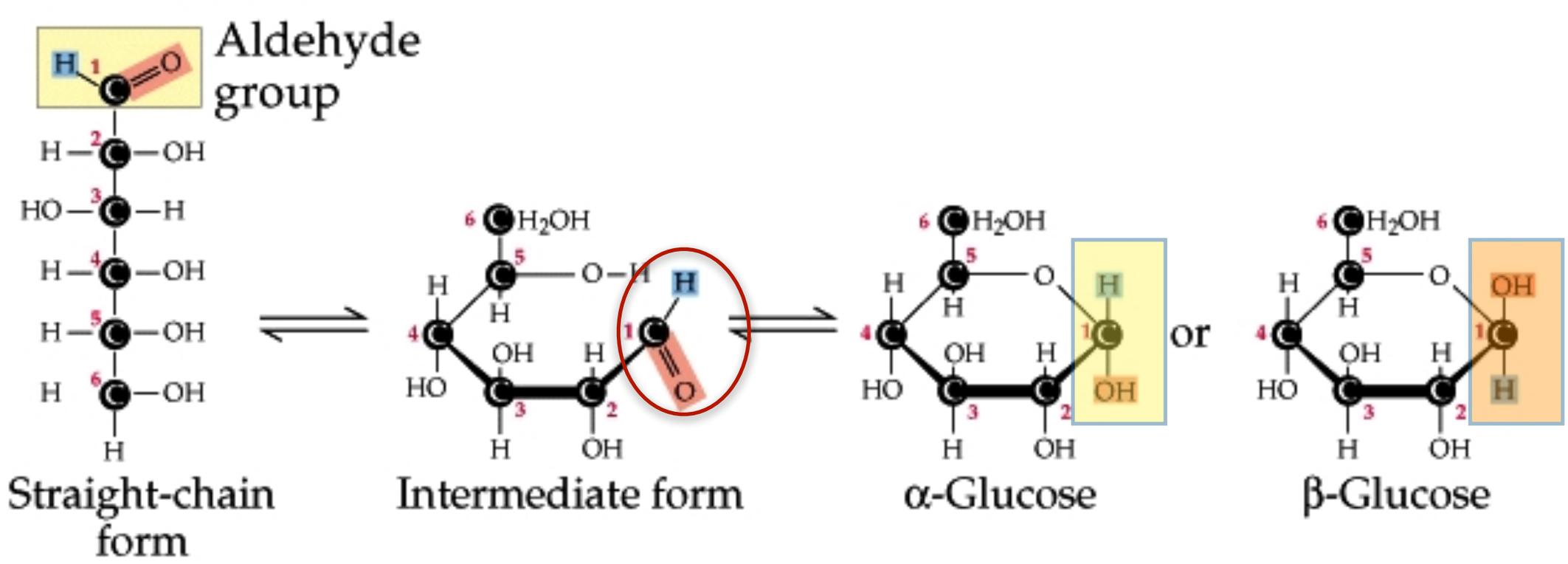

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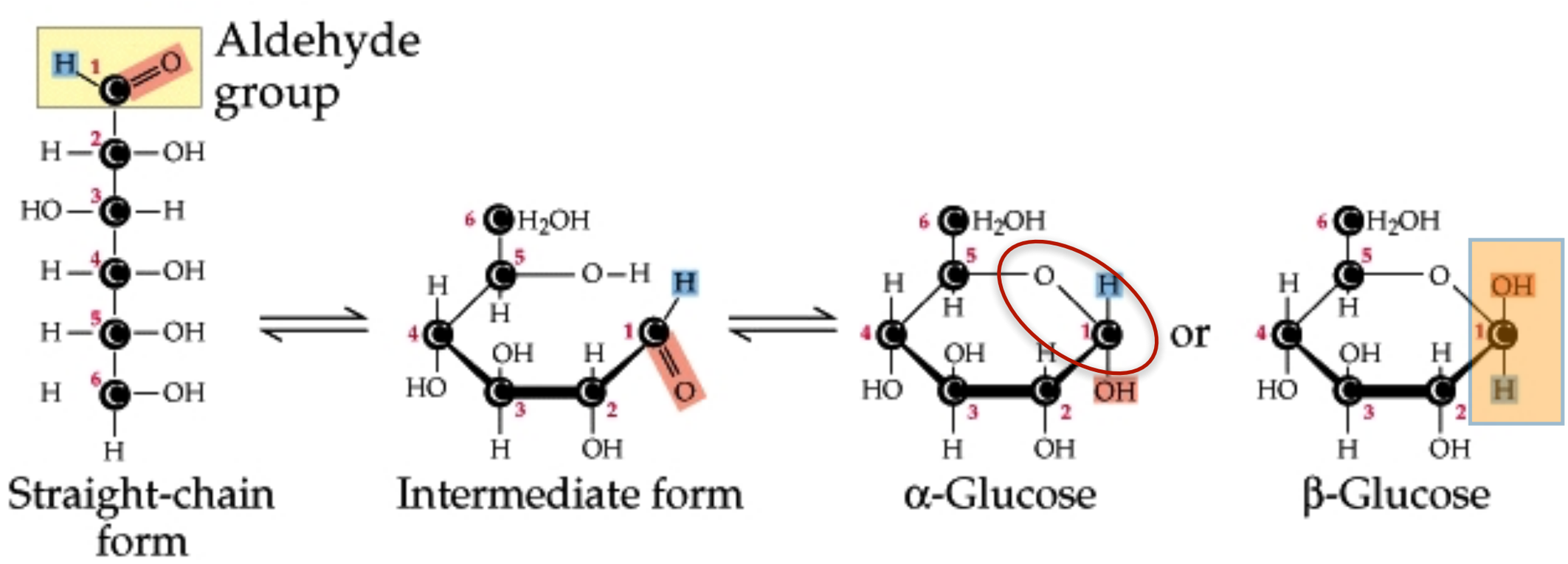

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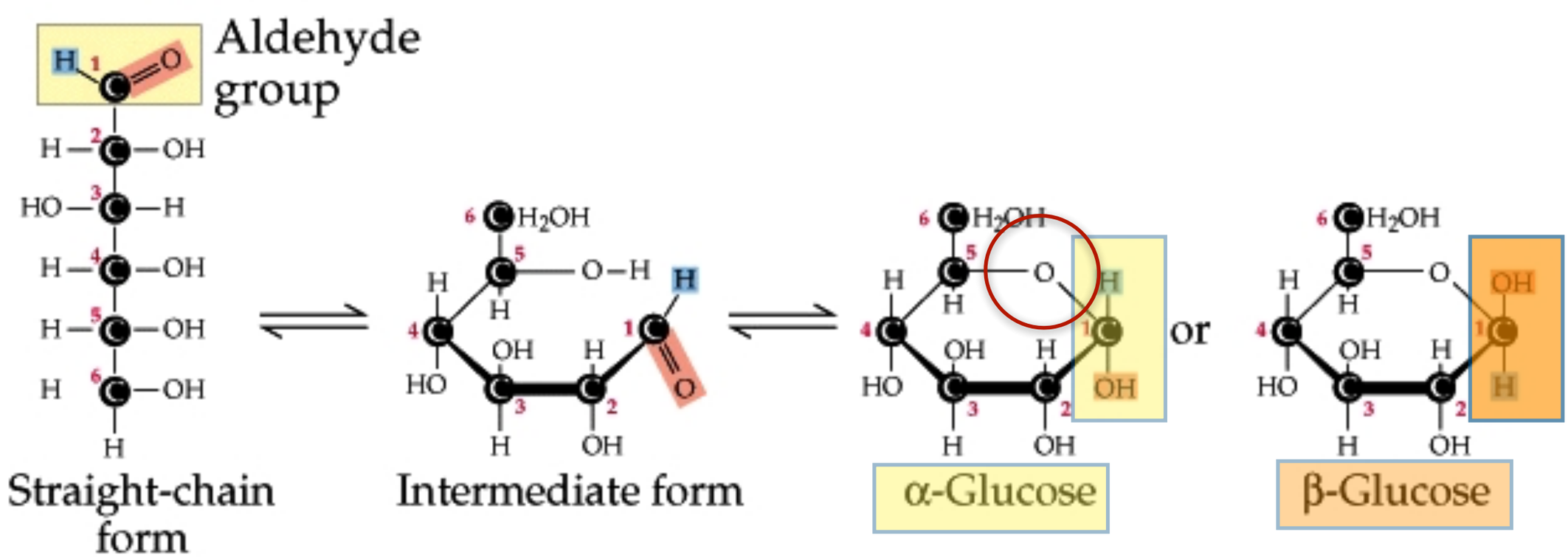
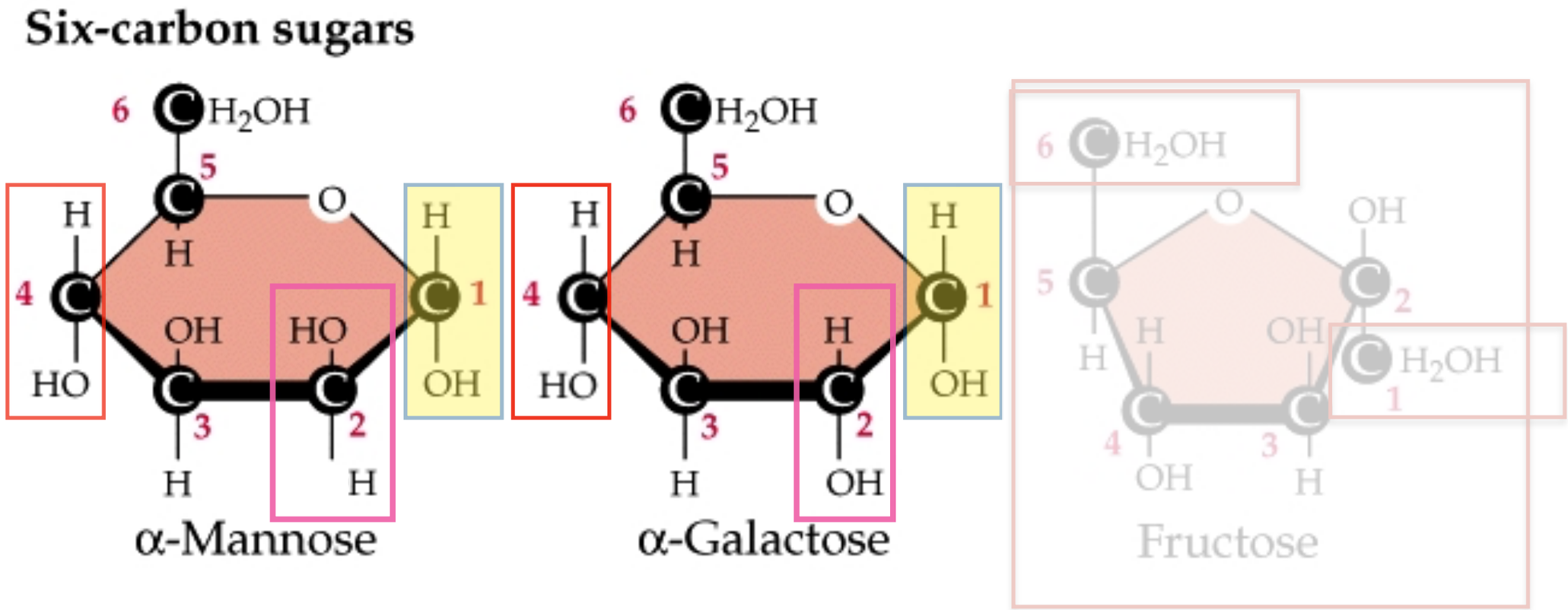
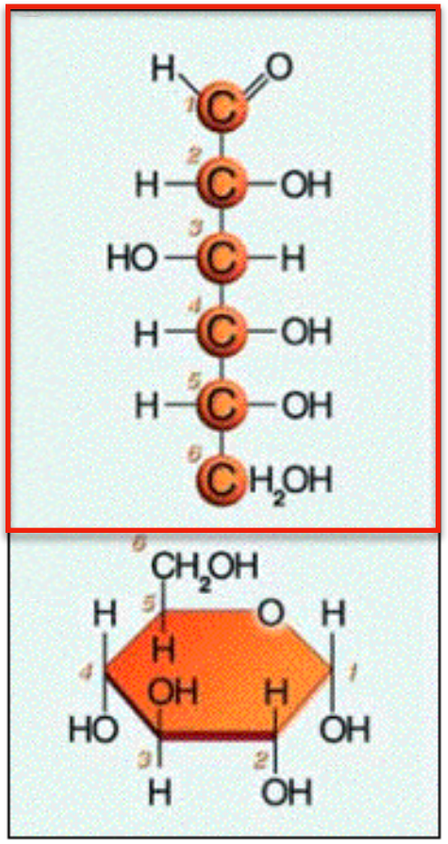


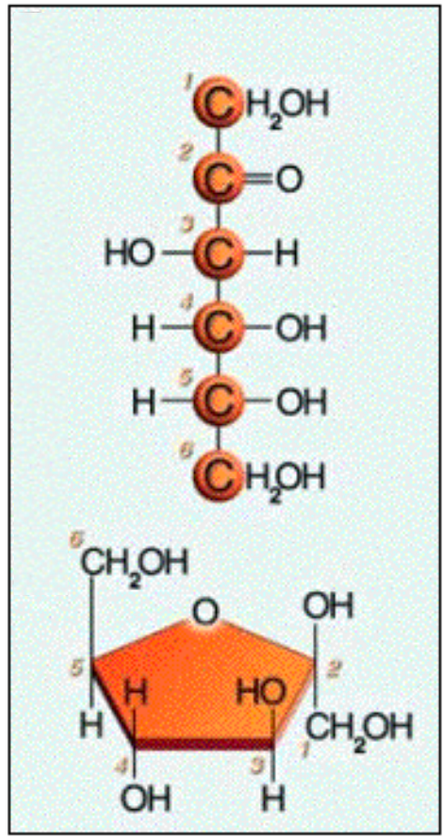
Carbohydrates: Sugars and Sugar Polymers



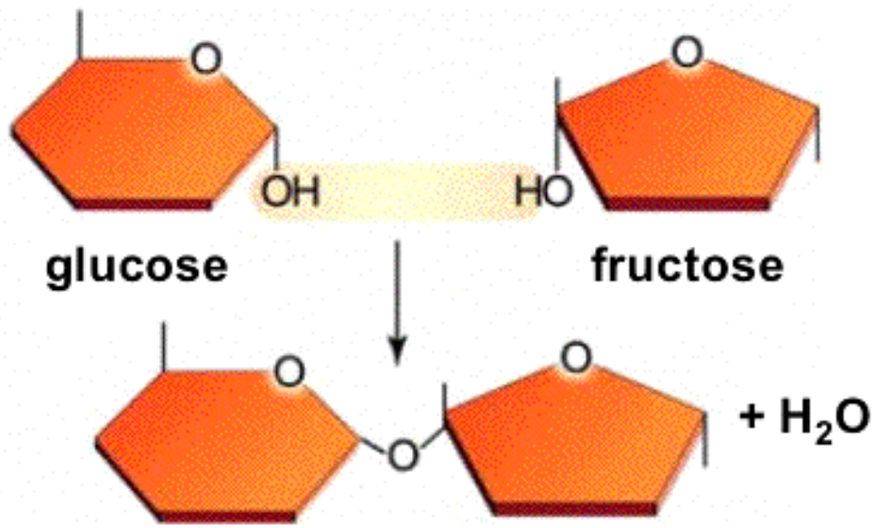
Carbohydrates: Sugars and Sugar Polymers



glucose



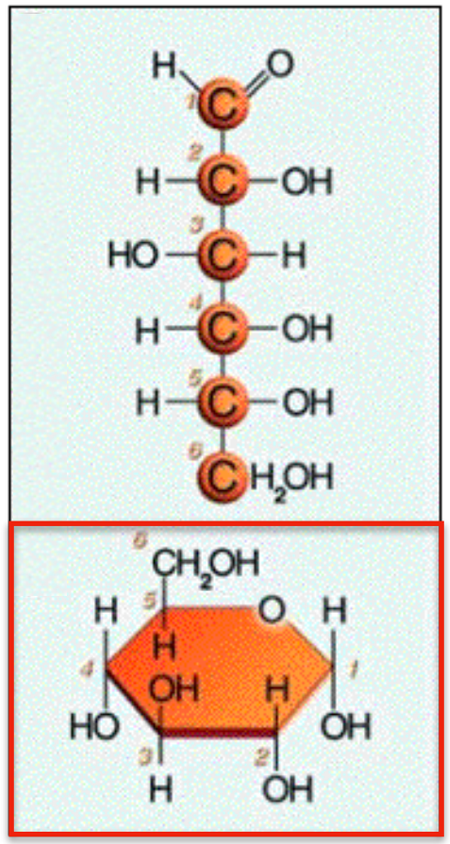
fructose



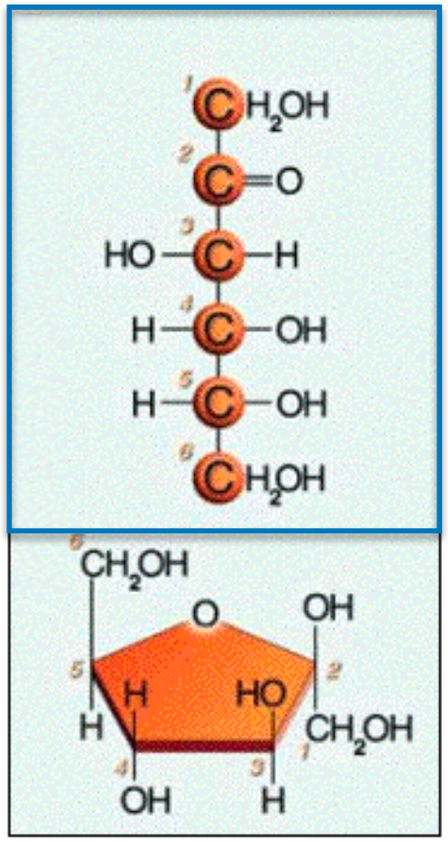
glucose fructose

sucrose

Carbohydrates: Sugars and Sugar Polymers



glucose



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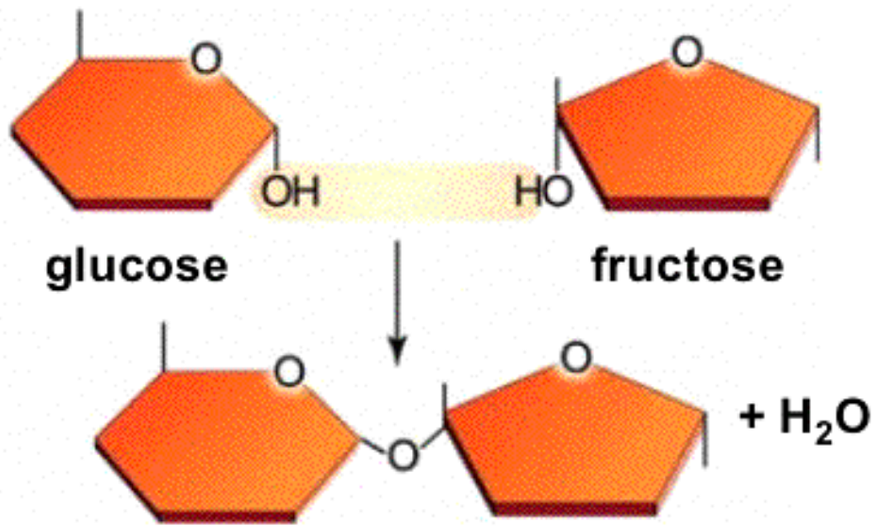
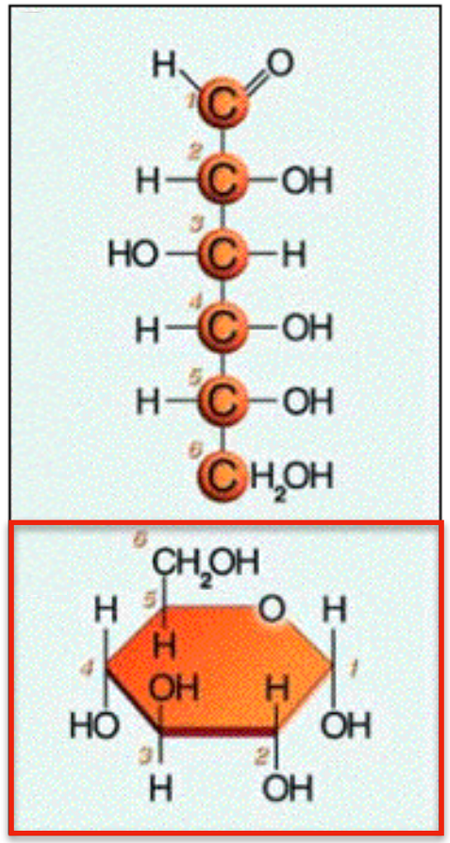
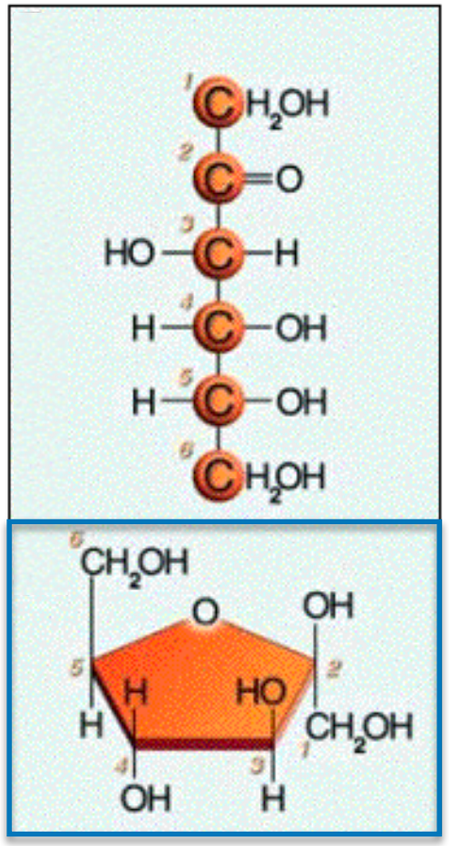


sucrose

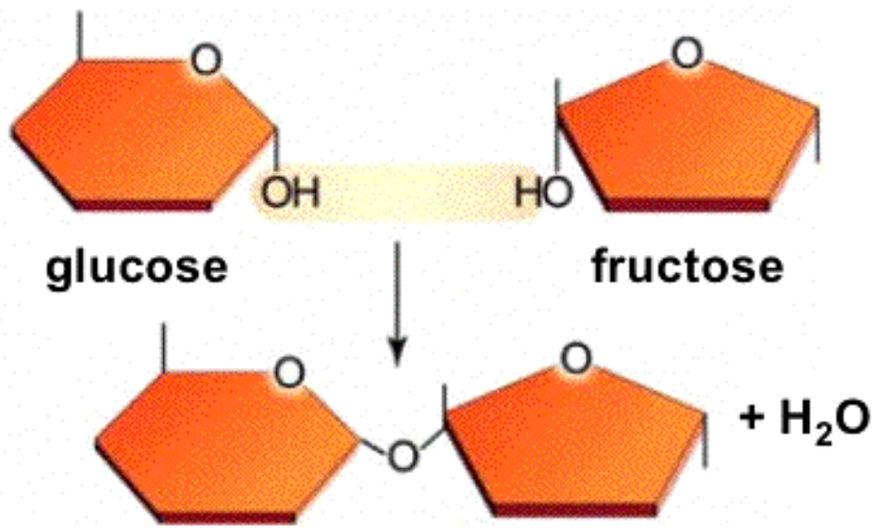
Carbohydrates: Sugars and Sugar Polymers



glucose



fructose



sucrose

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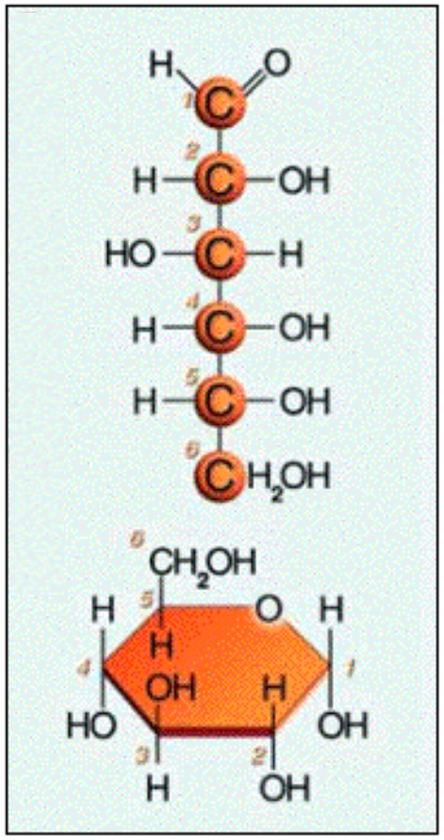
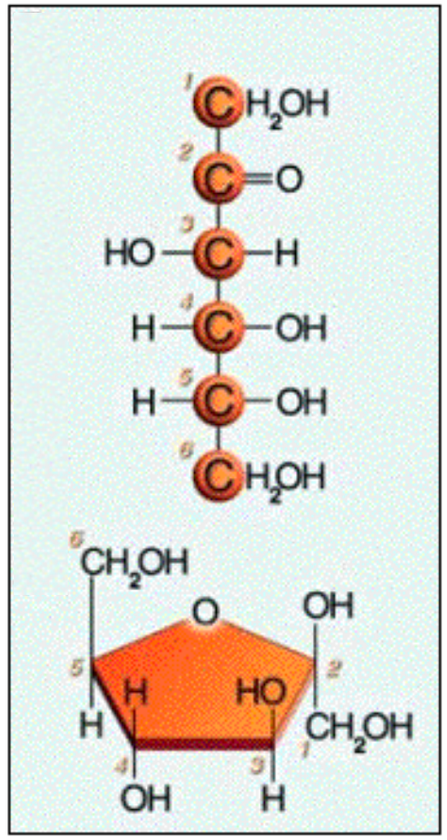
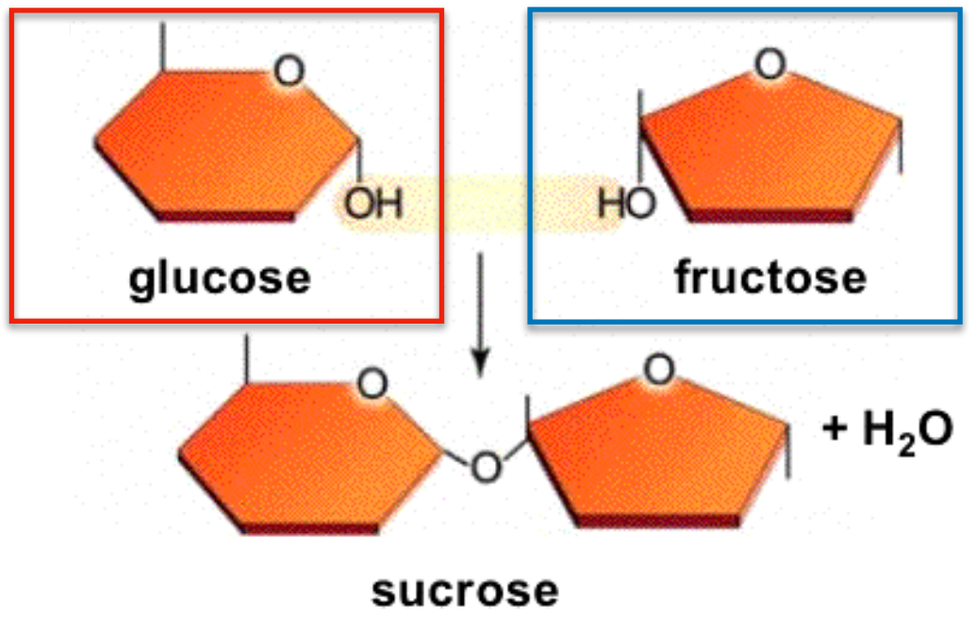


glucose



fructose



sucrose

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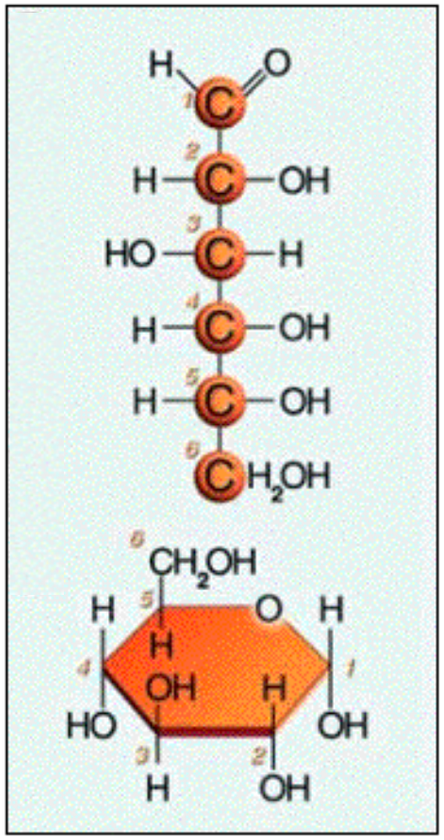
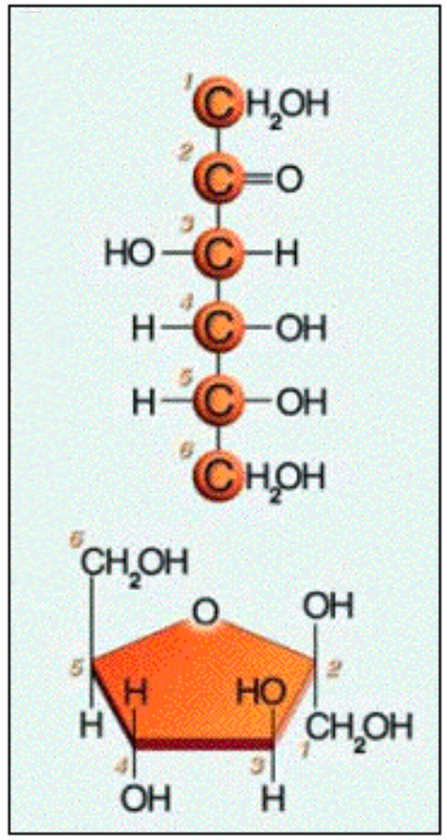


glucose



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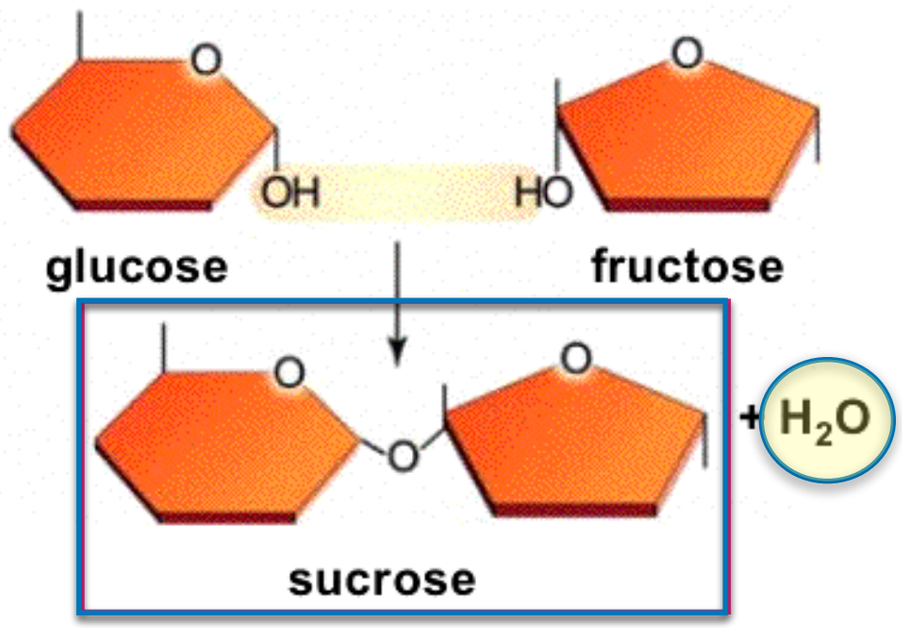
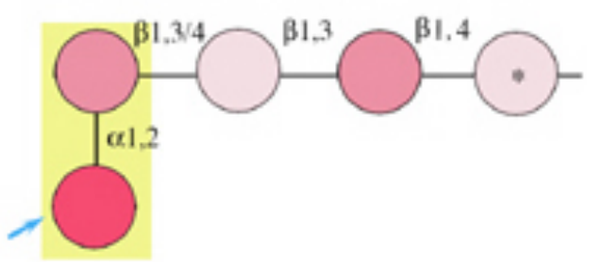


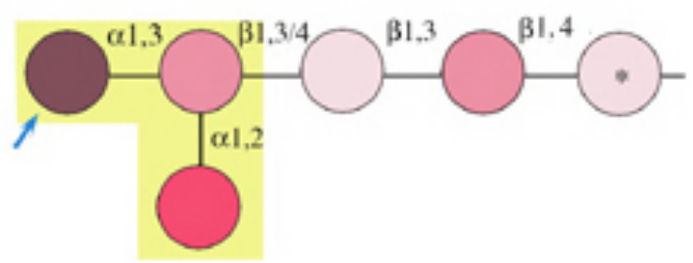
Carbohydrates: Sugars and Sugar Polymers

Oligosaccharides, which consist of between **3 and 20 monosaccharides**.

H - antigen =



A - antigen =



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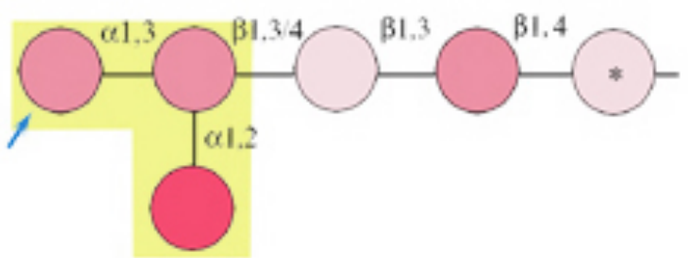

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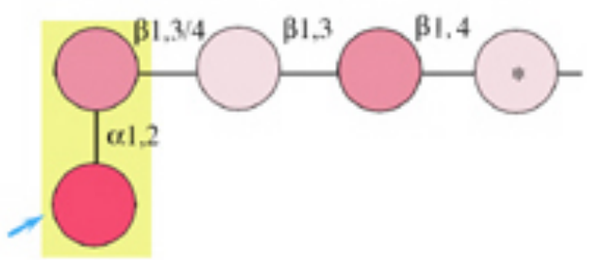

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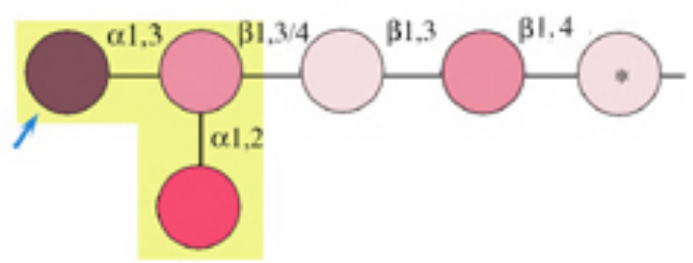

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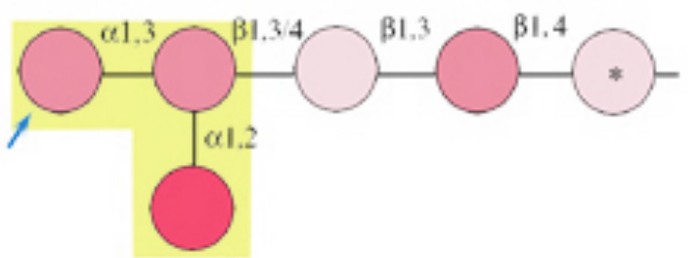
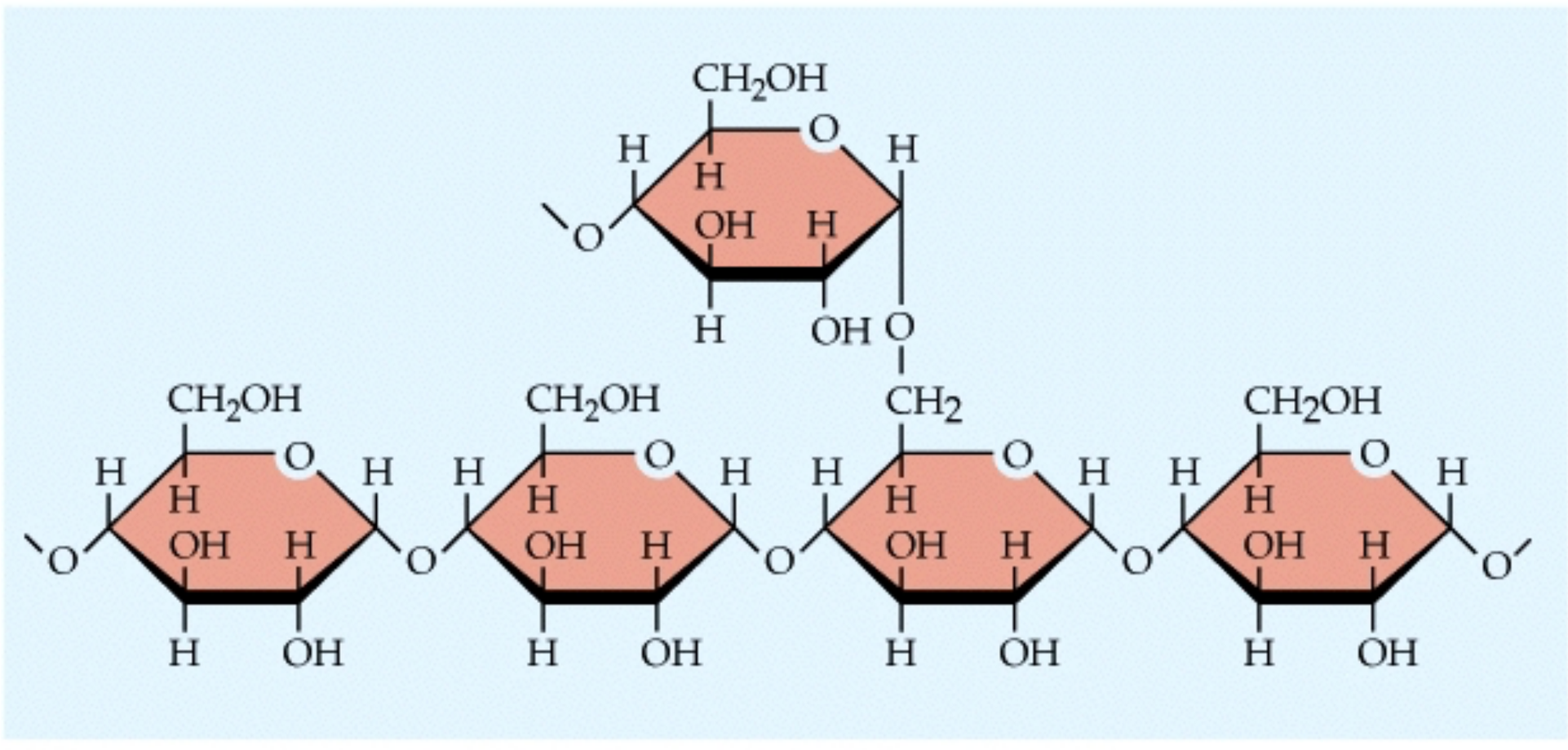


Carbohydrates: Sugars and Sugar Polymers

Polysaccharides, which are composed of hundreds to thousands of monosaccharides.

