Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.

Enduring understanding 4.A: Interactions within biological systems lead to complex properties.

PREFACE

The Structure and Function of Large Biological Molecules

- Remarkably the most important molecules of life fall into just 4 categories: carbs, lipids, proteins and nucleic acids

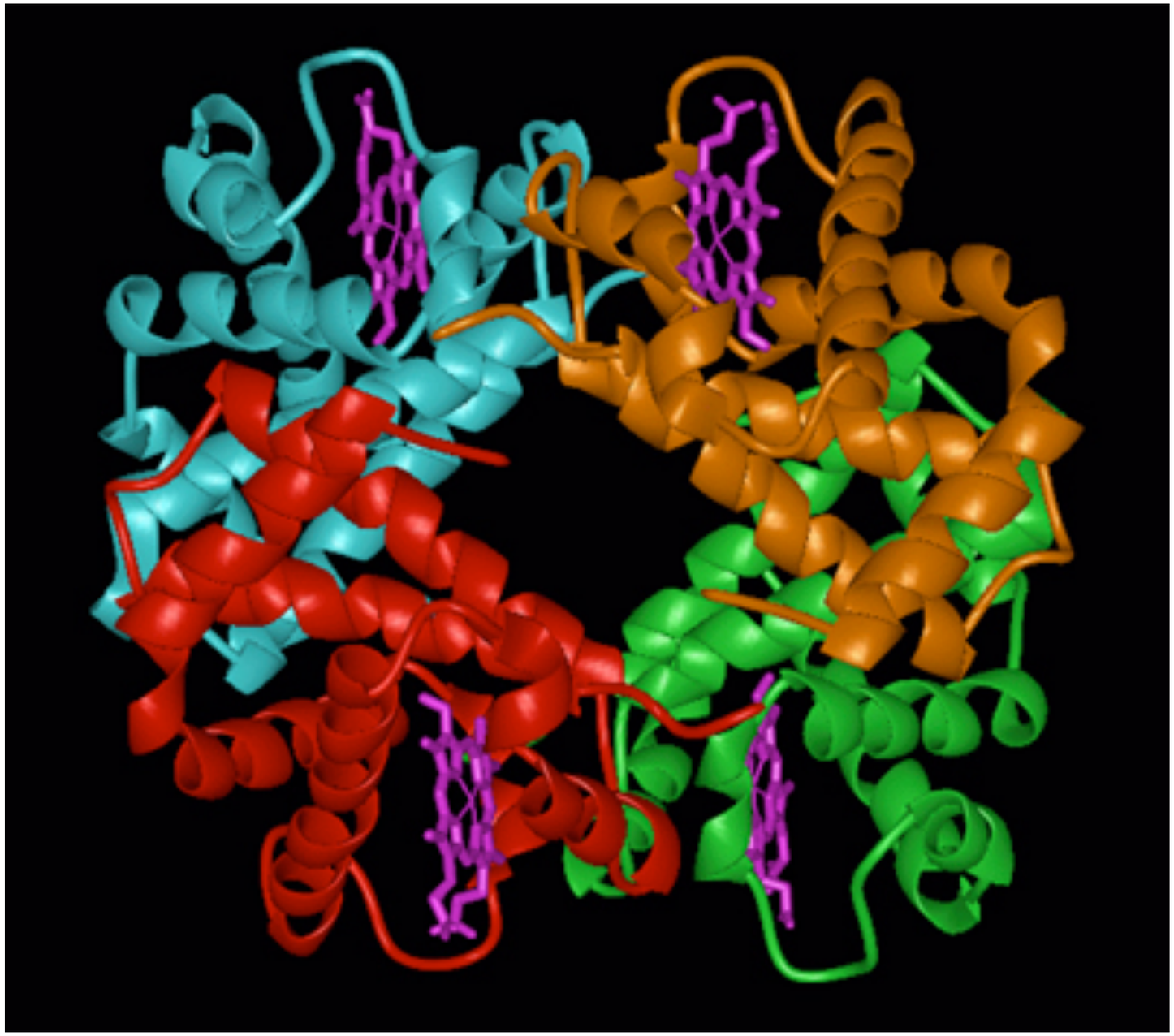
- Three of these classes contain huge molecules (macromolecules)

- The architecture of these molecules helps explain how the molecules work

- Also, like water, these molecules exhibit emergent properties

Biochemistry

Main Idea: These macromolecules are often long chains that consist of small units bond together.

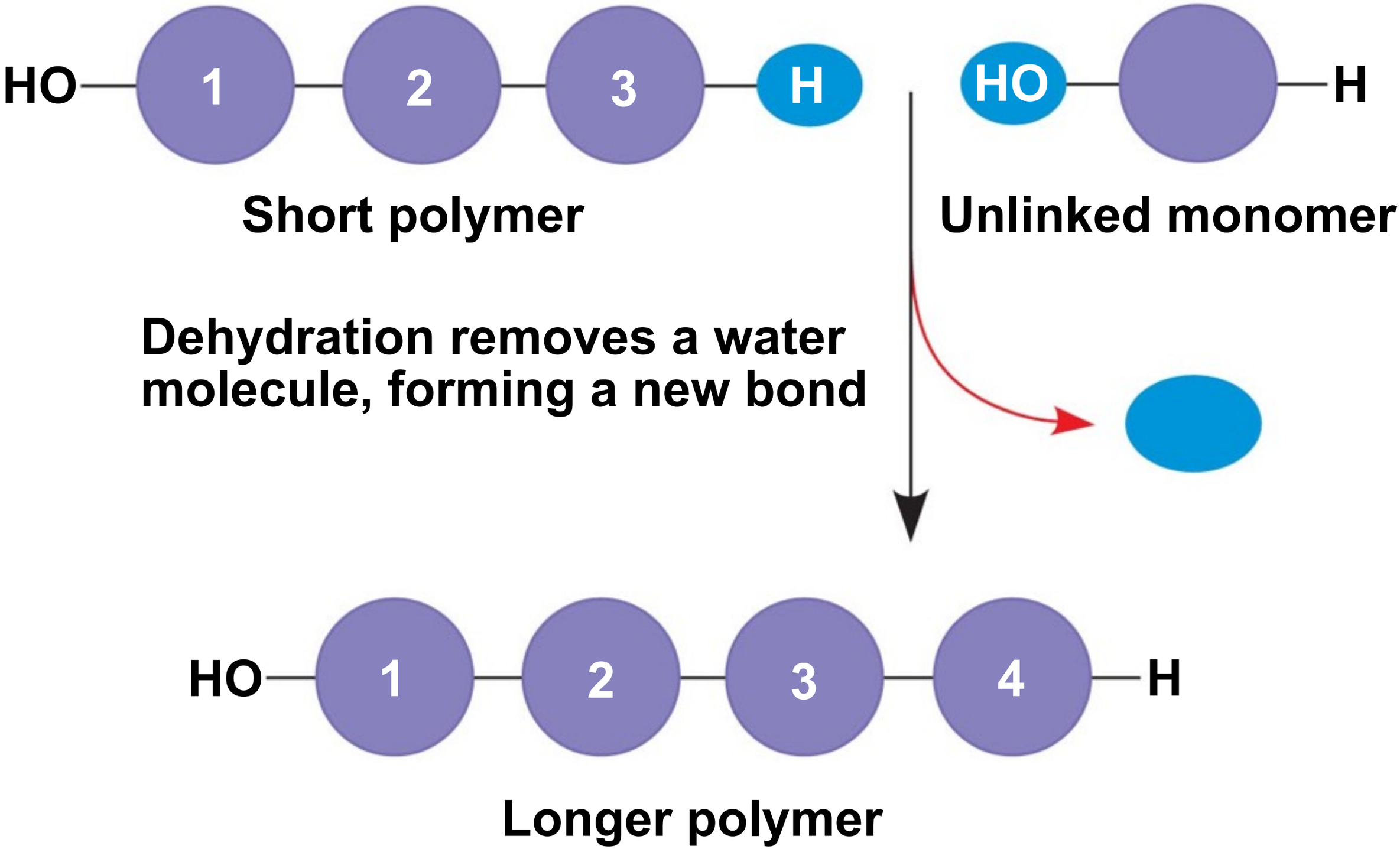


MACROMOLECULES ARE POLYMERS, BUILT FROM MONOMERS

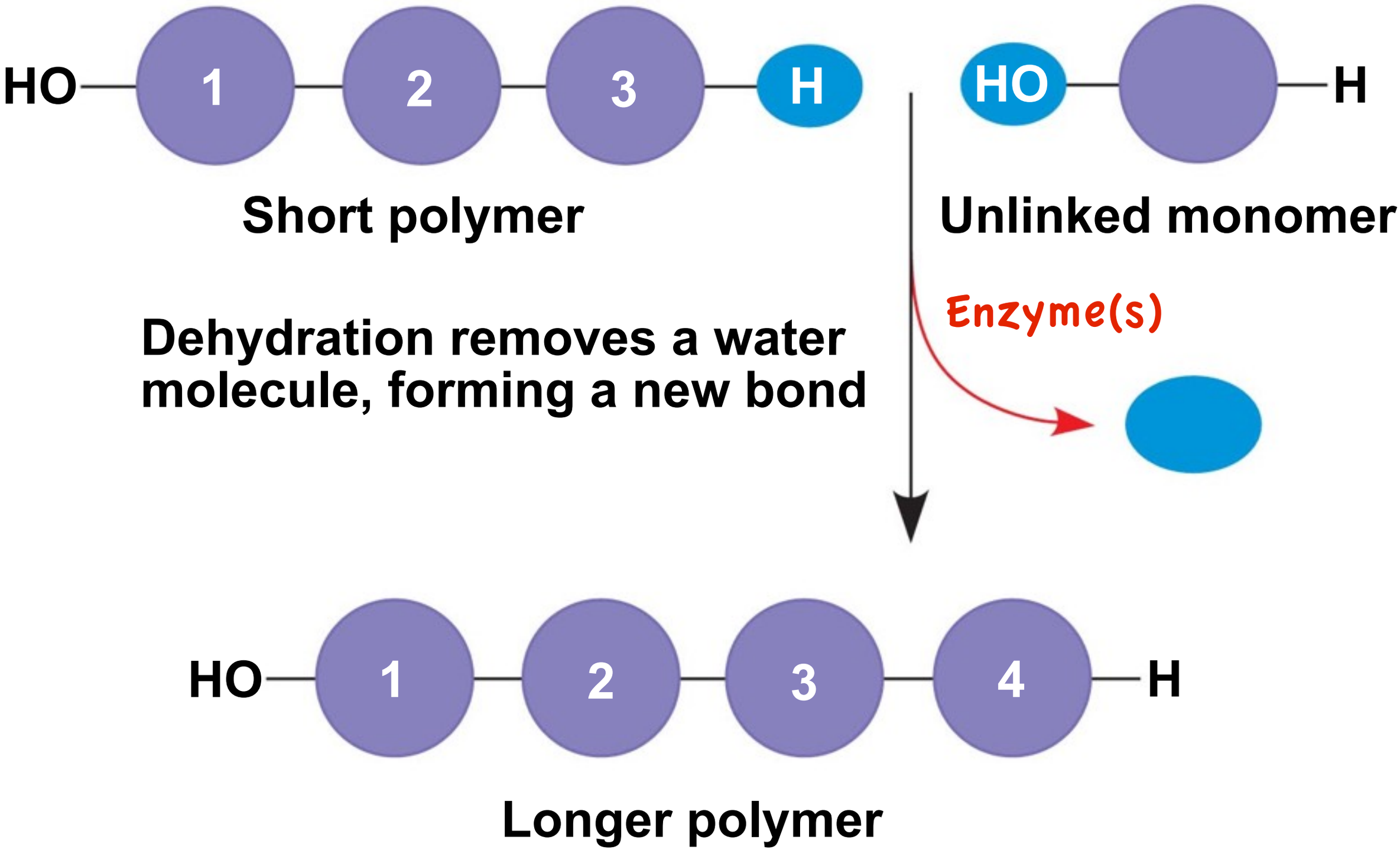
- *Polymers* are long chain-like molecules made up of smaller subunits
- *Monomers* are serve as the building blocks or subunits for polymers

The Synthesis and Breakdown of Polymers

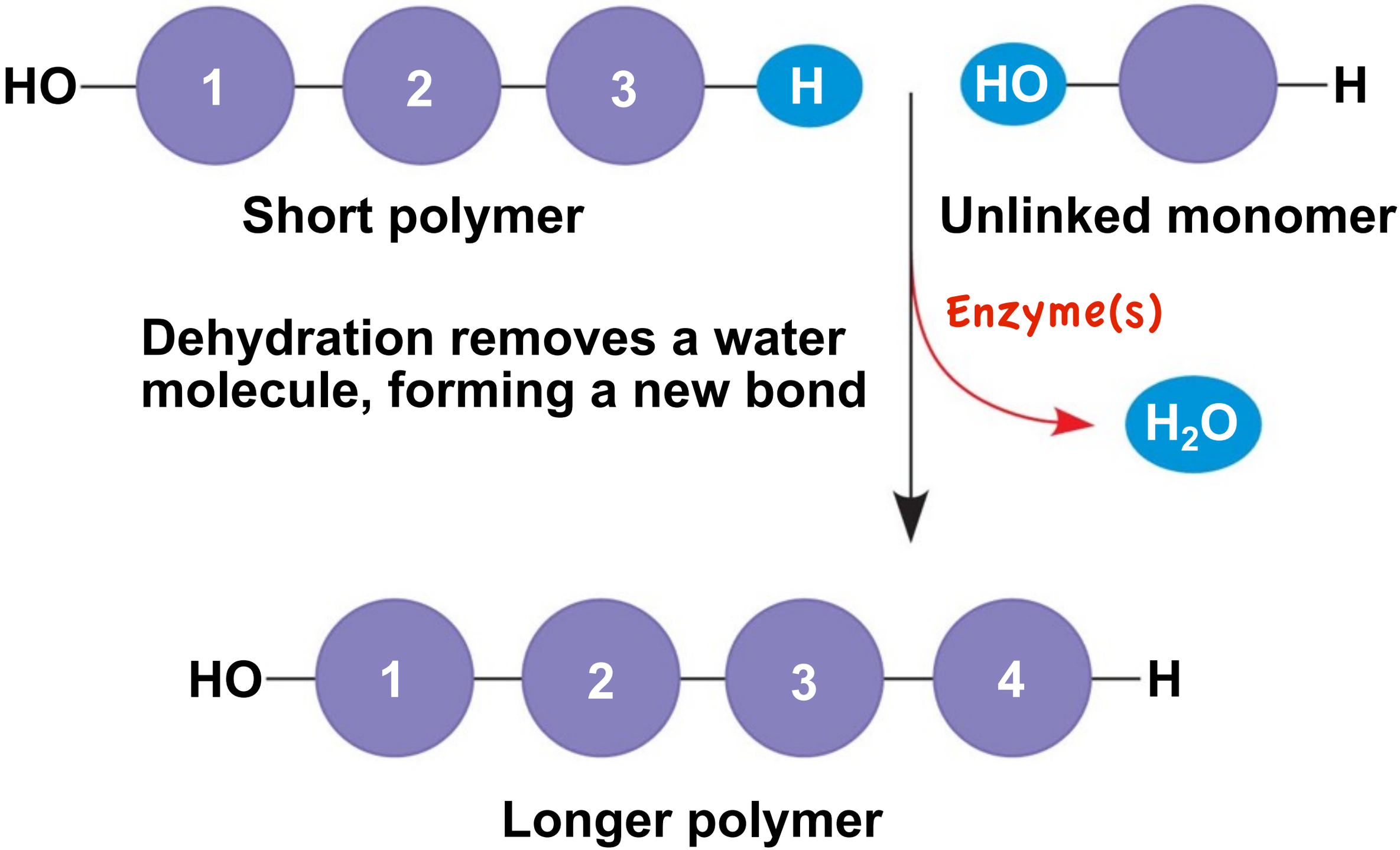
- Although *polymers* and *monomers* vary, the mechanism by which they are built and broken down is the roughly the same
- These building and breaking reactions occur in aqueous solutions and they are facilitated by *enzymes*.
  - *Enzymes* are proteins that speed up the rate of chemical reactions.
- Monomers are covalently bonded to each other through the loss of water, in a reaction called **dehydration synthesis**
- Monomers are separated by a reaction that is essentially the reverse of dehydration synthesis, this reaction is called **hydrolysis.**
  - Here we see enzymes catalyzing a reaction that uses water to split the bonds between monomers.



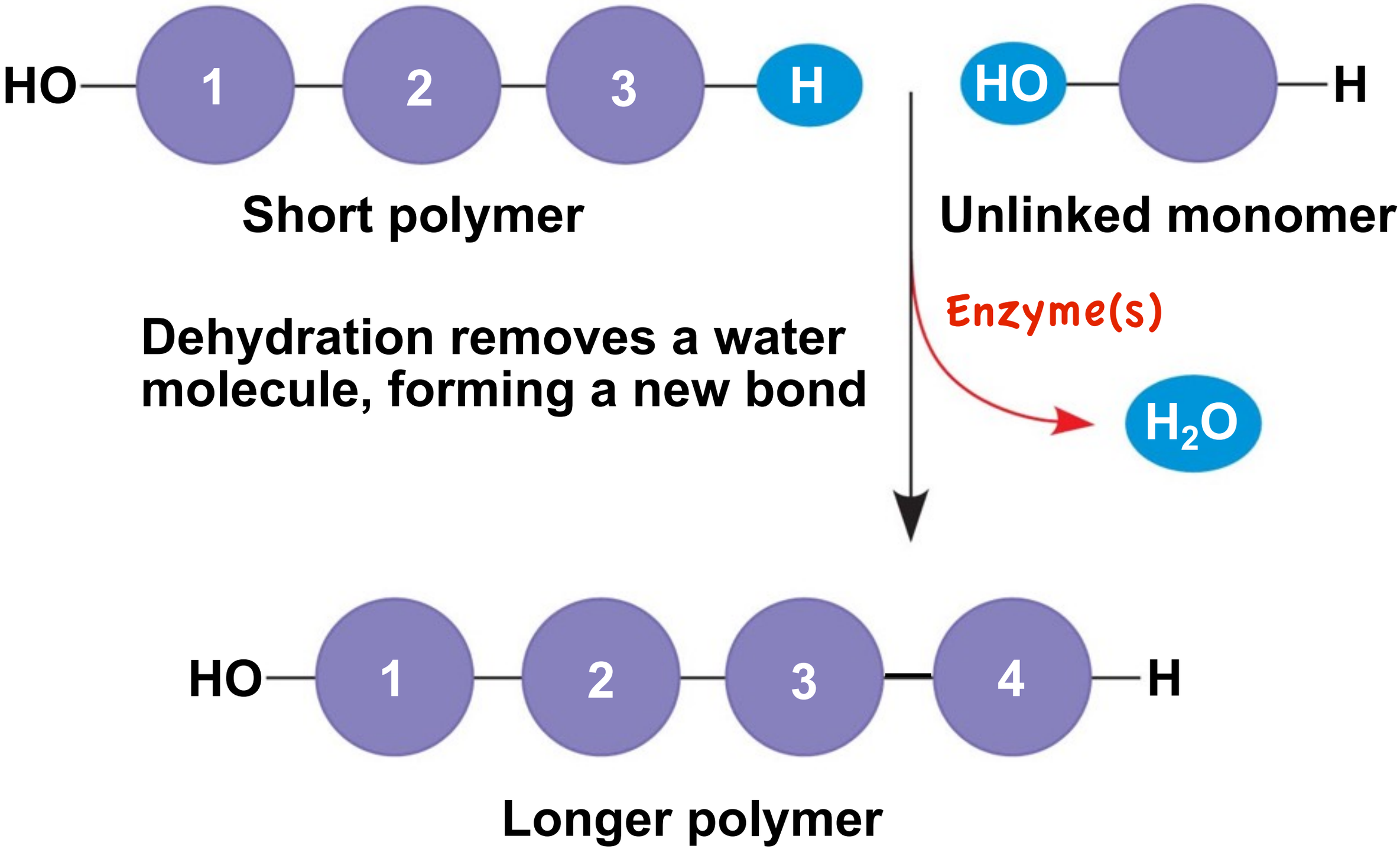
(a) Dehydration reaction in the synthesis of a polymer



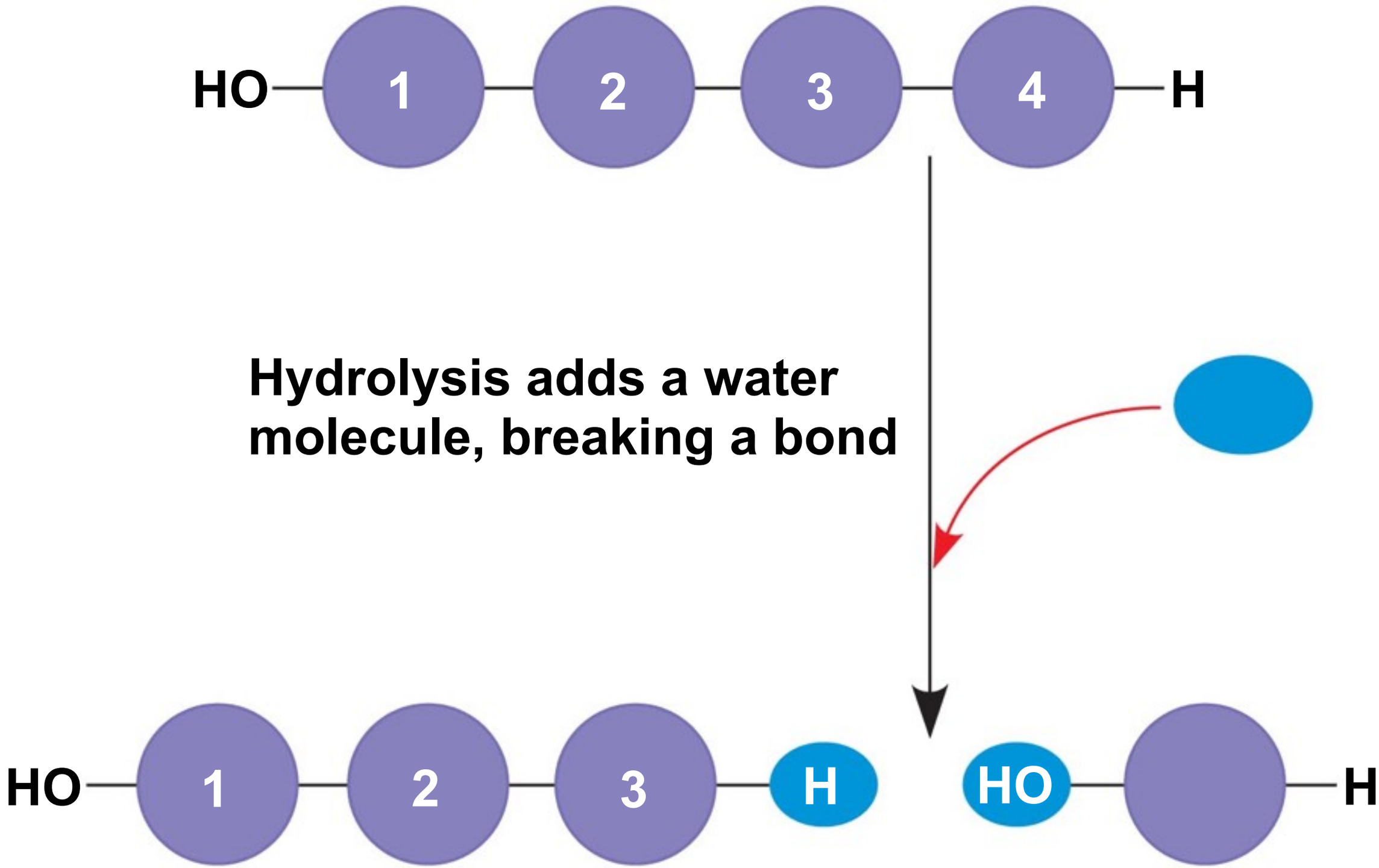
(a) Dehydration reaction in the synthesis of a polymer



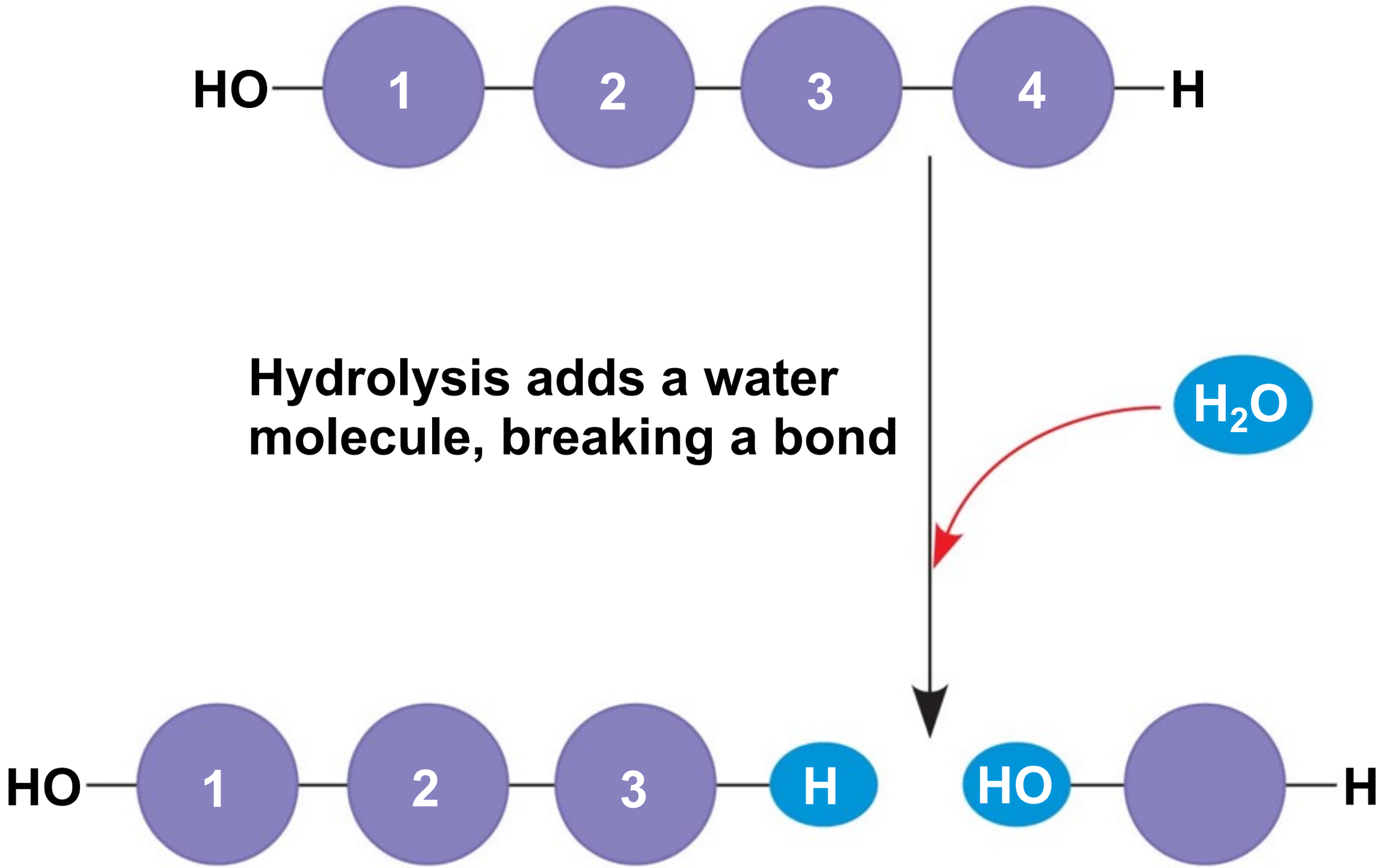
(a) Dehydration reaction in the synthesis of a polymer