(*a*) **Molecular structure**

Starch and glycogen



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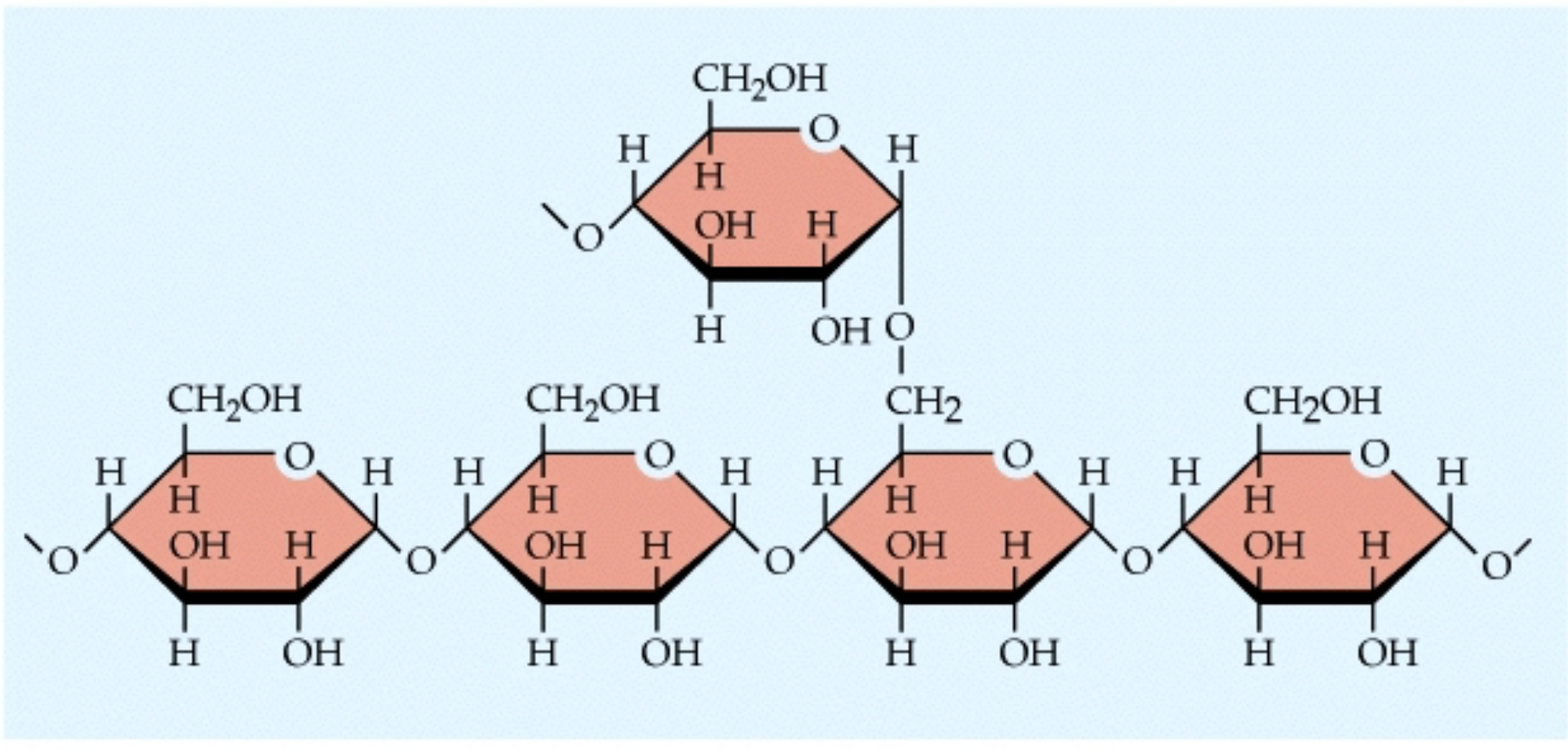


"Starch" is **a polysaccharide comprising glucose monomers, predominantly joined** in α 1,4 linkages.

α-1,4 glycosidic linkage

α-Glucose + β-Glucose → Formation of α linkage → H_2O + Maltose

α-Glucose

β-Glucose

Maltose

β-1,4 glycosidic linkage

β-Glucose + β-Glucose → Formation of β linkage → H_2O + Cellobiose

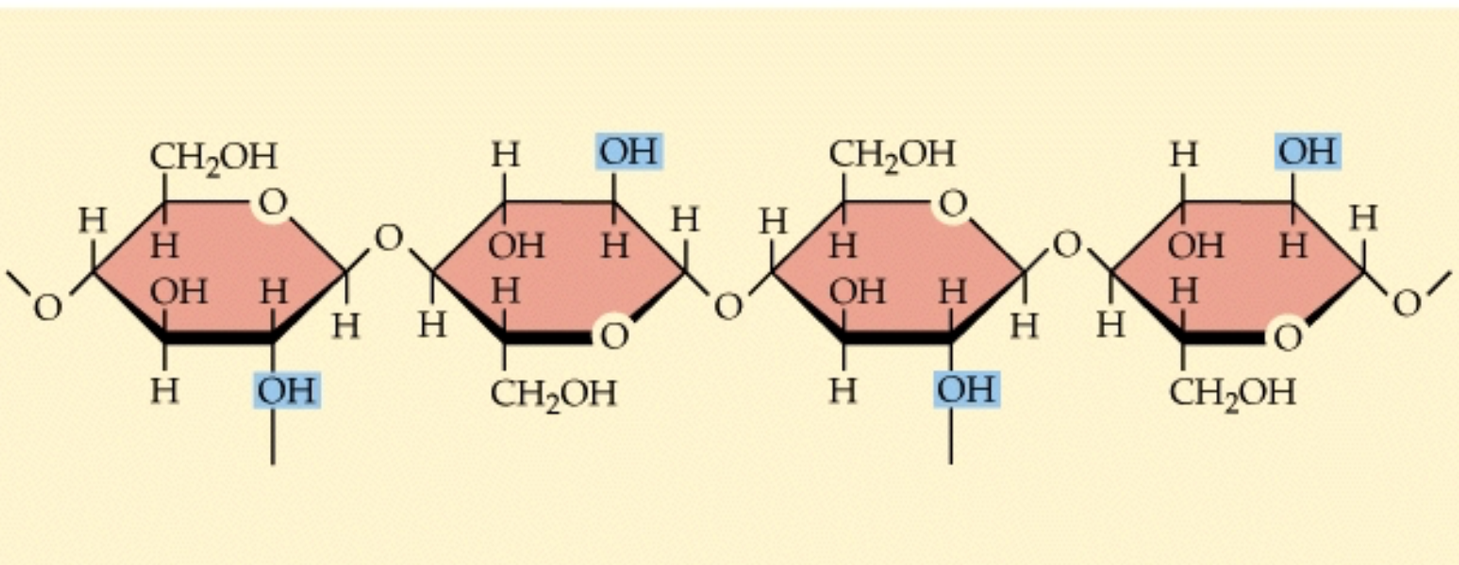
β-Glucose

β-Glucose

Cellobiose

(*a*) **Molecular structure**

Cellulose



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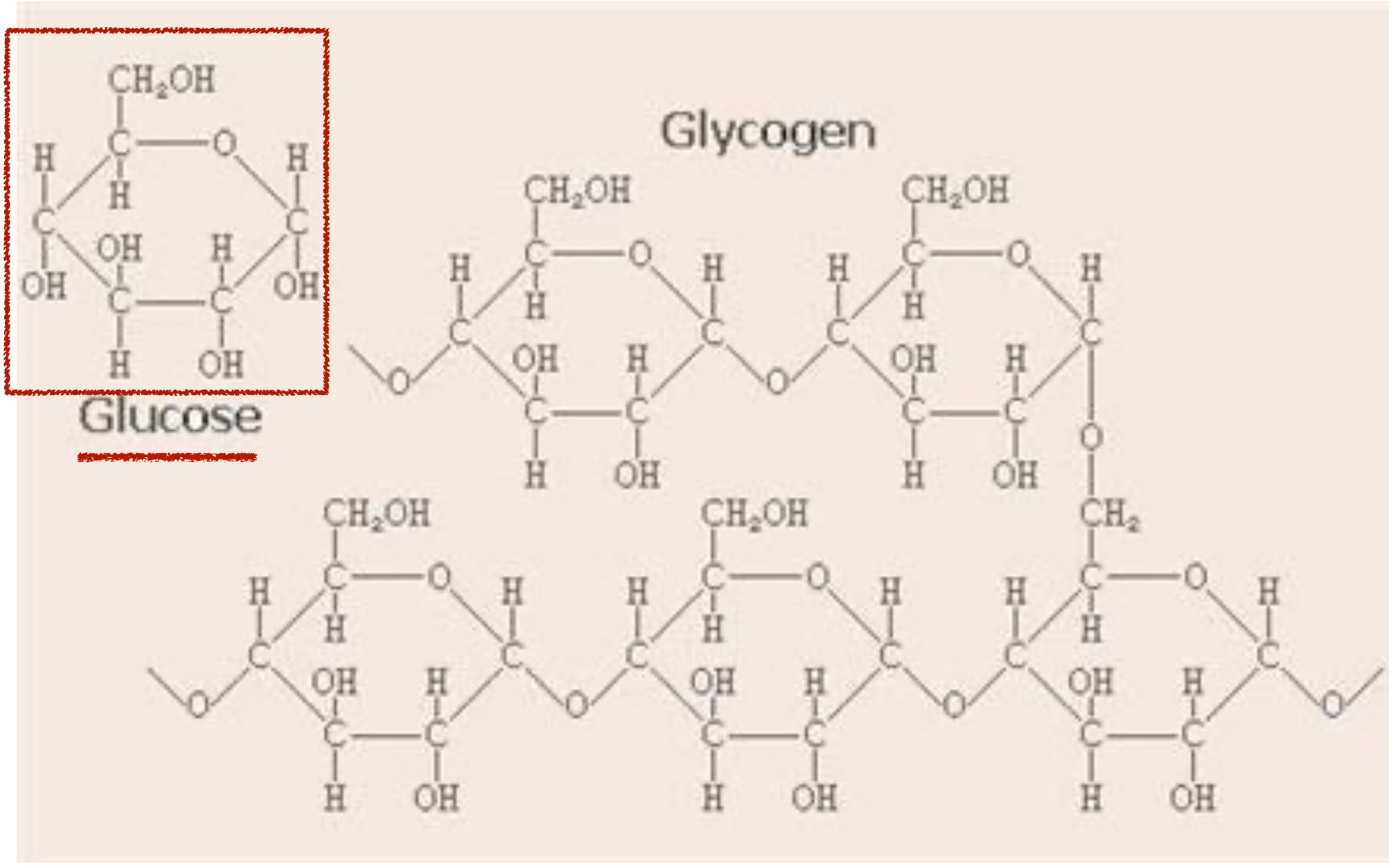

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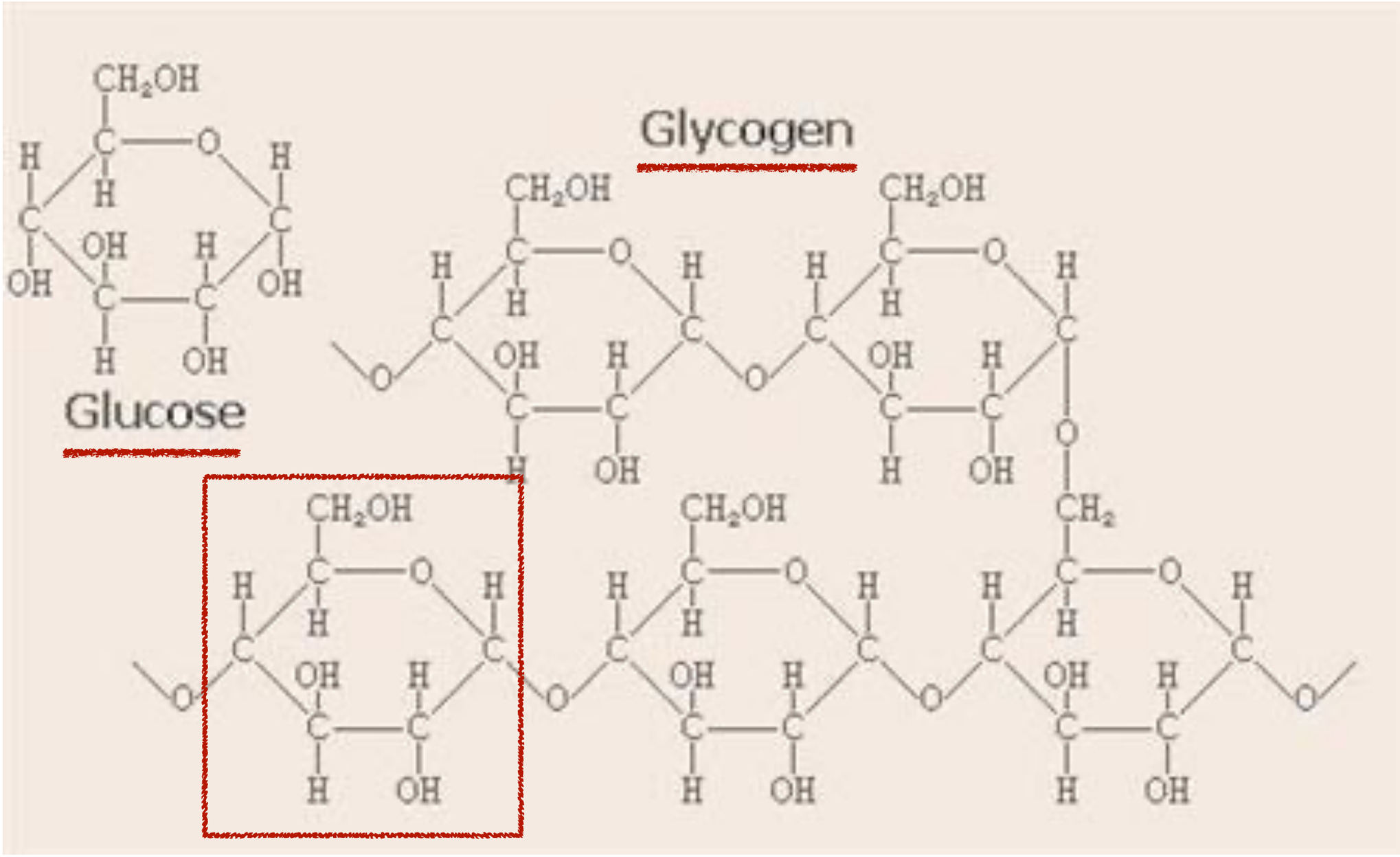

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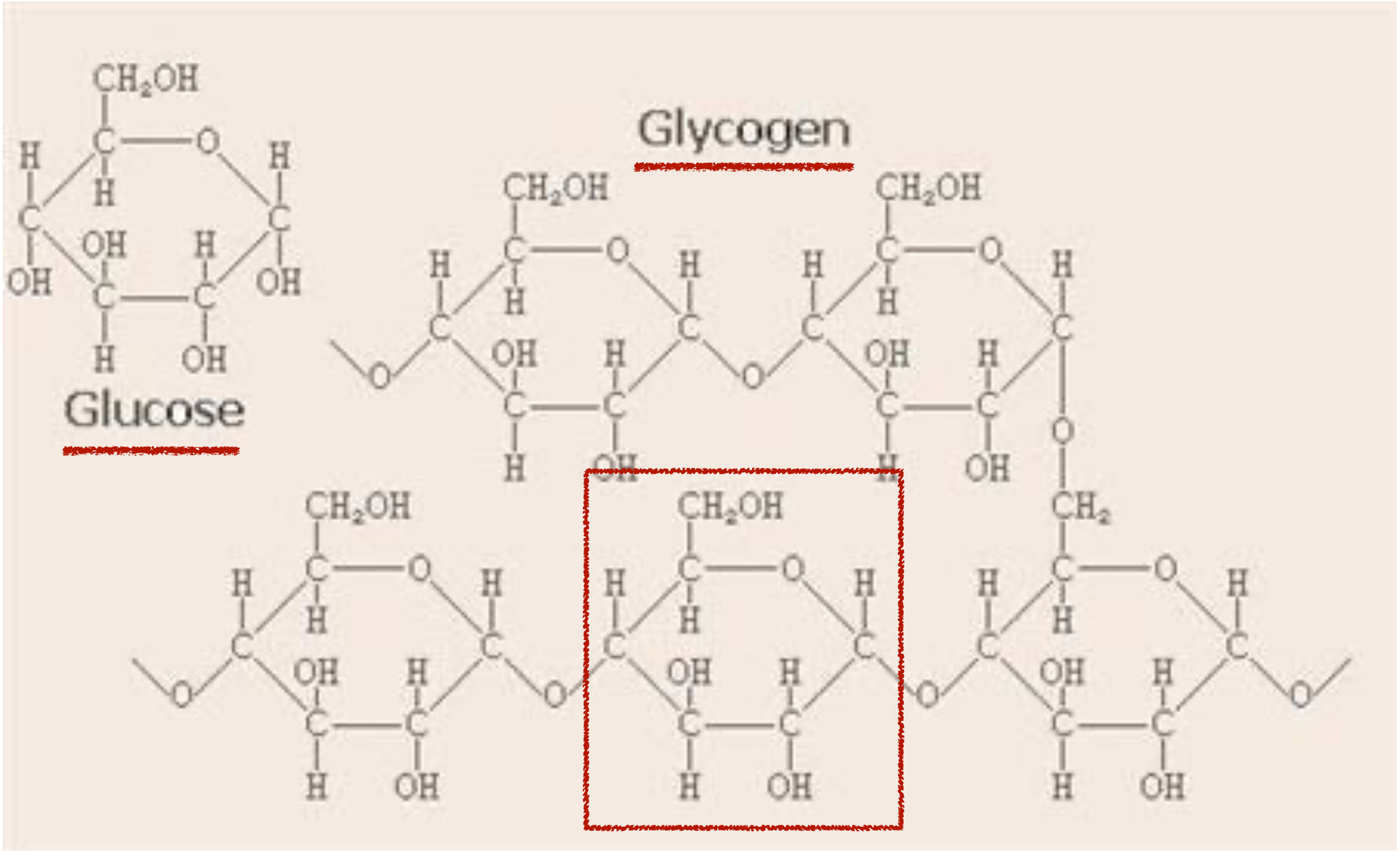

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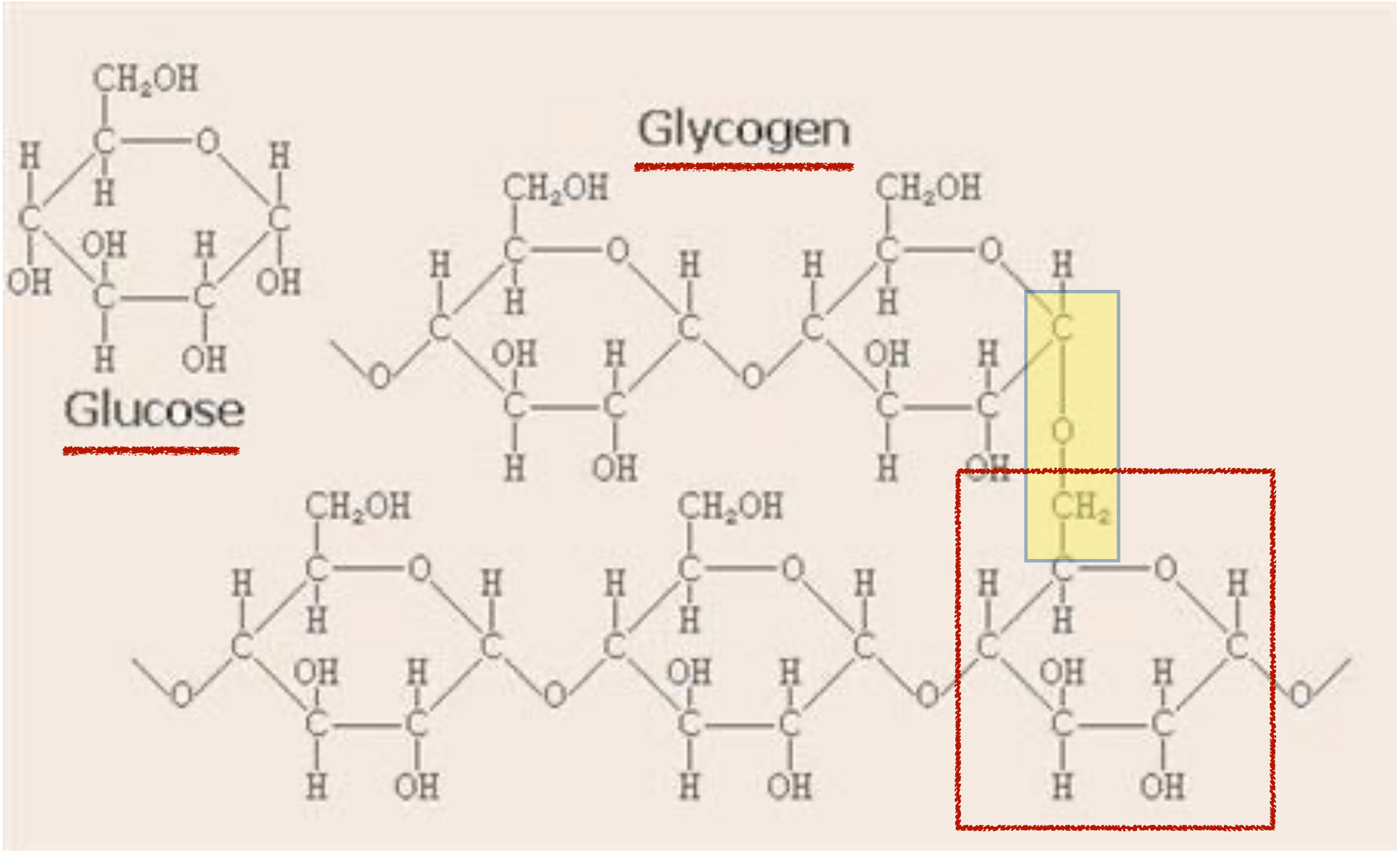
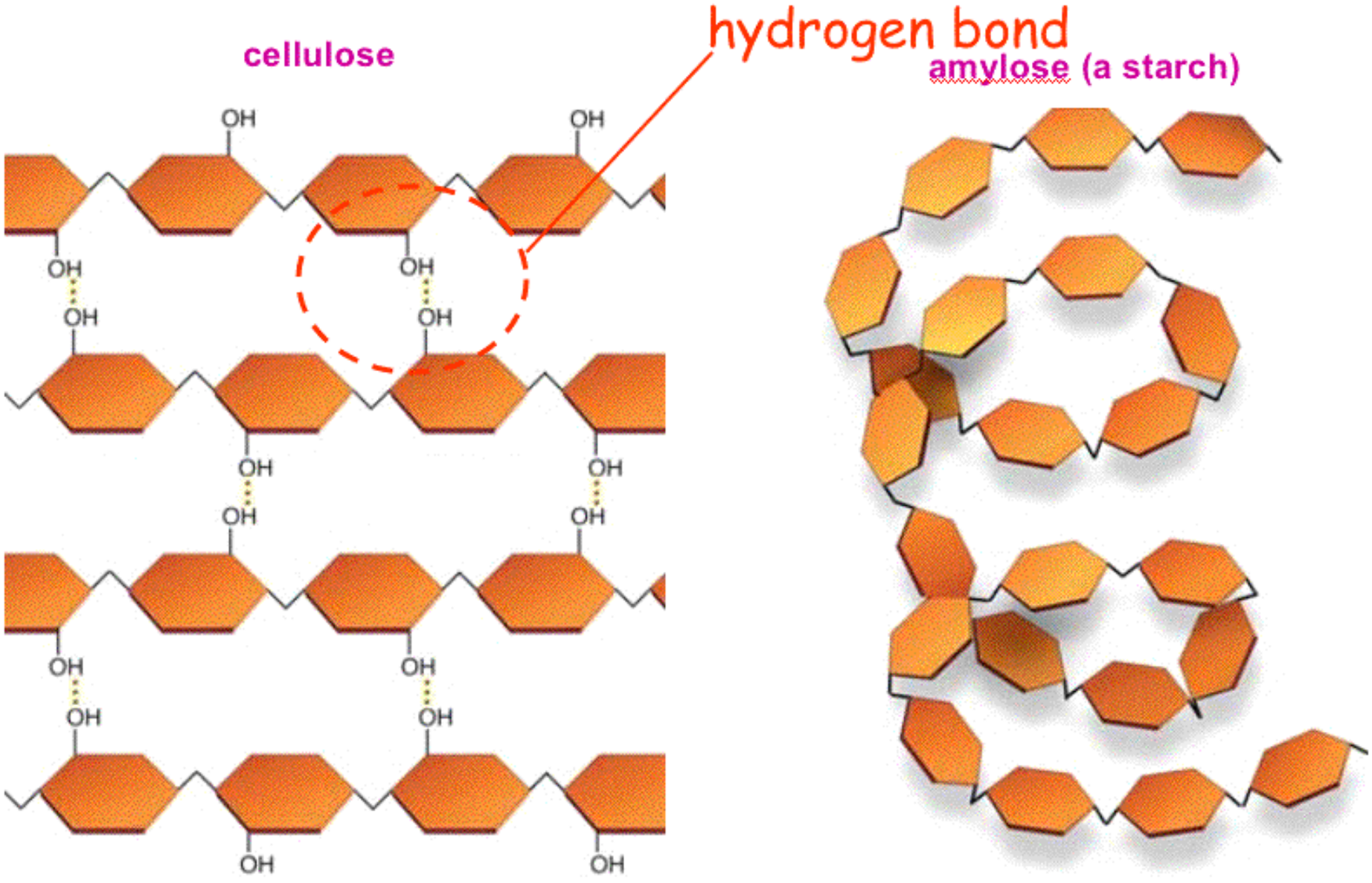


1. Glycogen is made up of only one molecule while starch is often made up of two.
2. While both are polymers of glucose, **glycogen is produced by animals** and is known as "animal starch" while **starch is produced by plants.**
3. Glycogen has a branched structure while starch has both chain and branched components.

Carbohydrates: Sugars and Sugar Polymers



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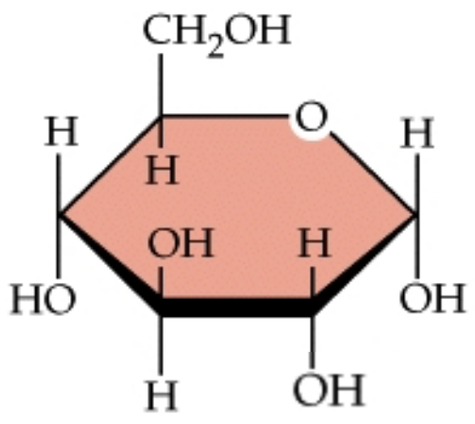
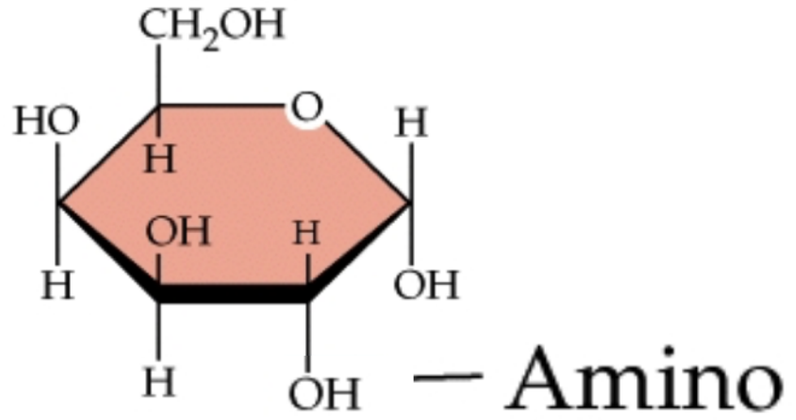
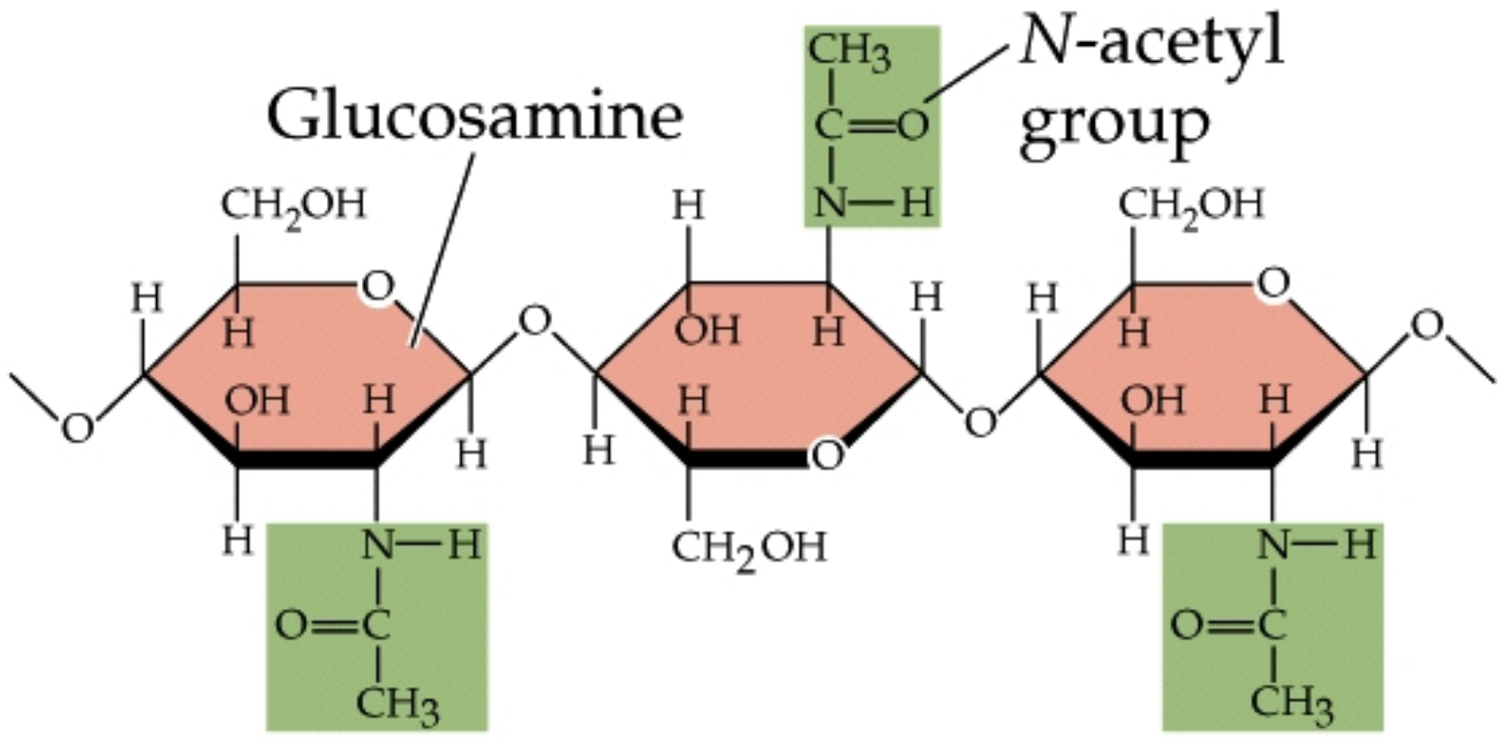
(*b*) Amino sugars



Glucosamine



Galactosamine



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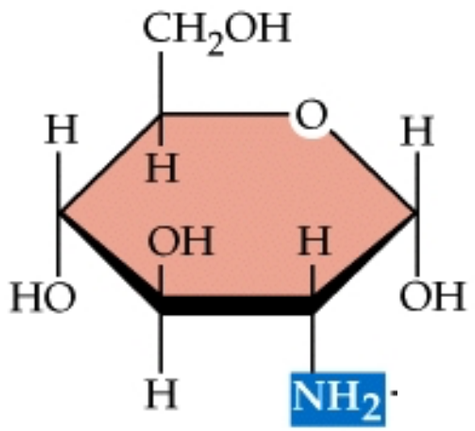
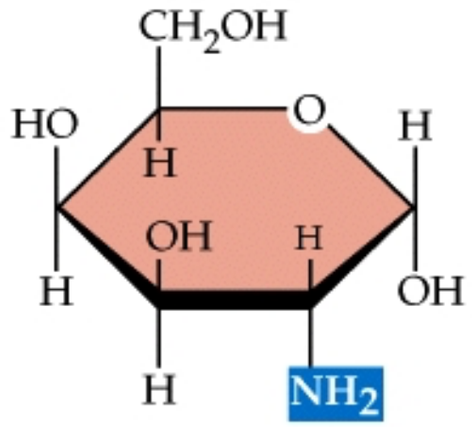


Glucosamine

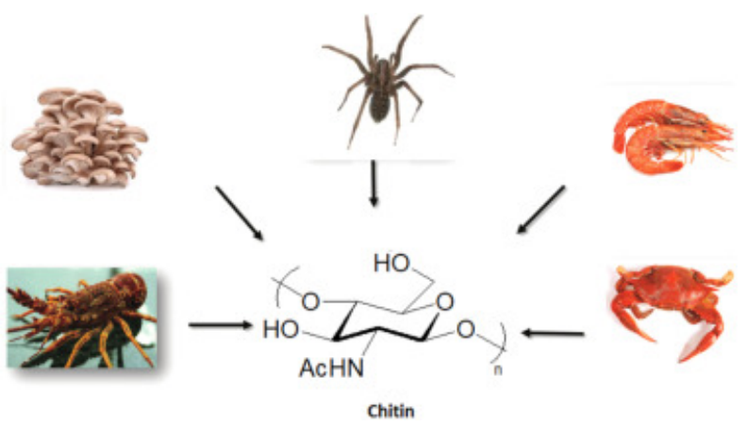


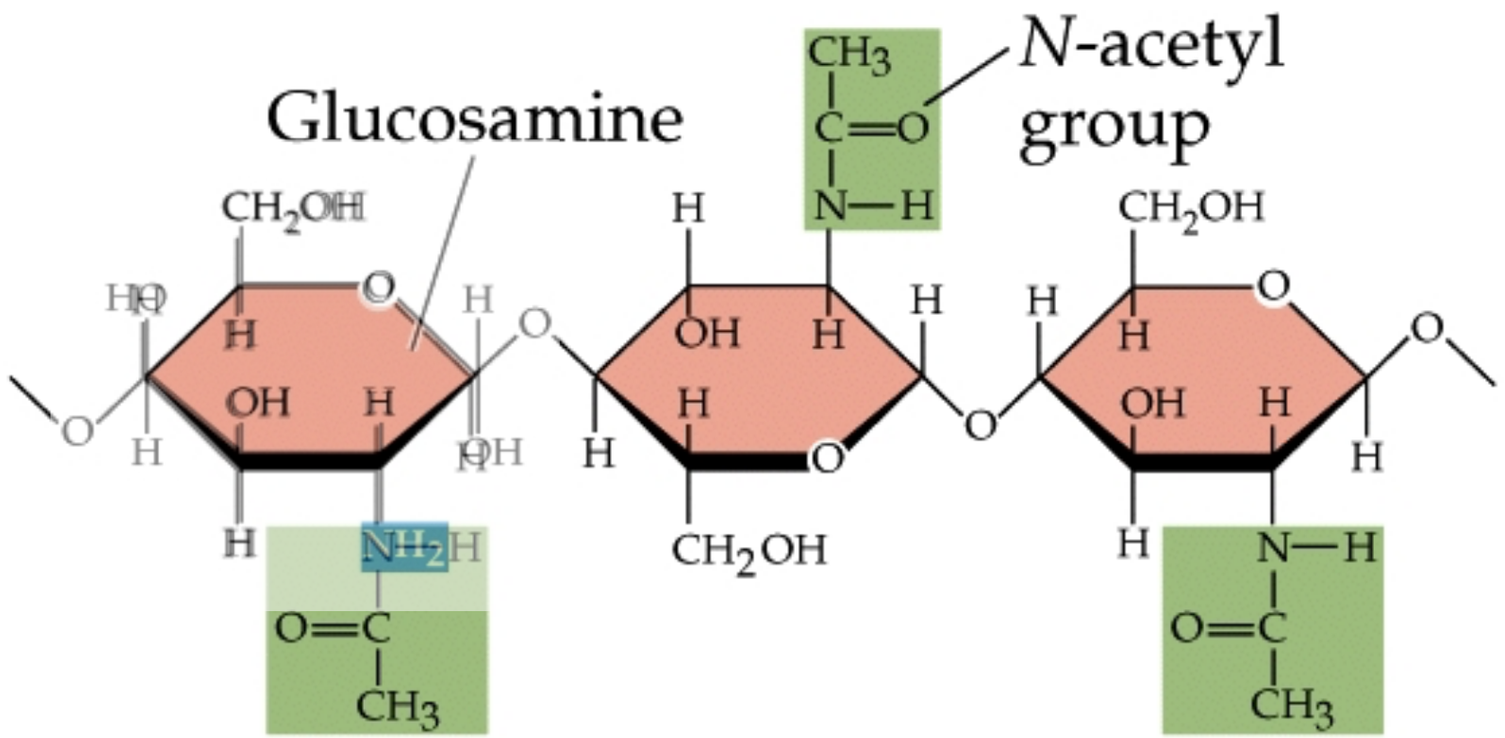
Galactosamine

Chitin

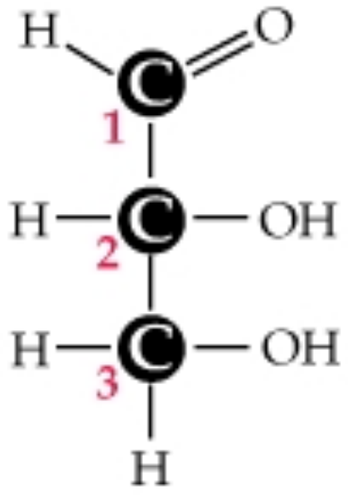
Chemical compound

Chitin $_n$ is a long-chain polymer of N-acetylglucosamine, an amide derivative of glucose. Chitin is probably the second most abundant polysaccharide in nature; an estimated 1 billion tons of chitin are produced each year in the biosphere.





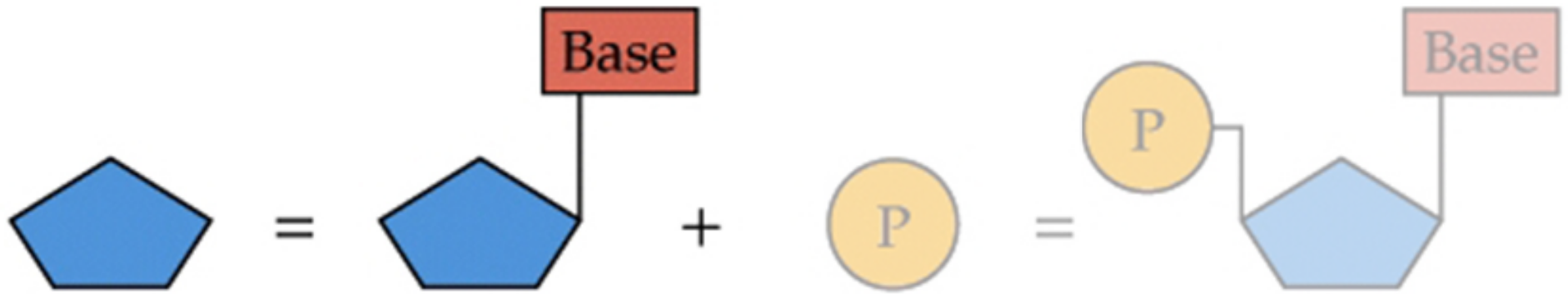
Three-carbon sugar



Five-carbon sugars

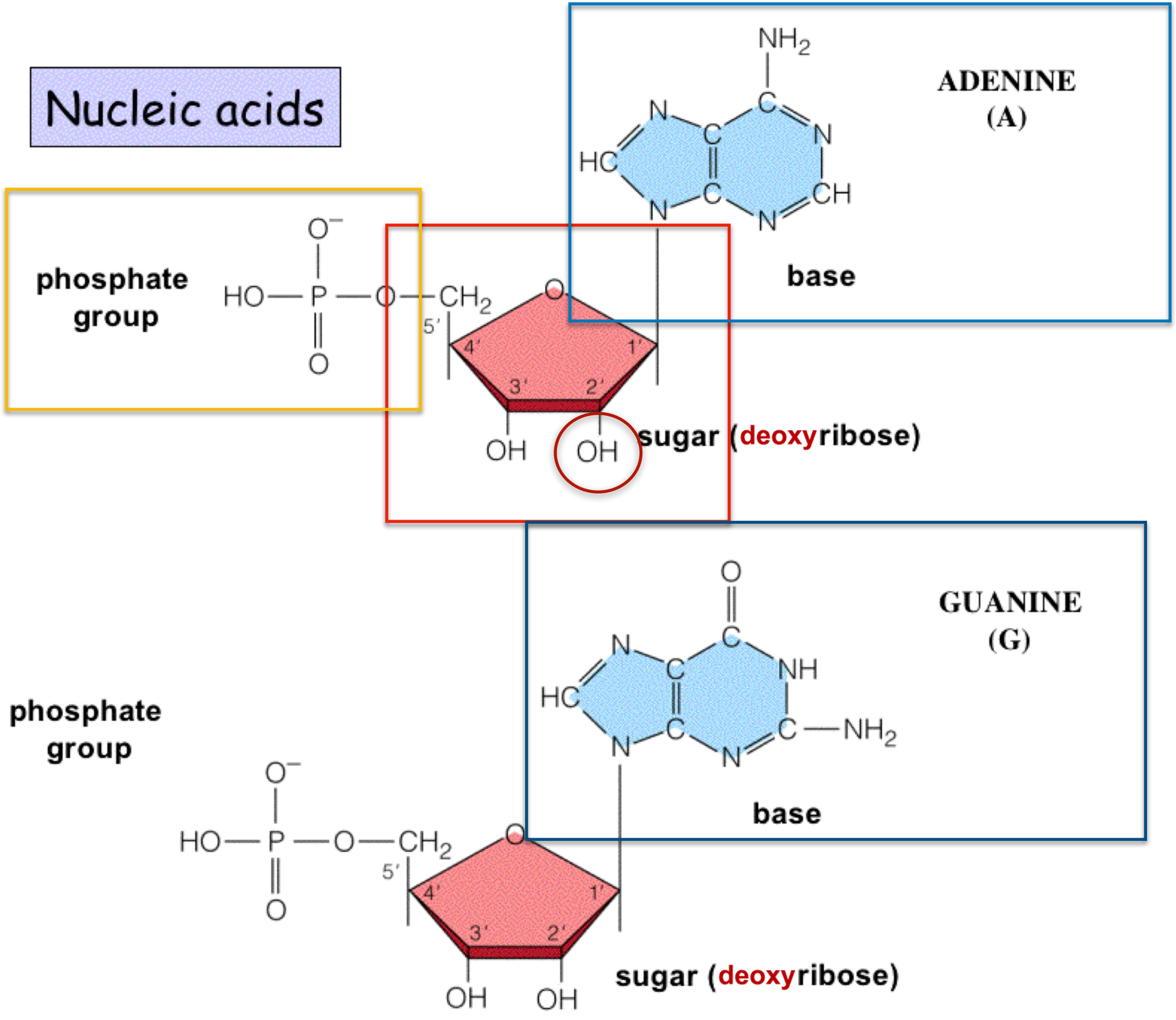
Ribose

Deoxyribose

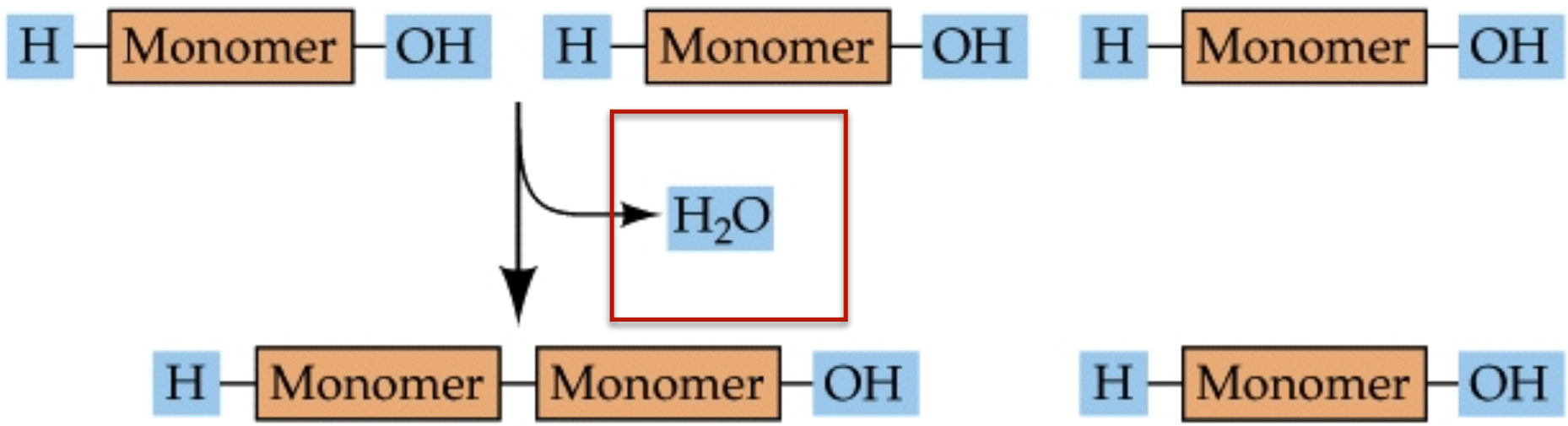


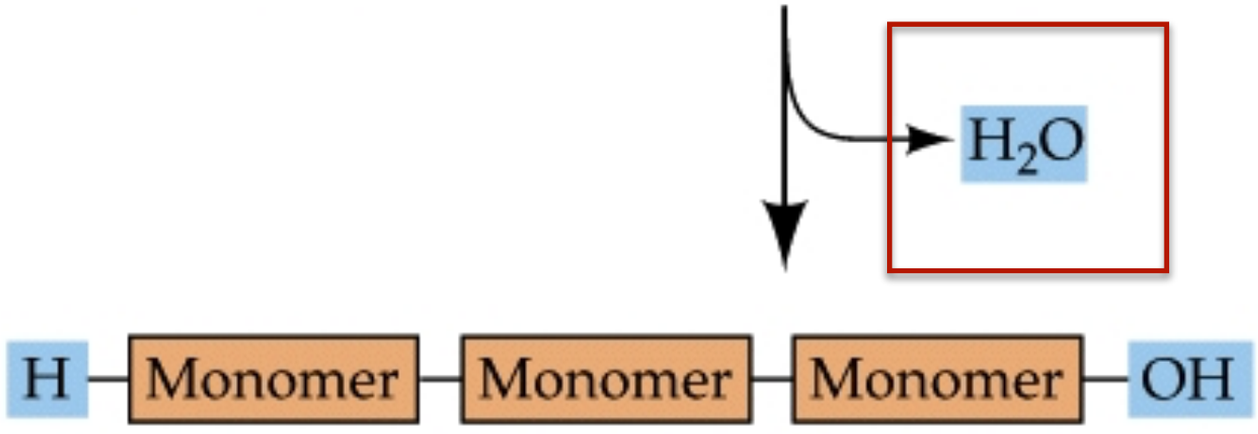
Ribose or deoxyribose **Nucleoside** Phosphate **Nucleotide**

Nucleic acids

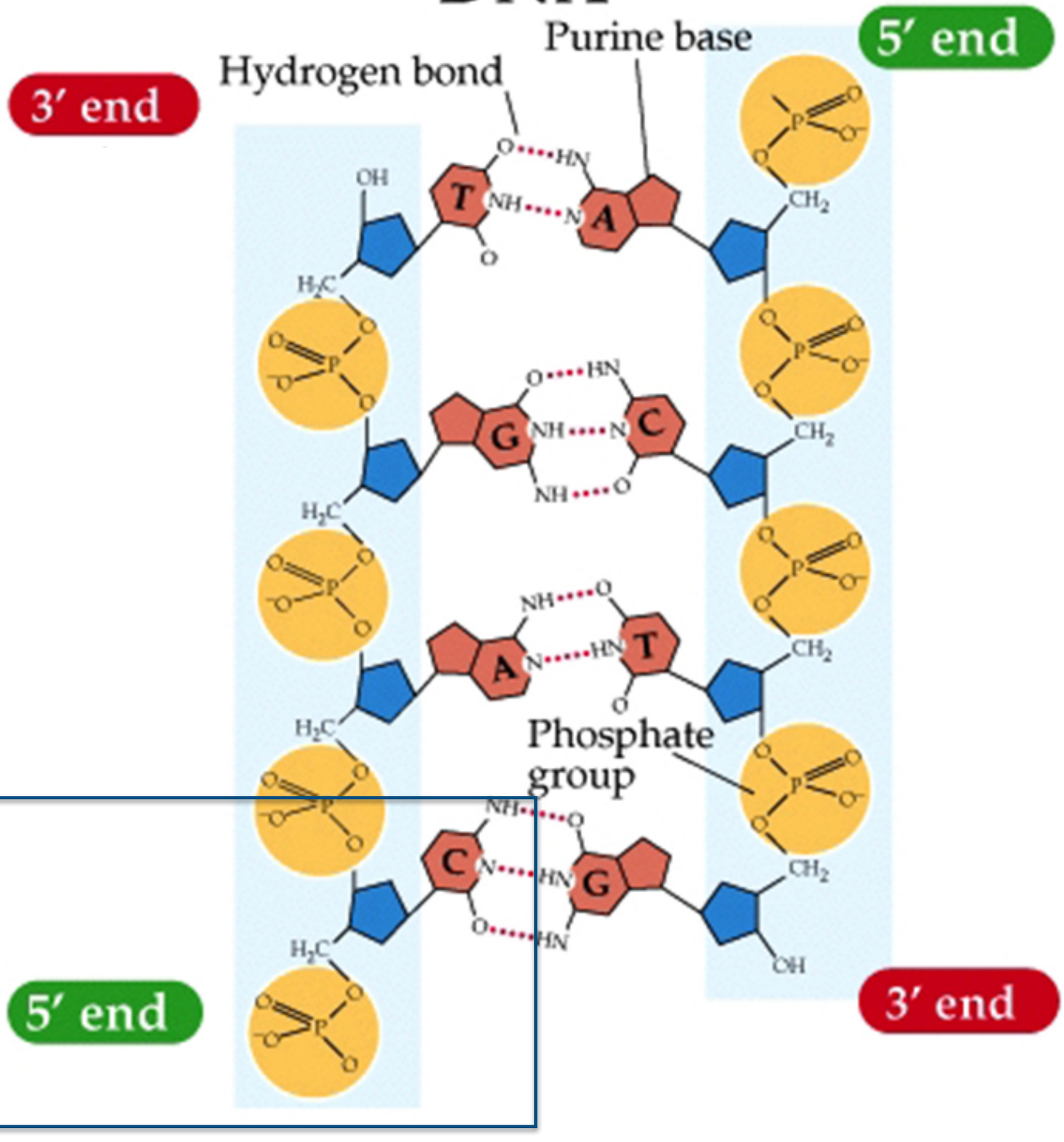


(*a*) **Condensation**

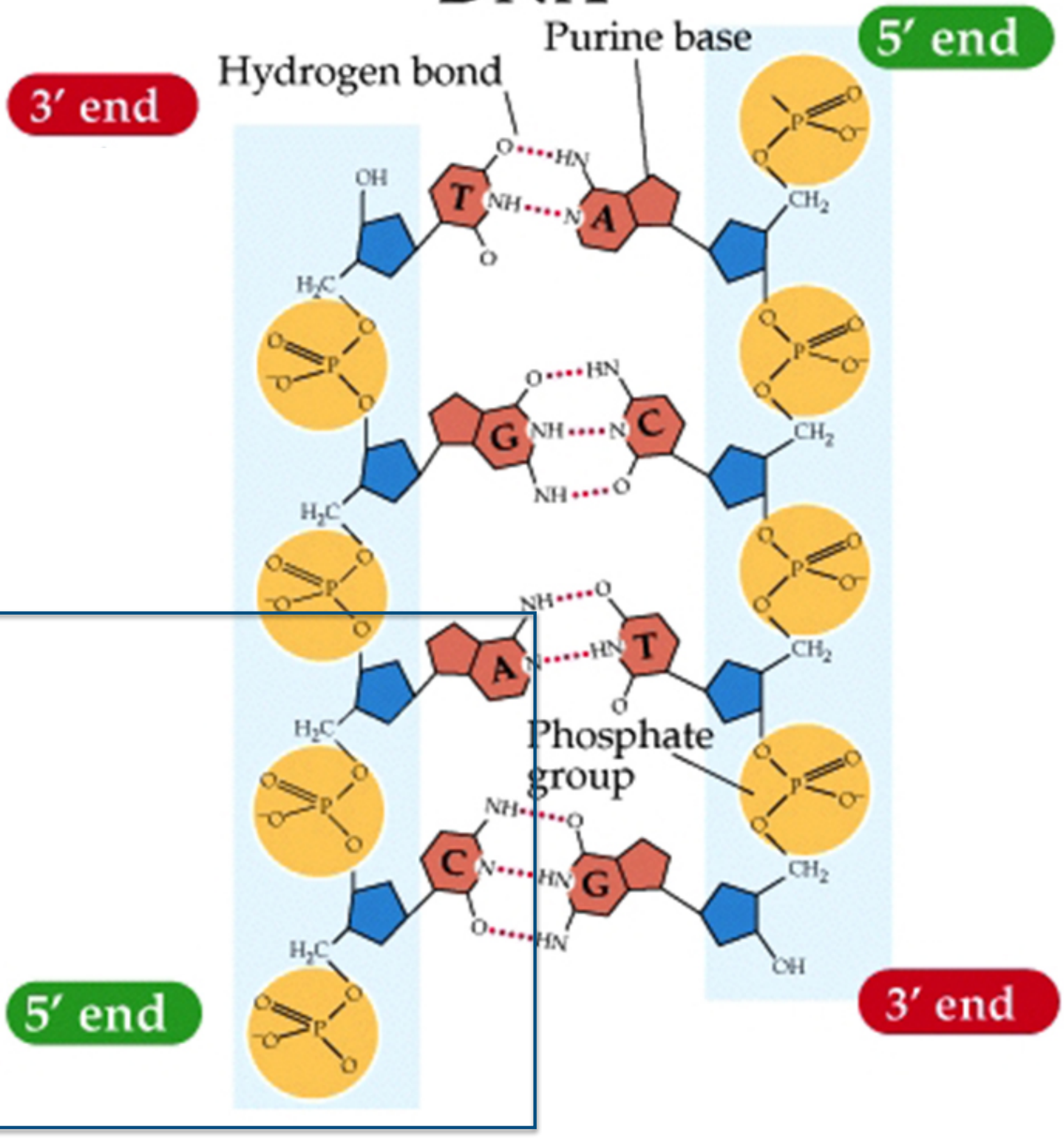




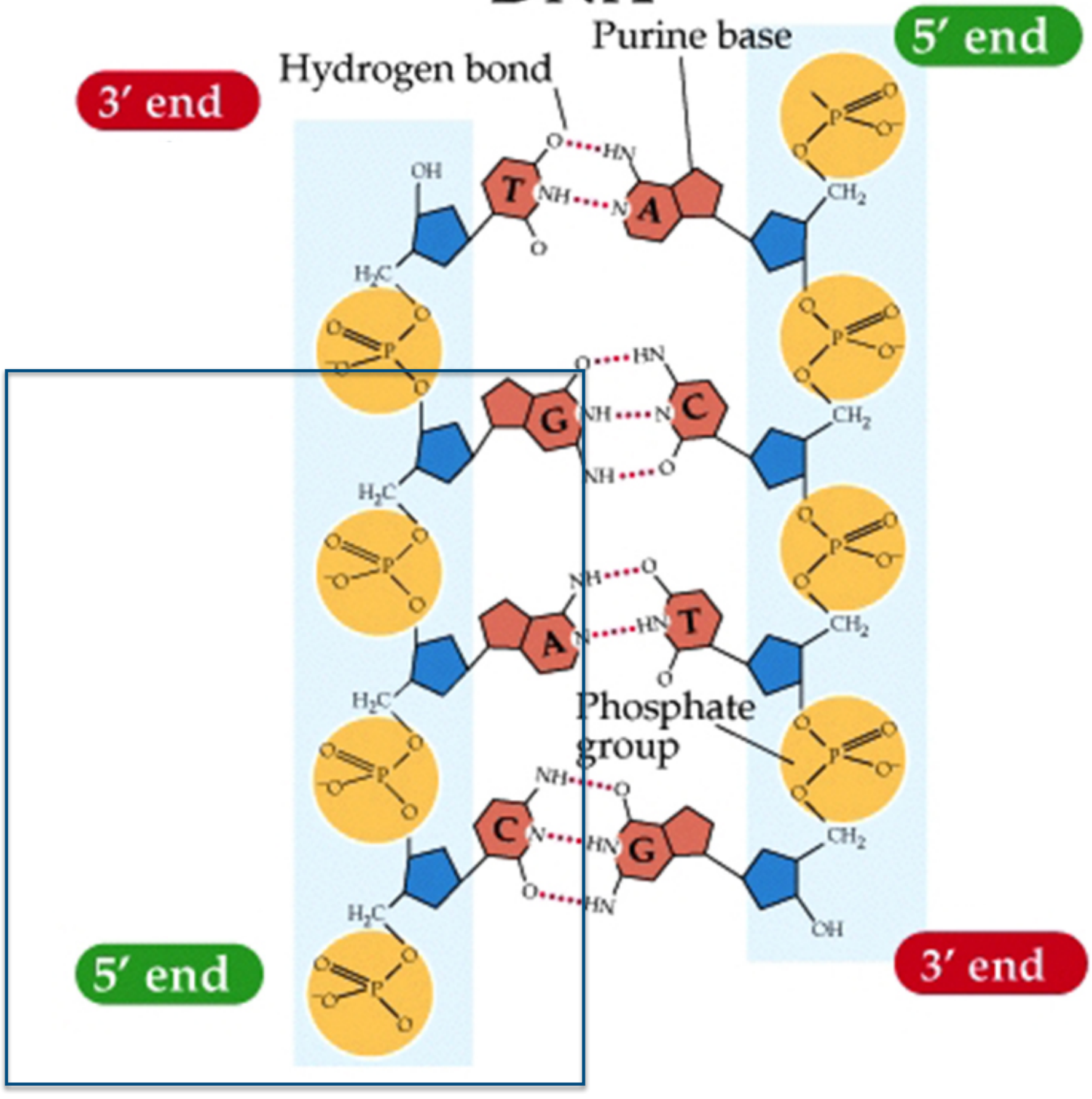
DNA


3′ end
Hydrogen bond
Purine base
5′ end
T
A
G
C
A
T
C
G
Phosphate group
5′ end
3′ end

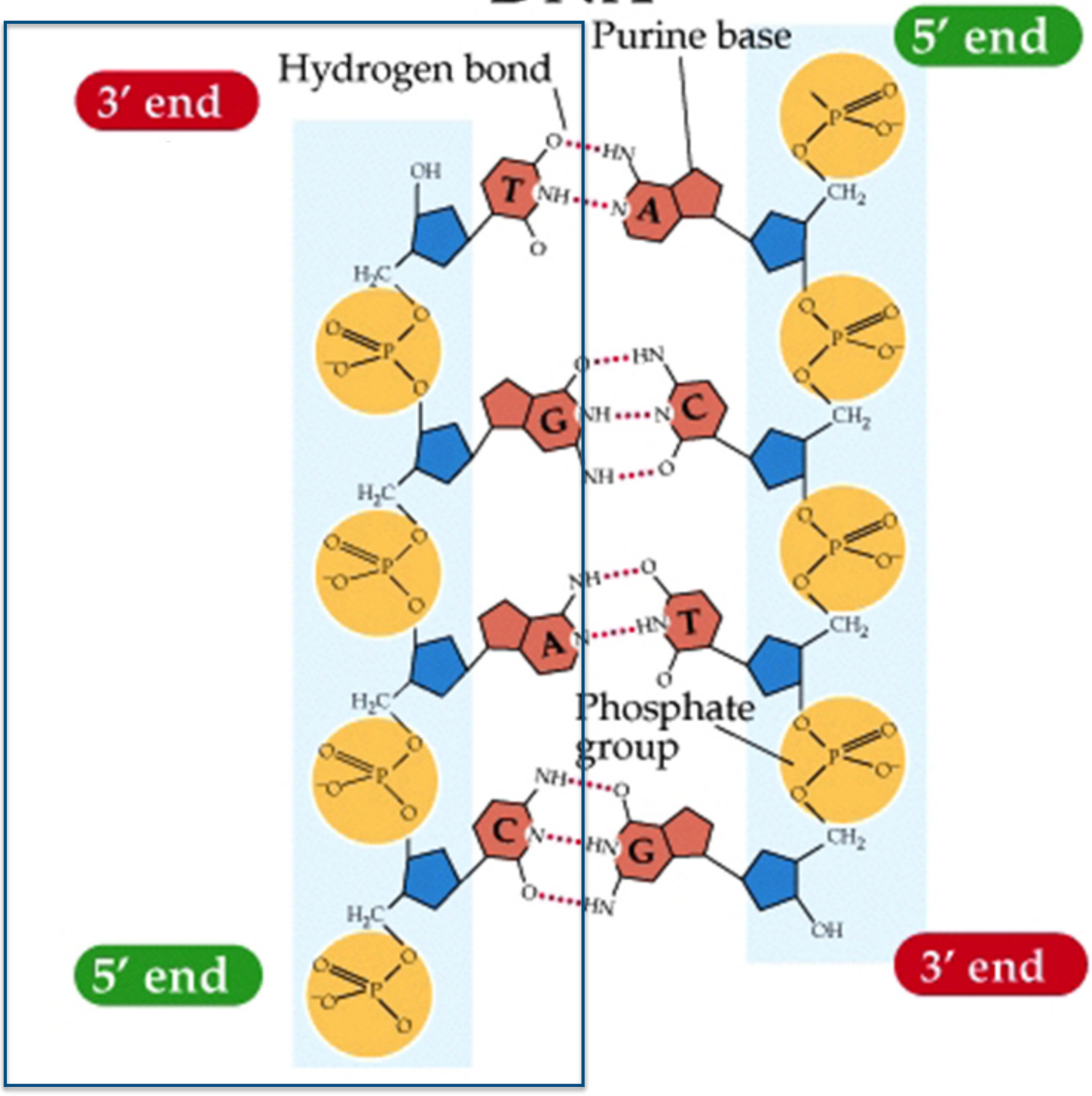
DNA


Purine base
Hydrogen bond
5′ end
3′ end
Phosphate group
5′ end
3′ end

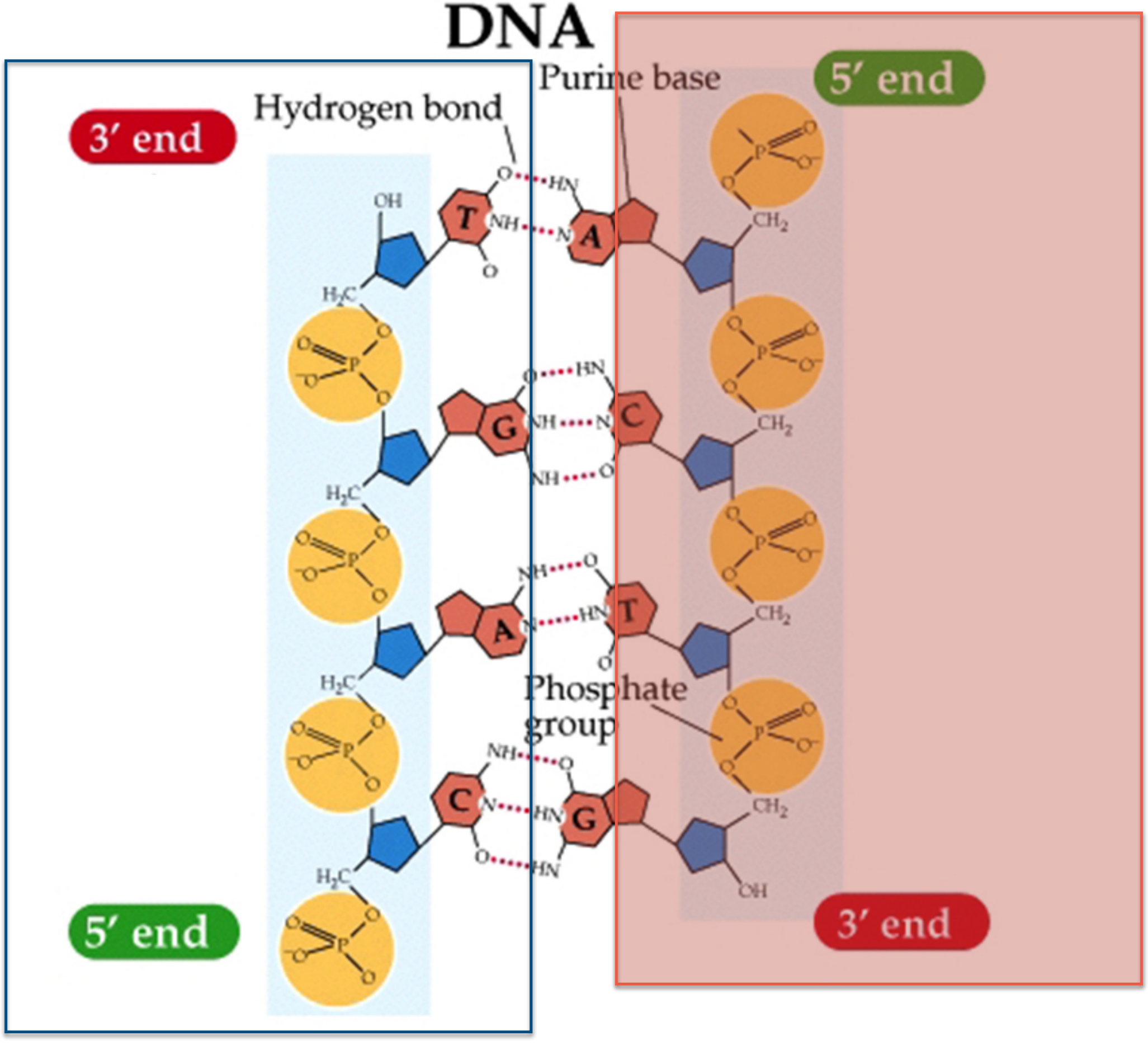
DNA


3′ end
Hydrogen bond
Purine base
5′ end
Phosphate group
5′ end
3′ end

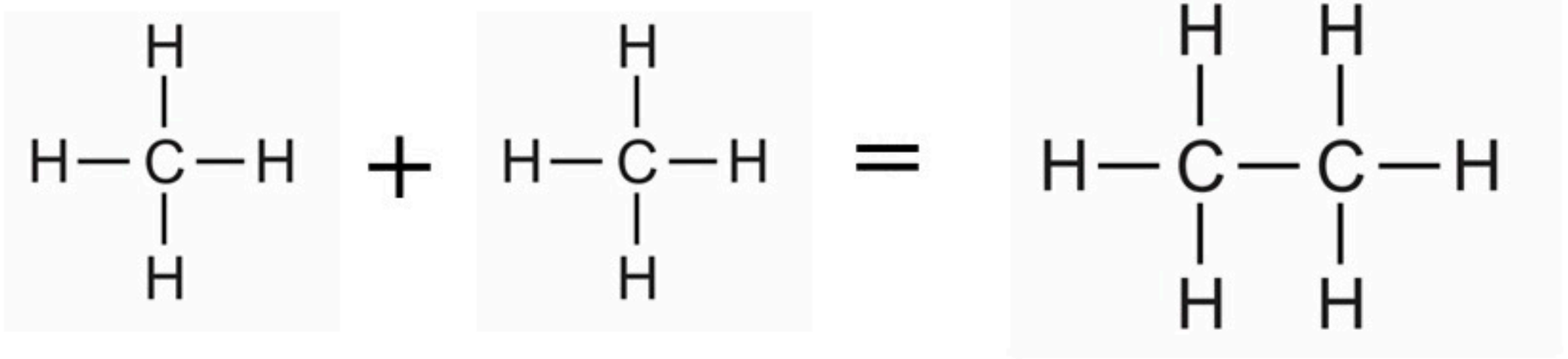
DNA


3′ end
Hydrogen bond
Purine base
5′ end
Phosphate group
5′ end
3′ end

DNA

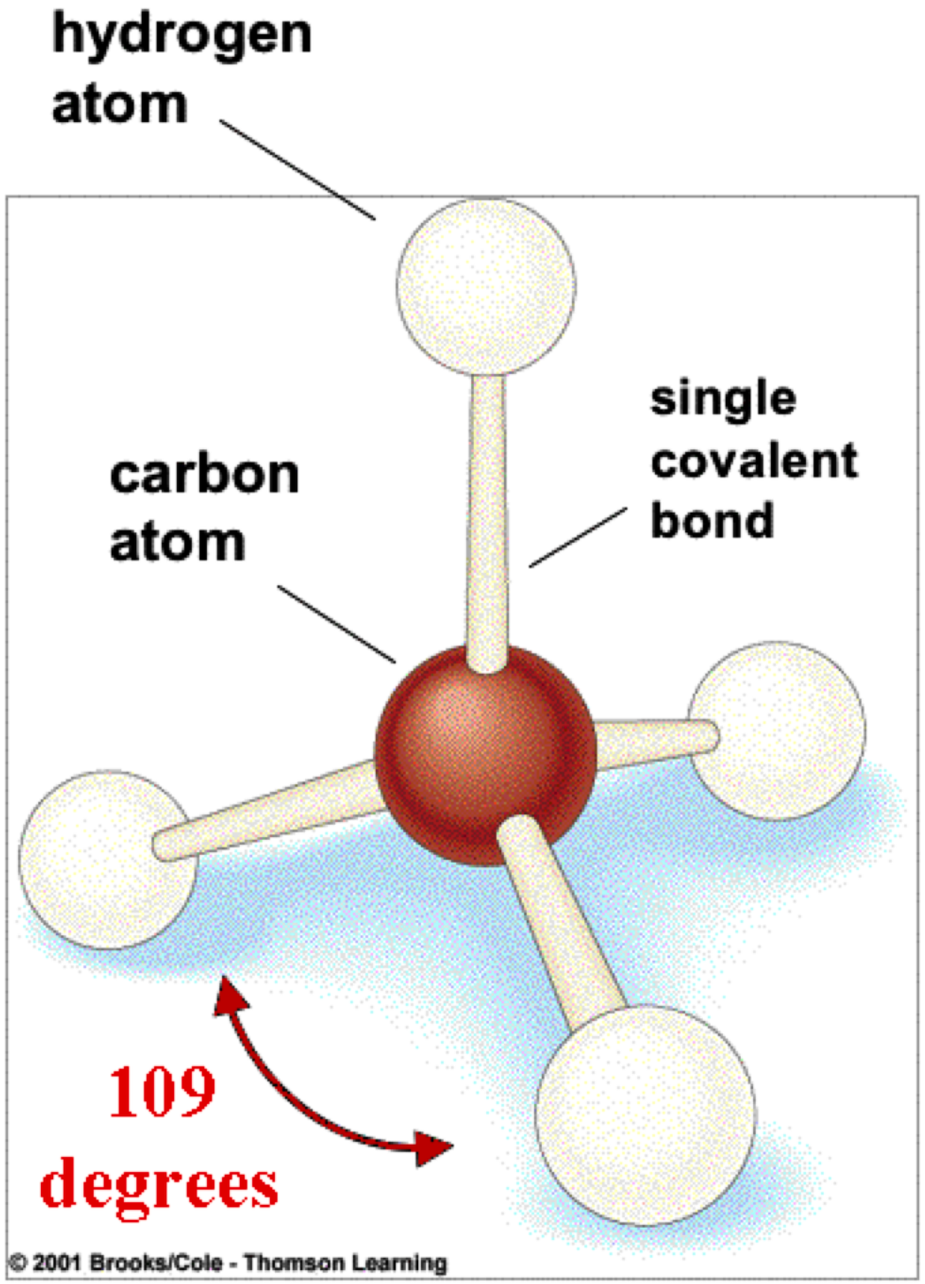

3′ end
Hydrogen bond
Purine base
5′ end
Phosphate group
5′ end
3′ end

Building larger molecules with carbon



Methane **Methane** **Ethane**

A closer look at carbon



methane(CH_4)

-atomic number of 6 (six protons)

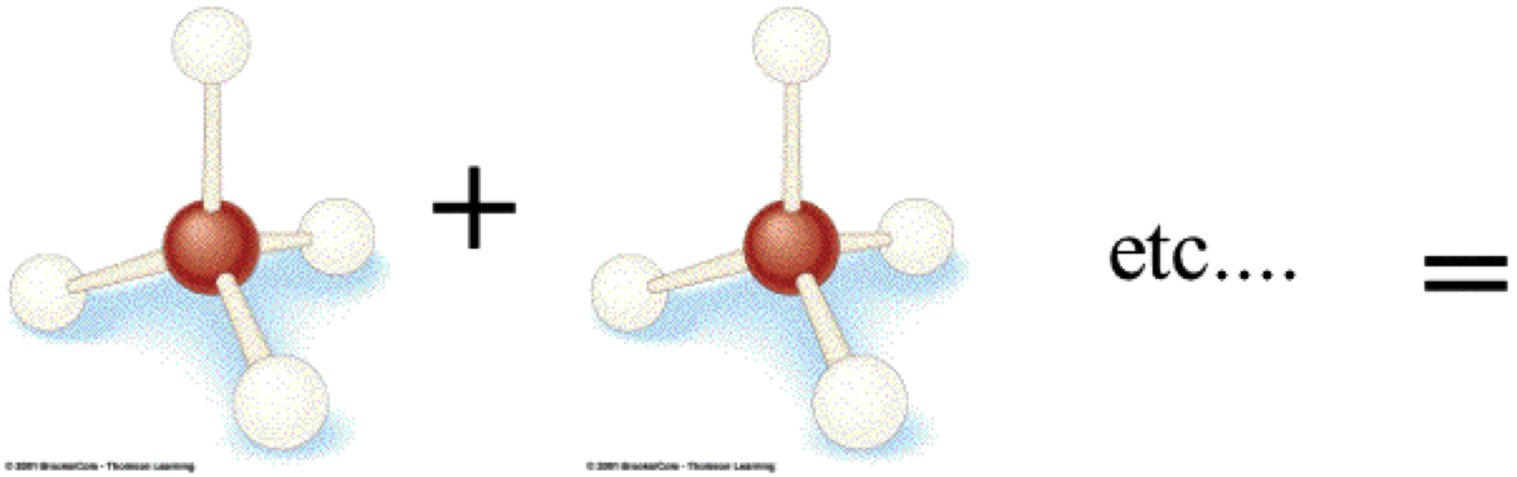
- 2 inner shell electrons

- +4 in its outer shell

- needs to share four electrons with partner atoms

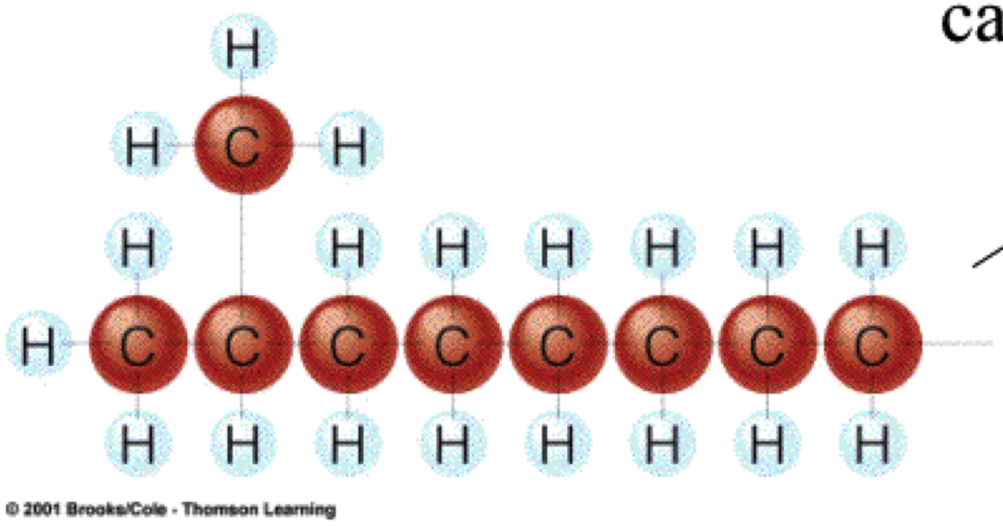
- tetrahedral geometry

Building larger molecules with carbon



+

etc.... =



carbon "backbone"