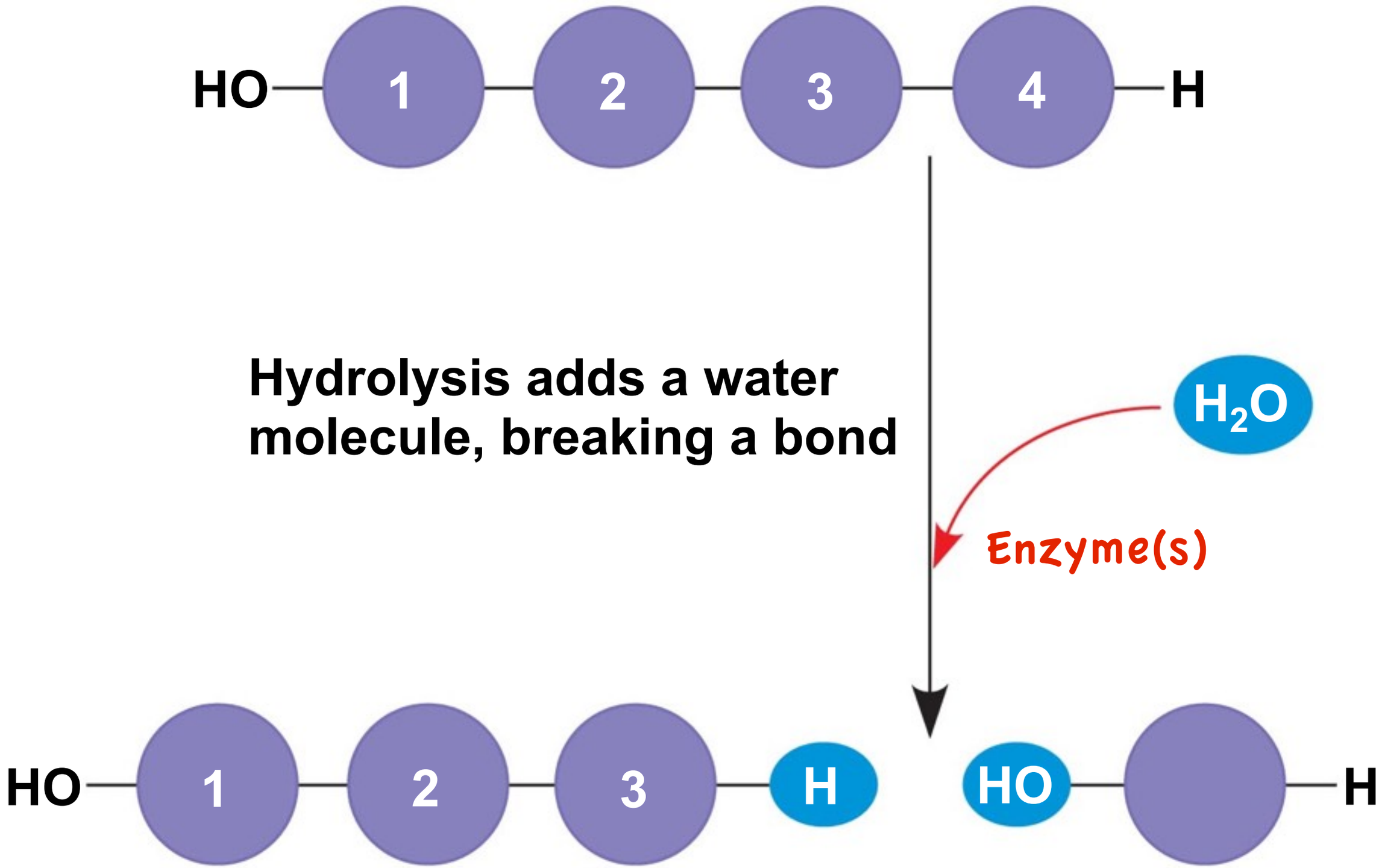
(a) Dehydration reaction in the synthesis of a polymer



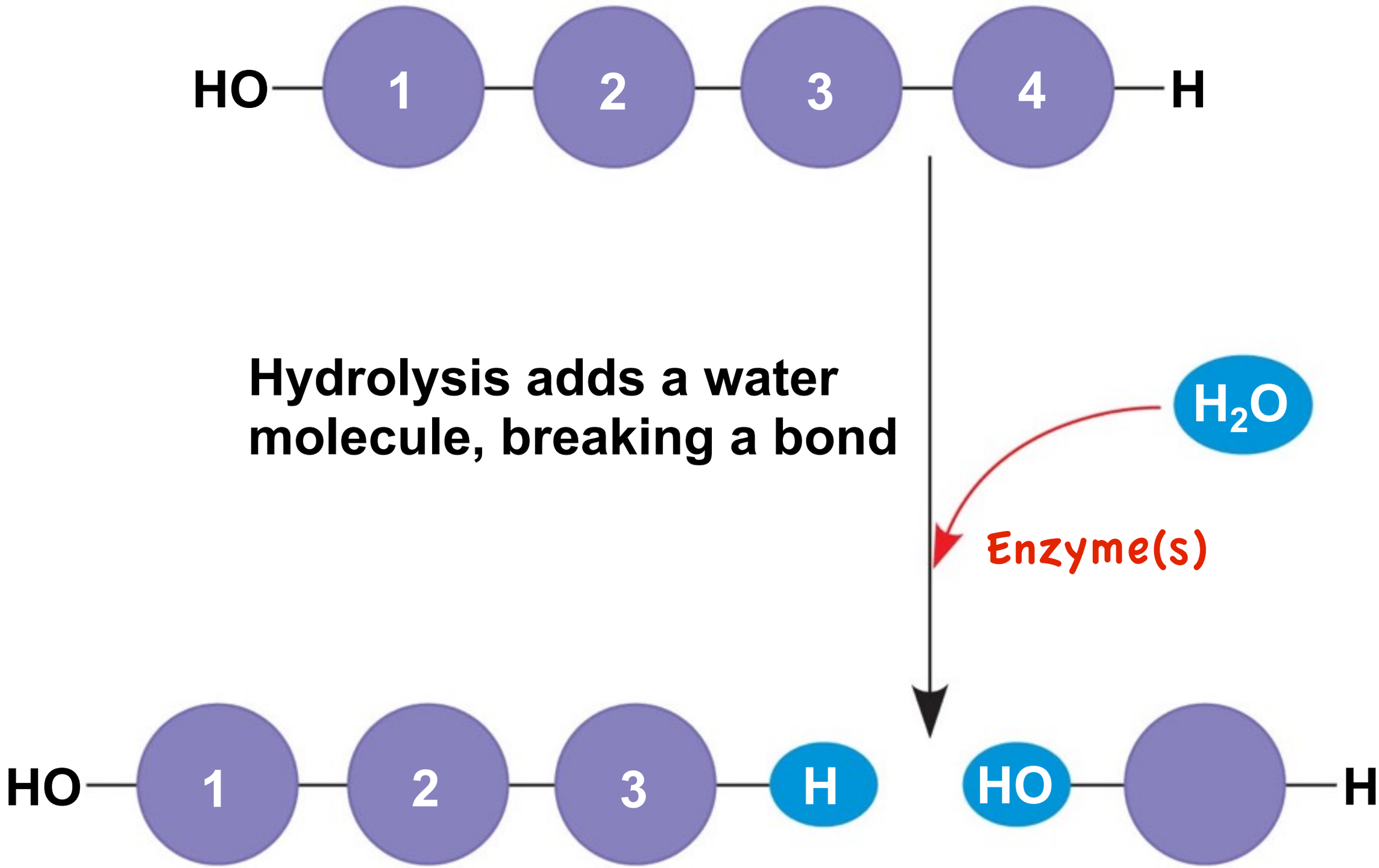
(b) Hydrolysis of a polymer



(b) Hydrolysis of a polymer



(b) Hydrolysis of a polymer



(b) Hydrolysis of a polymer

The Diversity of Polymers

- Each cell has thousands of different macromolecules
  - One cell can differ greatly from another cell even when these cells are part of the same organism
  - The differences in cells between species is even greater yet
- The molecular logic of life is both simple and elegant!
  - Small molecules (monomers) common in all organisms are ordered and arranged into unique macromolecules specific to cell types and species.
- Despite such great molecular diversity these macromolecules can be grouped into 4 common classes.

Essential knowledge 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.

a. Structure and function of polymers are derived from the way their monomers are assembled.

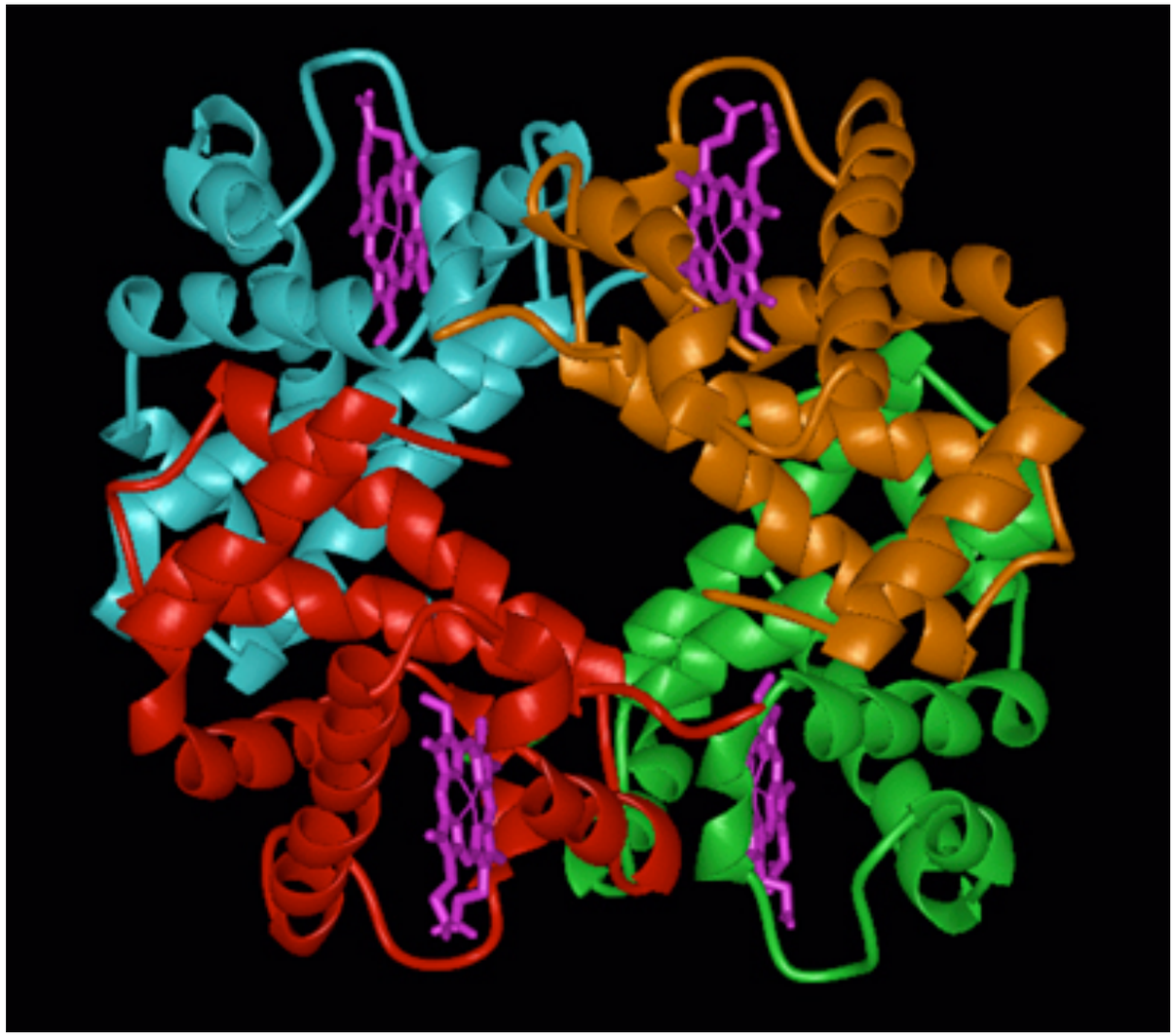
Evidence of student learning is a demonstrated understanding of each of the following:

1. In nucleic acids, biological information is encoded in sequences of nucleotide monomers. Each nucleotide has structural components: a five-carbon sugar (deoxyribose or ribose), a phosphate and a nitrogen base (adenine, thymine, guanine, cytosine or uracil). DNA and RNA differ in function and differ slightly in structure, and these structural differences account for the differing functions. [See also **1.D.1, 2.A.3, 3.A.1**]

✘✘ *The molecular structure of specific nucleotides is beyond the scope of the course and the AP Exam.*