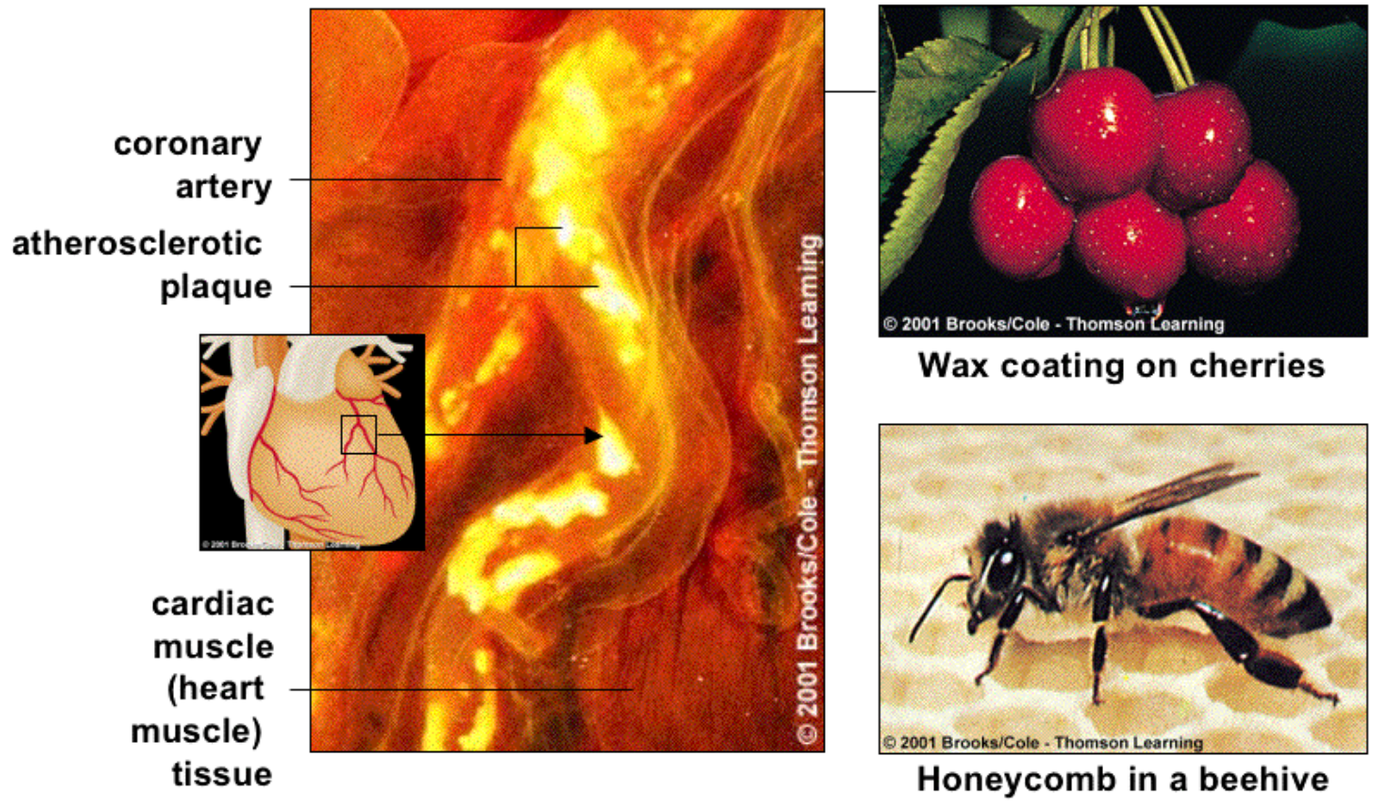
- a carbon chain

Lipids

Lipids are **not "technically" polymers**, because the different units and subunits are not necessarily held together by **covalent** bonds, but by other less well defined forces of association.
cell membranes (phospholipids),
capture of light energy (carotinoids),
hormones and vitamins (steroids and modified fatty acids),
thermal insulation,
electrical insulation of nerves etc,

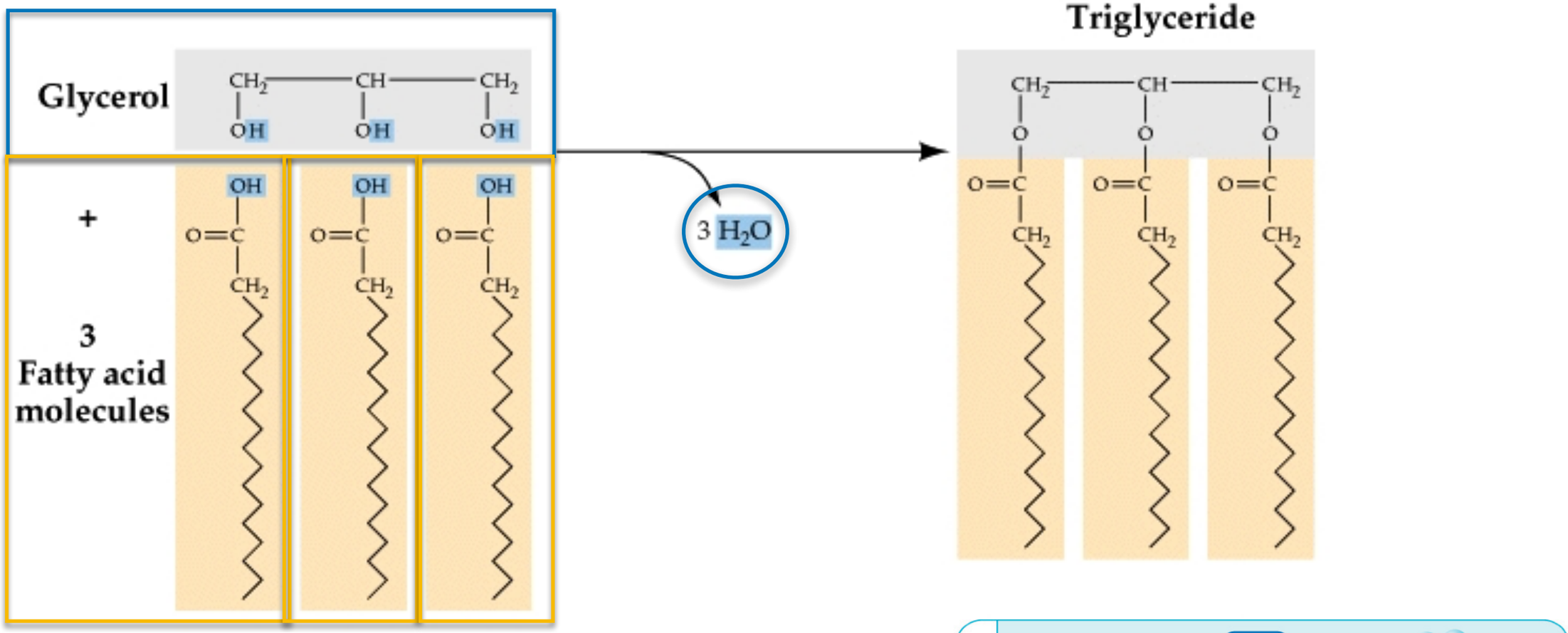
and

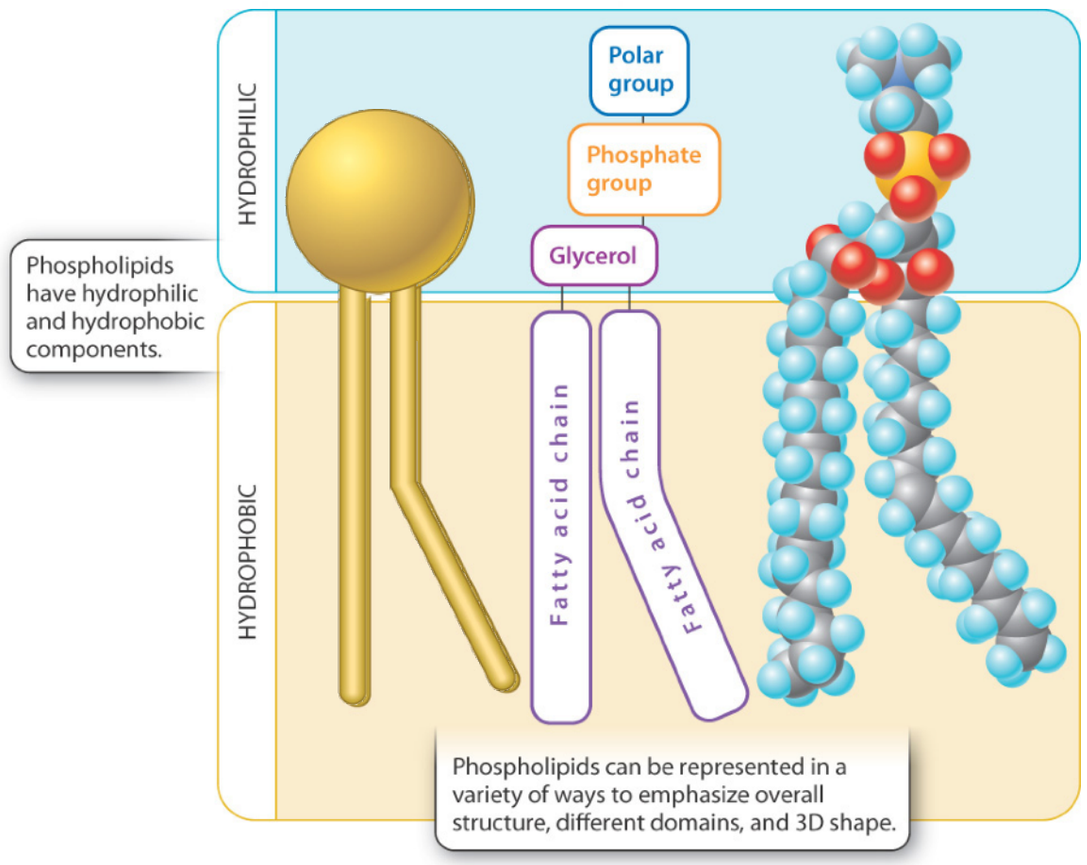
water repellency (waxes and oils



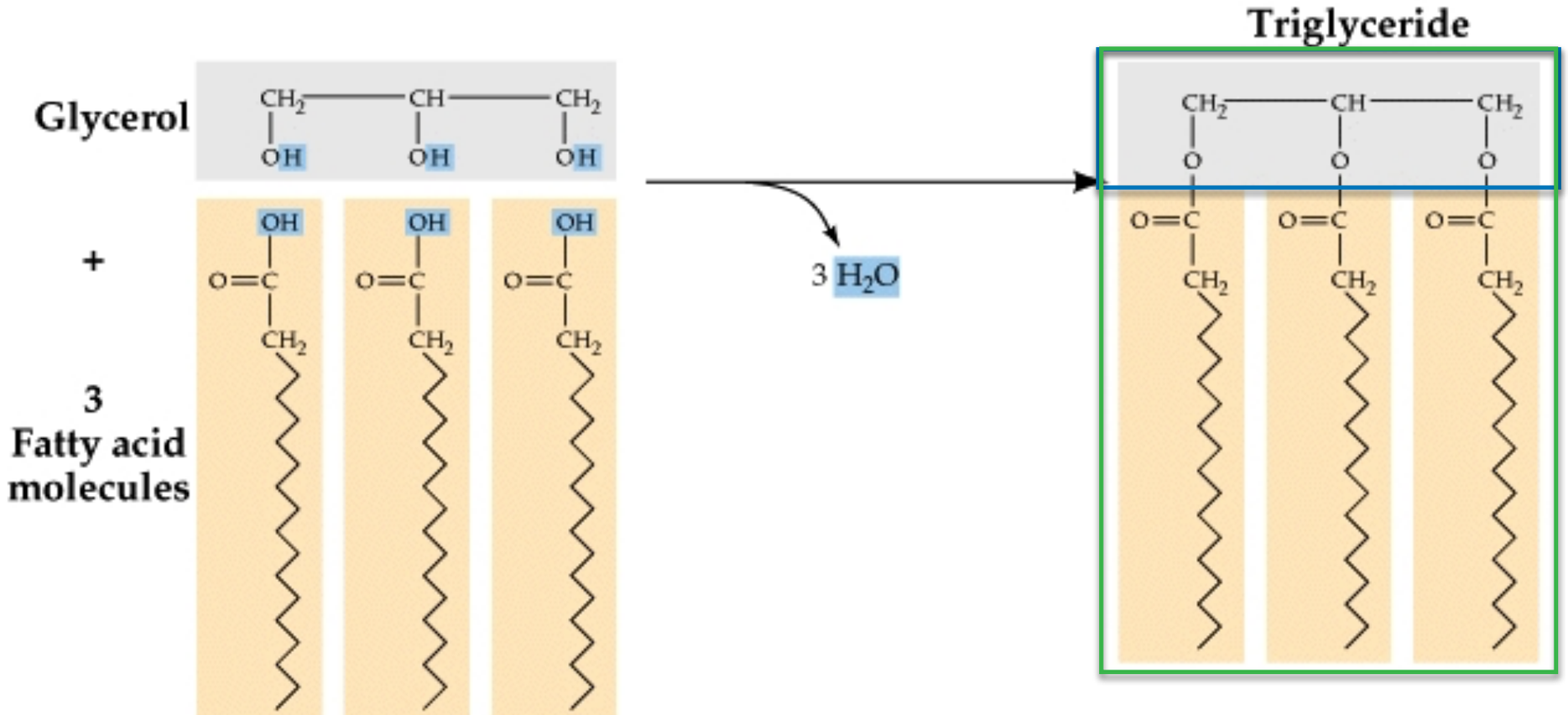
Cholesterol-rich atherosclerotic plaques

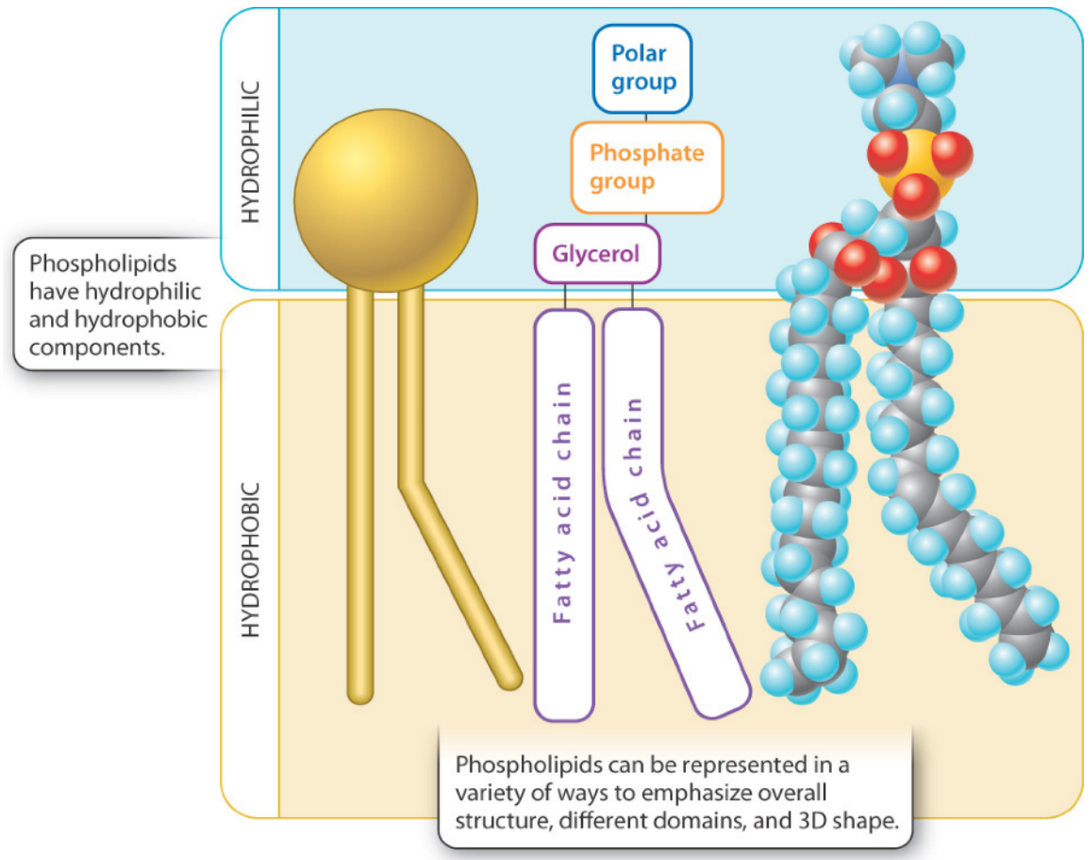
Lipids are in essence the "water-insoluble" molecules of life.



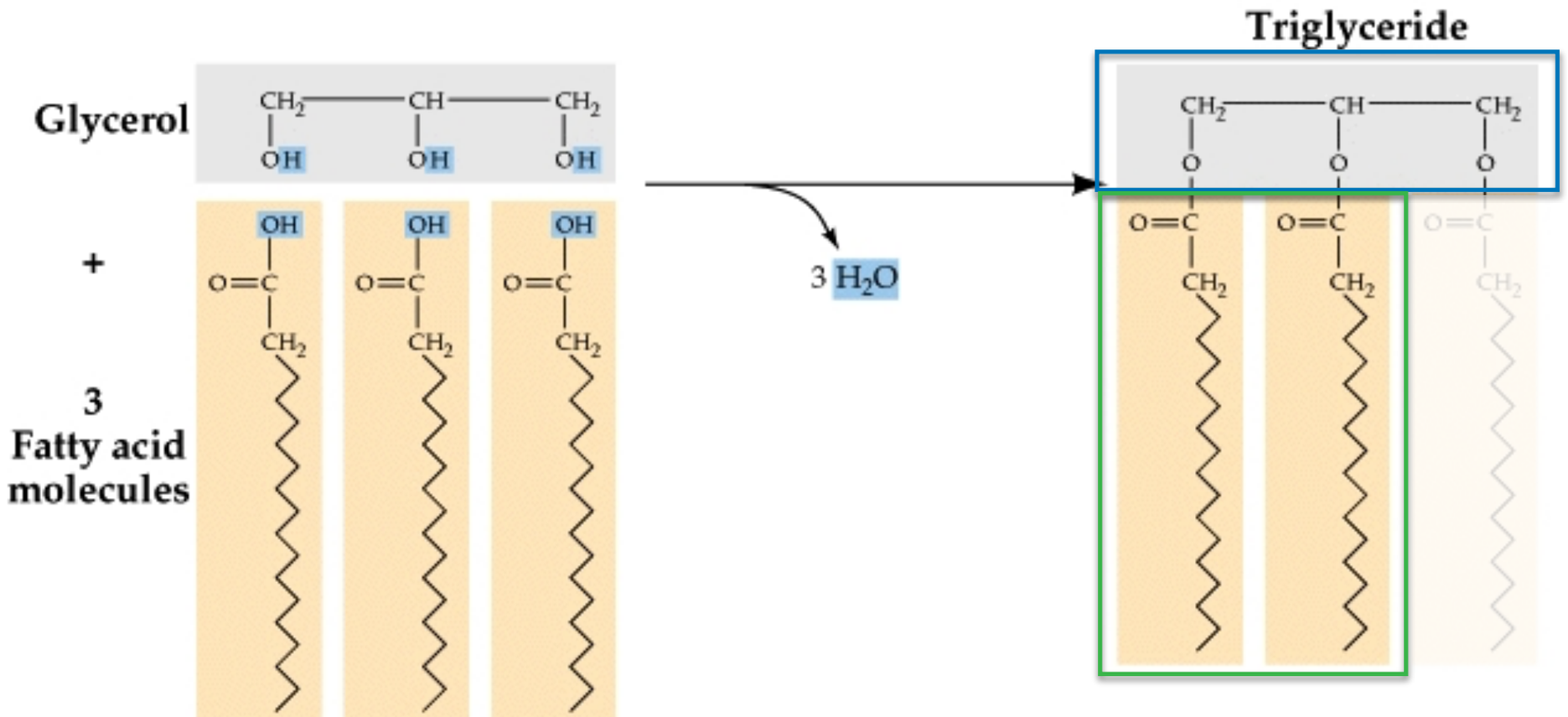


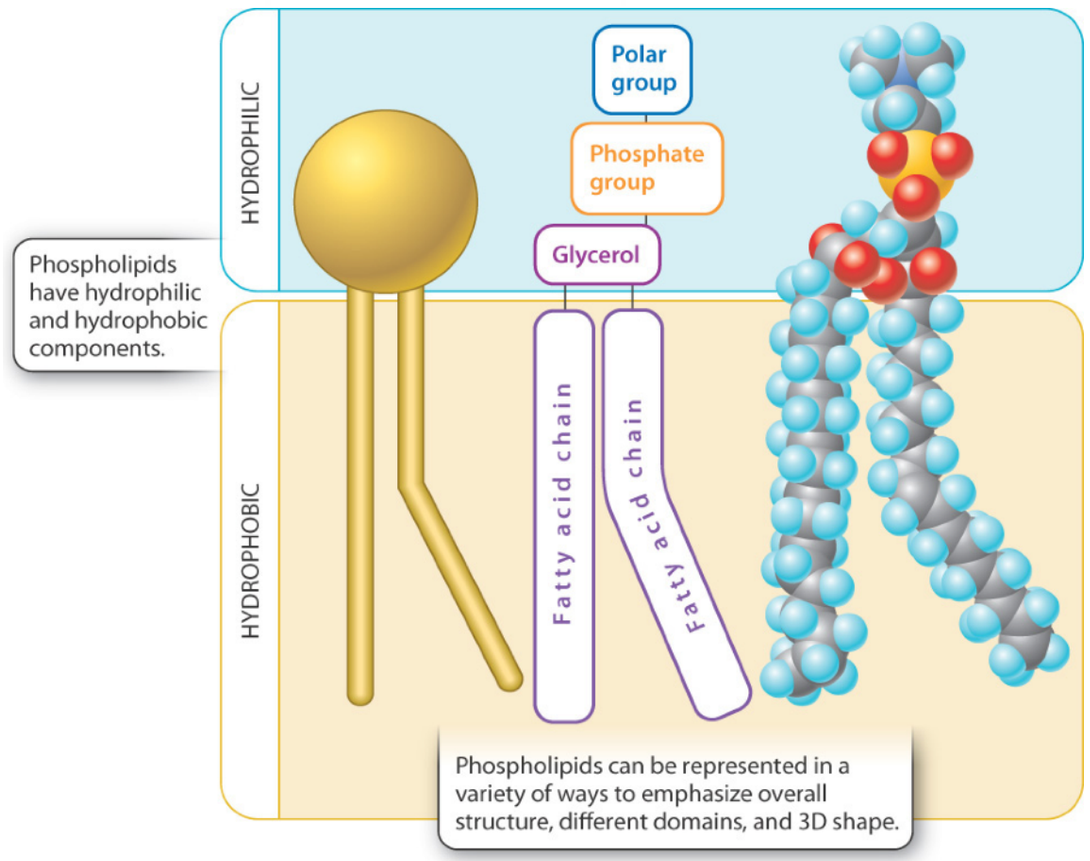
Lipids are in essence the "water-insoluble" molecules of life.



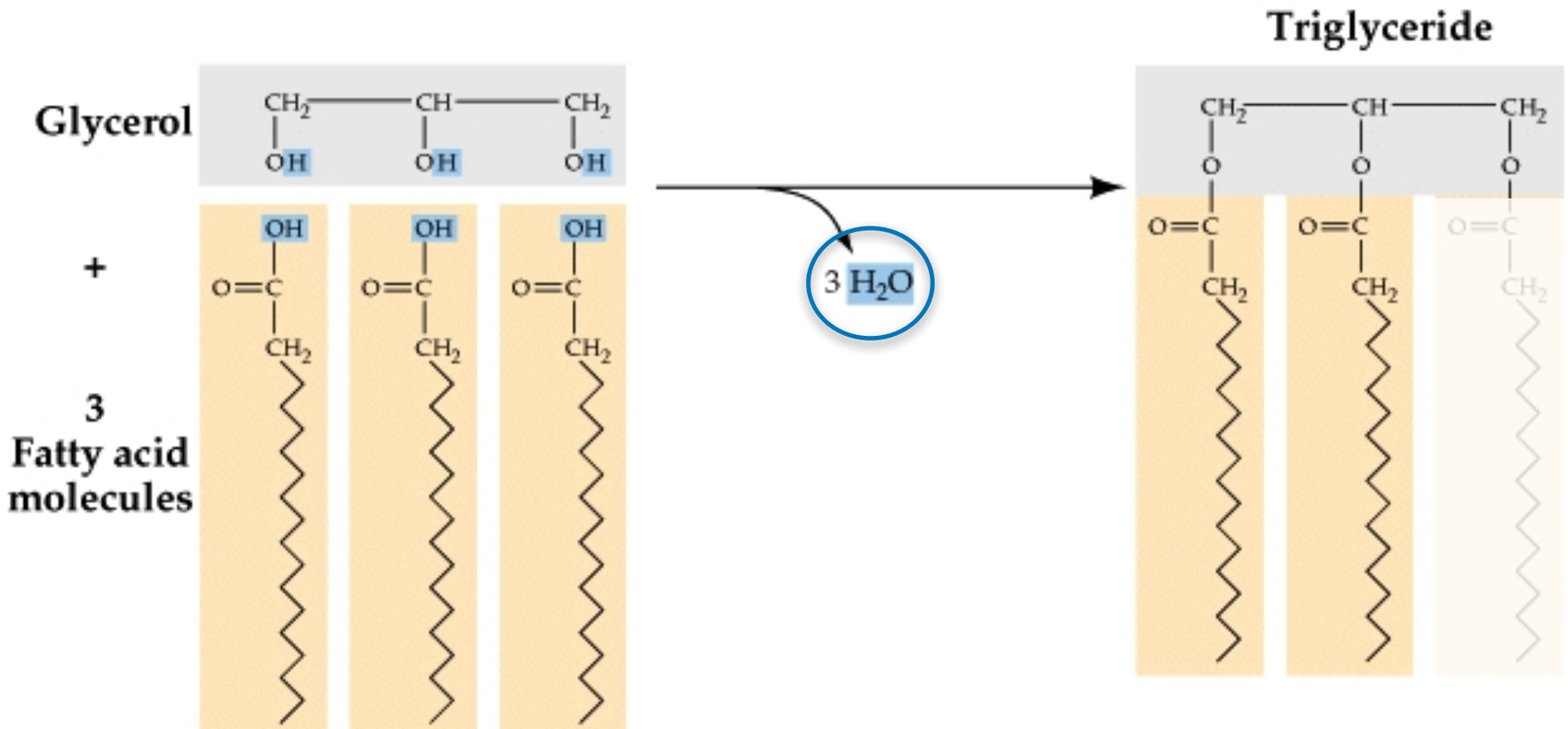


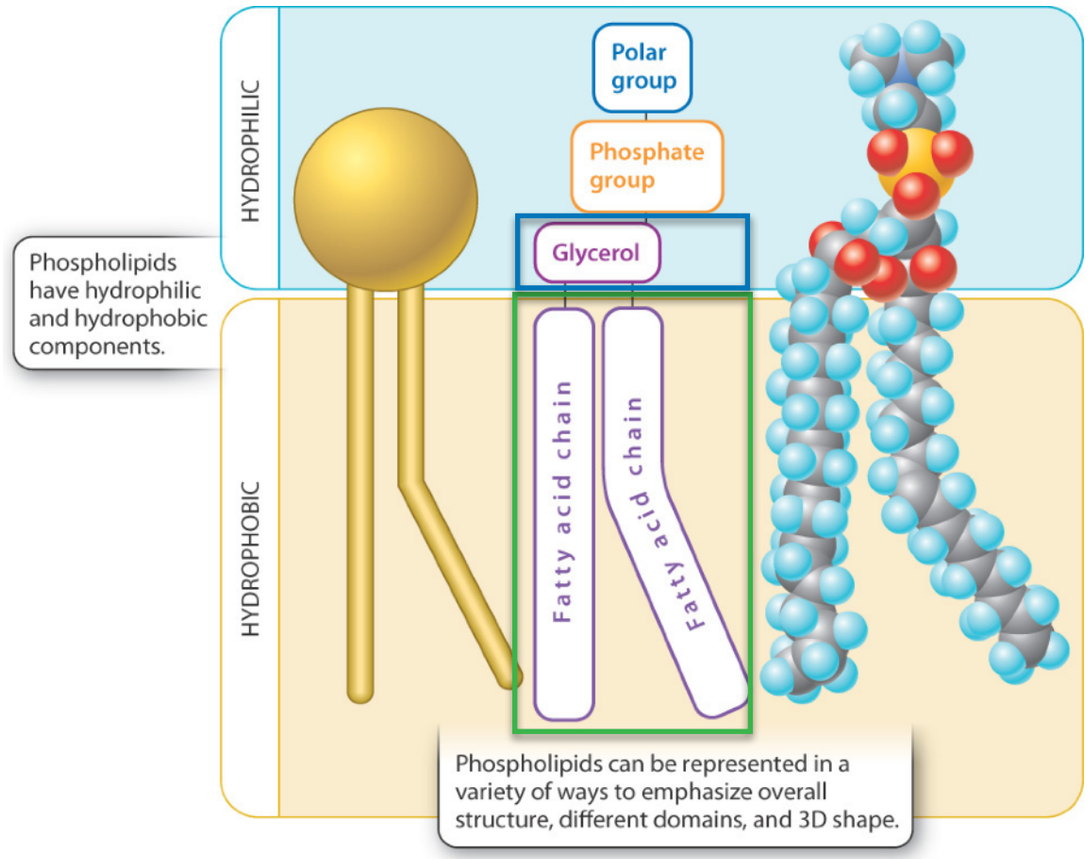
Lipids are in essence the "water-insoluble" molecules of life.



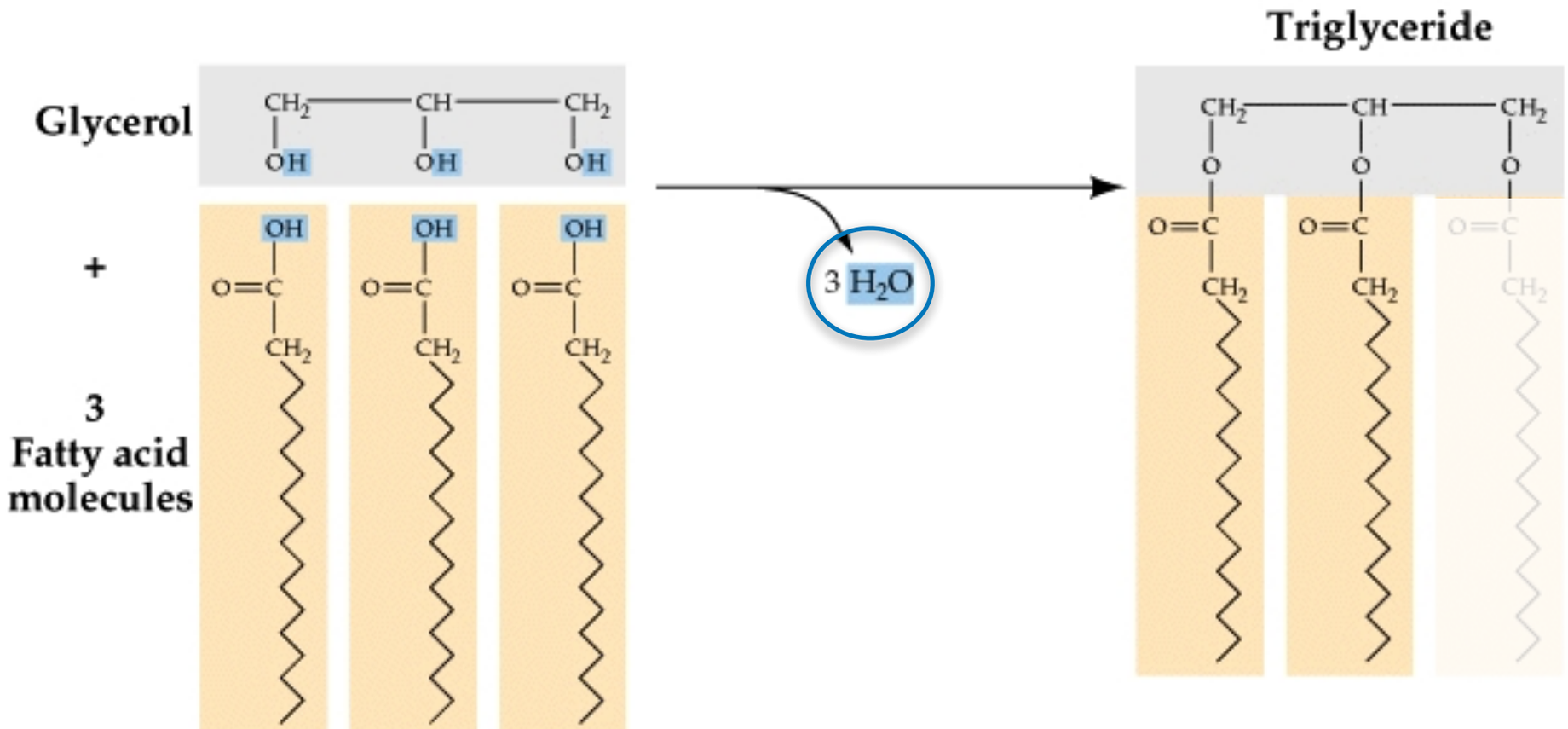


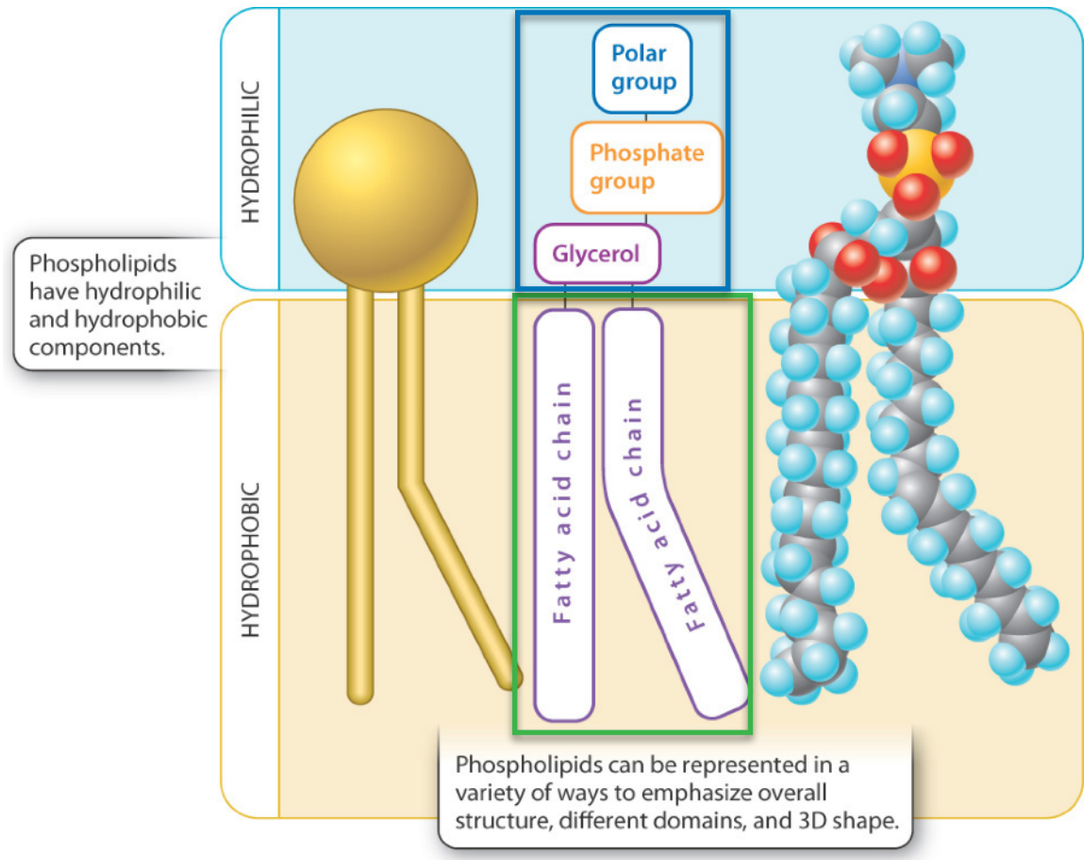
Lipids are in essence the "water-insoluble" molecules of life.

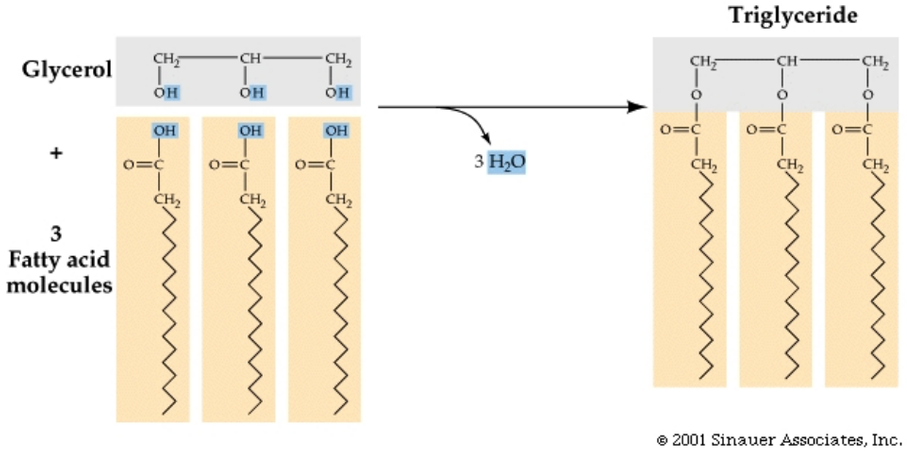




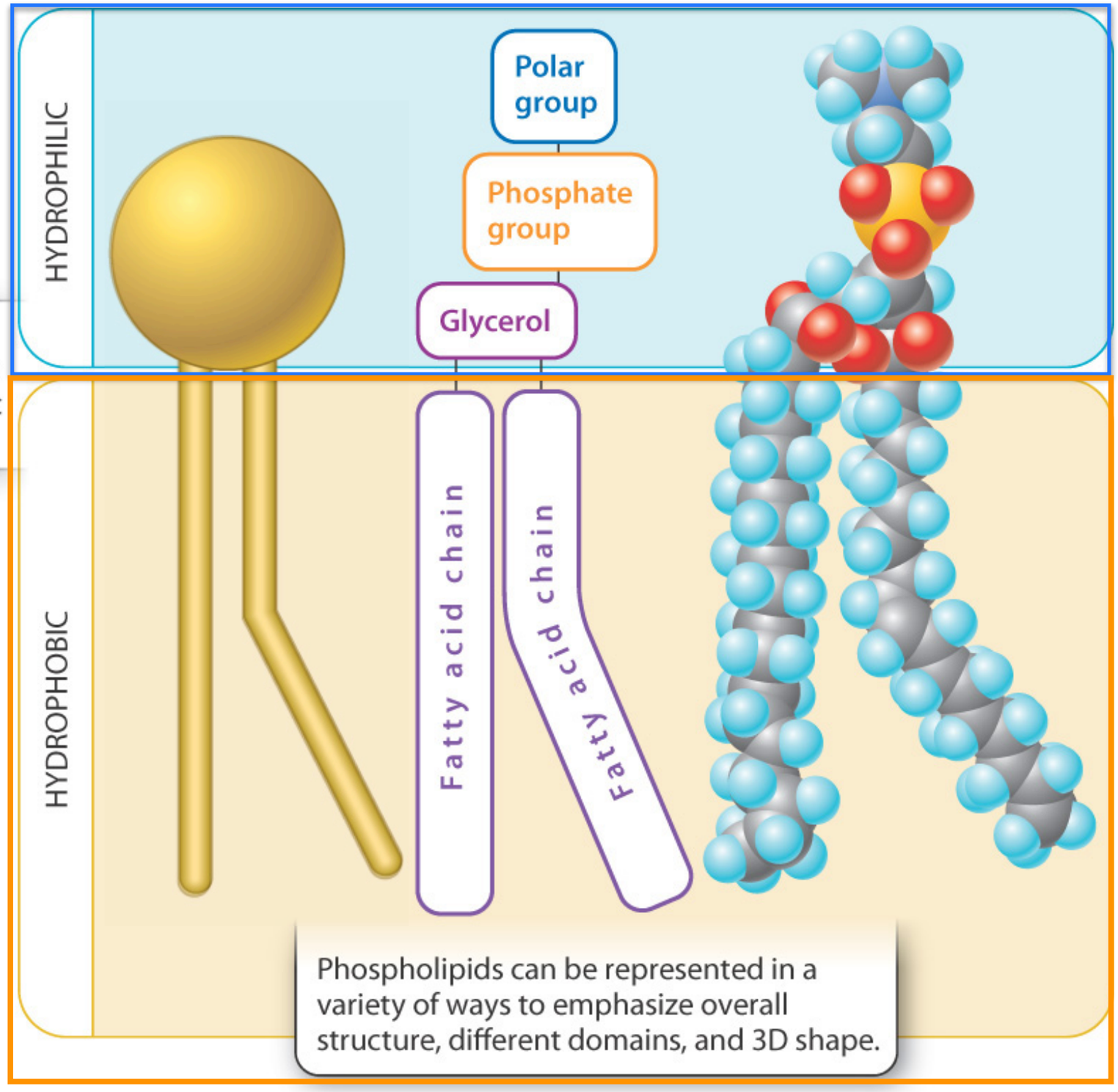
Lipids are in essence the "water-insoluble" molecules of life.





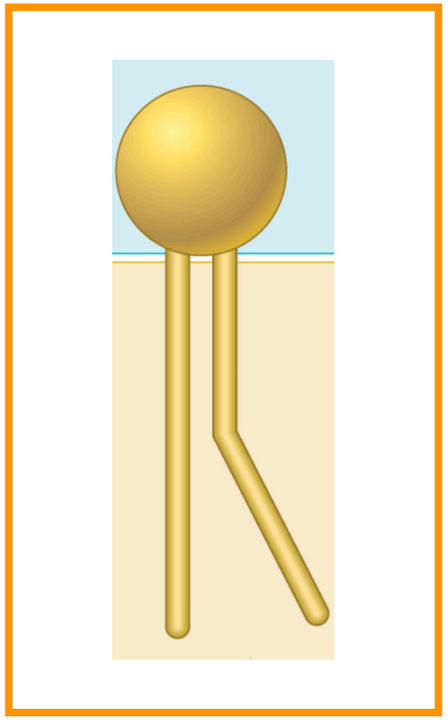


Phospholipids have hydrophilic and hydrophobic components.

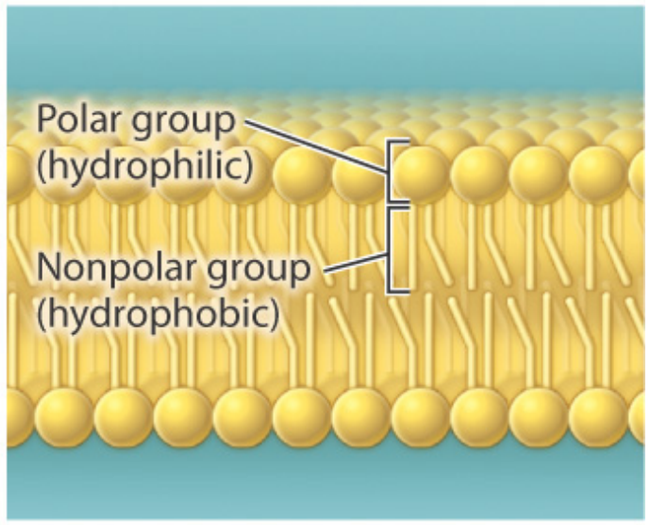


Phospholipids can be represented in a variety of ways to emphasize overall structure, different domains, and 3D shape.

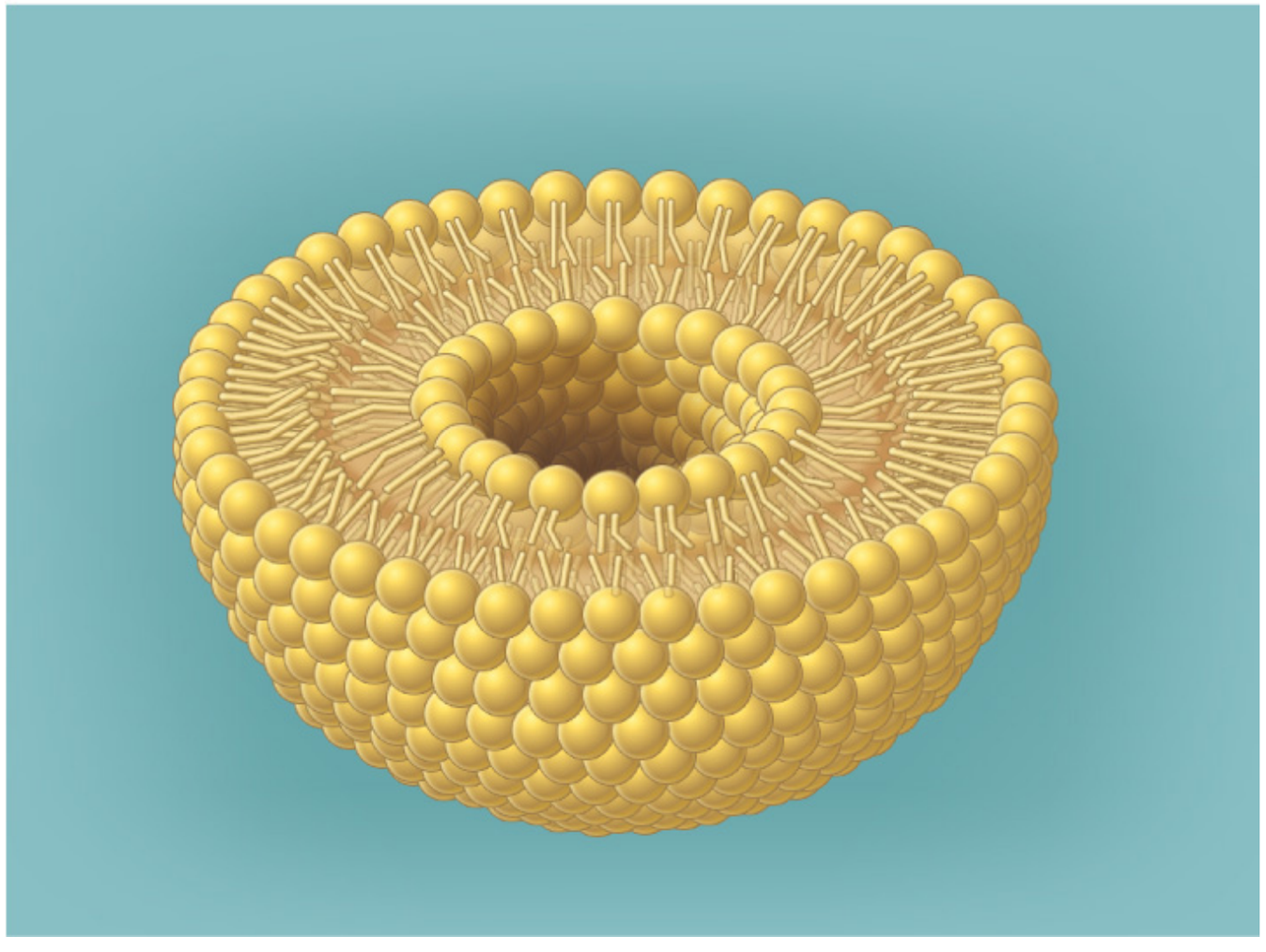
Lipids



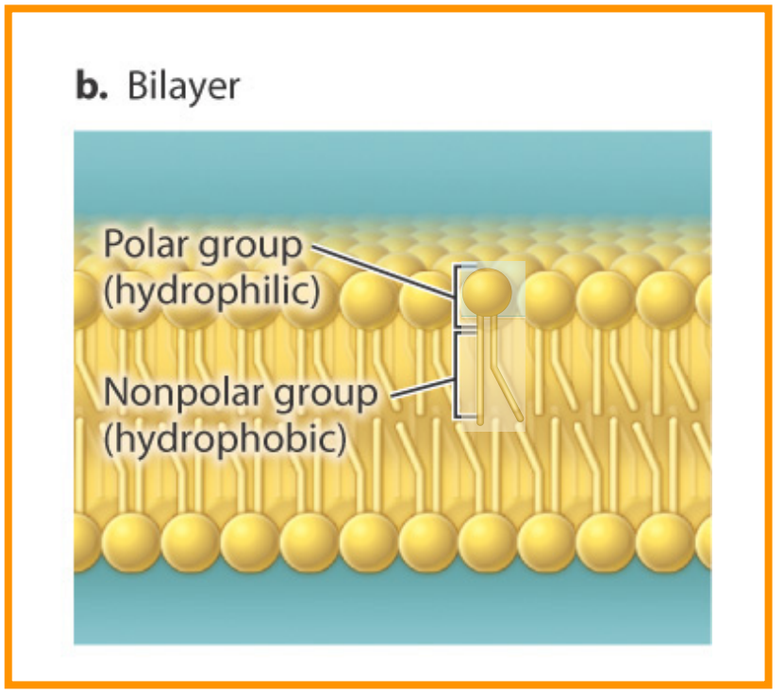
b. Bilayer

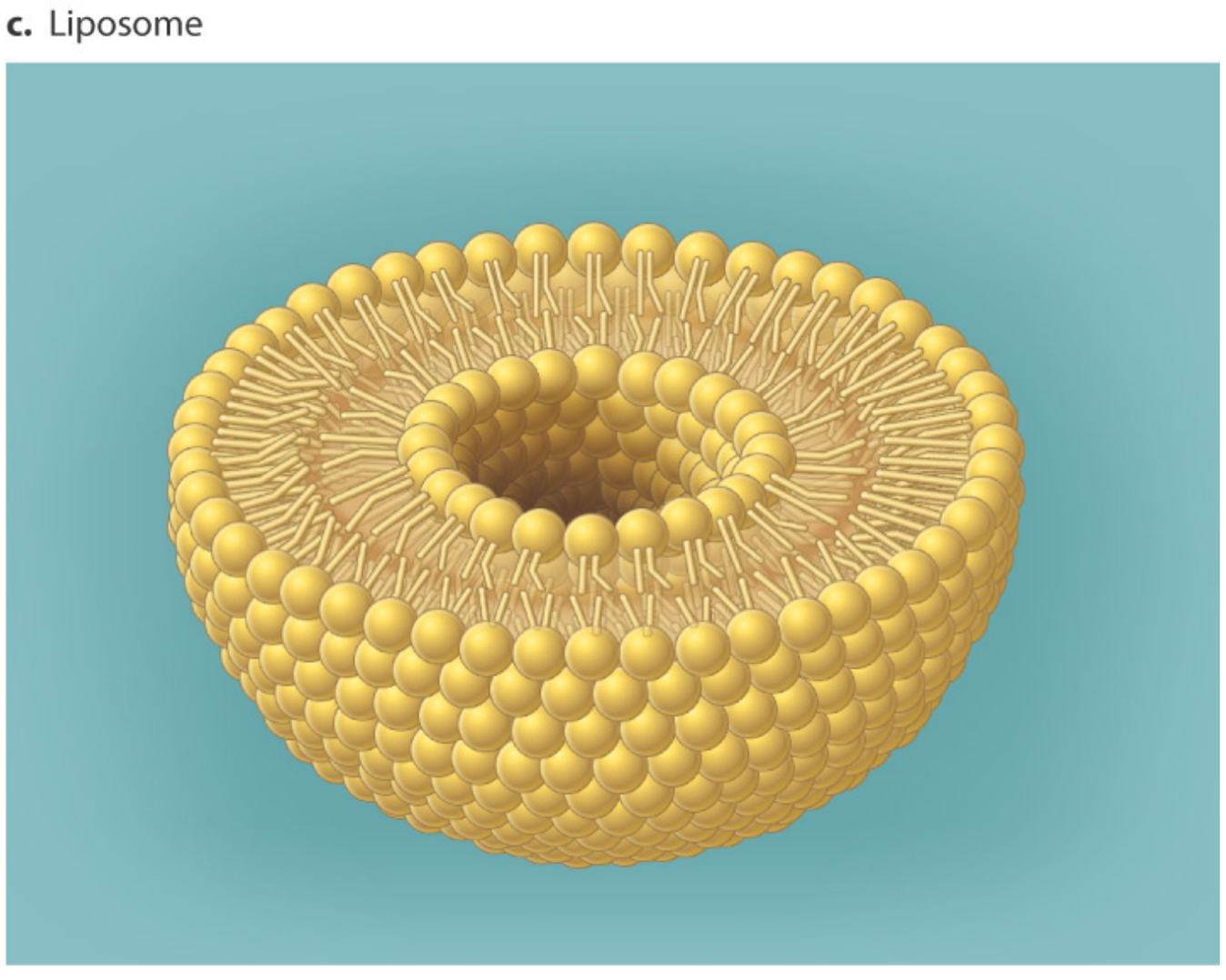


c. Liposome



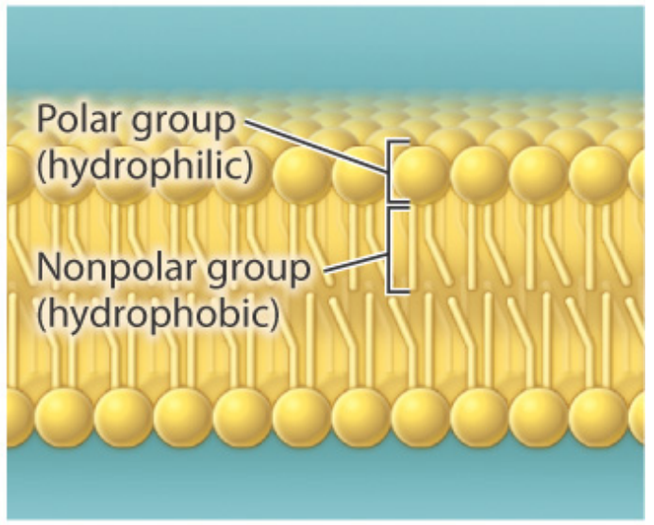
Lipids


b. Bilayer
Polar group
(hydrophilic)
Nonpolar group
(hydrophobic)

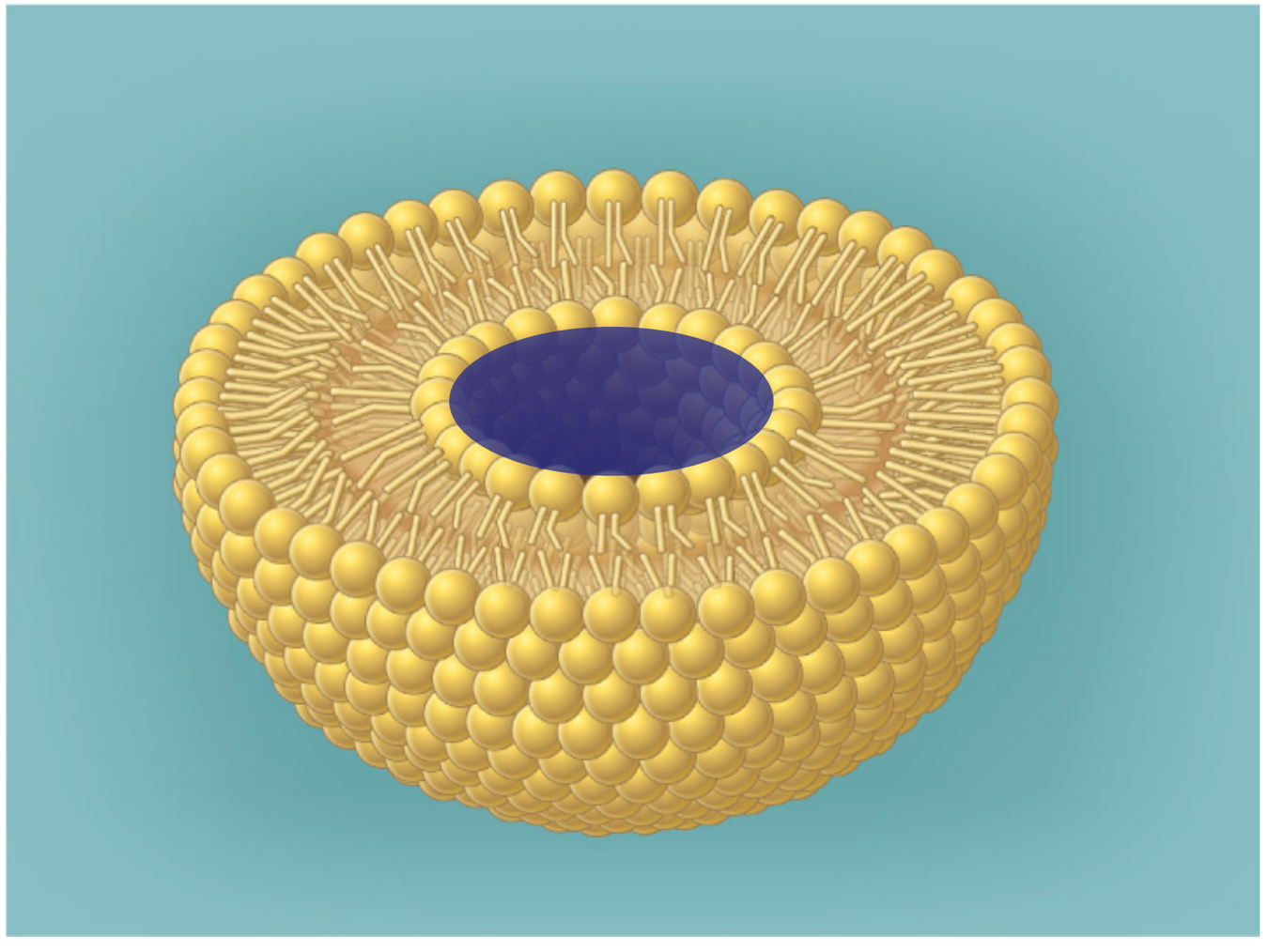

c. Liposome

Lipids

b. Bilayer

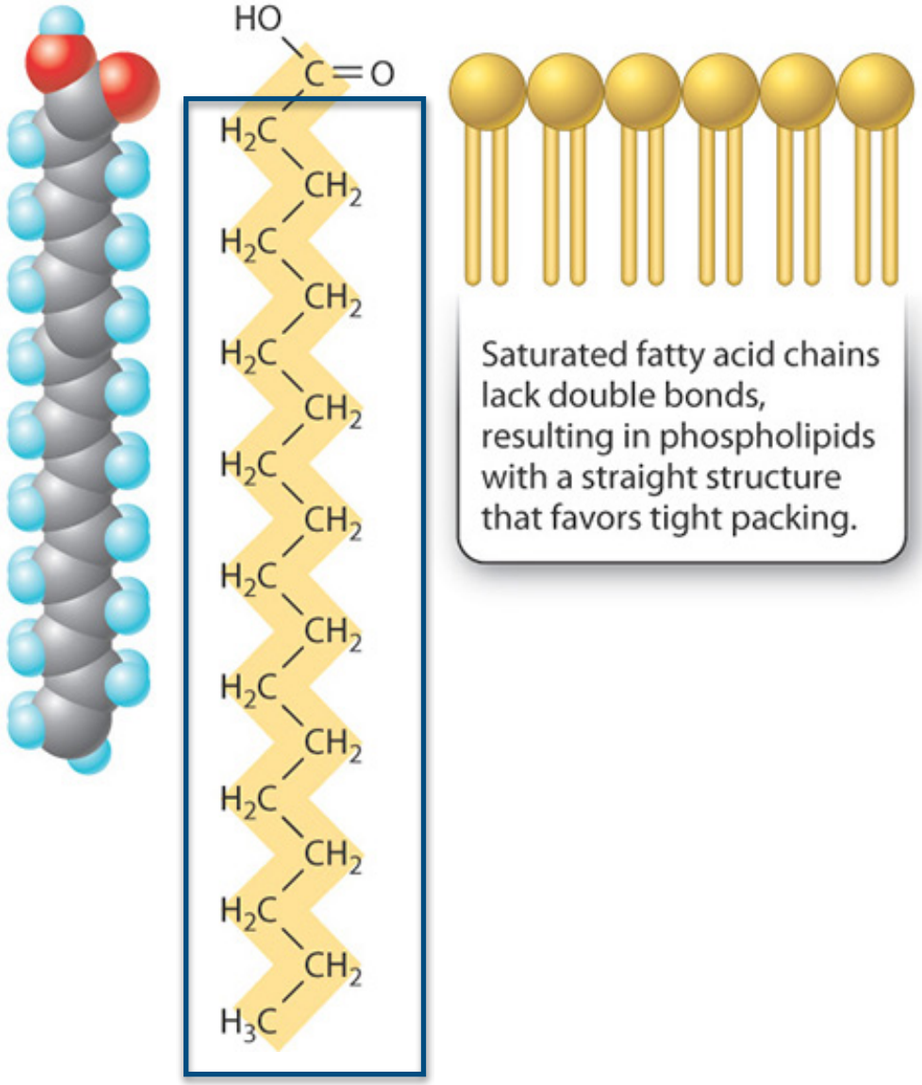


c. Liposome



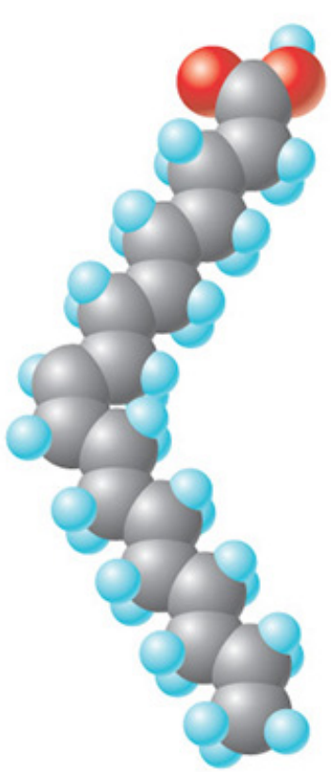
Lipids

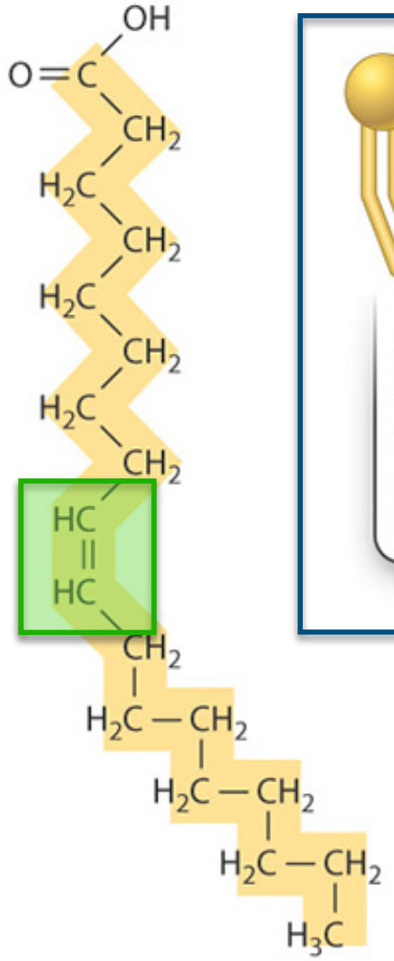
a. Stearic acid, $CH_3(CH_2)_{16}COOH$

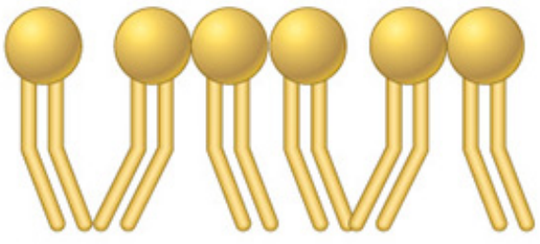


Saturated fatty acid chains lack double bonds, resulting in phospholipids with a straight structure that favors tight packing.

b. Oleic acid, $CH_3(CH_2)_7CH=CH(CH_2)_7COOH$

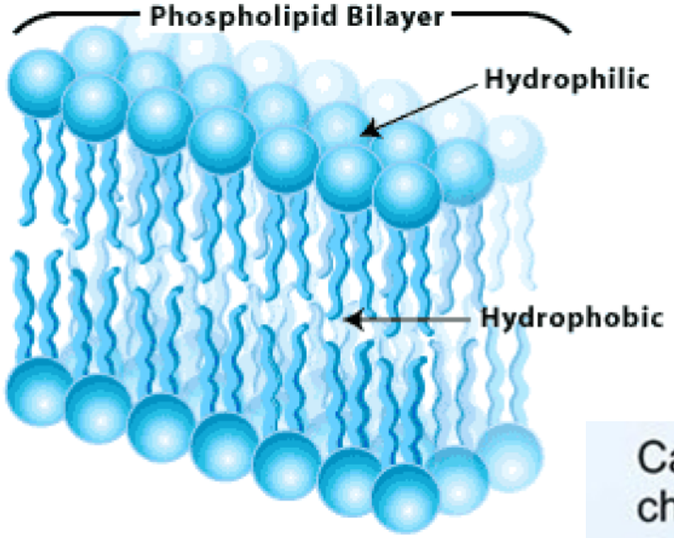


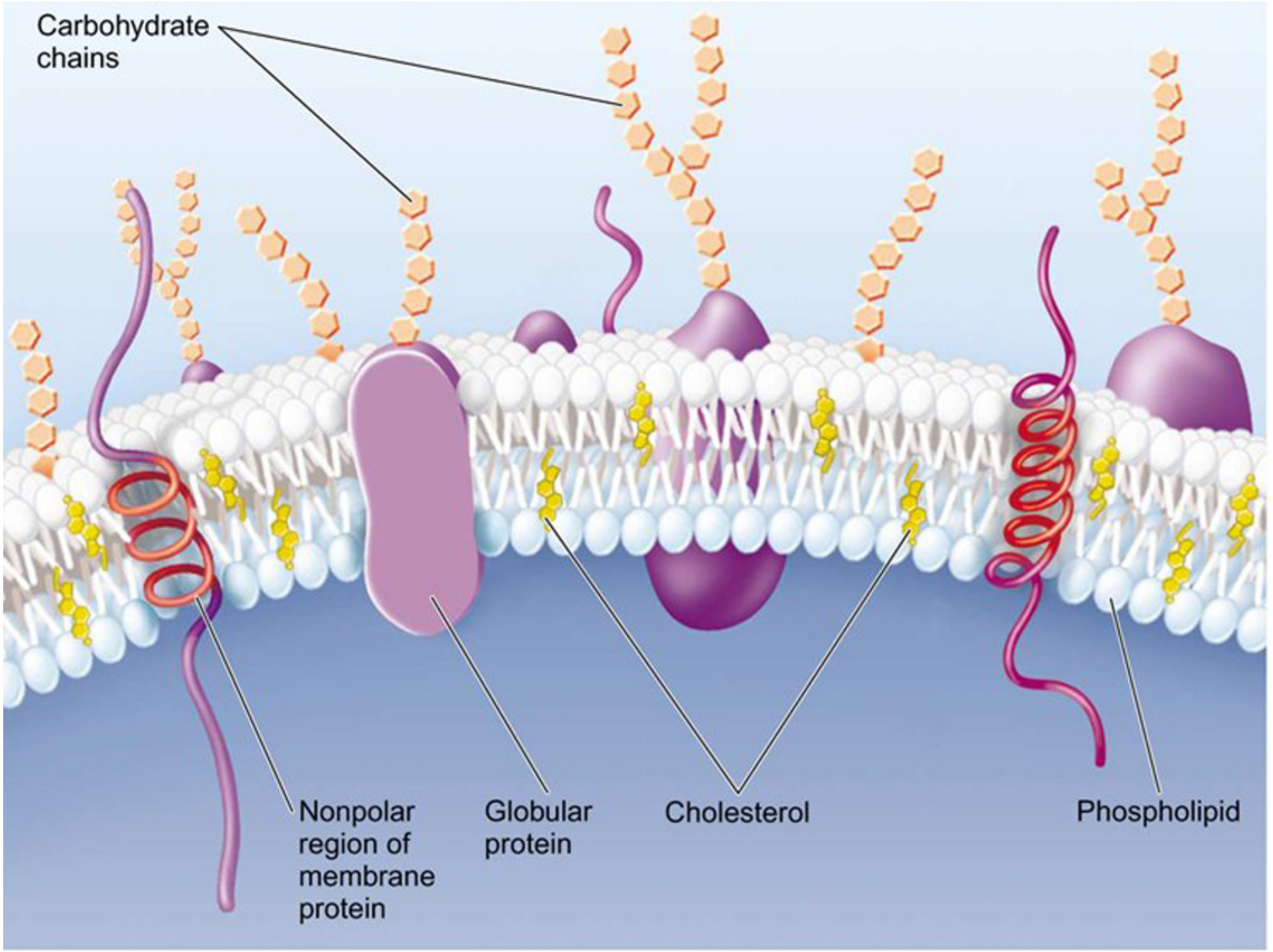




Unsaturated fatty acids have one or more double bonds that introduce kinks in the phospholipids, reducing the tightness of packing.

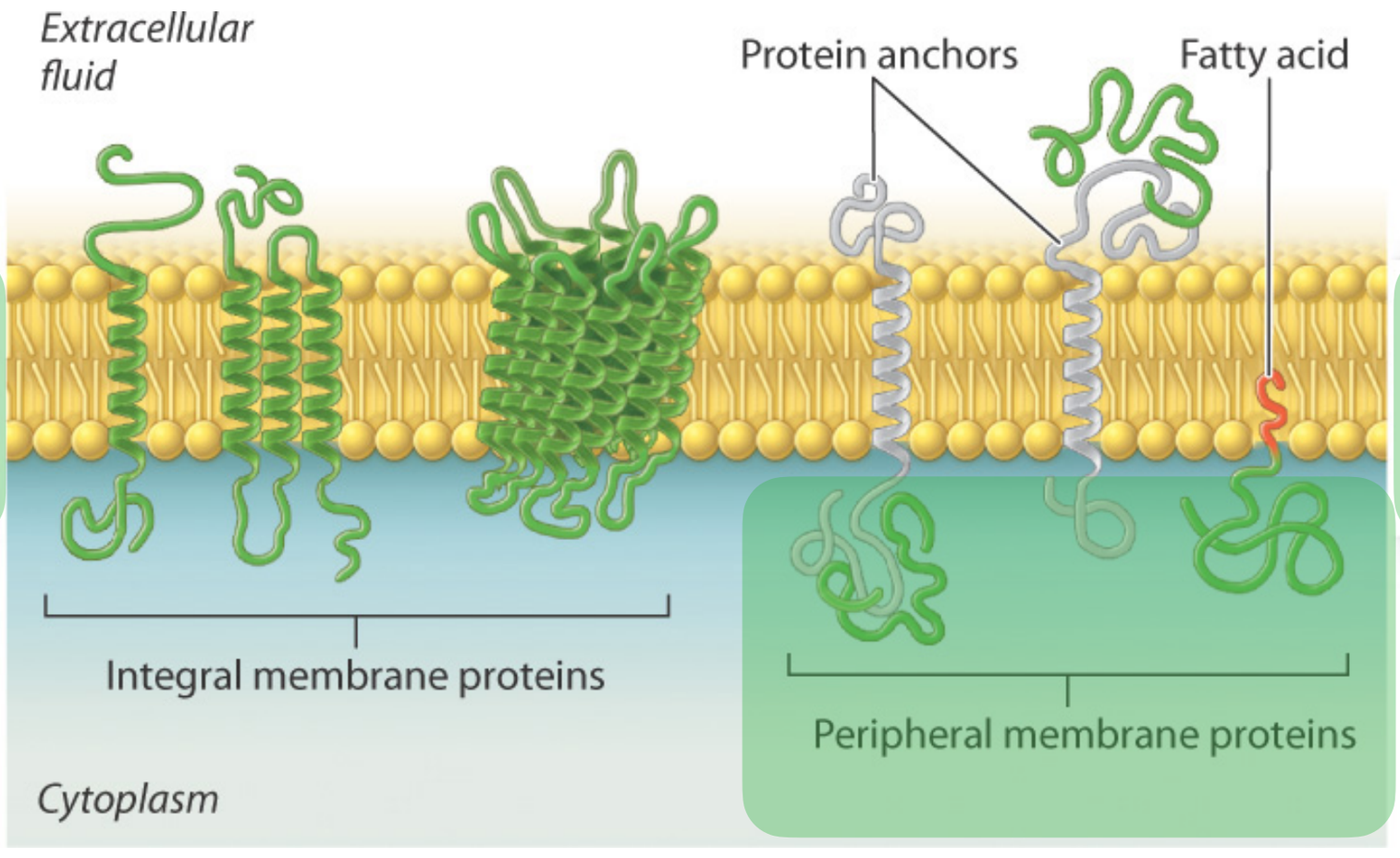
More Solid ———— **Less Solid**


Phospholipid Bilayer
Hydrophilic
Hydrophobic


Carbohydrate chains
Nonpolar region of membrane protein
Globular protein
Cholesterol
Phospholipid

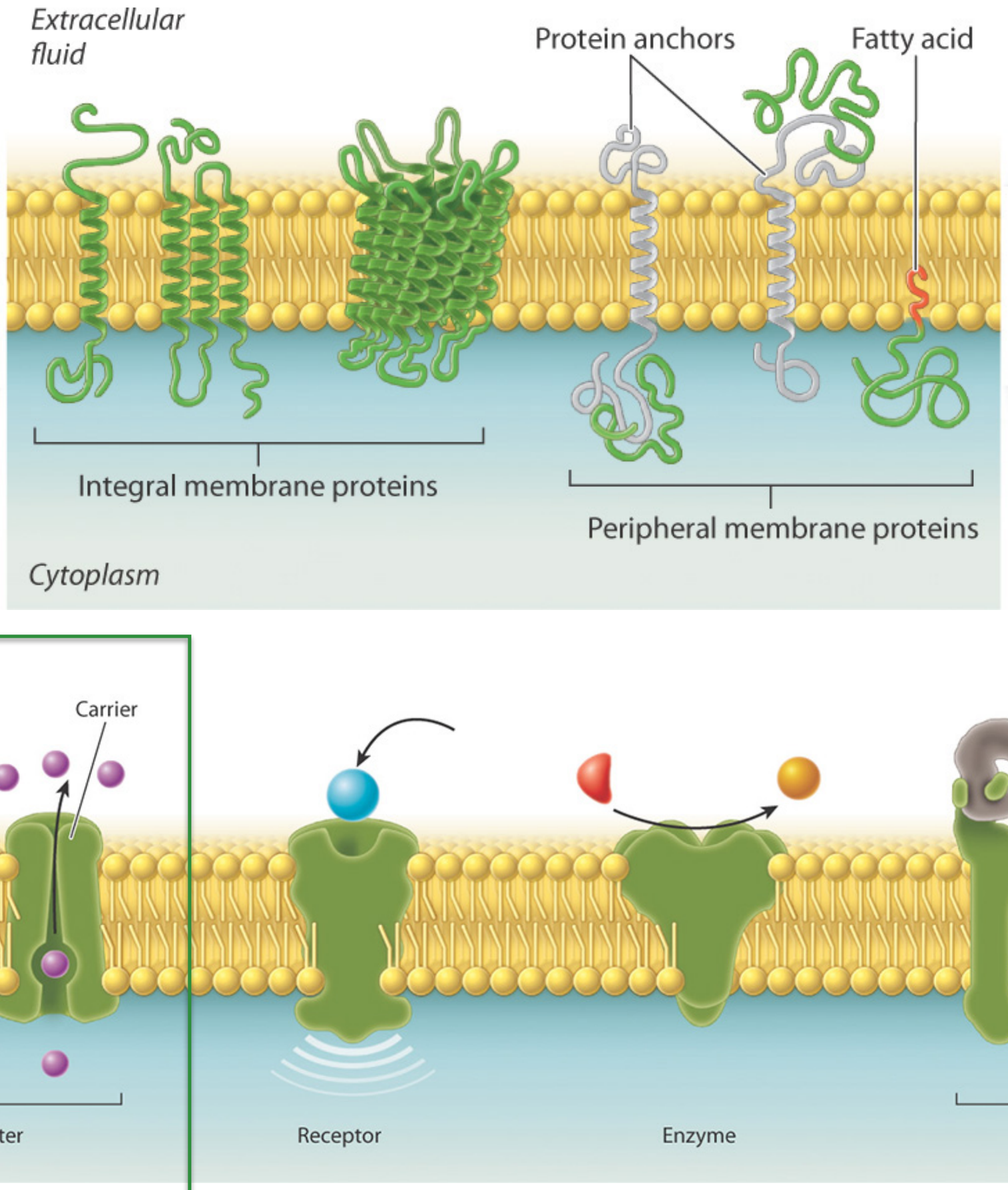
Lipids

Integral membrane proteins include transmembrane proteins that span the entire membrane.



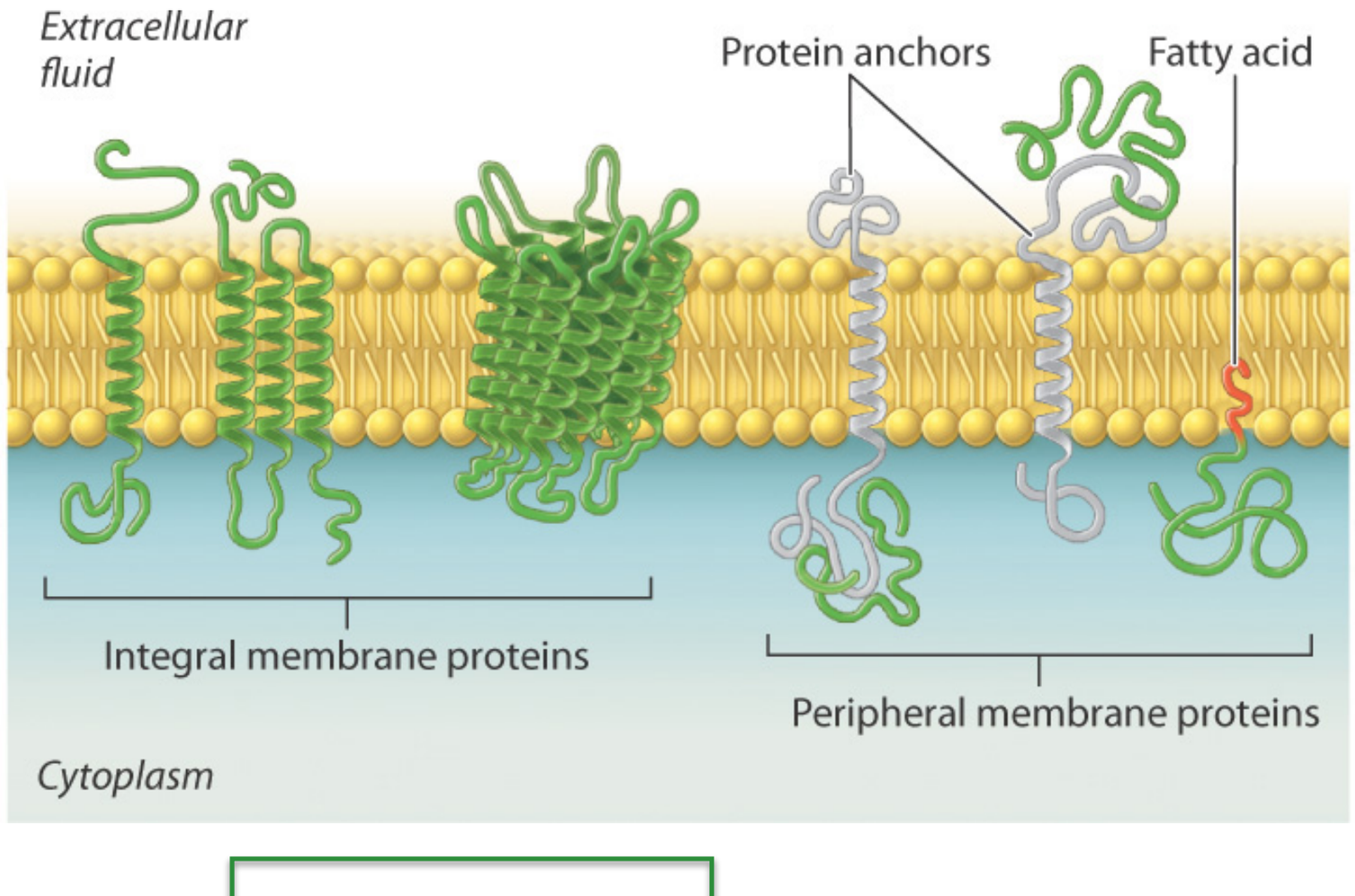
Peripheral membrane proteins are temporarily associated with either the internal or external side of the membrane.