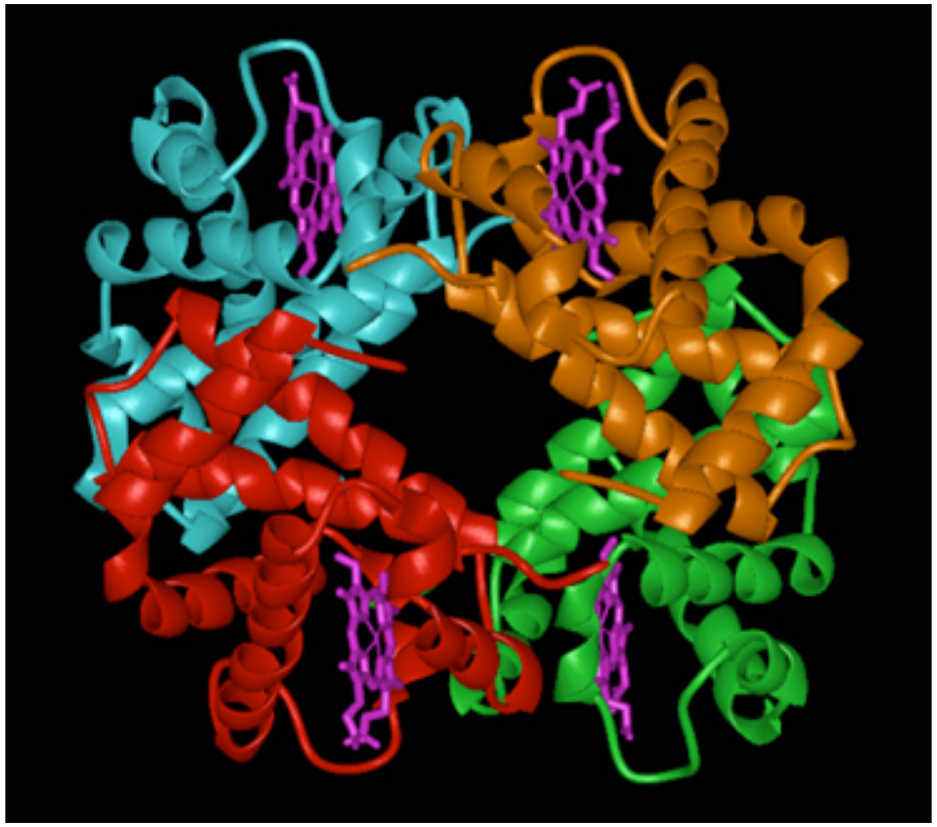
Main Idea: Nucleic acid polymers are built from monomers called nucleotides.

Main Idea: Nucleic acid polymers contain the information to build the primary structure of proteins.



NUCLEIC ACIDS STORE, TRANSMIT, AND HELP EXPRESS HEREDITARY INFORMATION

- Nucleic acids contain genes.
- Genes contain the information to build proteins.



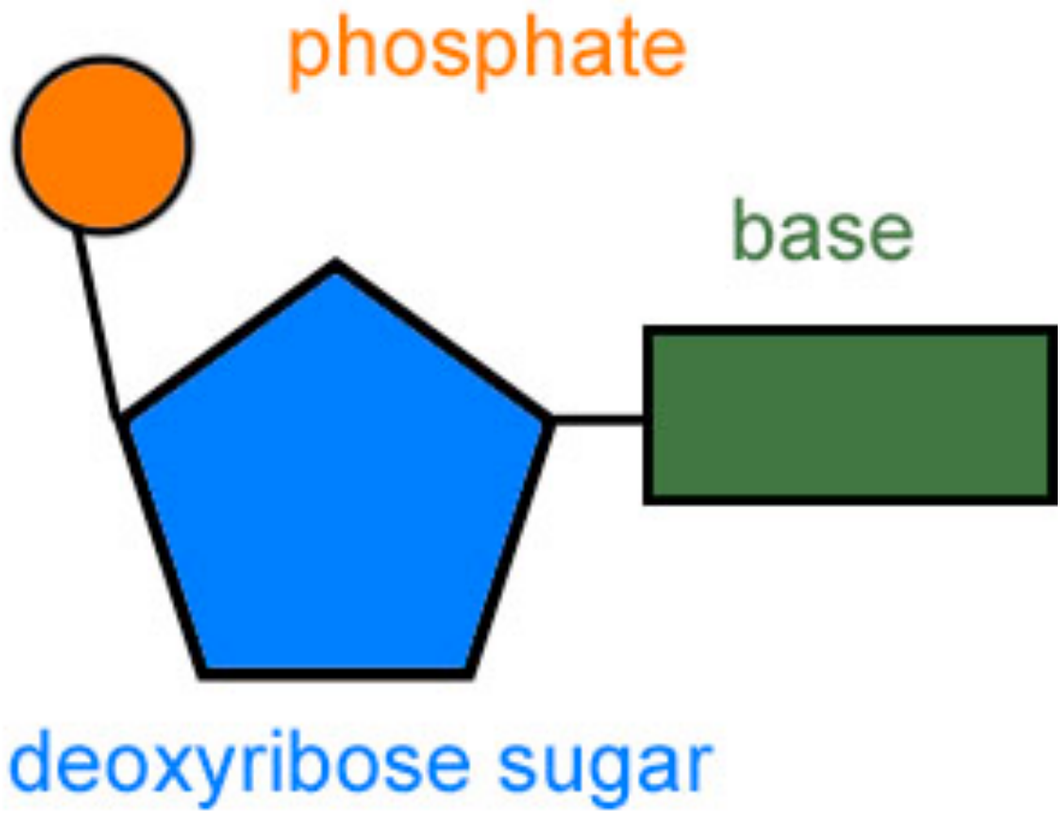
The Roles of Nucleic Acids

- DNA and RNA allow organisms to produce their complex components from one generation to the next.
  - DNA is material that we inherit from our parents.
  - DNA contains the blueprint for cell structures and the information for cellular activities.
- Think of DNA as the computer's software and PROTEINS as the hardware.

The Global Flow of Information...

The Components of Nucleic Acids

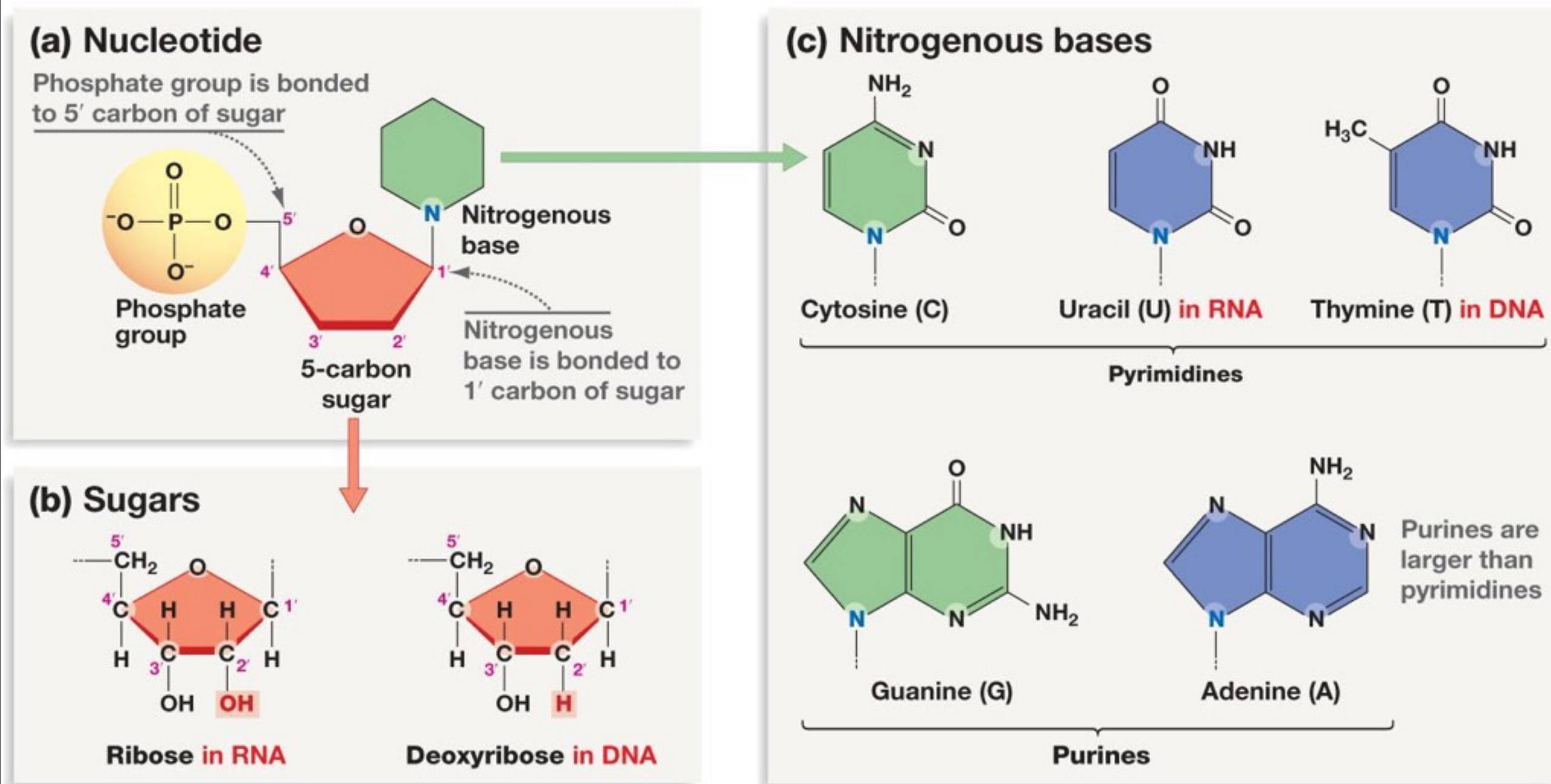
- Nucleic acids are true polymers.
- Polynucleotides (polymers) are made from nucleotides (monomers)



mRNA (vs DNA)

different sugars in the backbone

Uracil instead of thymine

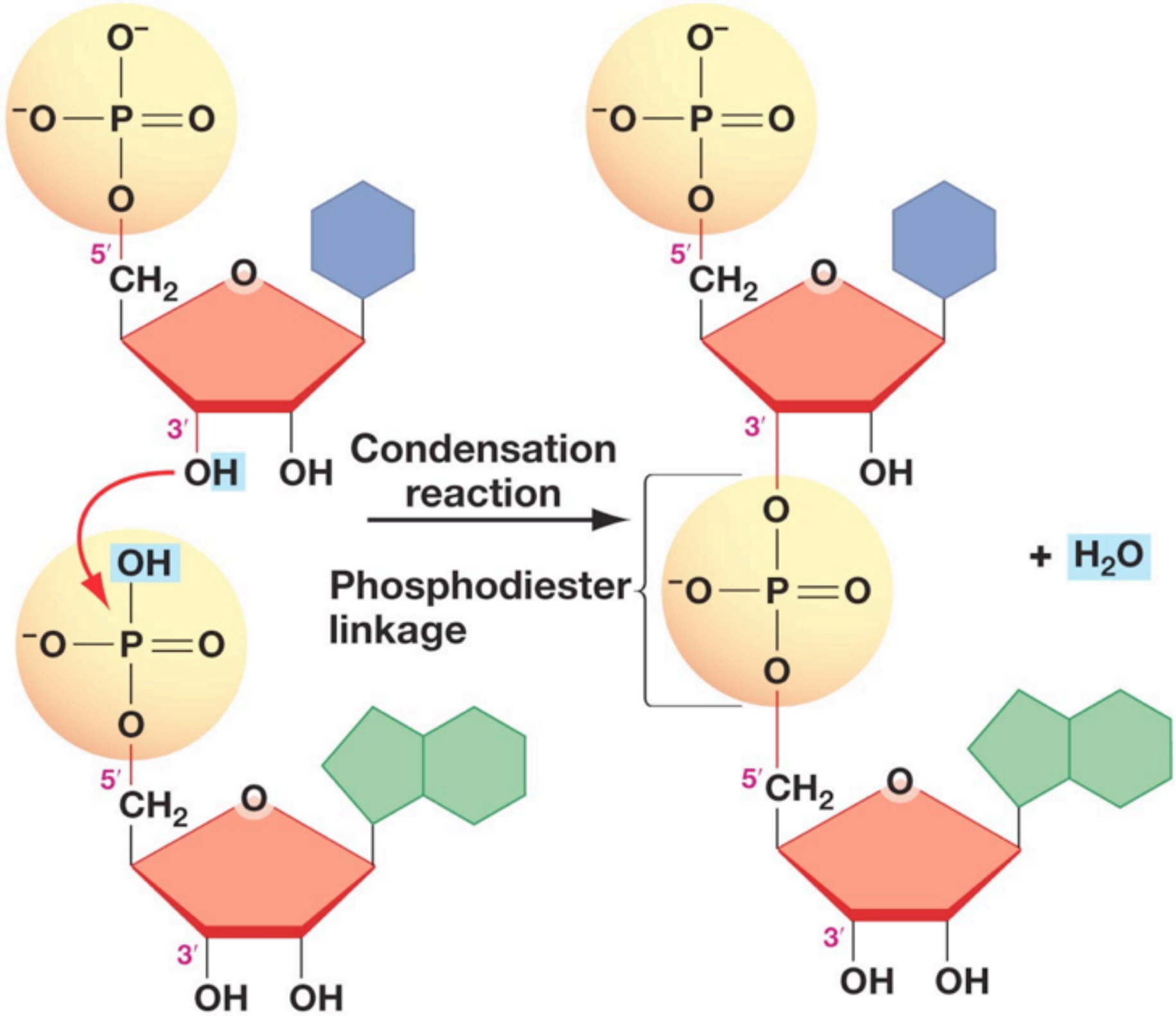


Essential knowledge 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.