Integral membrane proteins include transmembrane proteins that span the entire membrane.

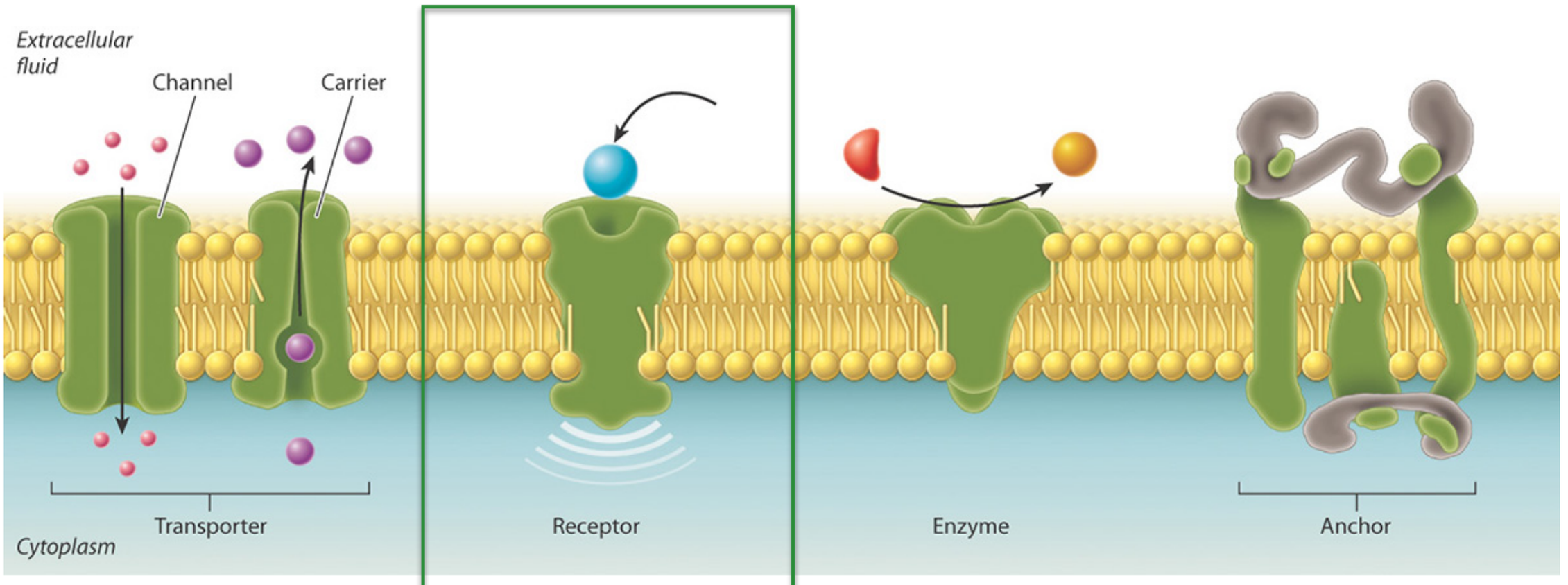


Peripheral membrane proteins are temporarily associated with either the internal or external side of the membrane.

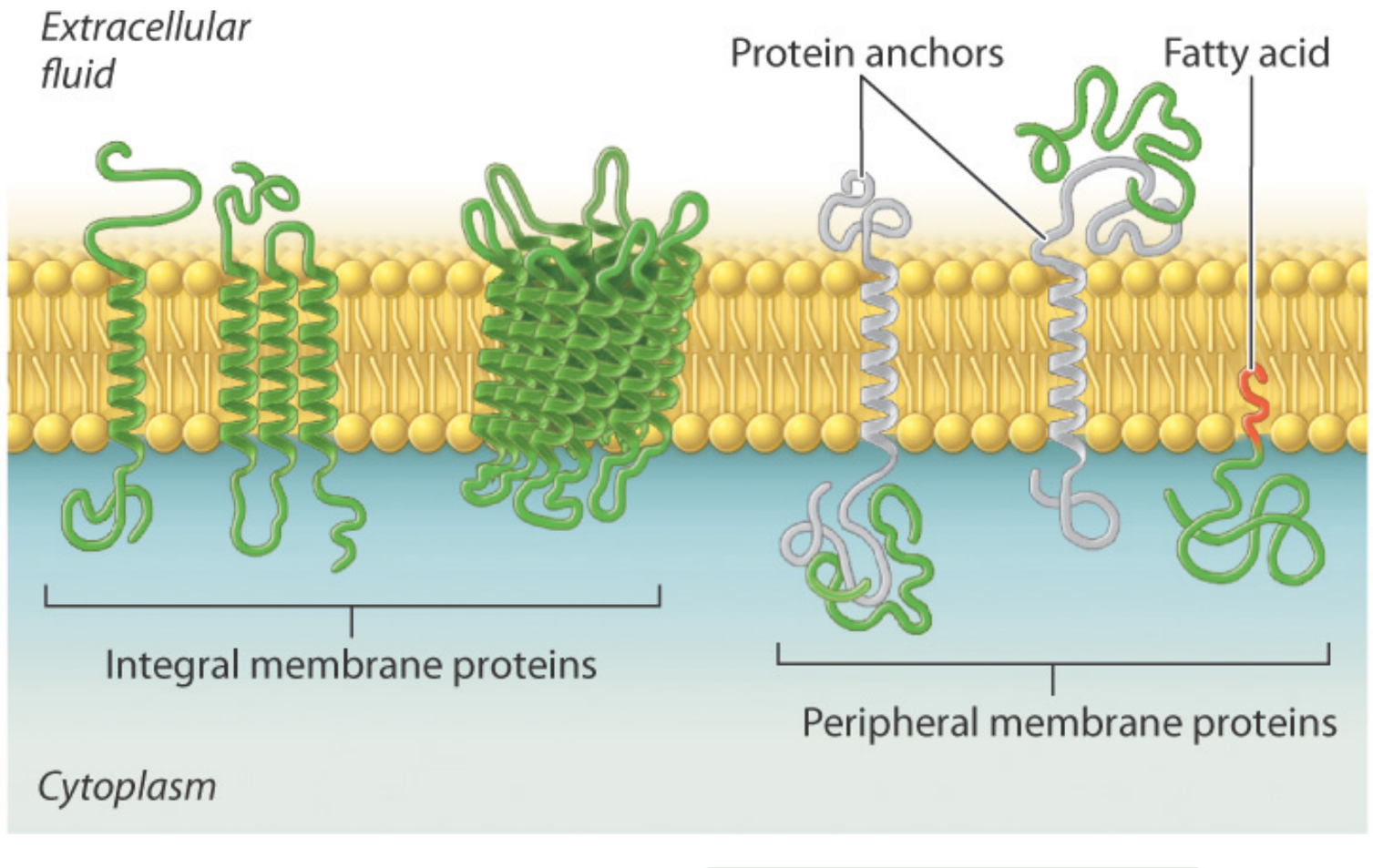
Integral membrane proteins include transmembrane proteins that span the entire membrane.



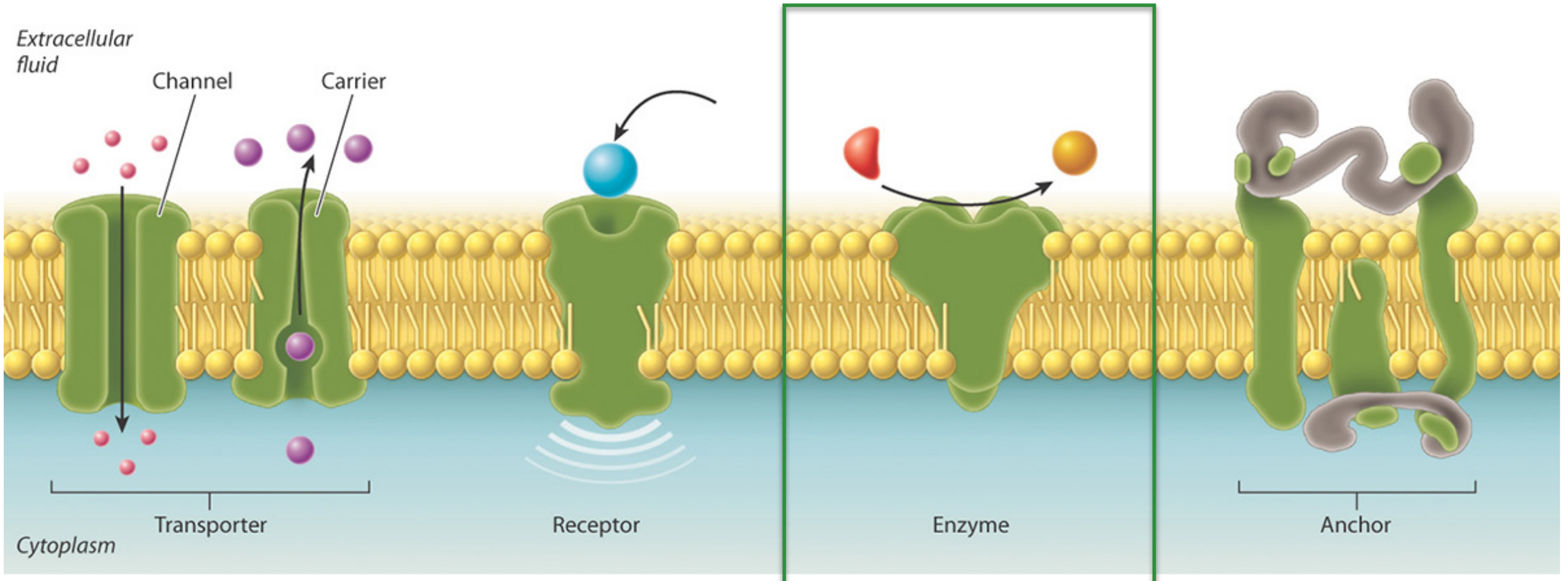
Peripheral membrane proteins are temporarily associated with either the internal or external side of the membrane.



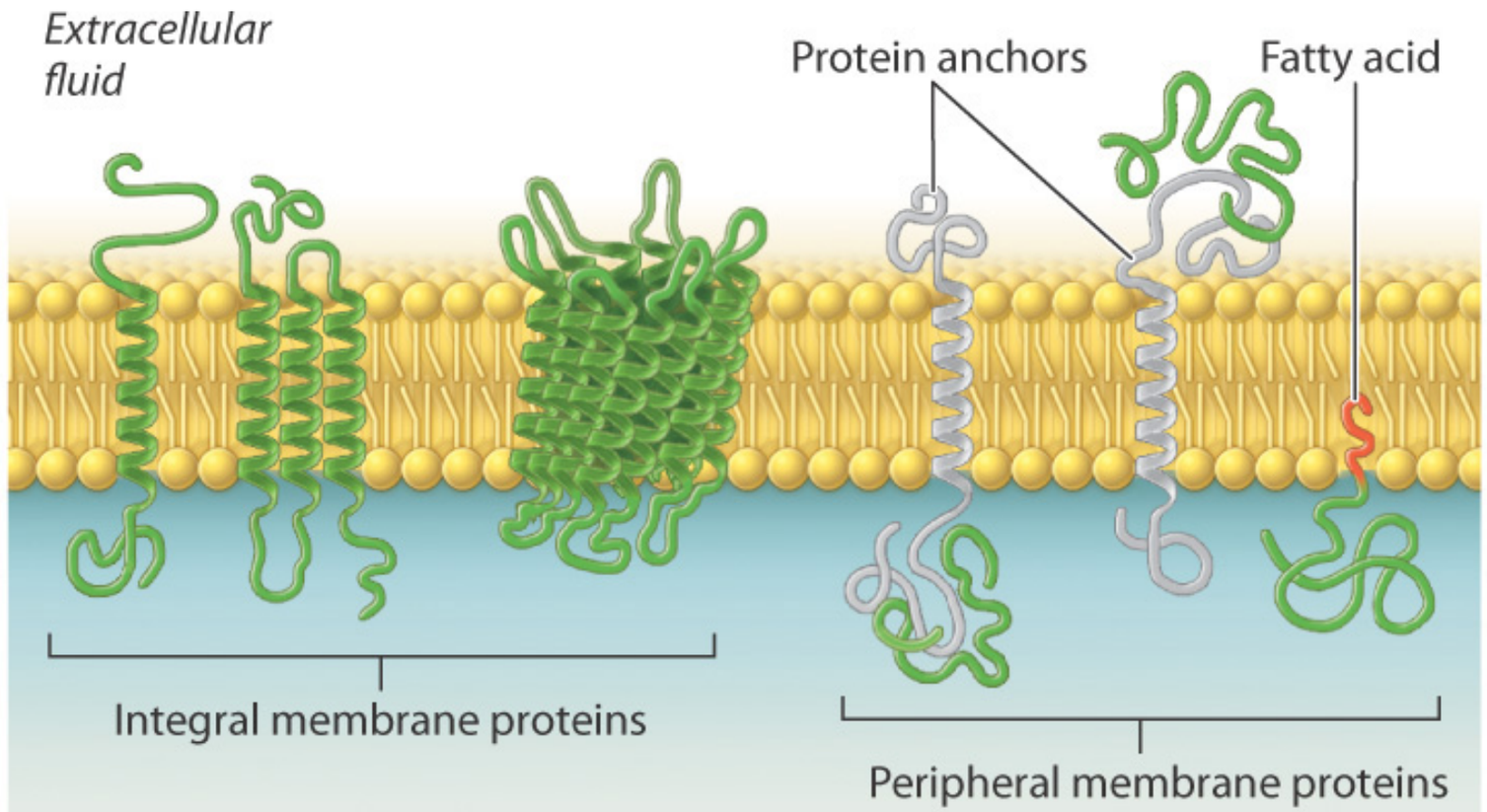
Integral membrane proteins include transmembrane proteins that span the entire membrane.



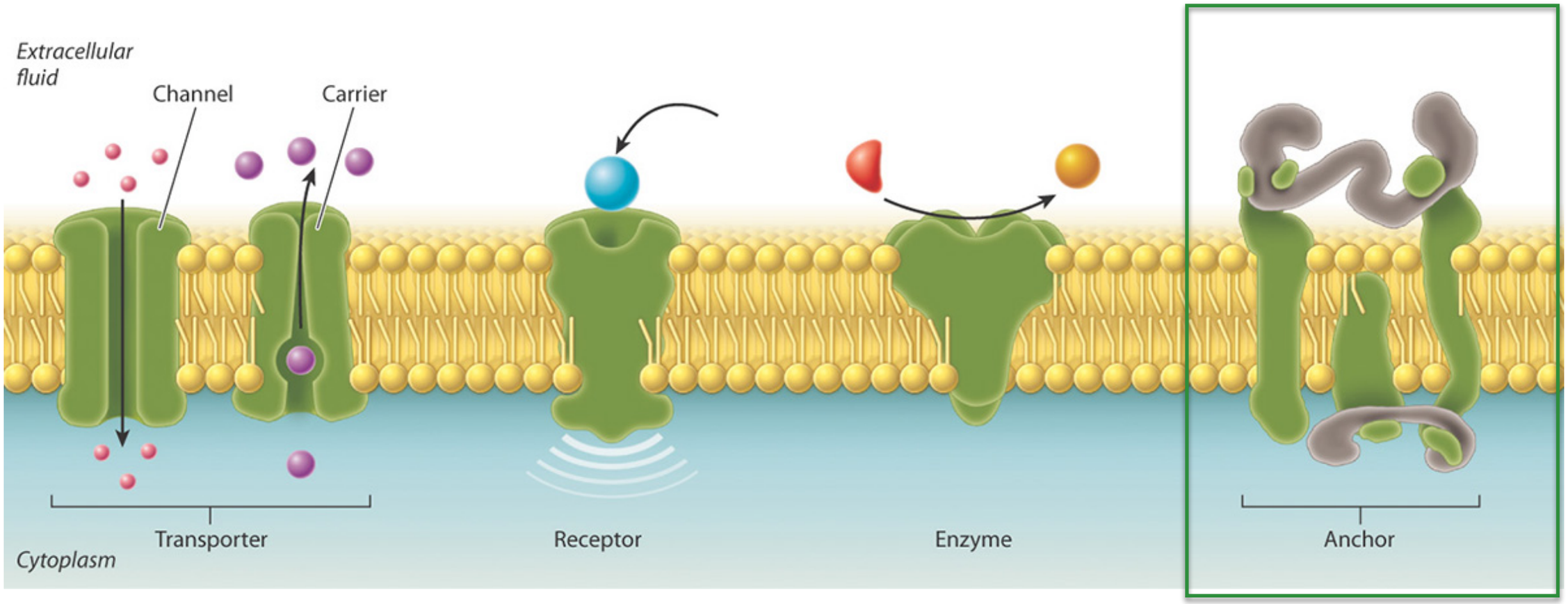
Peripheral membrane proteins are temporarily associated with either the internal or external side of the membrane.

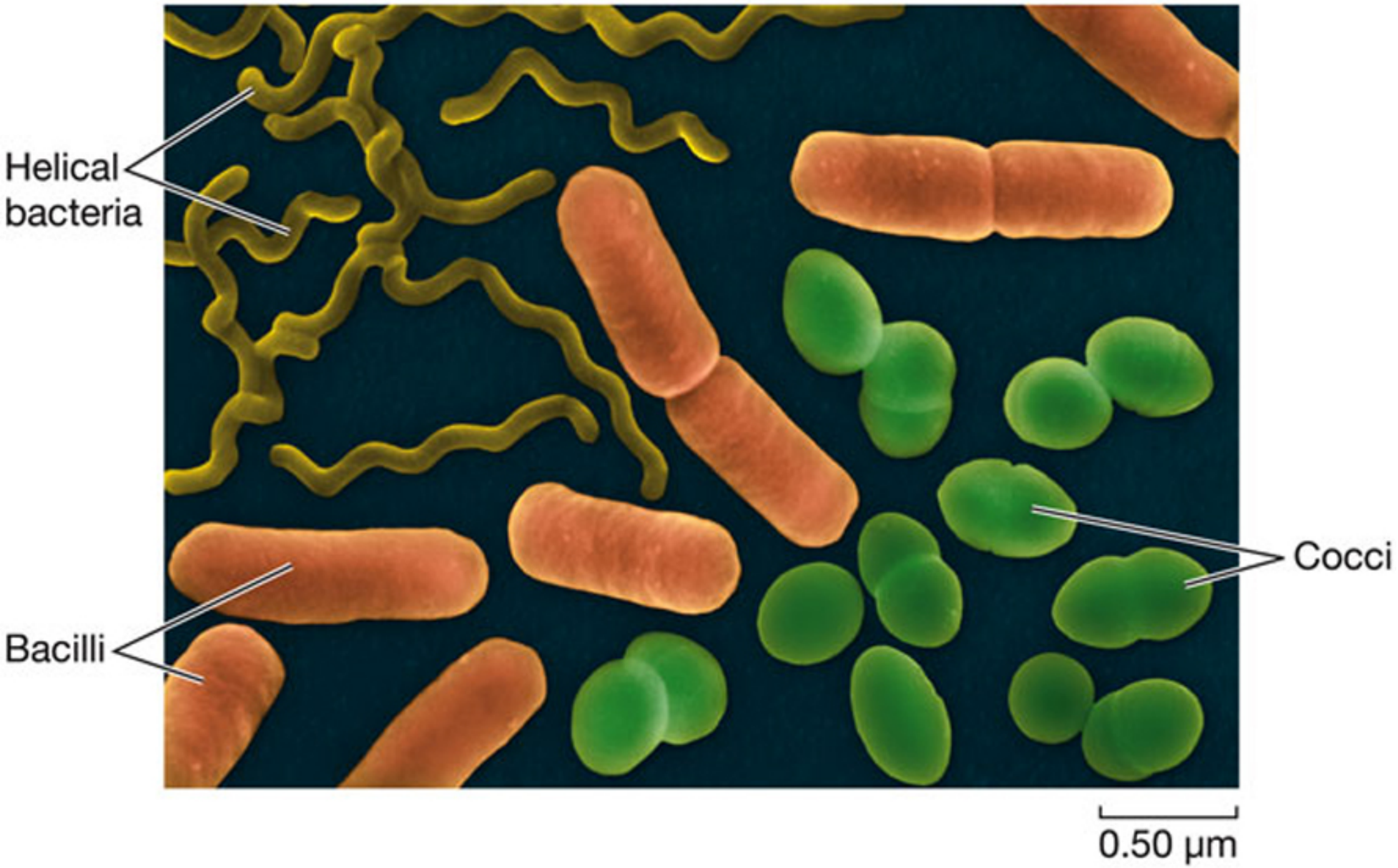


Integral membrane proteins include transmembrane proteins that span the entire membrane.



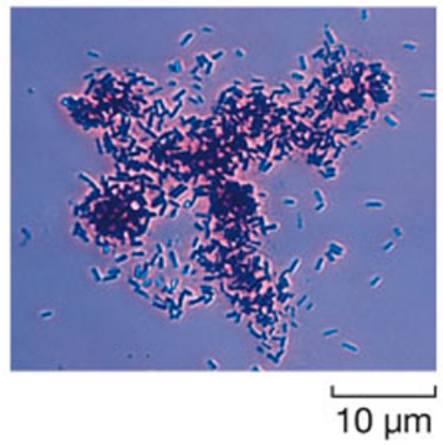
Peripheral membrane proteins are temporarily associated with either the internal or external side of the membrane.

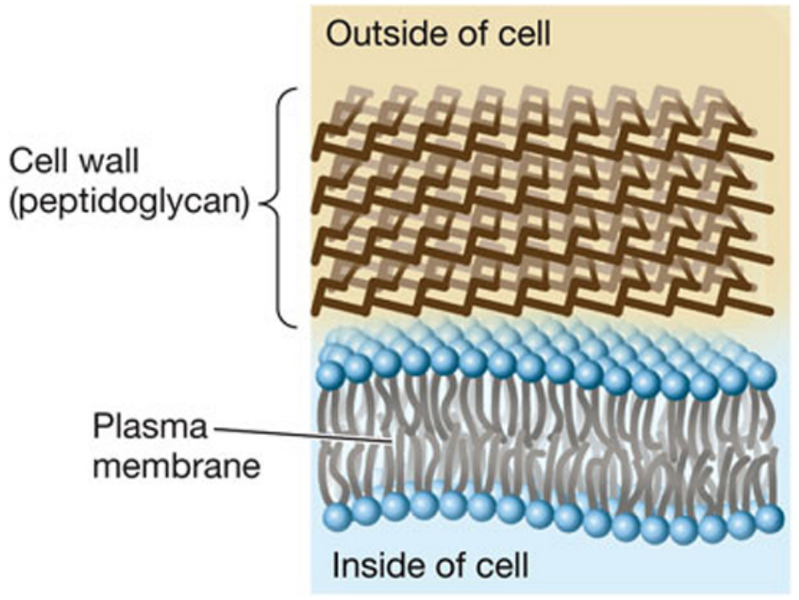




***LIFE 9e*, Figure 26.2**

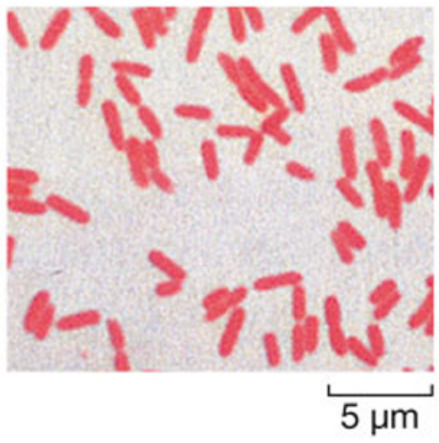
(A)

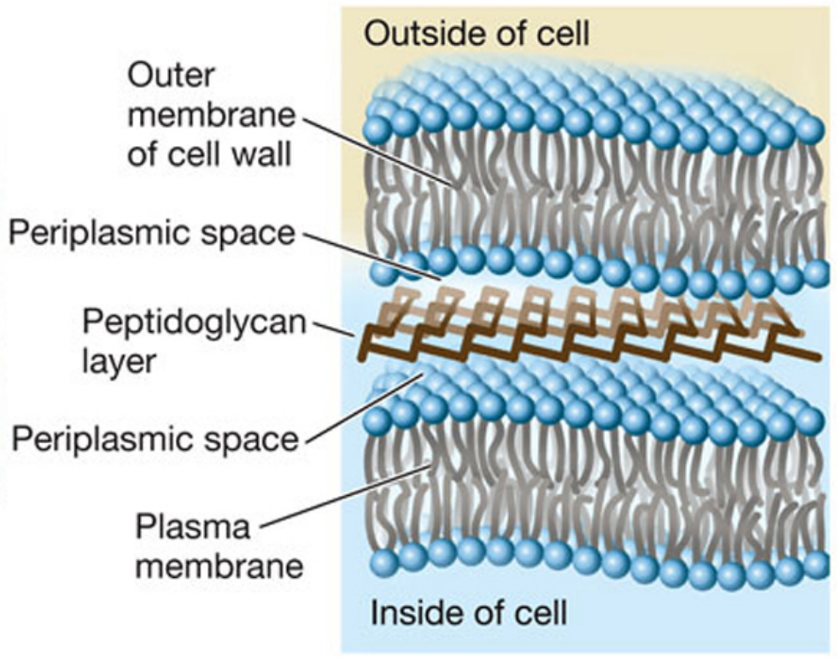




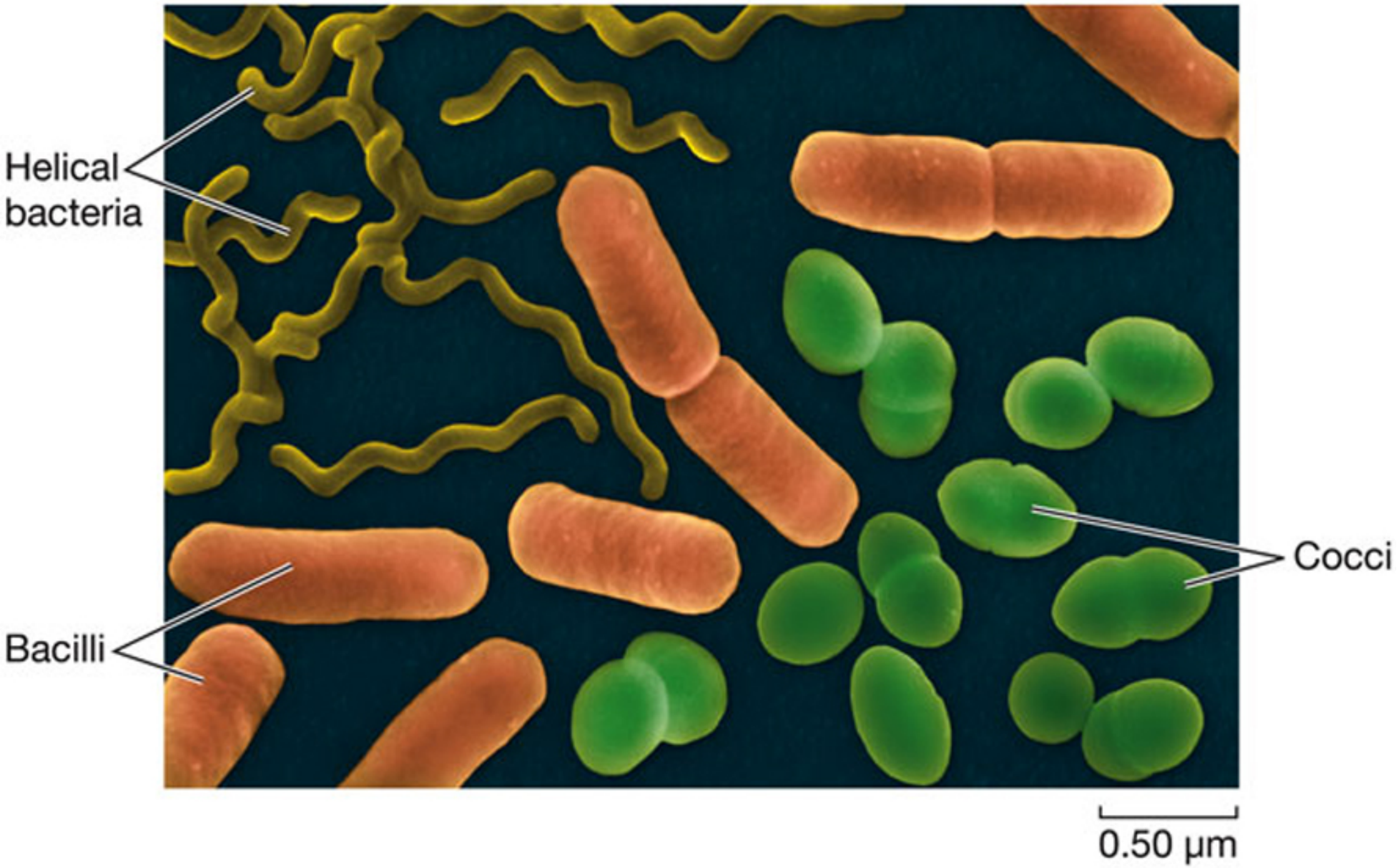
Gram positive

(B)



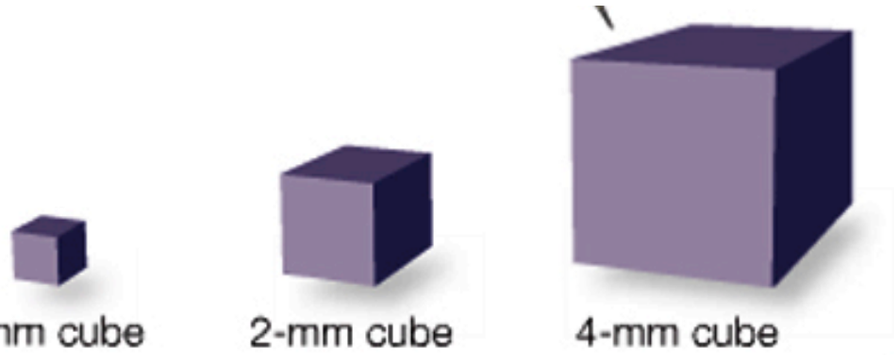


Gram negative



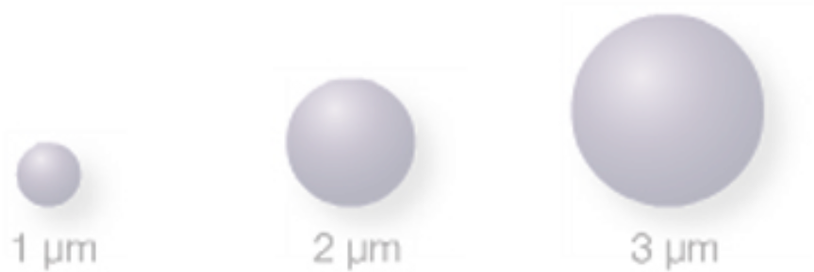
***LIFE 9e*, Figure 26.2**

(A) Cubes



	1-mm cube	2-mm cube	4-mm cube
Surface area	6 sides × 1^2 = 6 mm^2	6 sides × 2^2 = 24 mm^2	6 sides × 4^2 = 96 mm^2
Volume	1^3 = 1 mm^3	2^3 = 8 mm^3	4^3 = 64 mm^3
Surface area-to-volume ratio	6:1	3:1	1.5:1

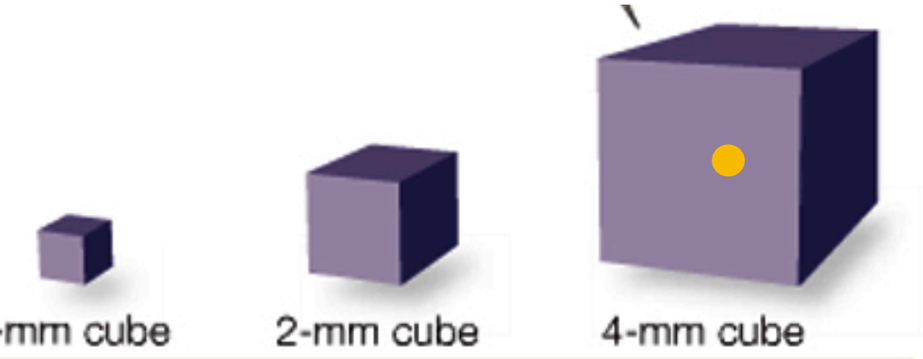
(B) Spheres



Diameter	1 µm	2 µm	3 µm
Surface area $4 \pi r^2$	3.14 μm^2	12.56 μm^2	28.26 μm^2
Volume $4/3 \pi r^3$	0.52 μm^3	4.19 μm^3	14.18 μm^3
Surface area-to-volume ratio	6:1	3:1	2:1

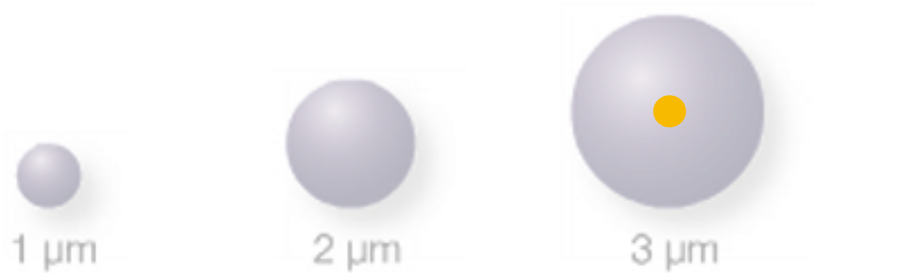
Surface area-to-volume ratio	6:1	3:1	1.5:1

(A) Cubes



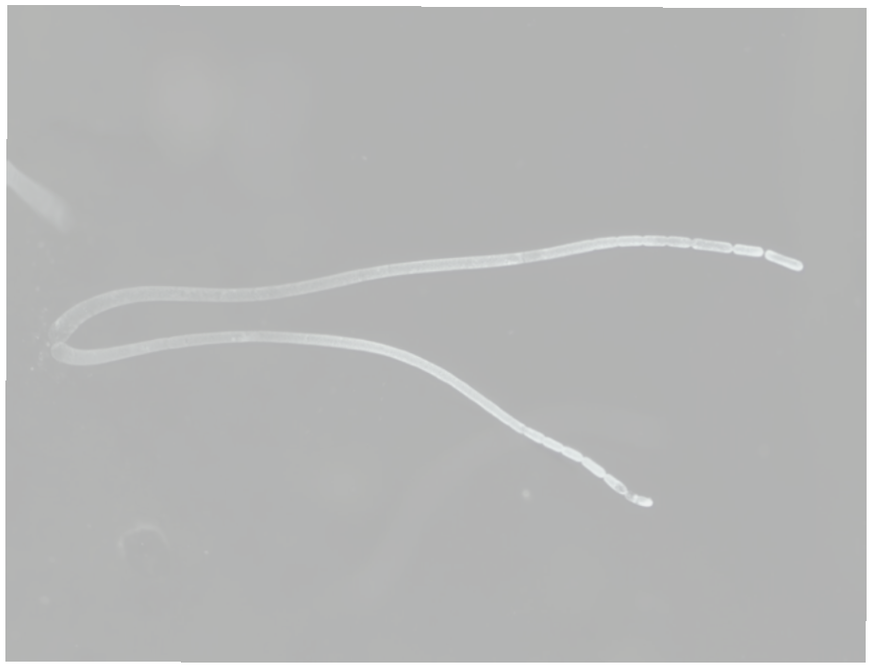
	1-mm cube	2-mm cube	4-mm cube
Surface area	6 sides × 1^2 = 6 mm^2	6 sides × 2^2 = 24 mm^2	6 sides × 4^2 = 96 mm^2
Volume	1^3 = 1 mm^3	2^3 = 8 mm^3	4^3 = 64 mm^3

(B) Spheres

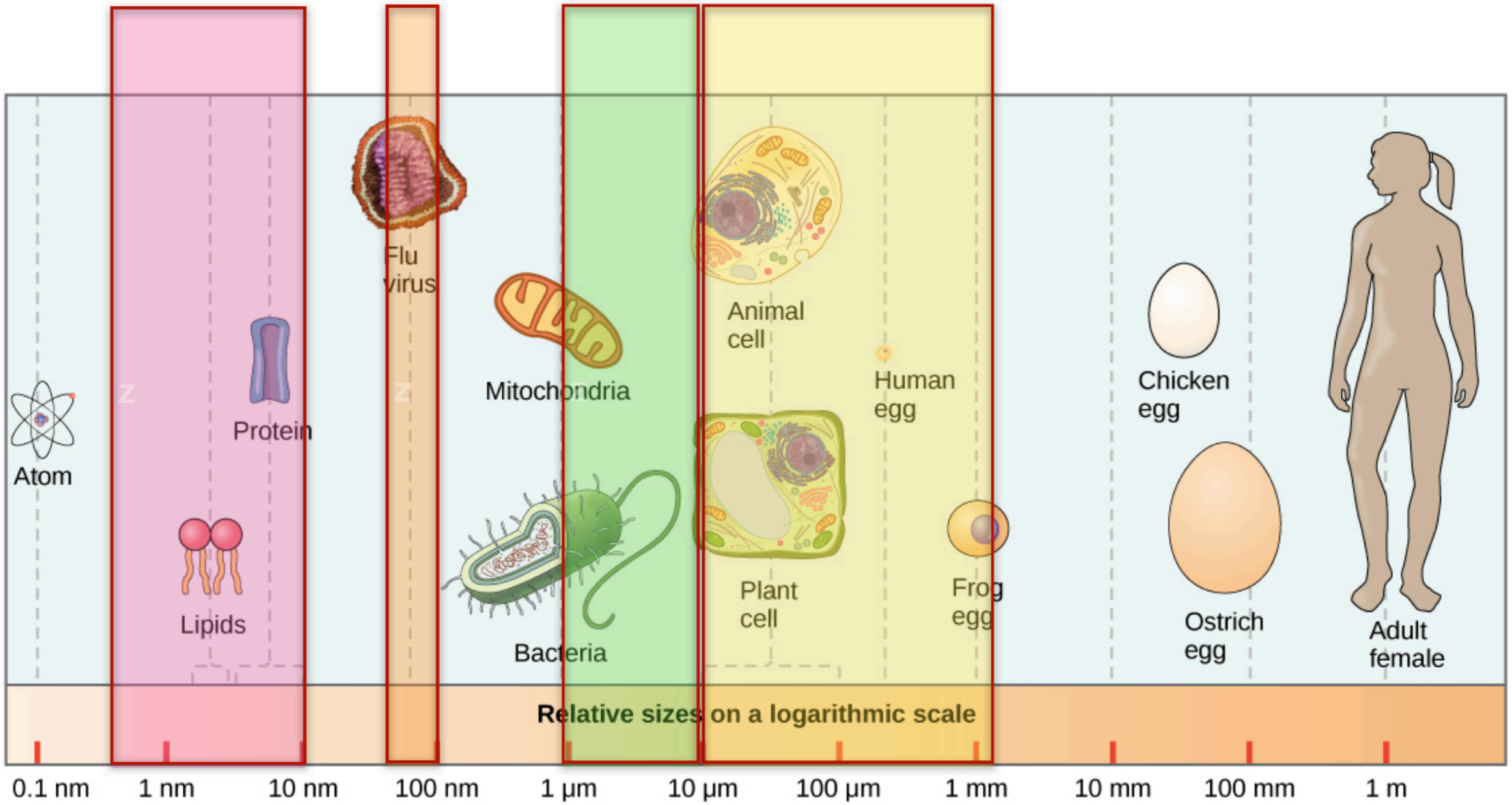


Diameter	1 µm	2 µm	3 µm
Surface area $4 \pi r^2$	3.14 μm^2	12.56 μm^2	28.26 μm^2
Volume $4/3 \pi r^3$	0.52 μm^3	4.19 μm^3	14.18 μm^3
Surface area-to-volume ratio	6:1	3:1	2:1

So, aside from anomalies like ***Thiomargarita sp.*** **Prokaryotes** stay small to allow for sufficient **SA / V** ratios to allow for diffusion in and out of the cell



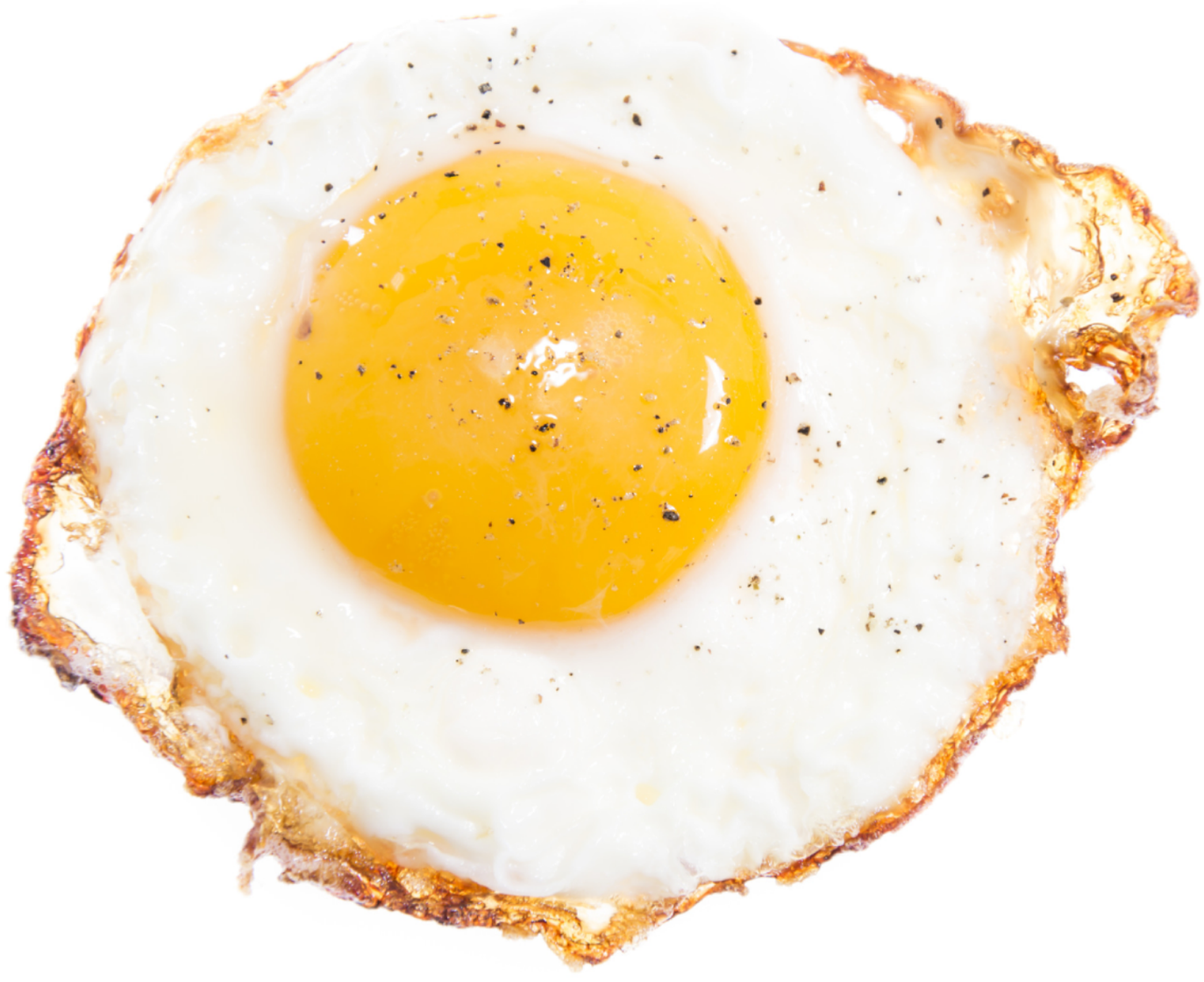
How do **Eukaryotes** handle this problem of decreased SA / V ratios ?



Unaided Eye

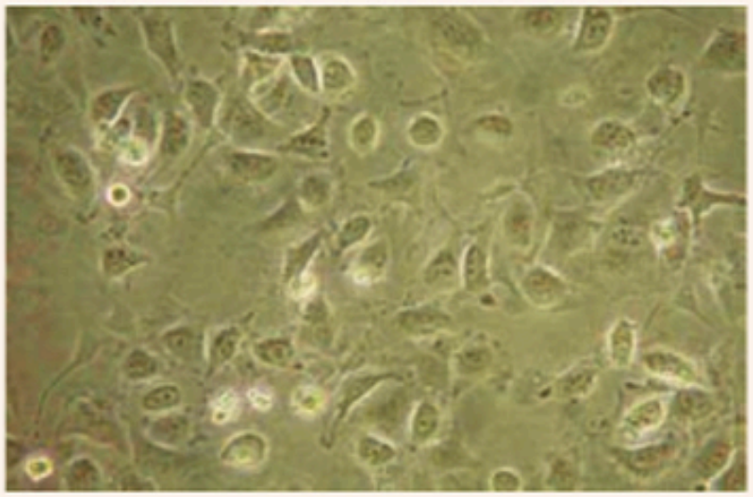
Light Microscope

Electron Microscope SEM/AFM



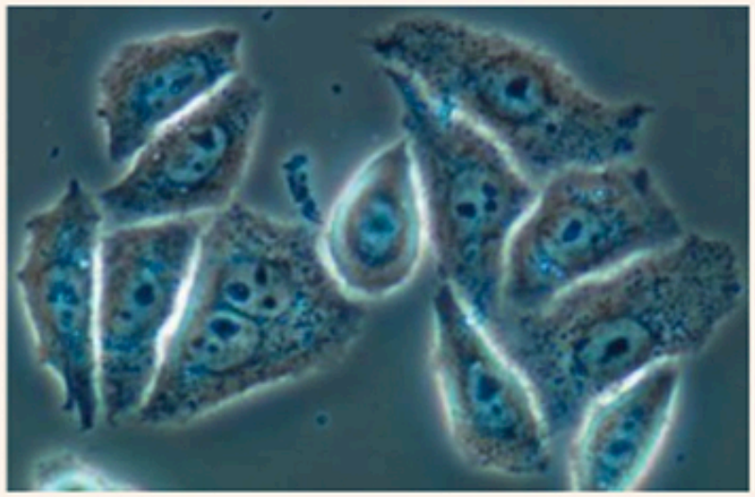
GREATER

Surface Area / Volume



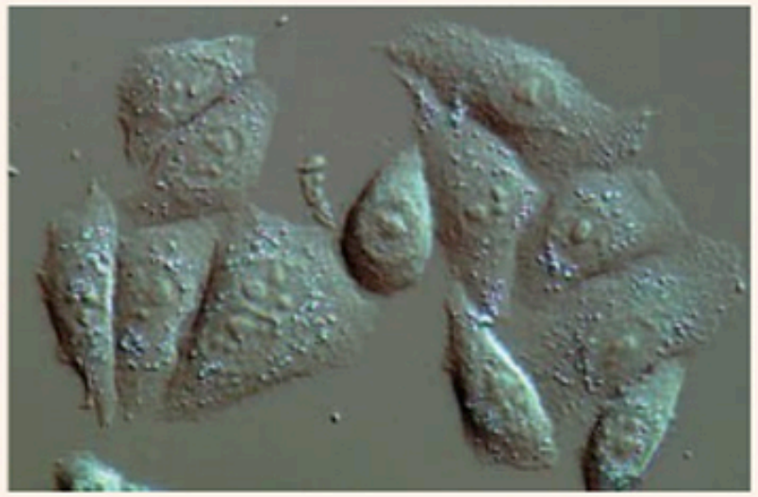
140 µm

In **bright-field microscopy**, light passes directly through these human cells. Unless natural pigments are present, there is little contrast and details are not distinguished.



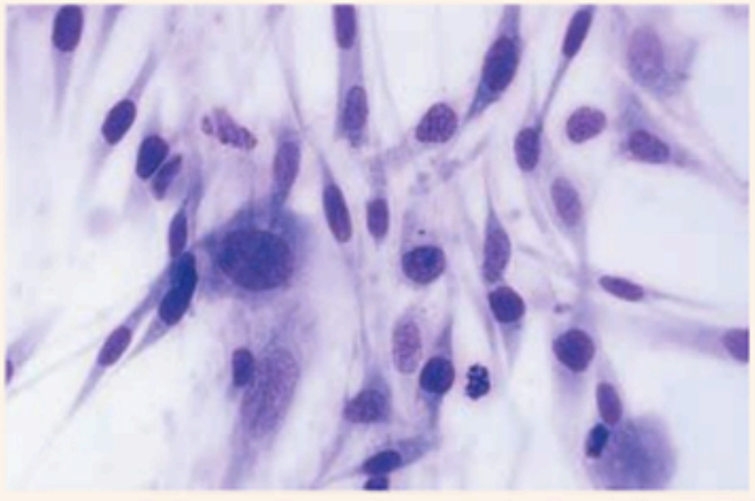
30 µm

In **phase-contrast microscopy**, contrast in the image is increased by emphasizing differences in refractive index (the capacity to bend light), thereby enhancing light and dark regions in the cell.



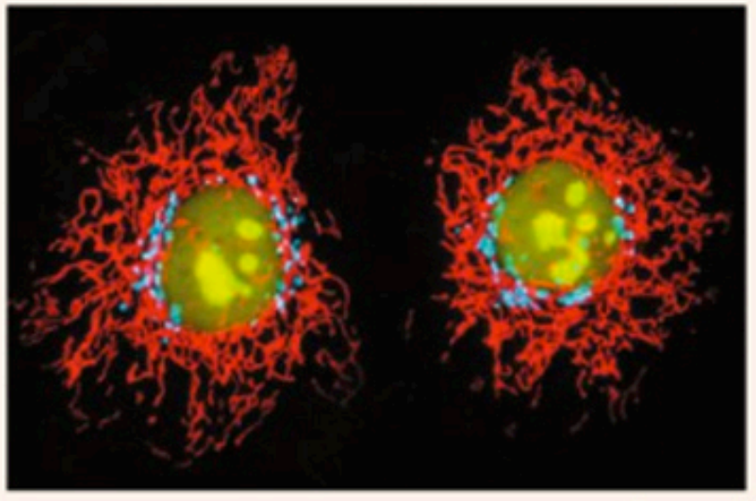
30 µm

Differential interference-contrast microscopy uses two beams of polarized light. The combined images look as if the cell is casting a shadow on one side.



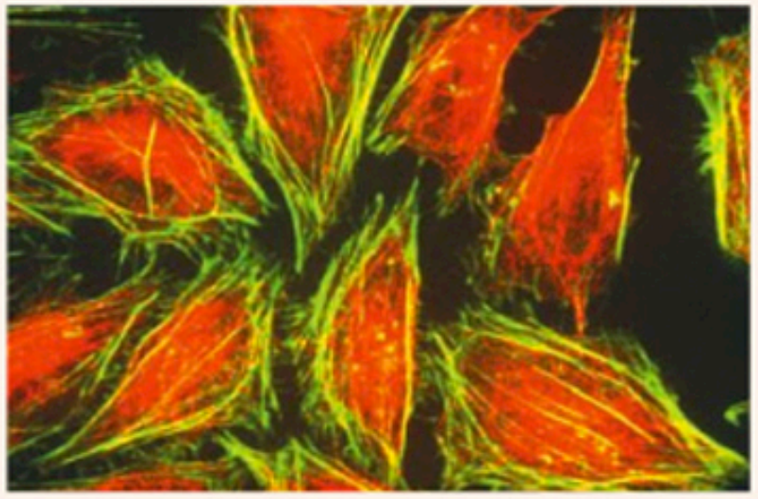
30 µm

In **stained bright-field microscopy**, a stain enhances contrast and reveals details not otherwise visible. Stains differ greatly in their chemistry and their capacity to bind to cell materials, so many choices are available.



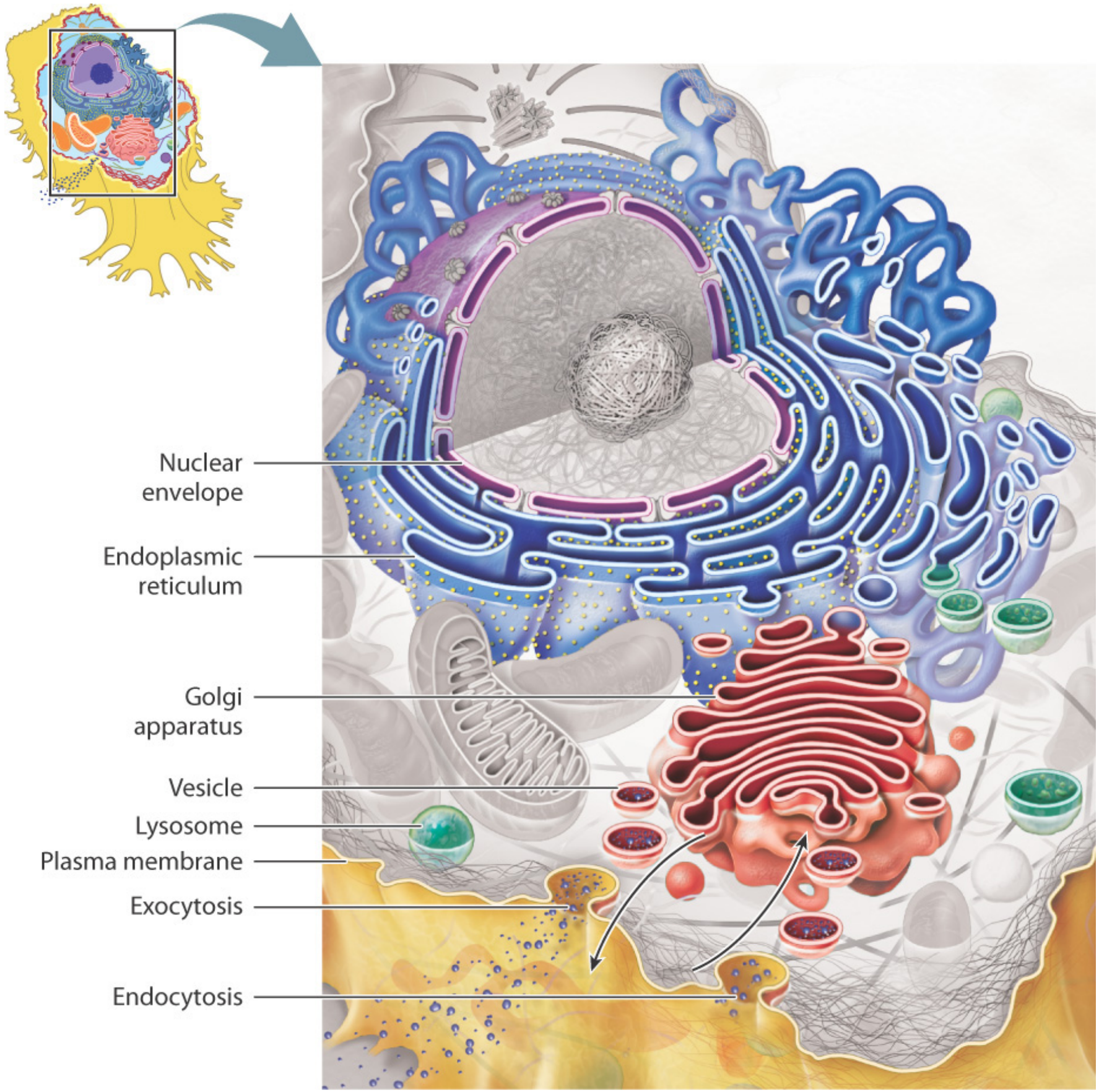
20 µm

In **fluorescence microscopy**, a natural substance in the cell or a fluorescent dye that binds to a specific cell material is stimulated by a beam of light, and the longer-wavelength fluorescent light is observed coming directly from the dye.



20 µm

Confocal microscopy uses fluorescent materials but adds a system of focusing both the stimulating and emitted light so that a single plane through the cell is seen. The result is a sharper two-dimensional image than with standard fluorescence microscopy.


Nuclear envelope
Endoplasmic reticulum
Golgi apparatus
Vesicle
Lysosome
Plasma membrane
Exocytosis
Endocytosis

The **nucleus** contains most of the cell's genetic material (DNA).

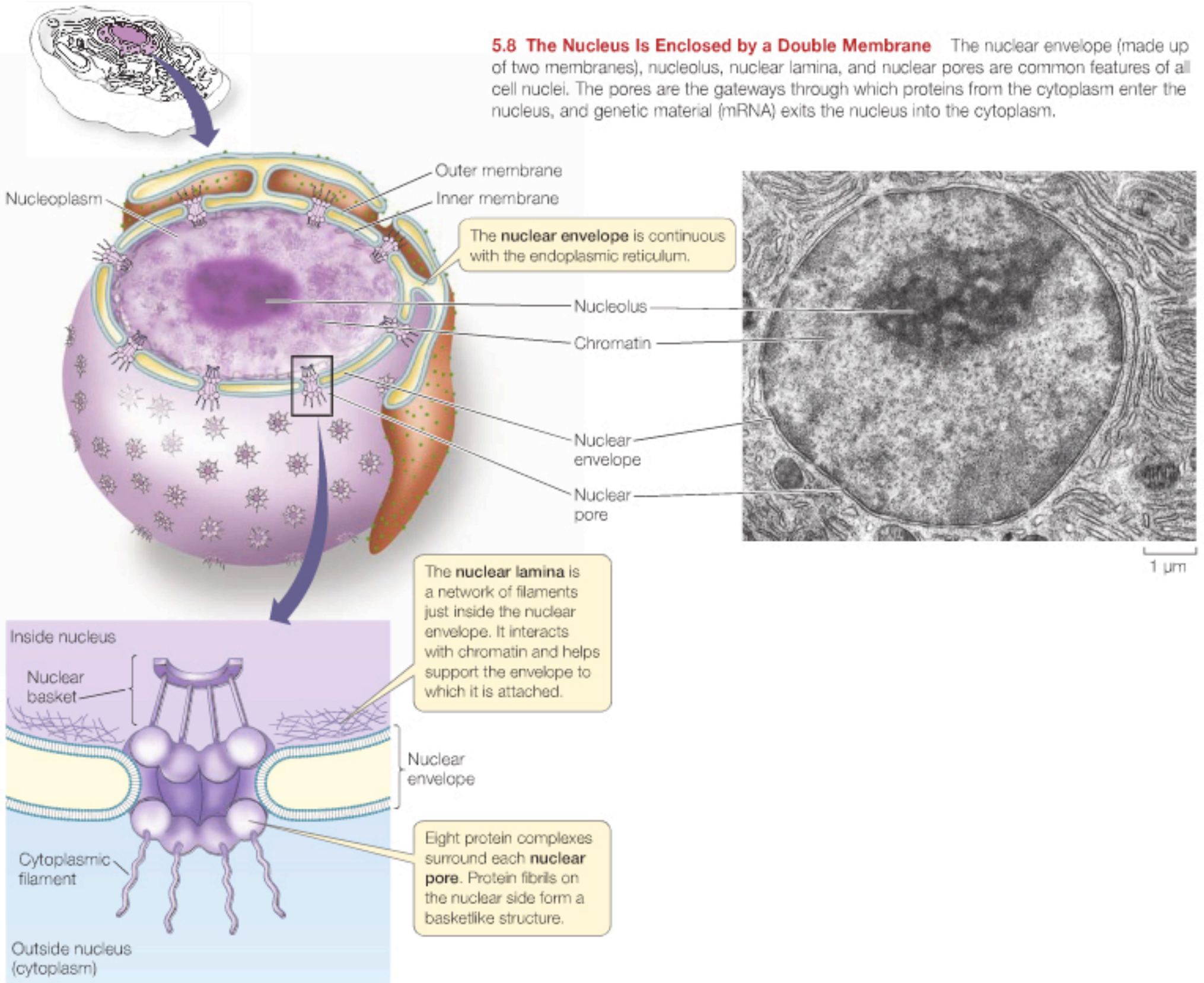
The **mitochondrion** is the power plant and industrial park of the cell in that it is the major source of for the storage and conversion of energy.

The **chloroplast** performs photosynthesis in bacterial and plant cells. As you know,

The **endoplasmic reticulum** and **Golgi apparatus** make up distinct compartments where proteins are packaged and sent to appropriate locations in the cell.

The **lysosome** and **vacuole** are cellular digestive systems, where large molecules are hydrolyzed into usable monomers.

Eukaryotic cells tend to be larger than prokaryotic cells, and as such with all the volume changes and Volume/Surface Area ratio changes they have had to adapt a far more sophisticated network of **support structures** comprising the ***cytoskeleton***, that provides shape and structure to cells, among other functions.


5.8 The Nucleus Is Enclosed by a Double Membrane The nuclear envelope (made up of two membranes), nucleolus, nuclear lamina, and nuclear pores are common features of all cell nuclei. The pores are the gateways through which proteins from the cytoplasm enter the nucleus, and genetic material (mRNA) exits the nucleus into the cytoplasm.
Nucleoplasm
Outer membrane
Inner membrane
The nuclear envelope is continuous with the endoplasmic reticulum.
Nucleolus
Chromatin
Nuclear envelope
Nuclear pore
1 μm
Inside nucleus
Nuclear basket
The nuclear lamina is a network of filaments just inside the nuclear envelope. It interacts with chromatin and helps support the envelope to which it is attached.
Nuclear envelope
Cytoplasmic filament
Eight protein complexes surround each nuclear pore. Protein fibrils on the nuclear side form a basketlike structure.
Outside nucleus (cytoplasm)

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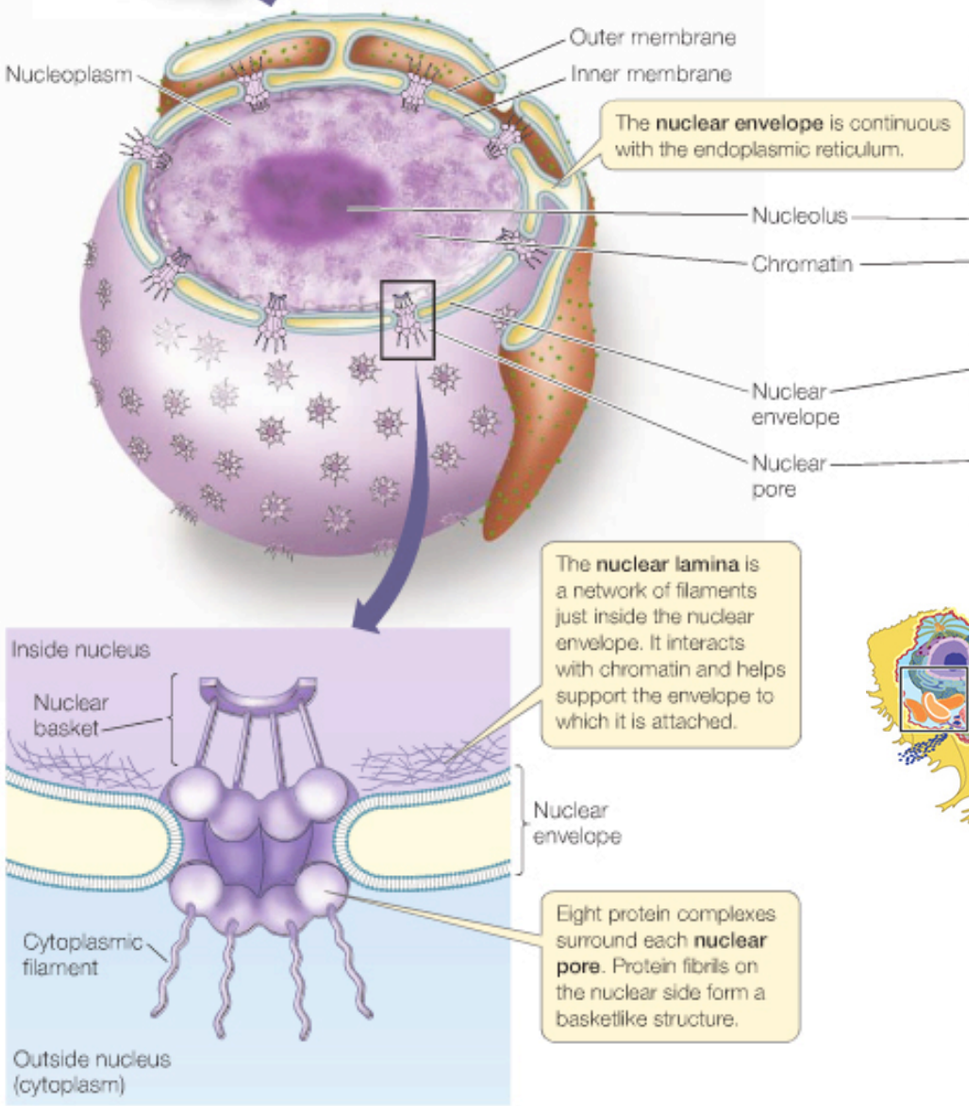
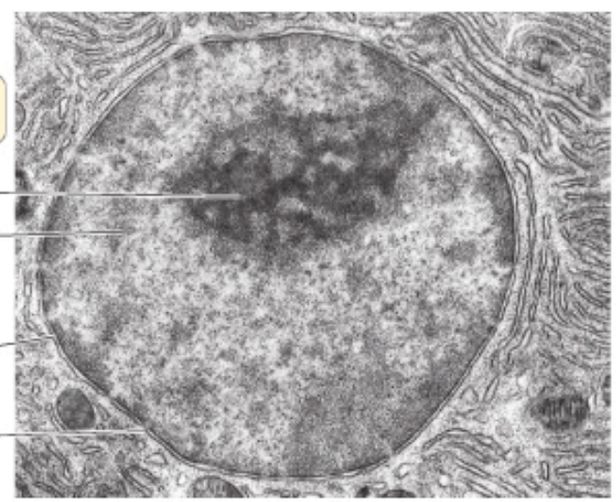
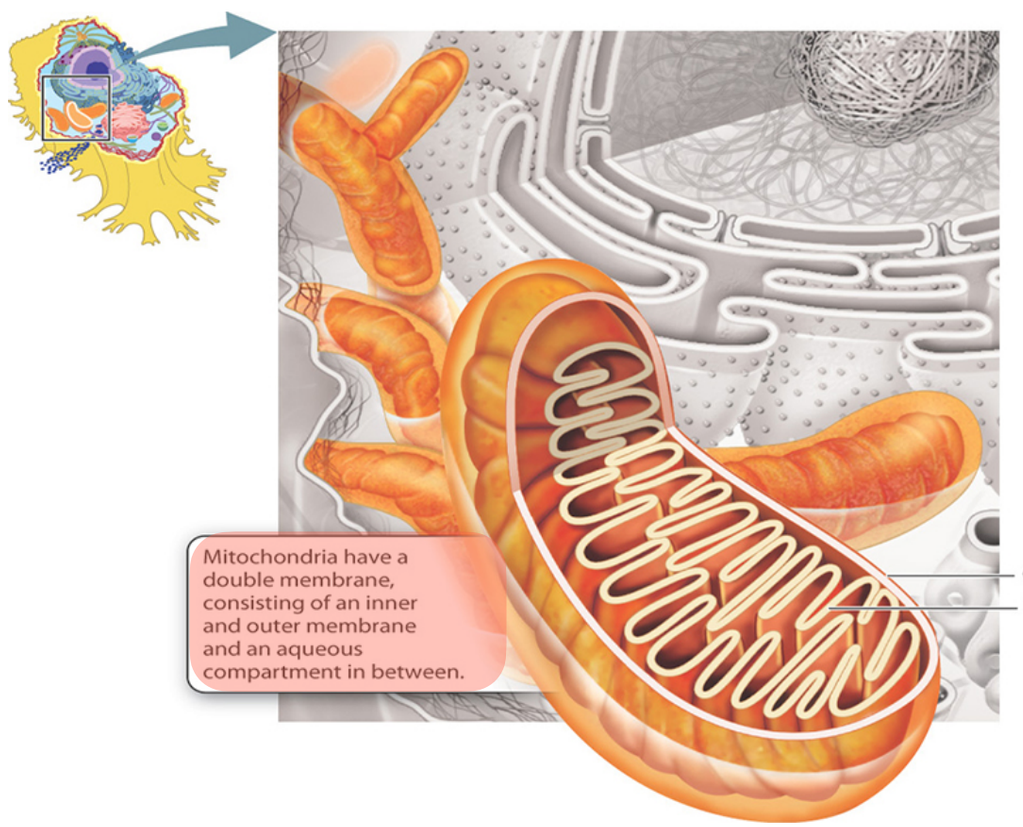
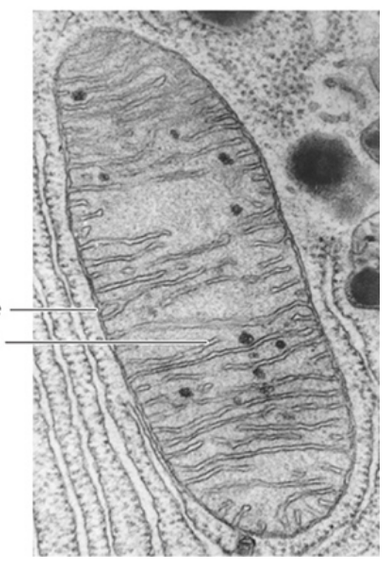
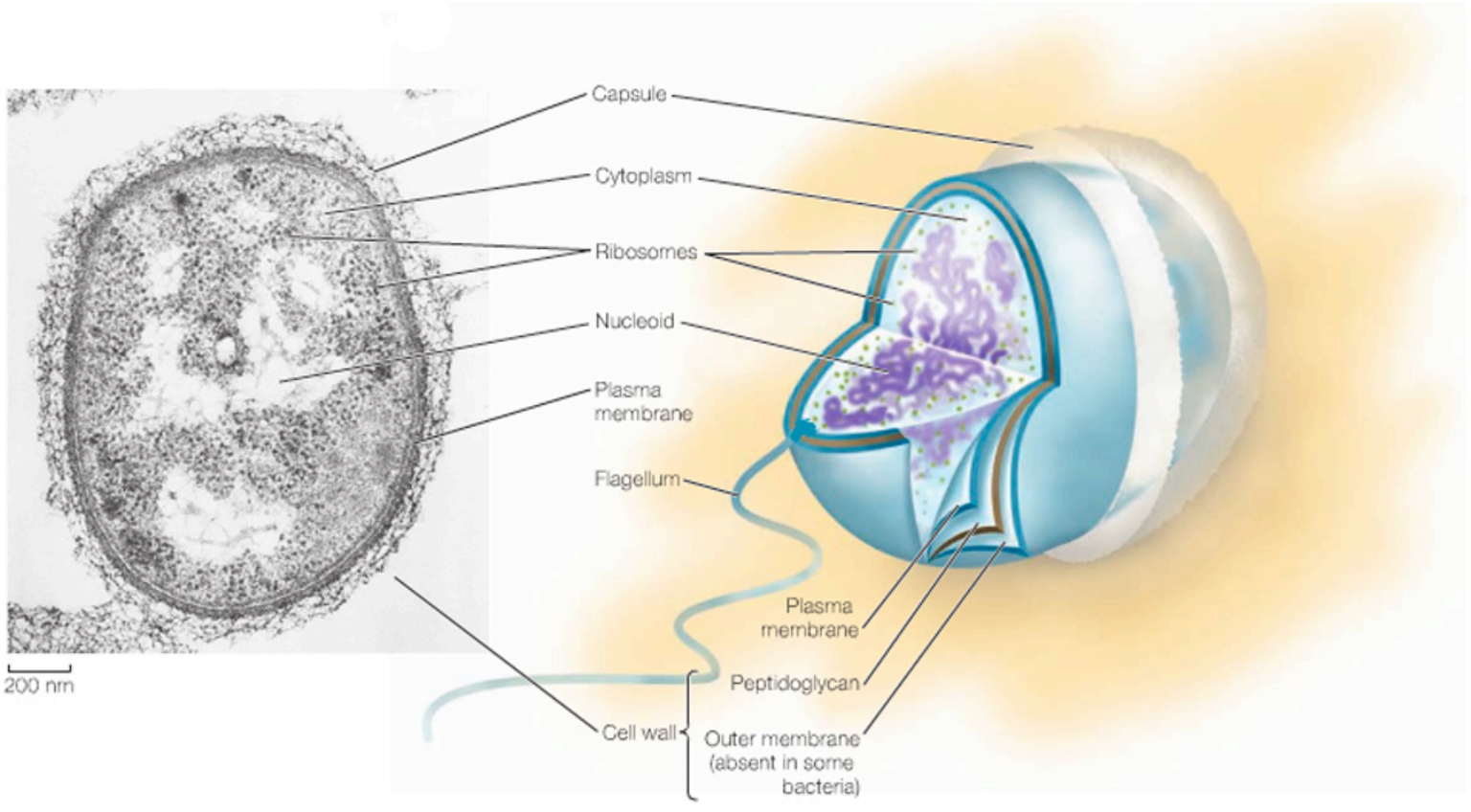


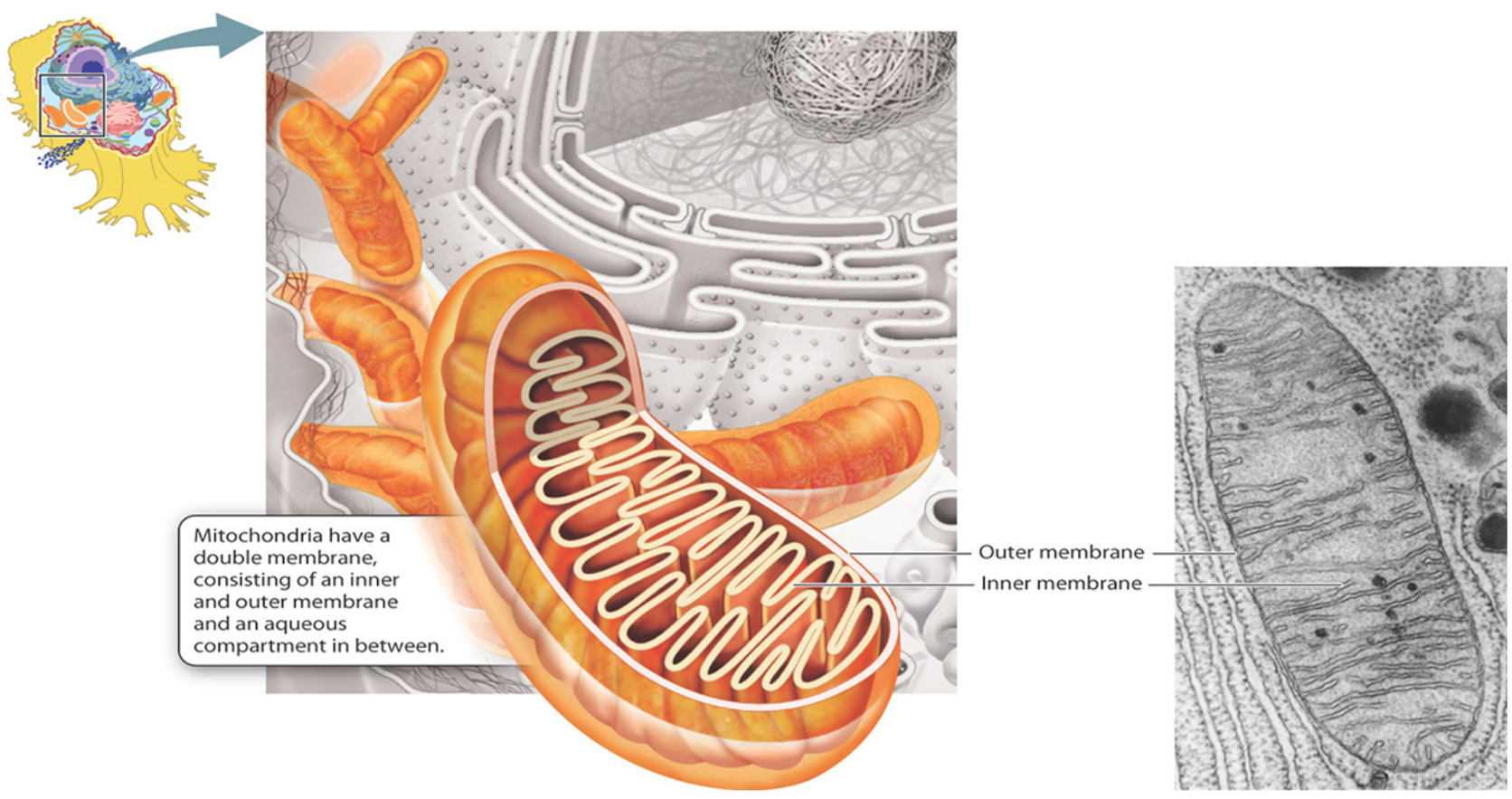








5.4 A Prokaryotic Cell The bacterium *Pseudomonas aeruginosa* illustrates the typical structures shared by all prokaryotic cells. This bacterium also has a protective outer membrane that not all prokaryotes have. The flagellum and capsule are also structures found in some, but not all, prokaryotic cells.