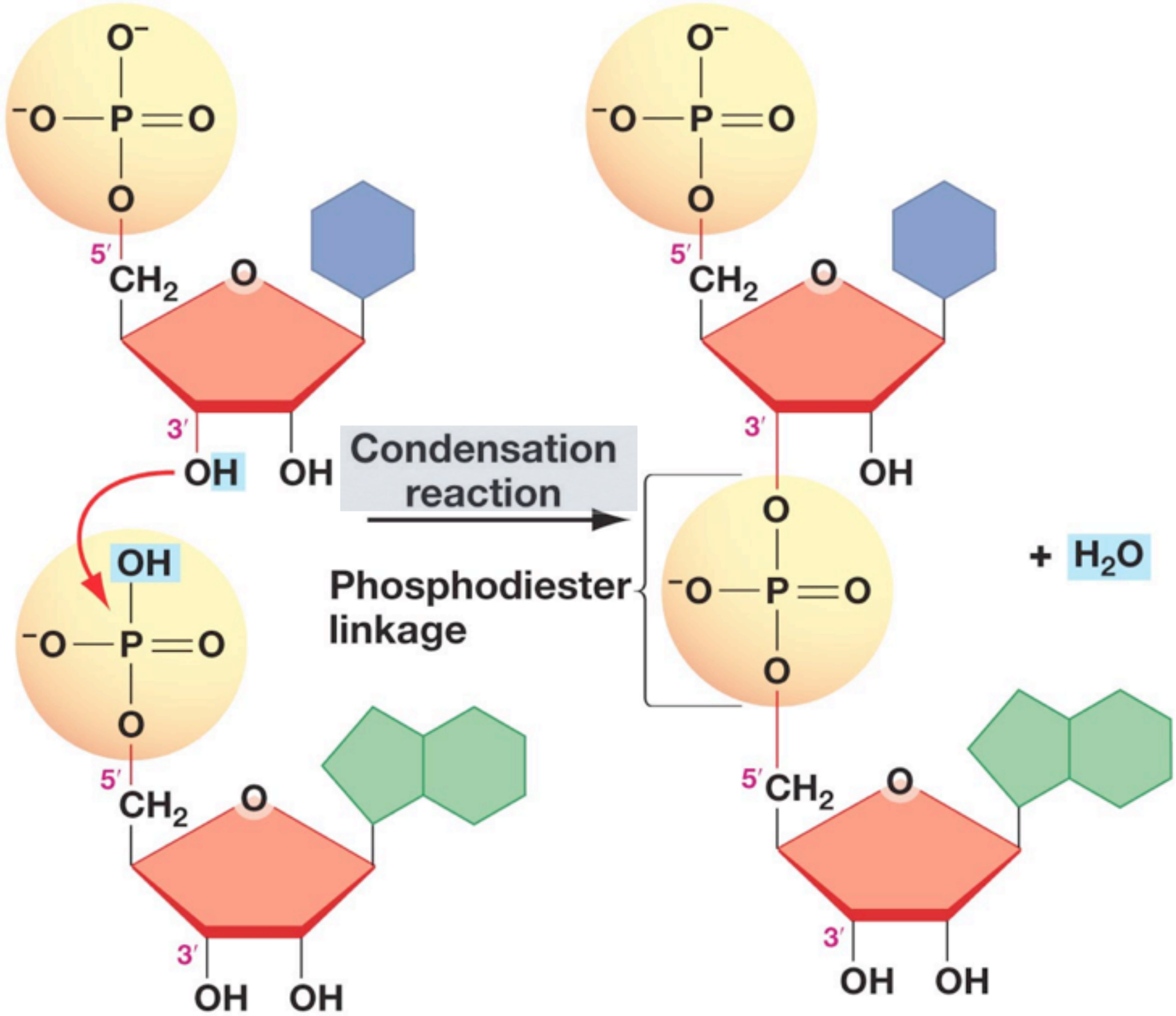
b. Directionality influences structure and function of the polymer.

1. Nucleic acids have ends, defined by the and 5' carbons of the sugar in the nucleotide, that determine the direction in which complementary nucleotides are added during DNA synthesis and the direction in which transcription occurs (from 5' to). [See also **3.A.1**]

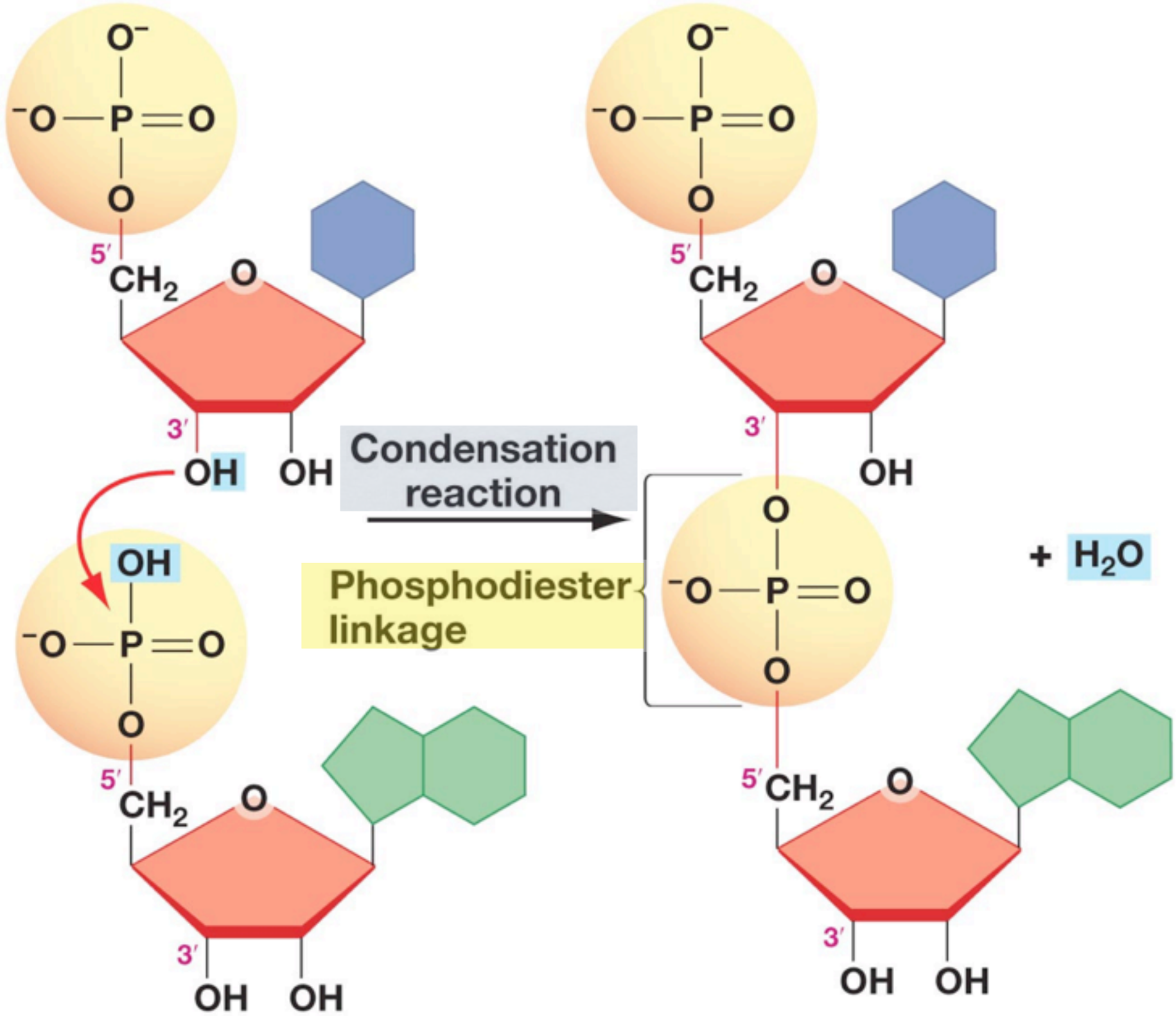
Nucleotide Polymers



Nucleotide Polymers

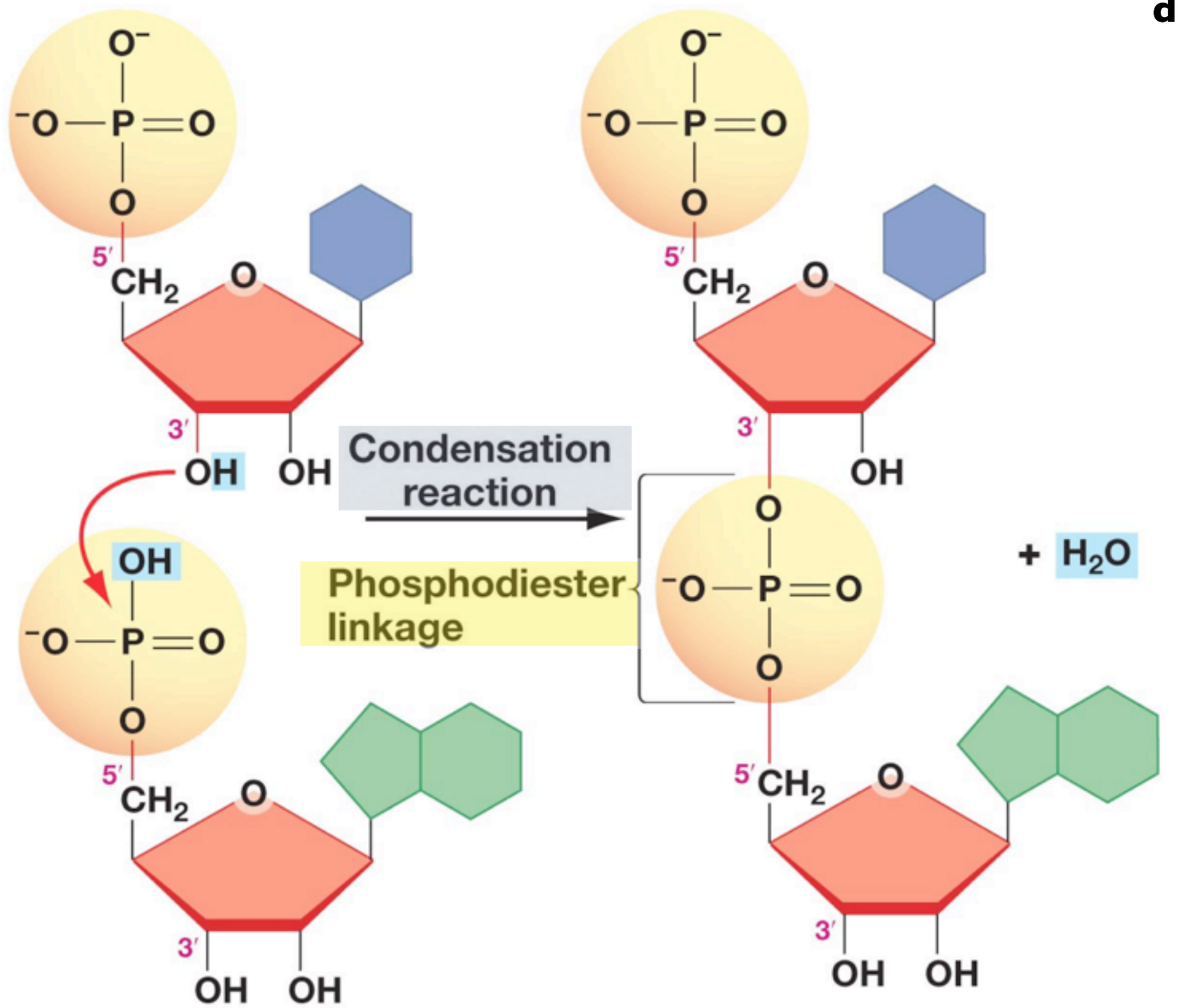


Nucleotide Polymers



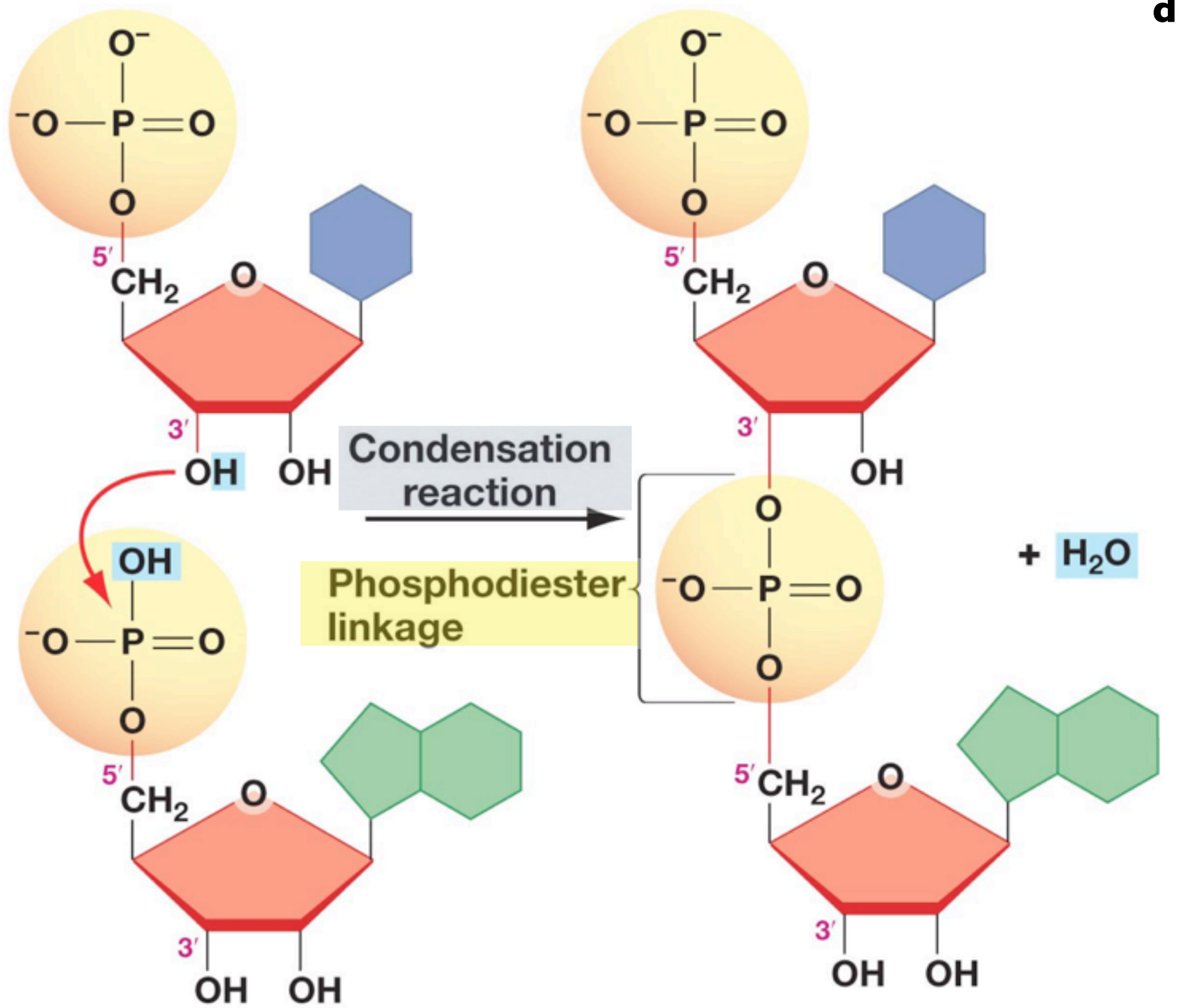
Nucleotide Polymers

DNA, has directionality



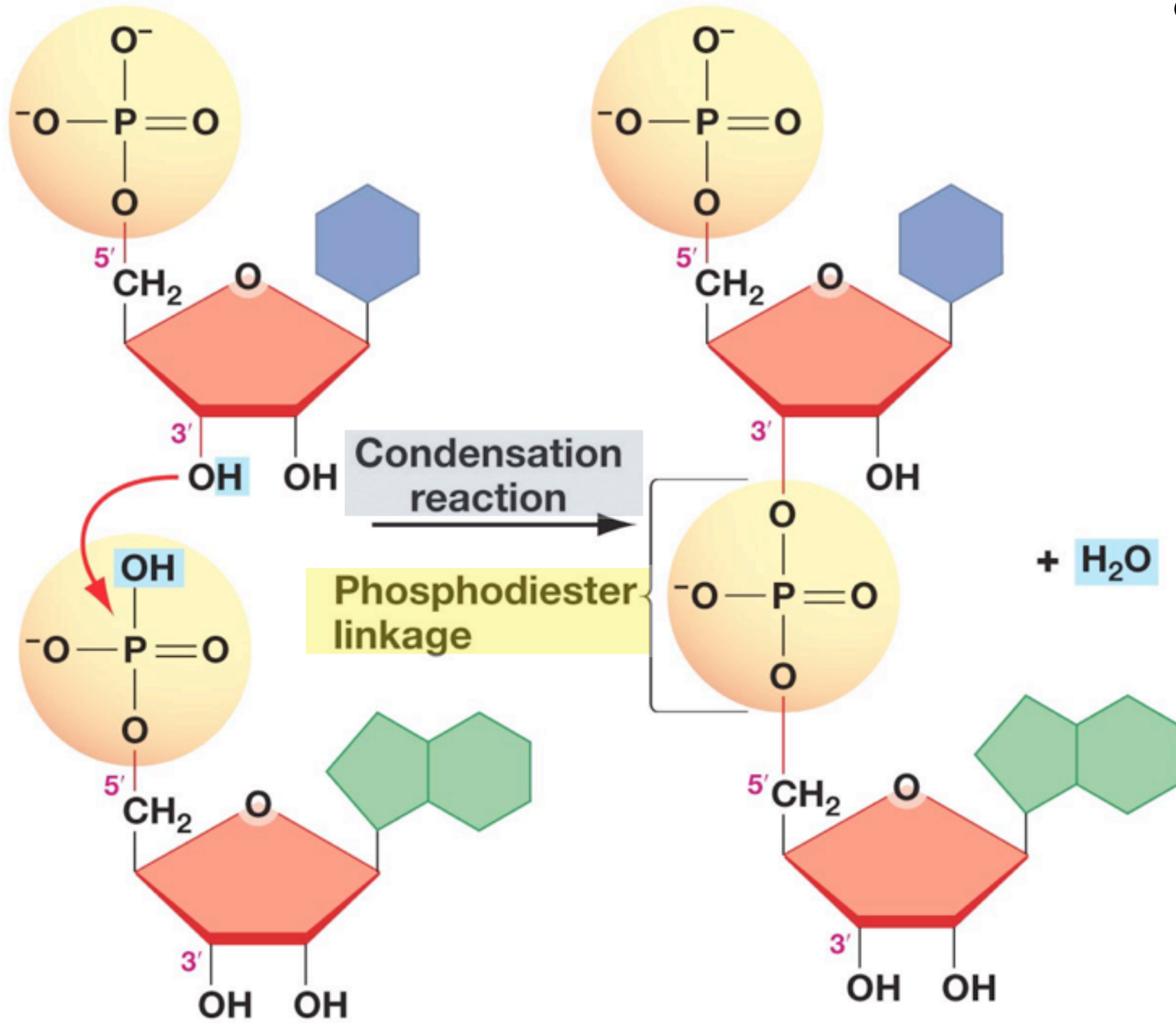
Nucleotide Polymers

DNA, has directionality



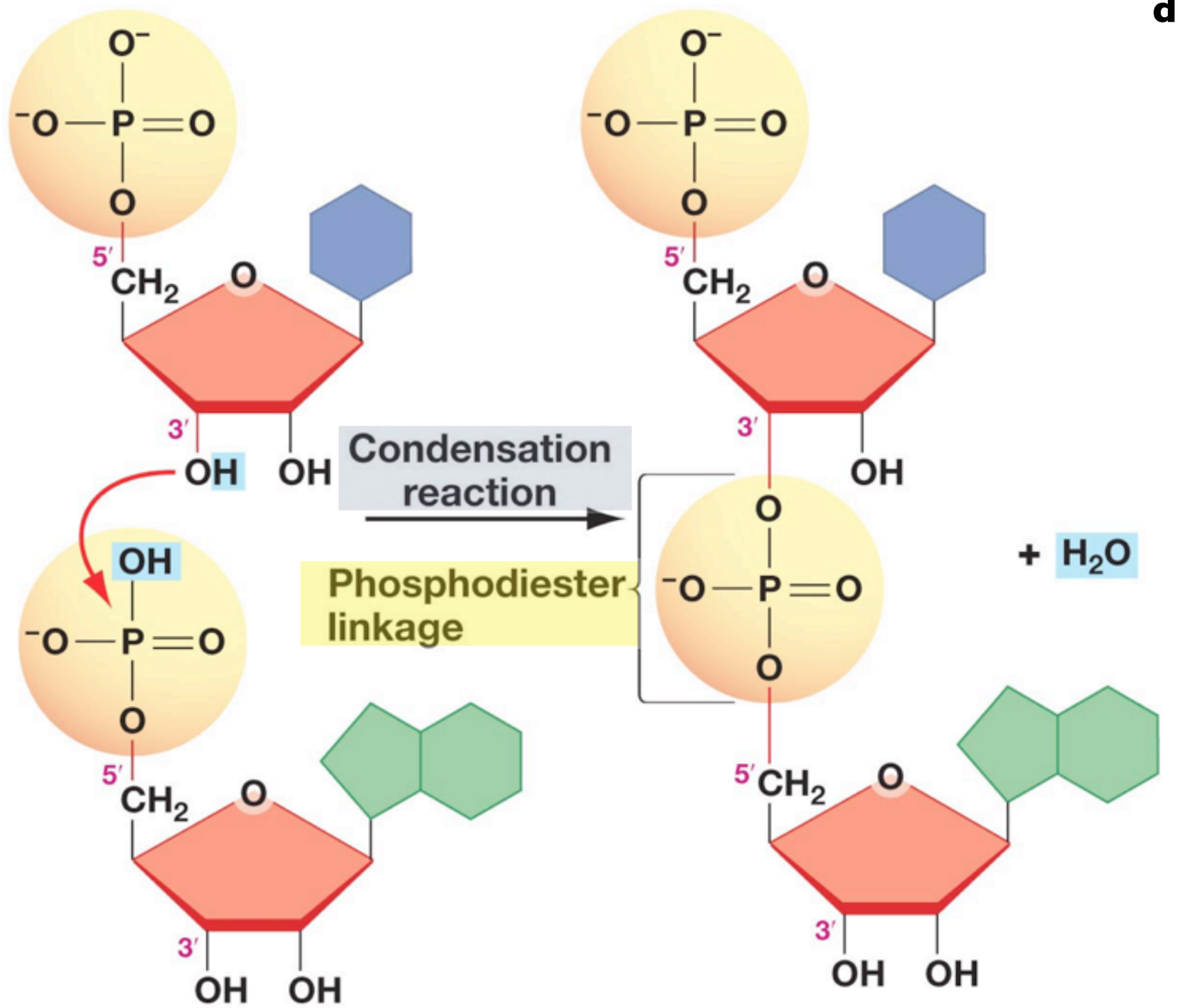