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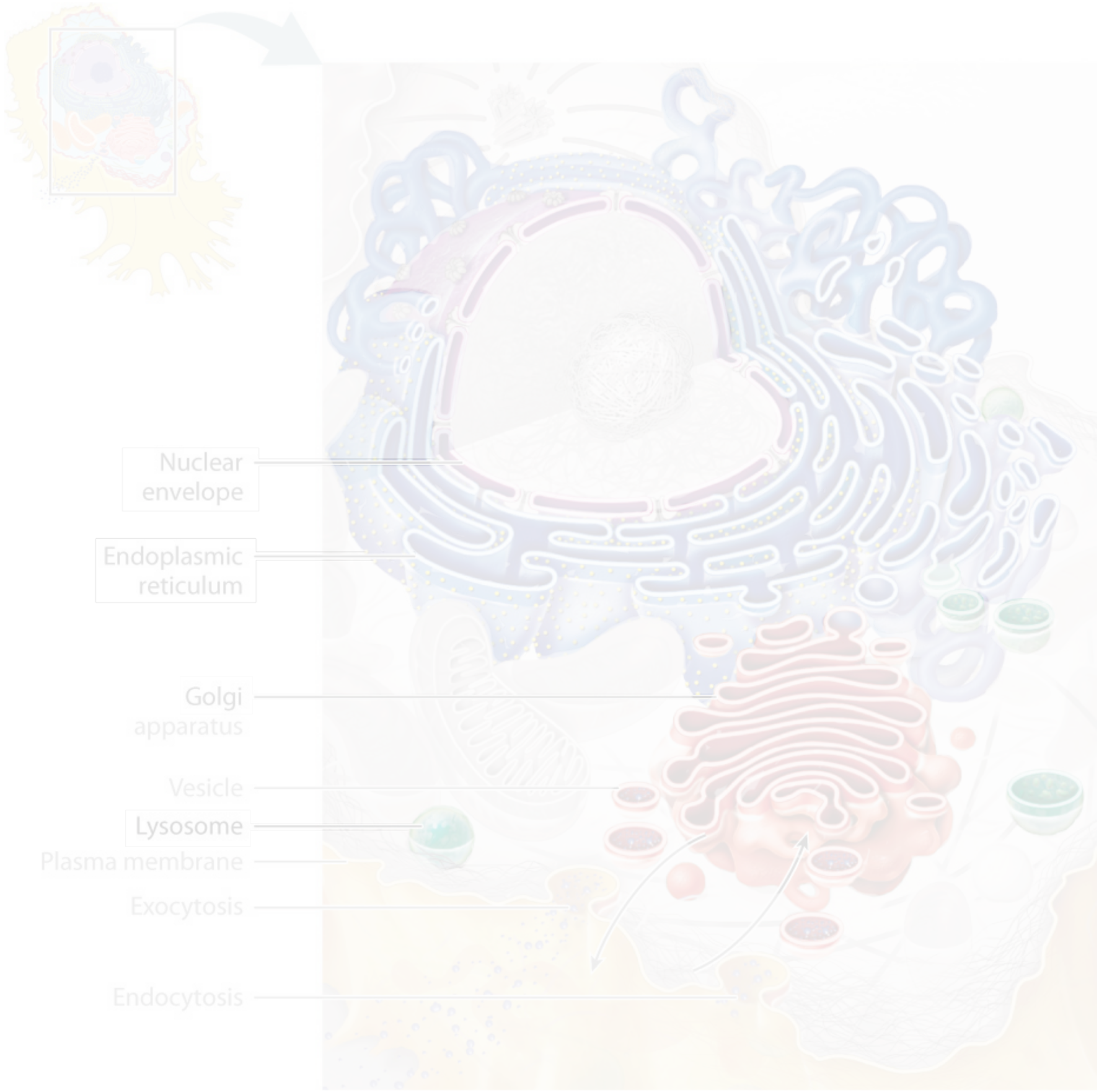
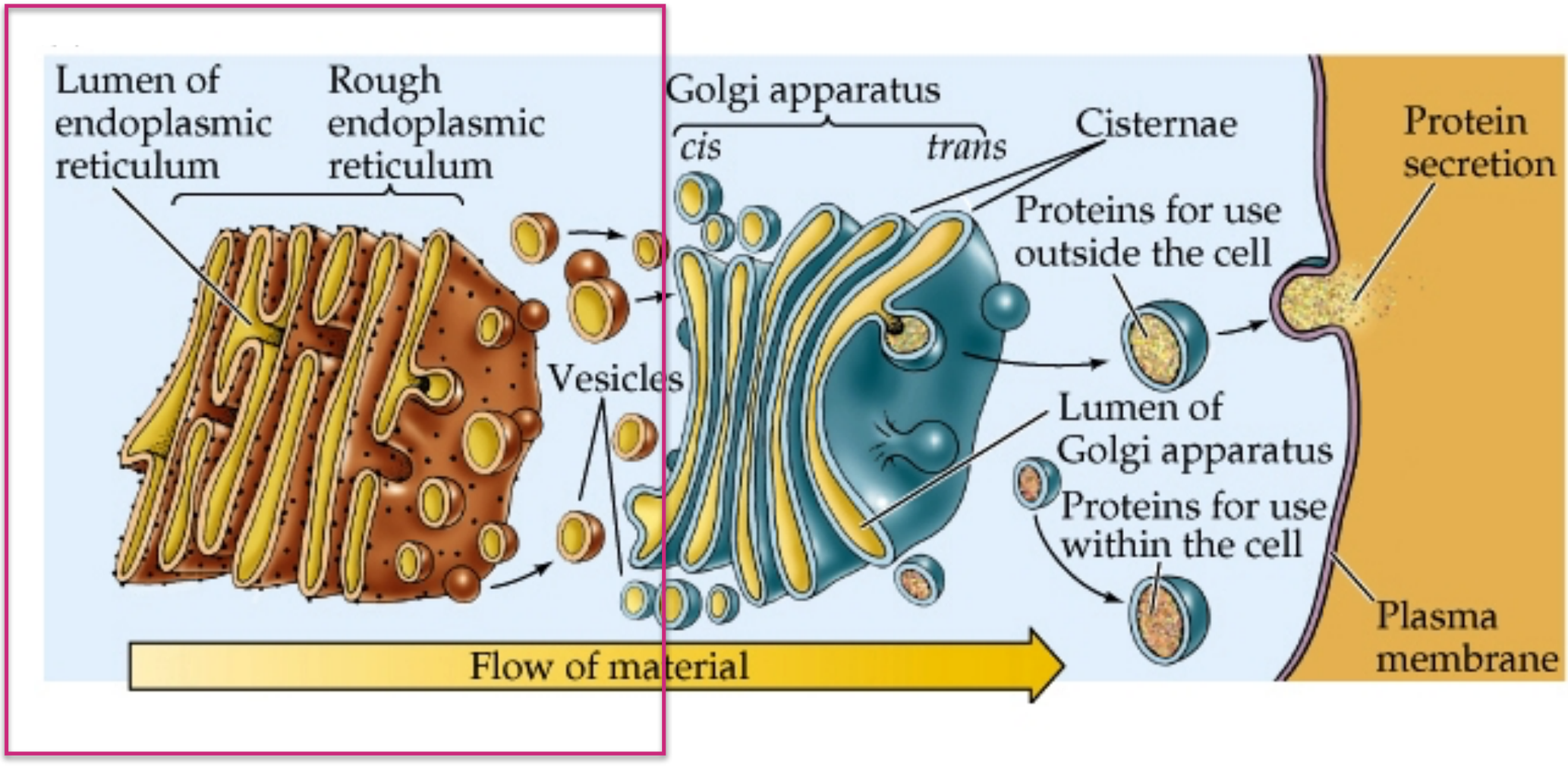
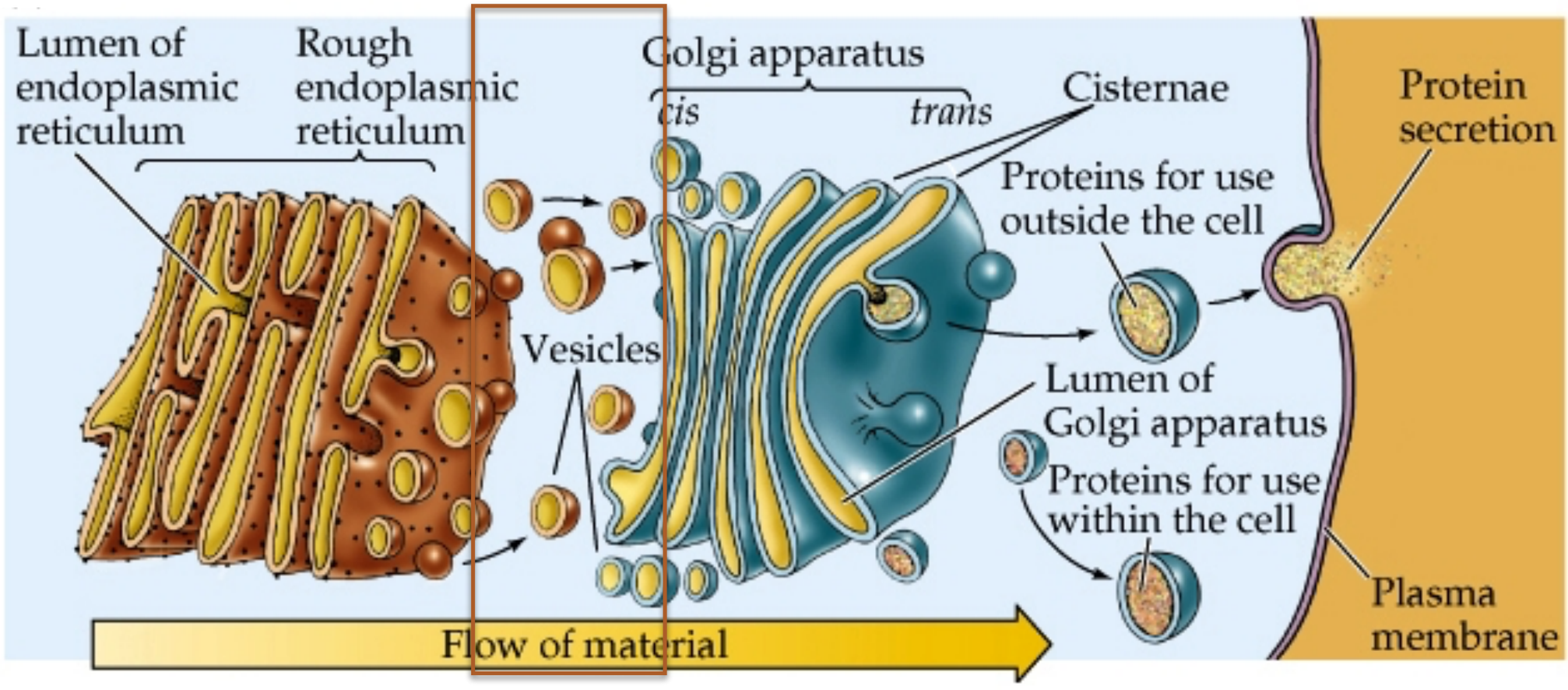

Nuclear envelope
Endoplasmic reticulum
Golgi apparatus
Vesicle
Lysosome
Plasma membrane
Exocytosis
Endocytosis


Lumen of endoplasmic reticulum
Rough endoplasmic reticulum
Golgi apparatus
cis
trans
Cisternae
Protein secretion
Proteins for use outside the cell
Vesicles
Lumen of Golgi apparatus
Proteins for use within the cell
Plasma membrane
Flow of material


Lumen of endoplasmic reticulum
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Protein secretion
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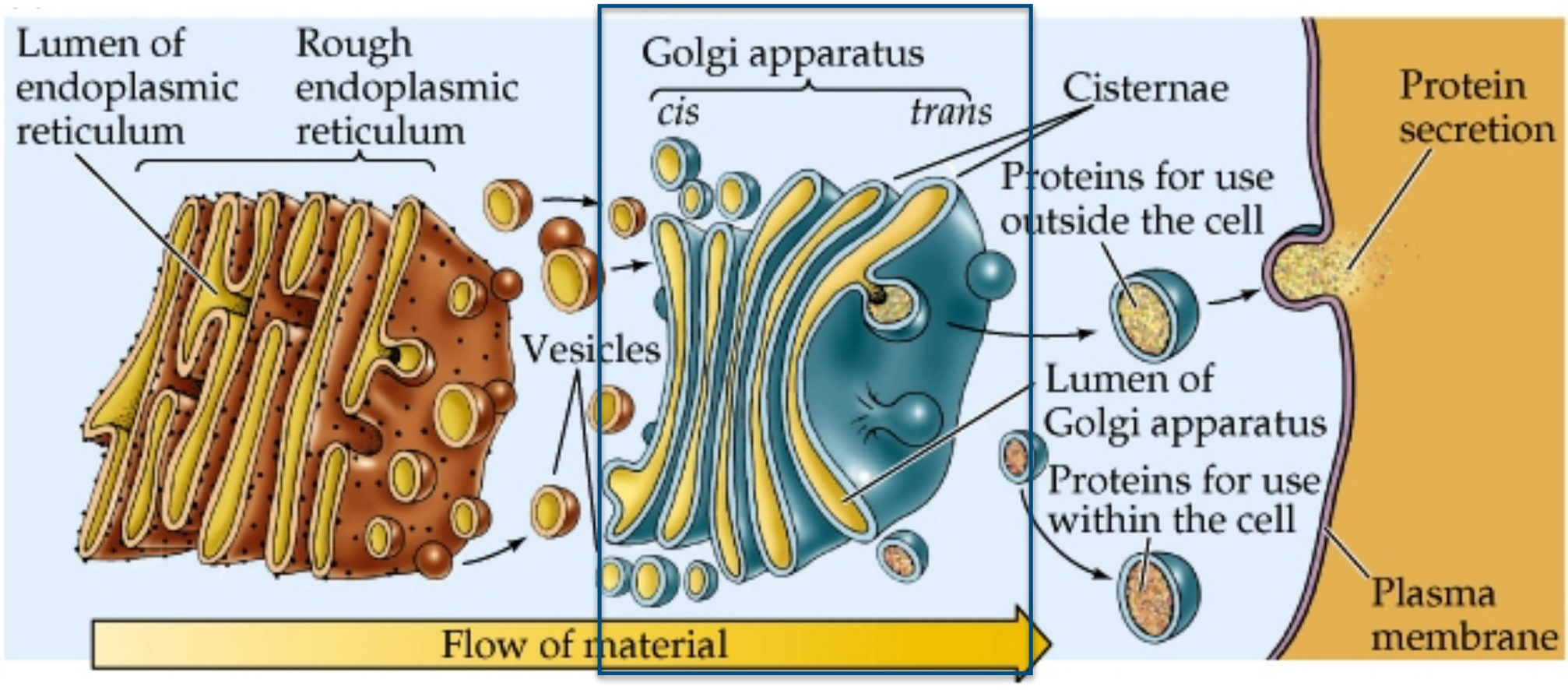
Vesicles
Lumen of Golgi apparatus
Proteins for use within the cell
Plasma membrane
Flow of material


Lumen of endoplasmic reticulum
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trans
Cisternae
Protein secretion
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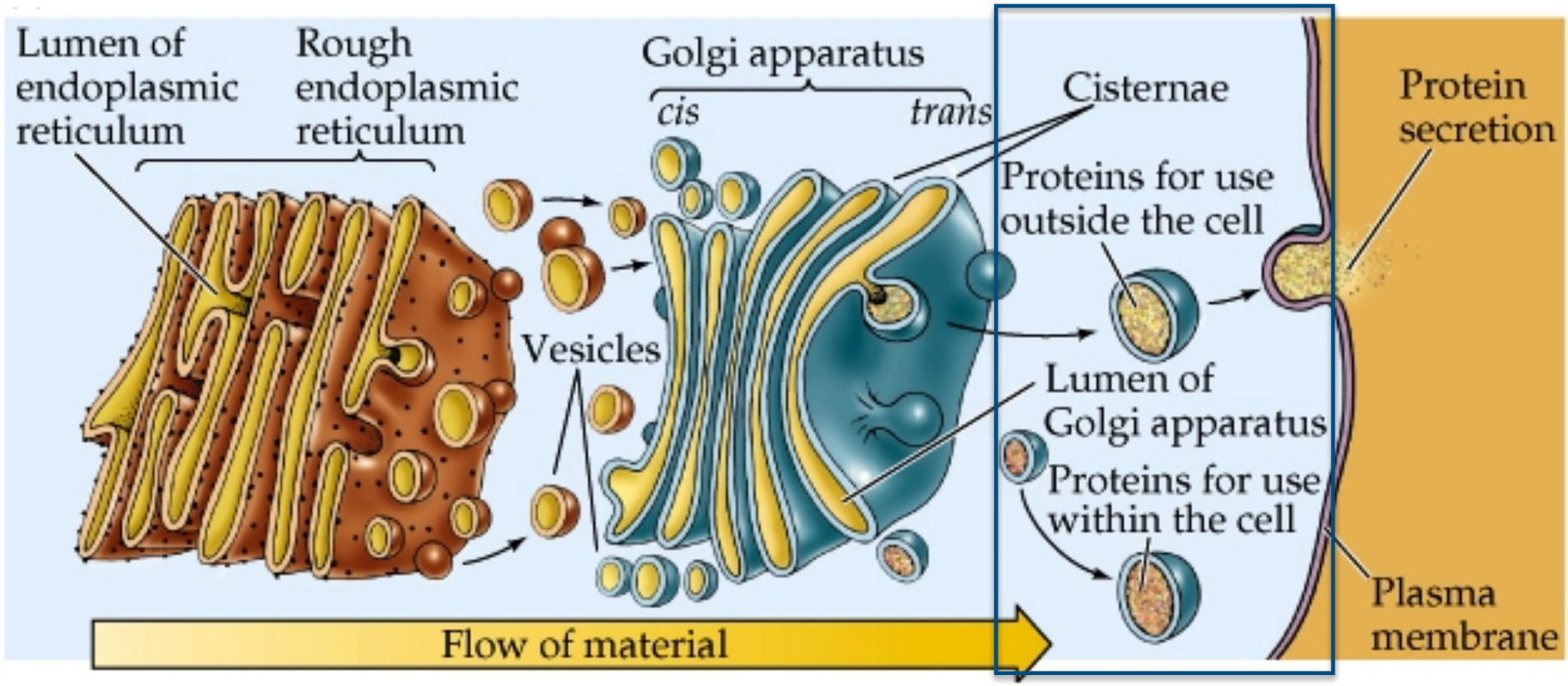
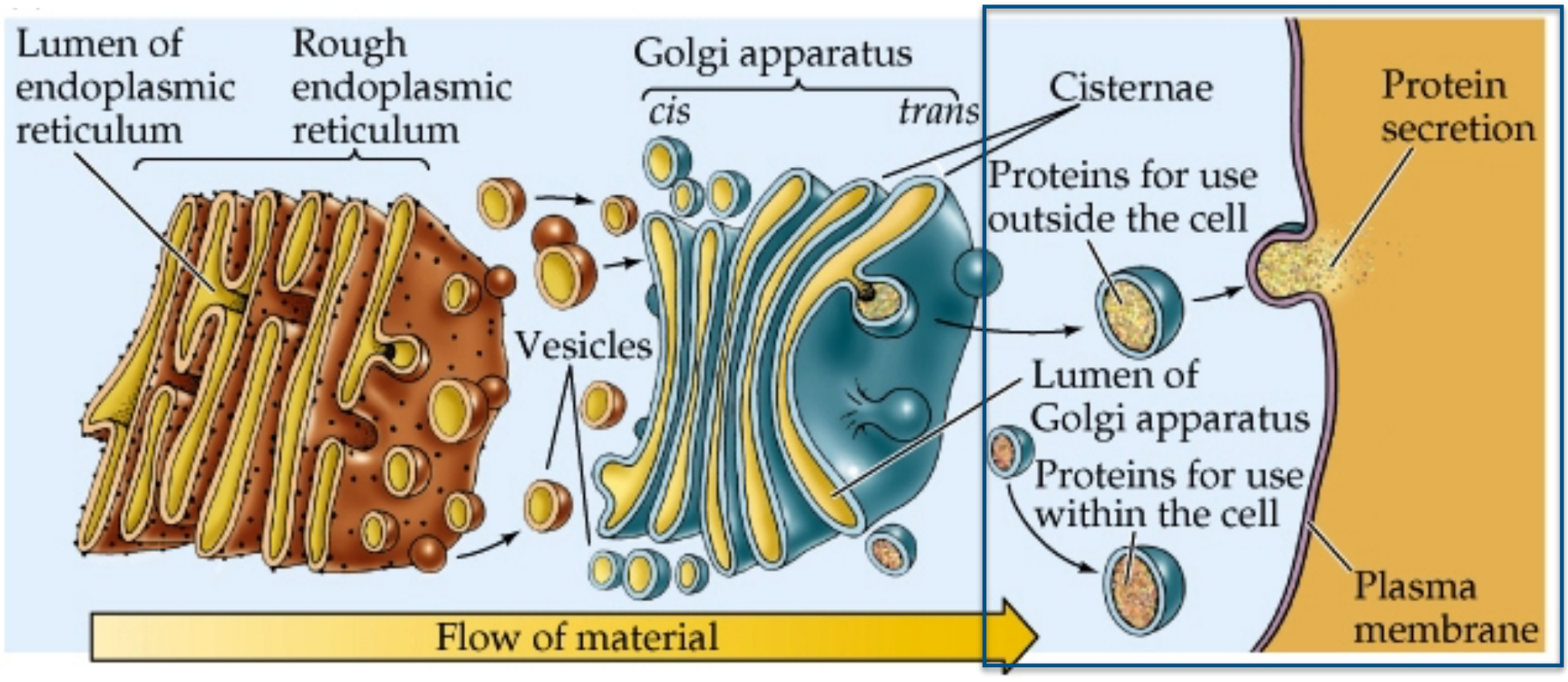
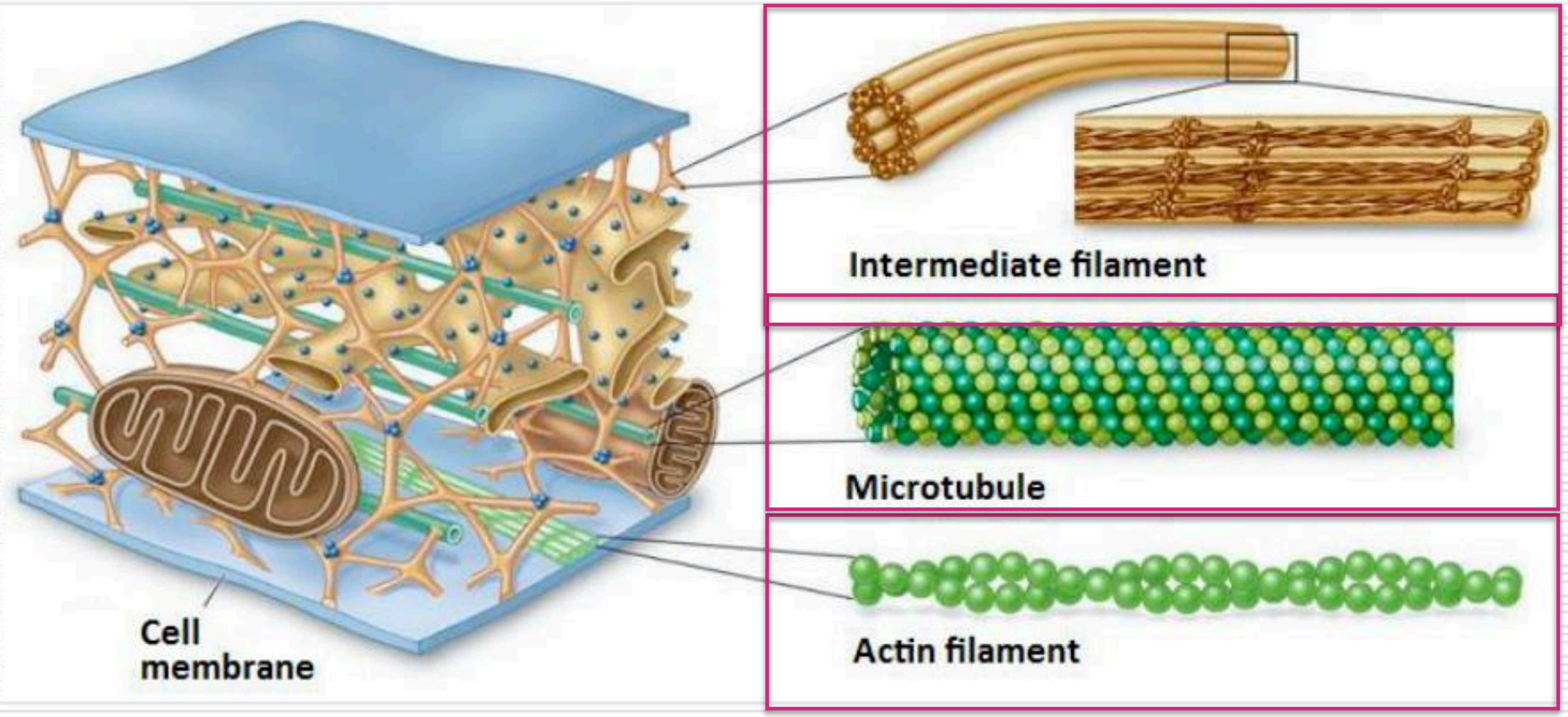
Vesicles
Lumen of Golgi apparatus
Proteins for use within the cell
Plasma membrane
Flow of material

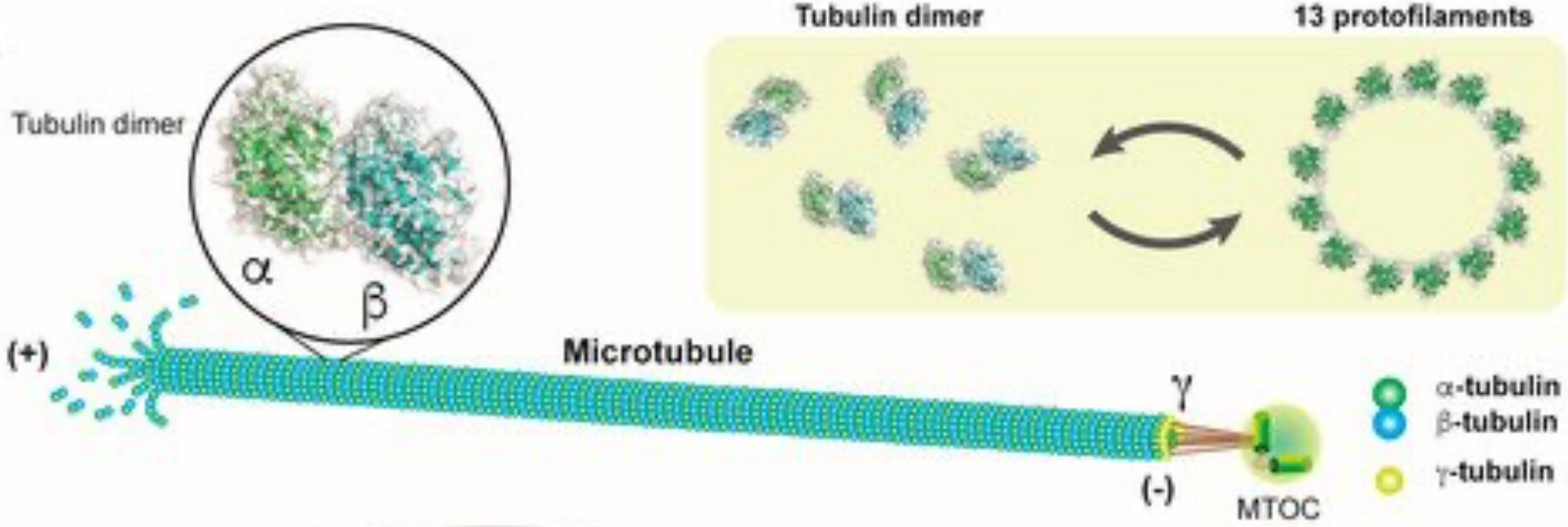

Lumen of endoplasmic reticulum
Rough endoplasmic reticulum
Golgi apparatus
cis
trans
Cisternae
Protein secretion
Proteins for use outside the cell
Vesicles
Lumen of Golgi apparatus
Proteins for use within the cell
Plasma membrane
Flow of material


Lumen of endoplasmic reticulum
Rough endoplasmic reticulum
Golgi apparatus
cis
trans
Cisternae
Protein secretion
Proteins for use outside the cell
Vesicles
Lumen of Golgi apparatus
Proteins for use within the cell
Plasma membrane
Flow of material

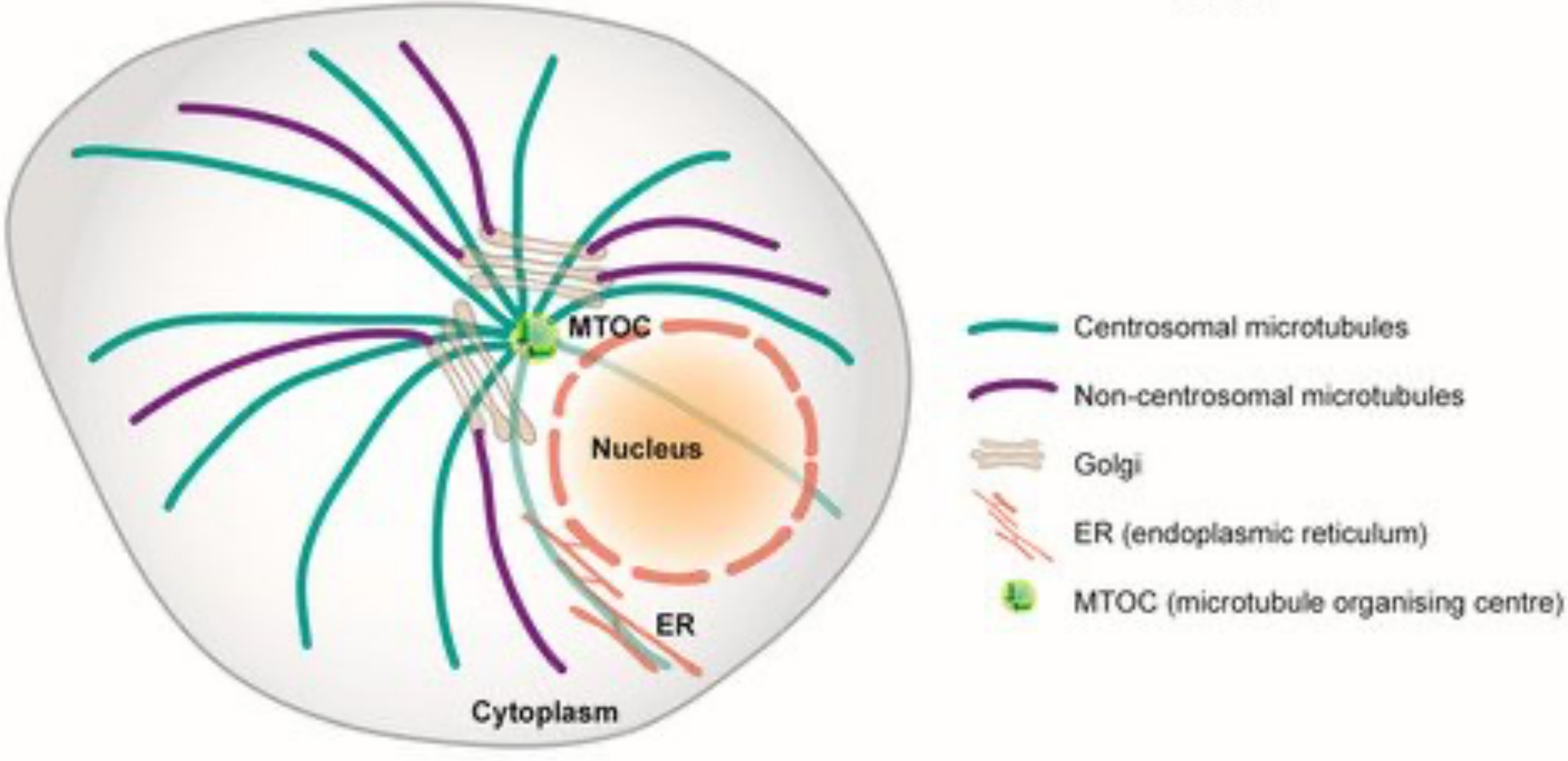
Cytoskeleton Protein Fibers

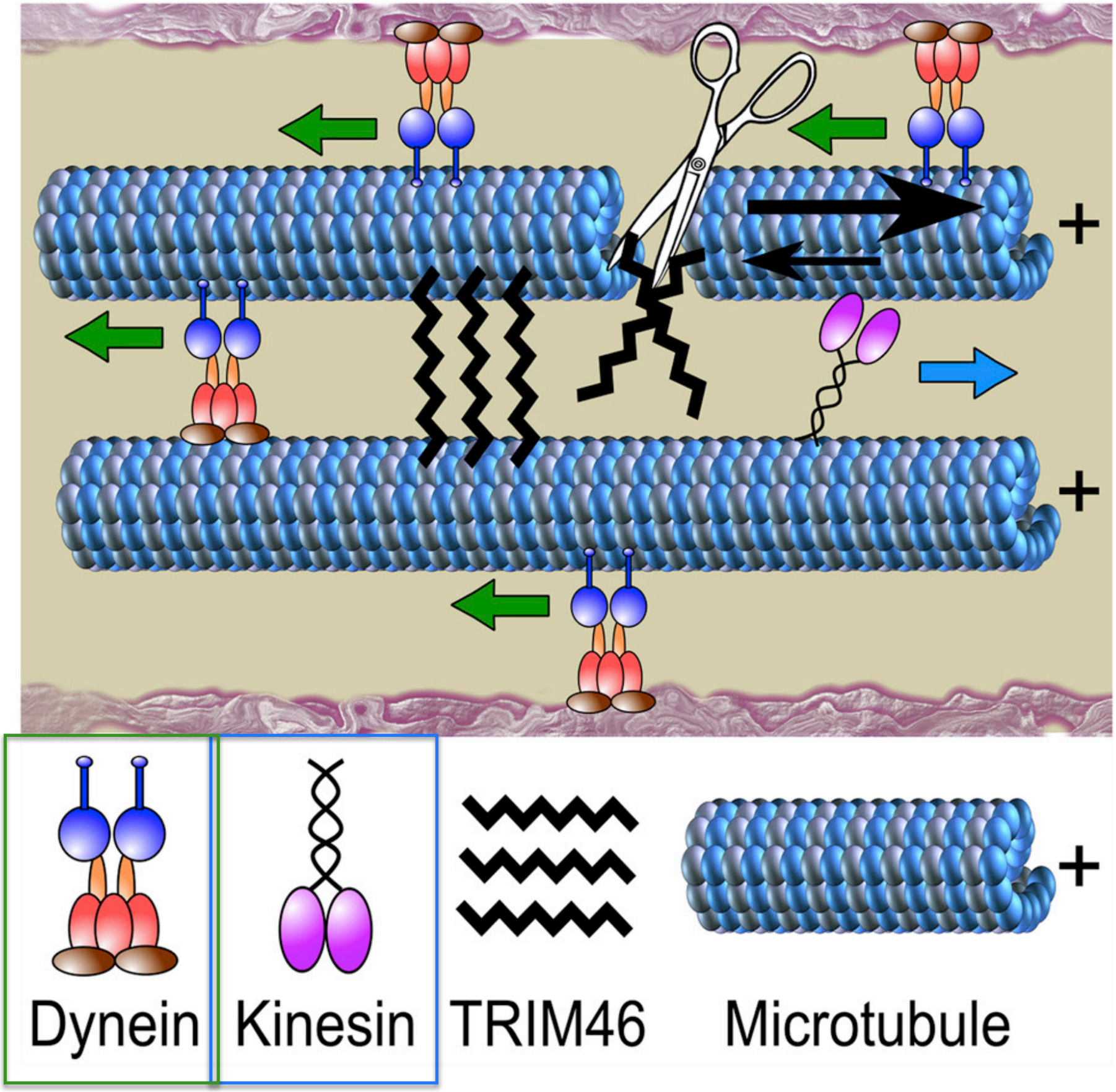


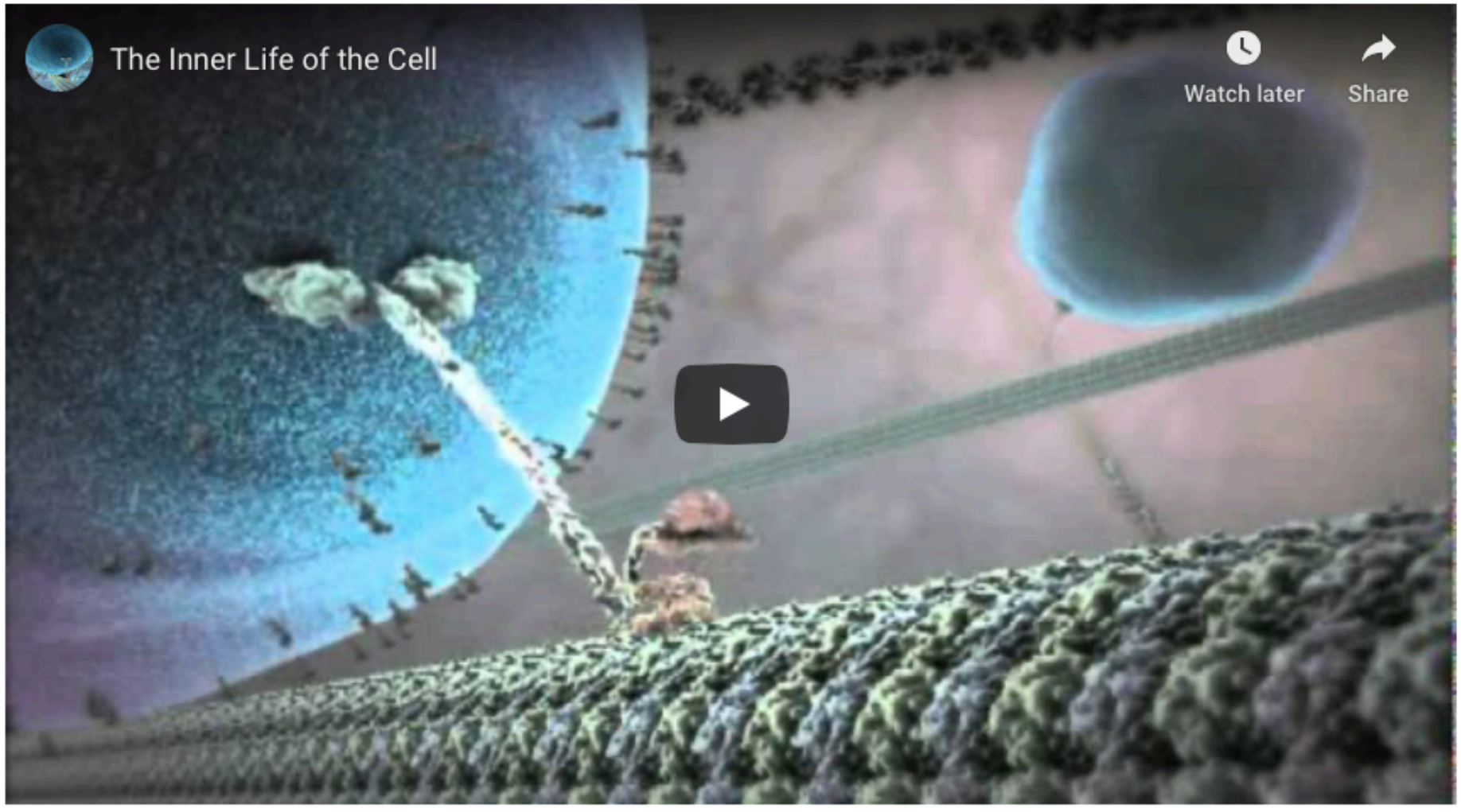
A


Tubulin dimer
13 protofilaments
Tubulin dimer
α
β
(+)
Microtubule
γ
(-)
MTOC
α-tubulin
β-tubulin
γ-tubulin

B


MTOC
Nucleus
ER
Cytoplasm
Centrosomal microtubules
Non-centrosomal microtubules
Golgi
ER (endoplasmic reticulum)
MTOC (microtubule organising centre)


+
+
+
Dynein
Kinesin
TRIM46
Microtubule



http://www.youtube.com/watch?v=wJyUtbn0O5Y