Nucleotide Polymers

DNA, has directionality



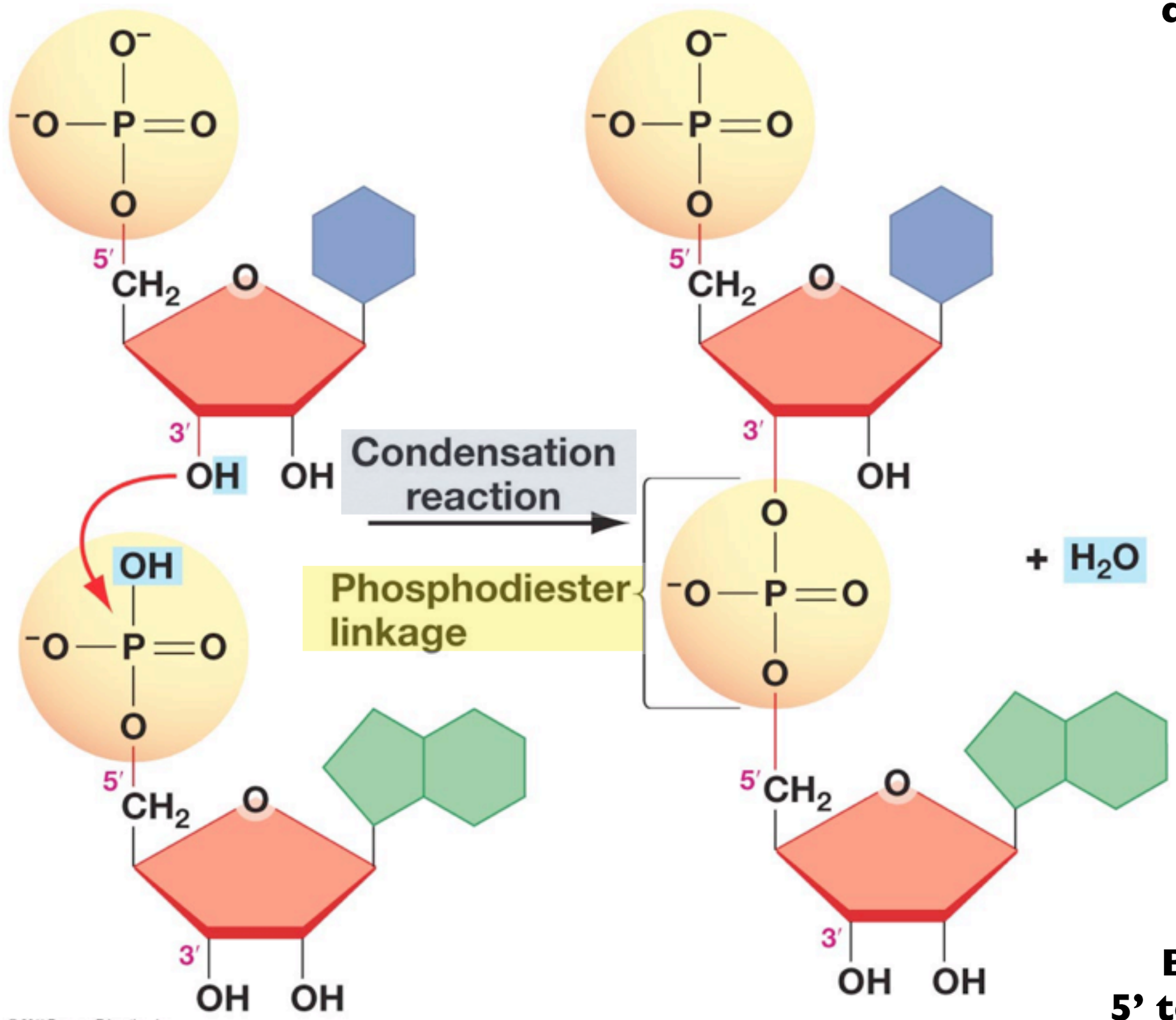
Nucleotide Polymers

DNA, has directionality



Nucleotide Polymers

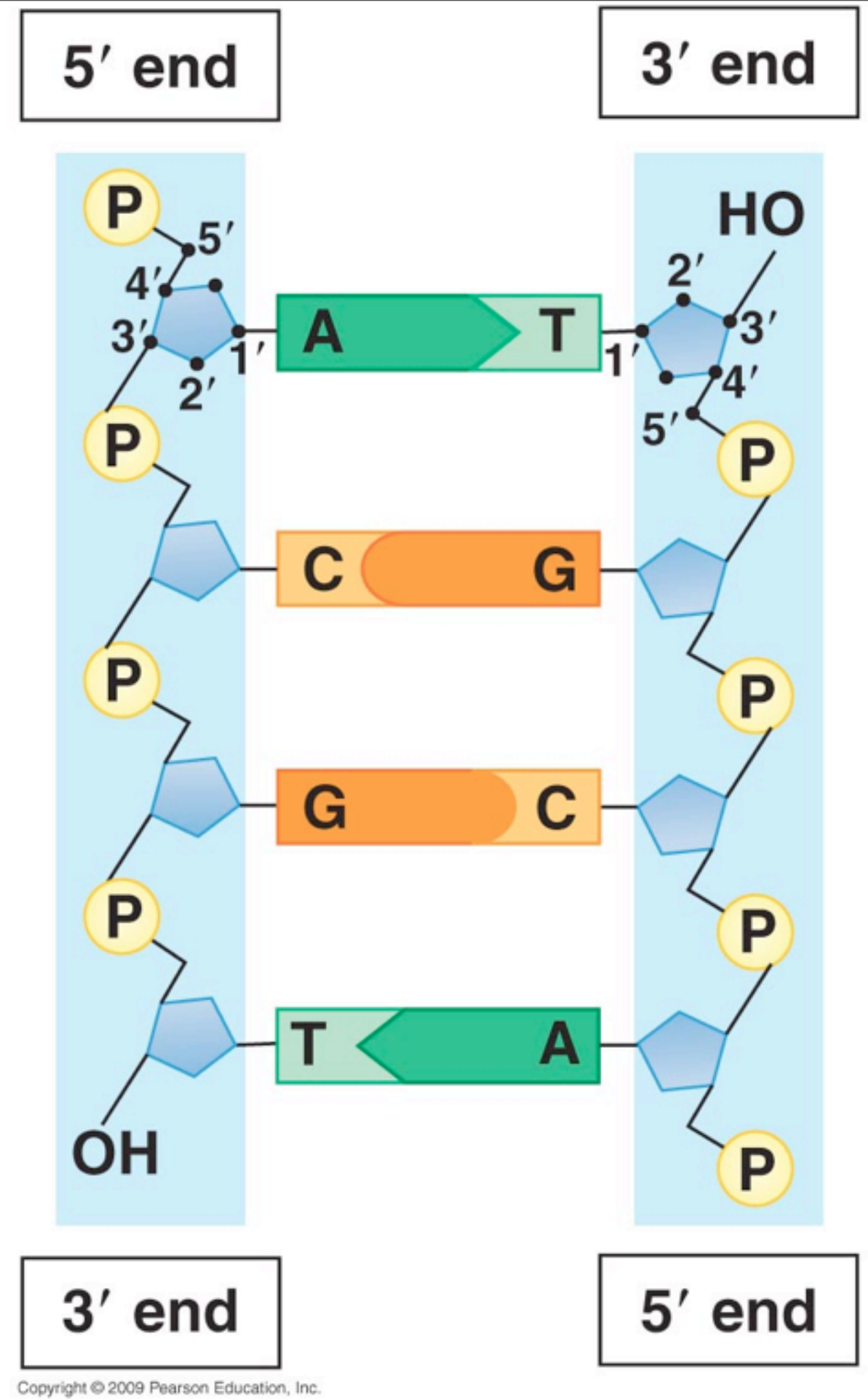
DNA, has directionality



Built in the 5’ to 3’ direction

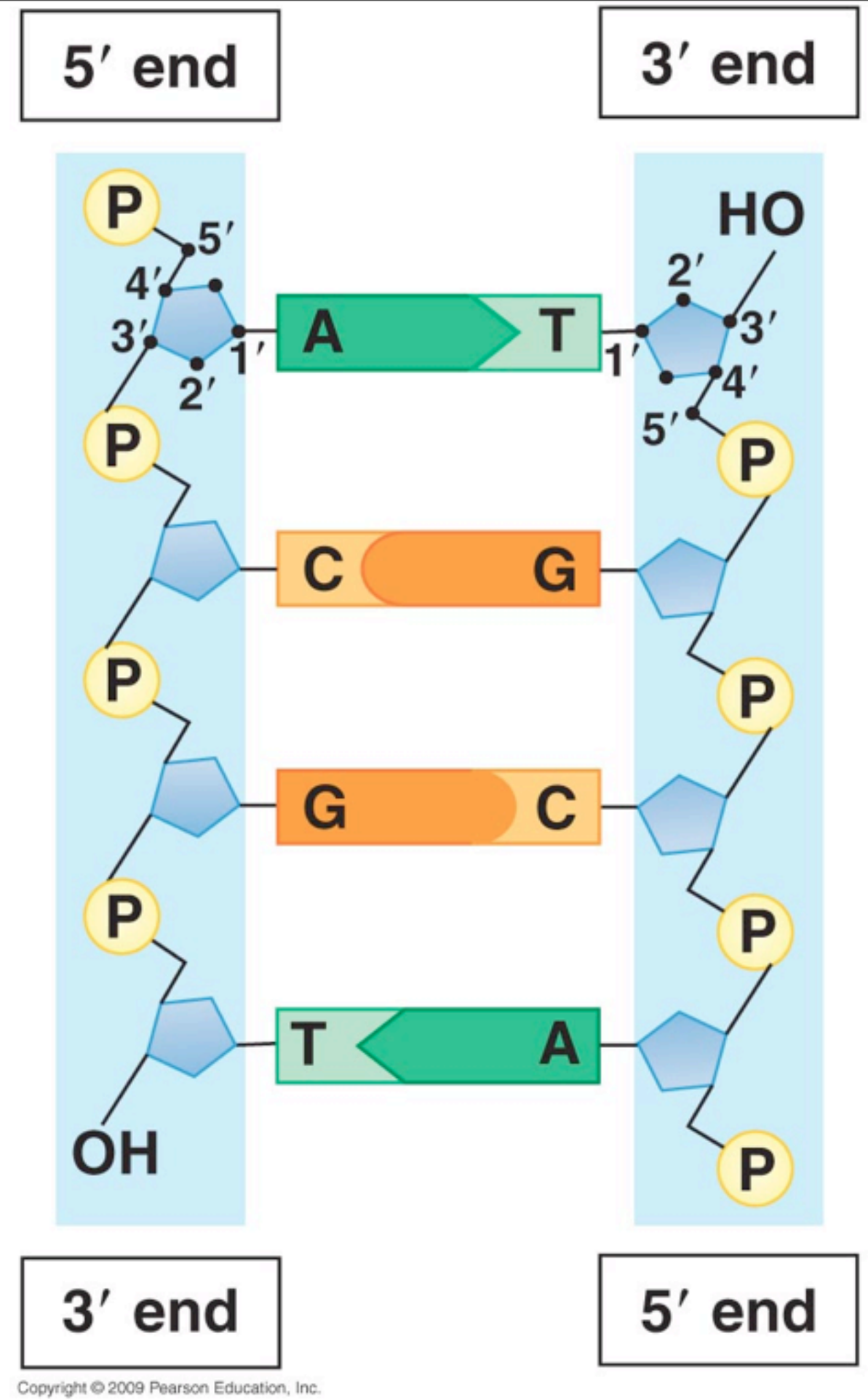
Antiparallel Strands

Antiparallel Strands



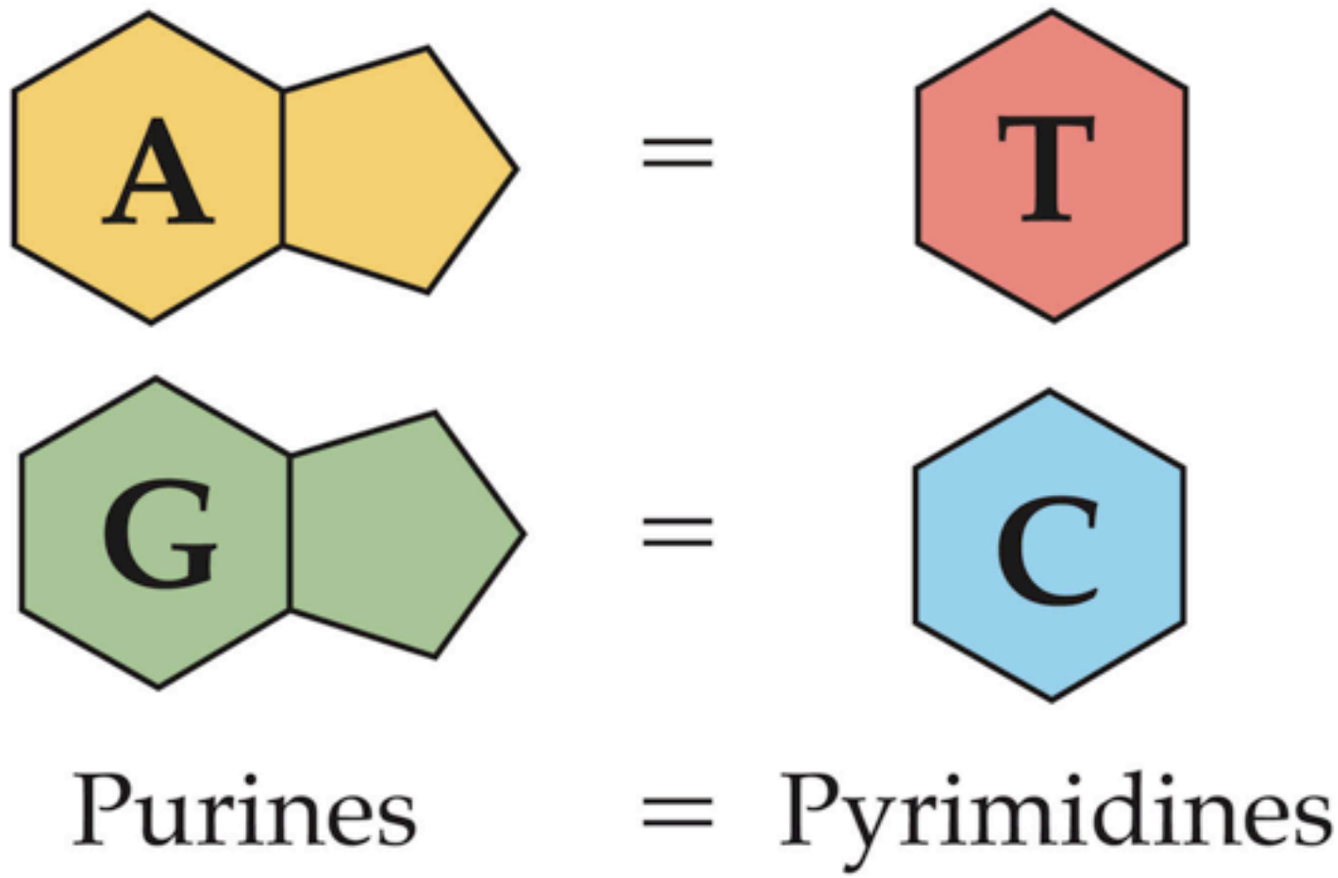
Antiparallel Strands

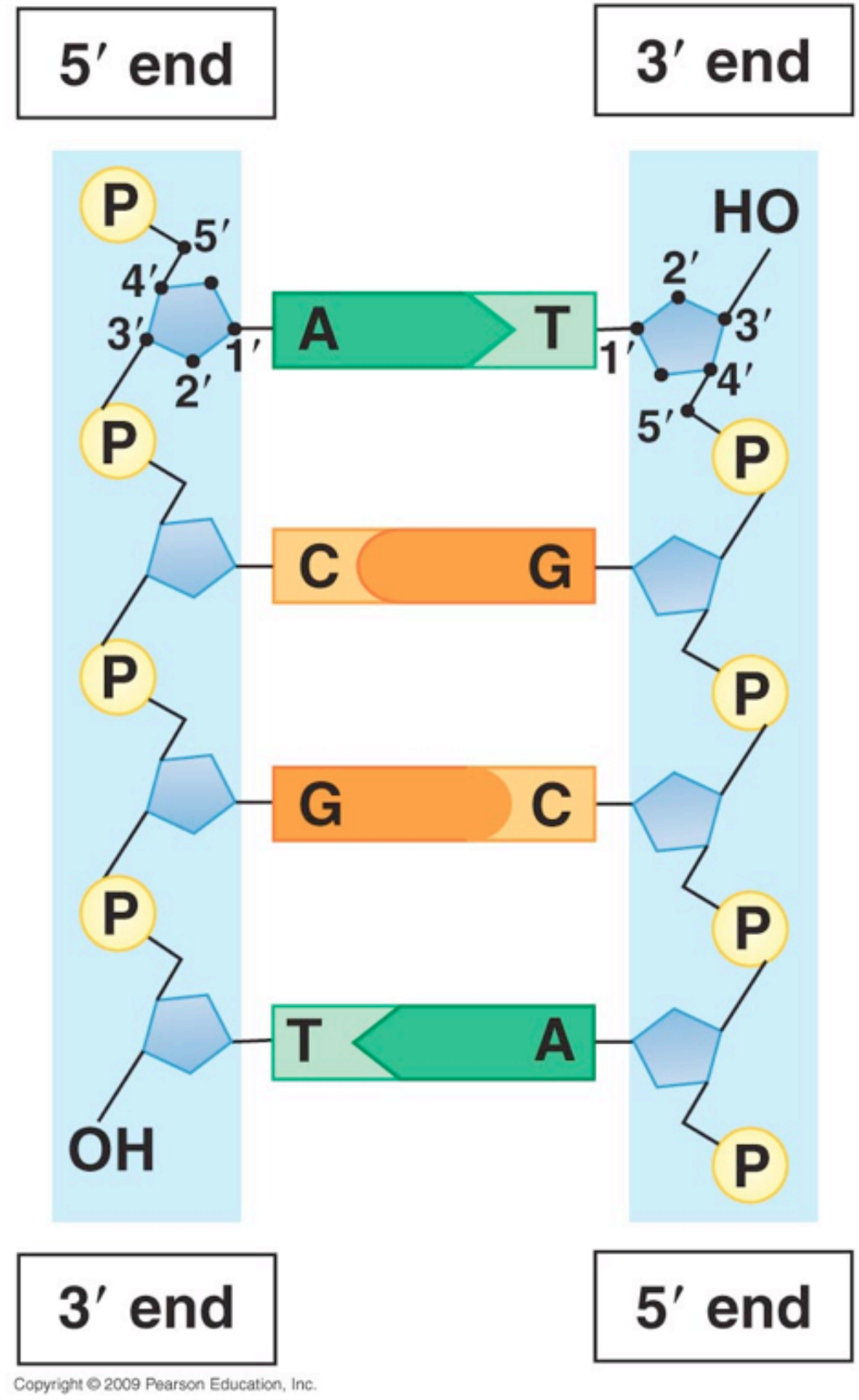
Base Pair Rules

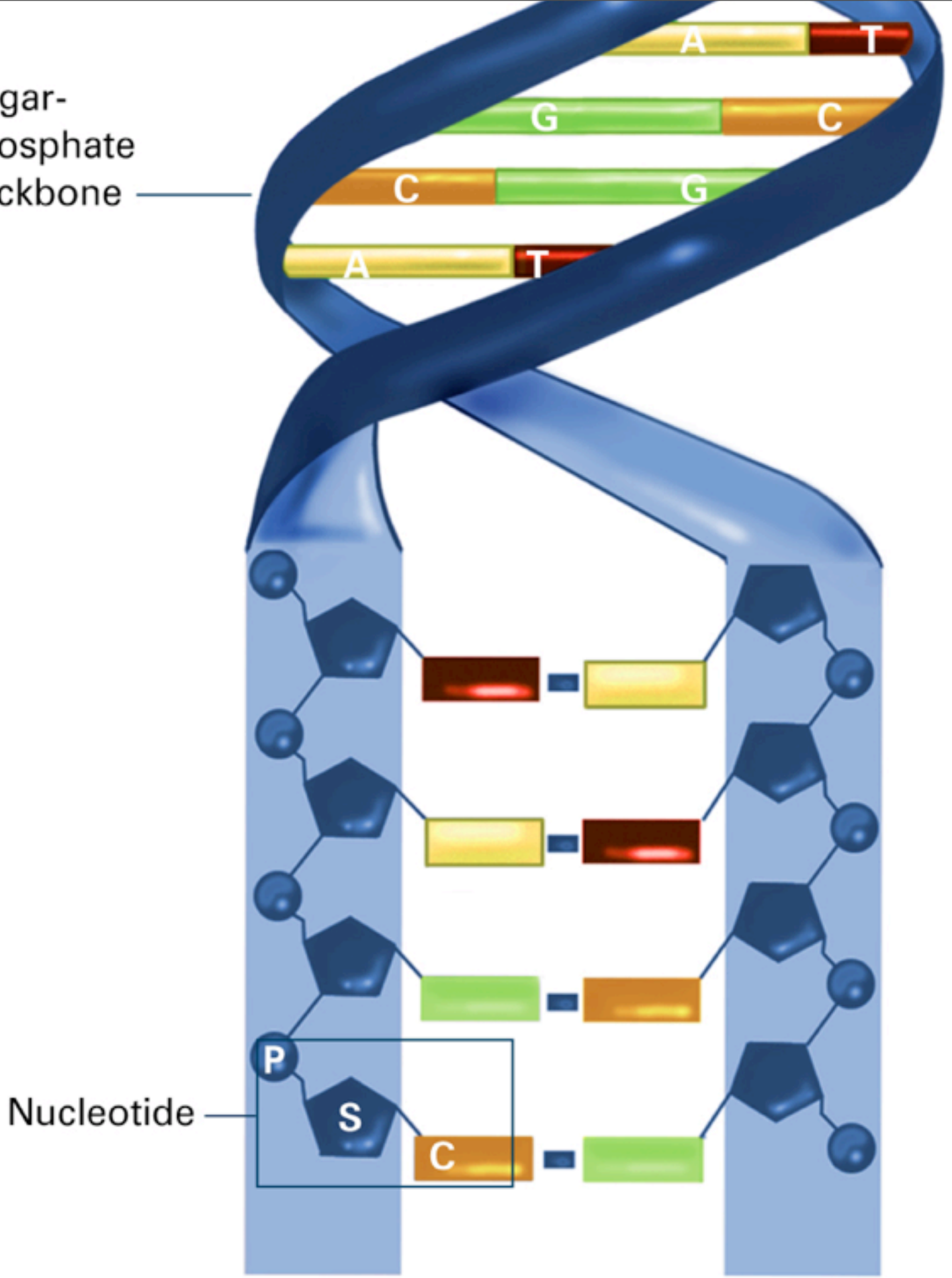


Antiparallel Strands

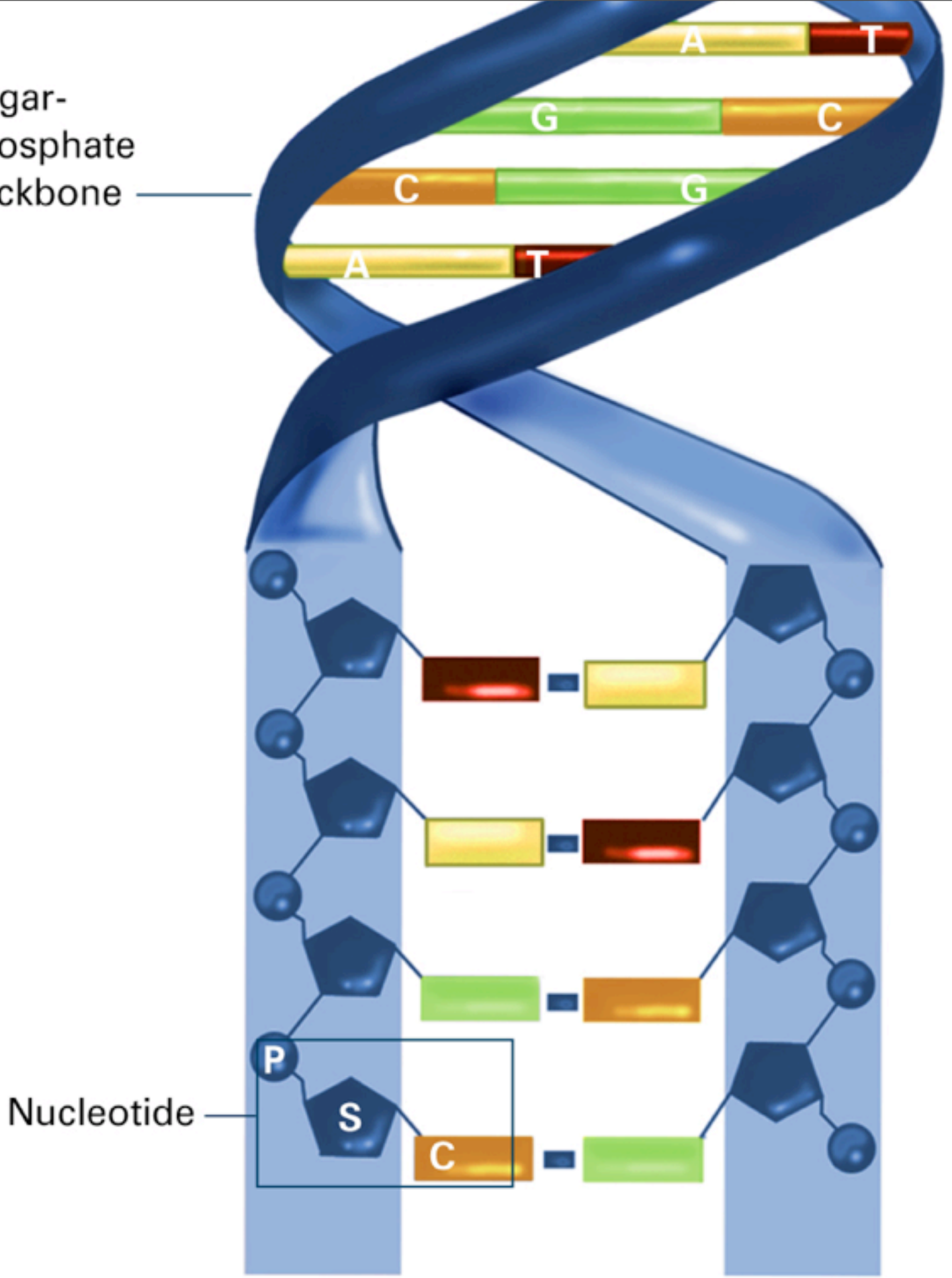
Base Pair Rules

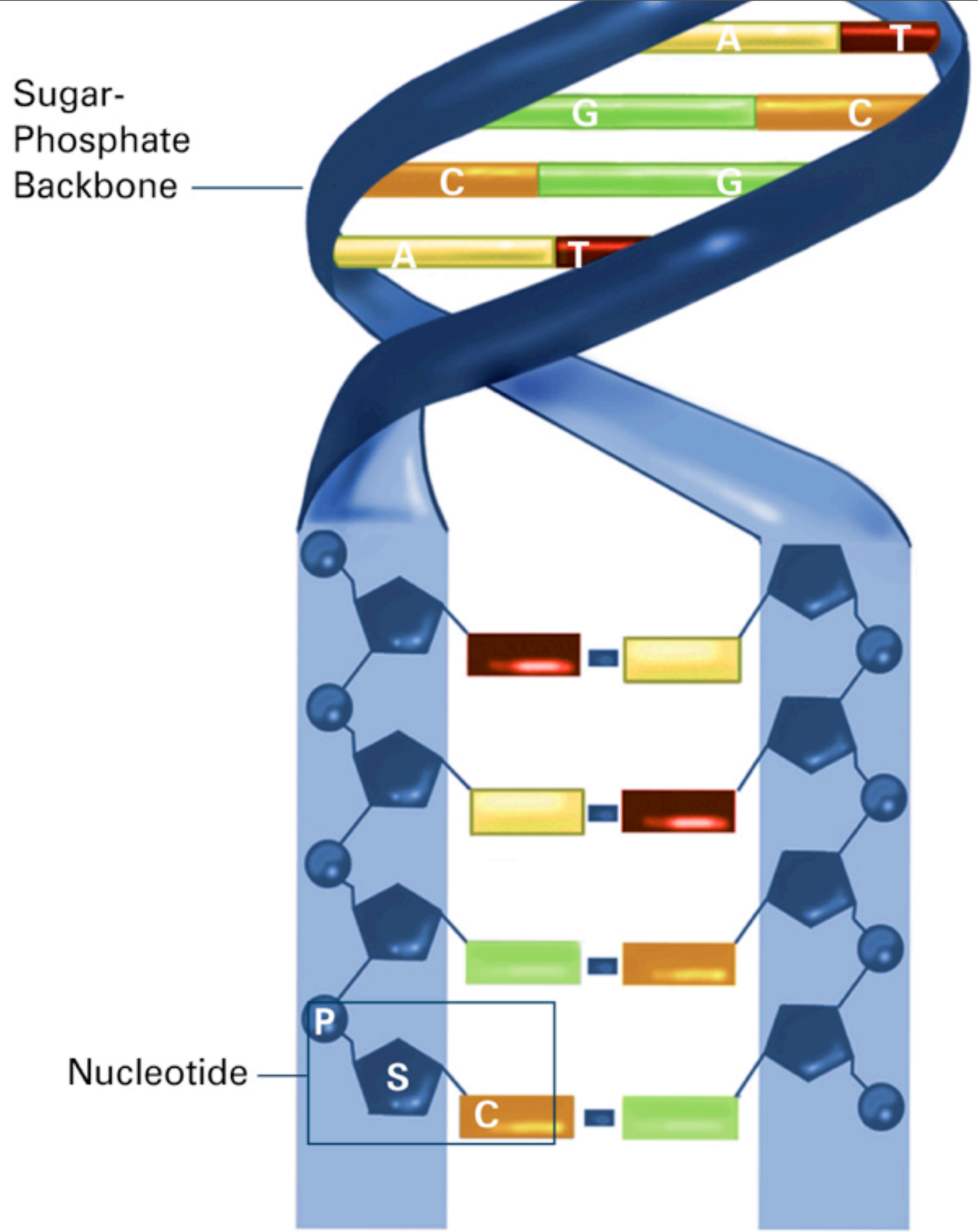





Sugar-
Phosphate
Backbone
A
T
G
C
C
G
A
T
Nucleotide
P
S
C

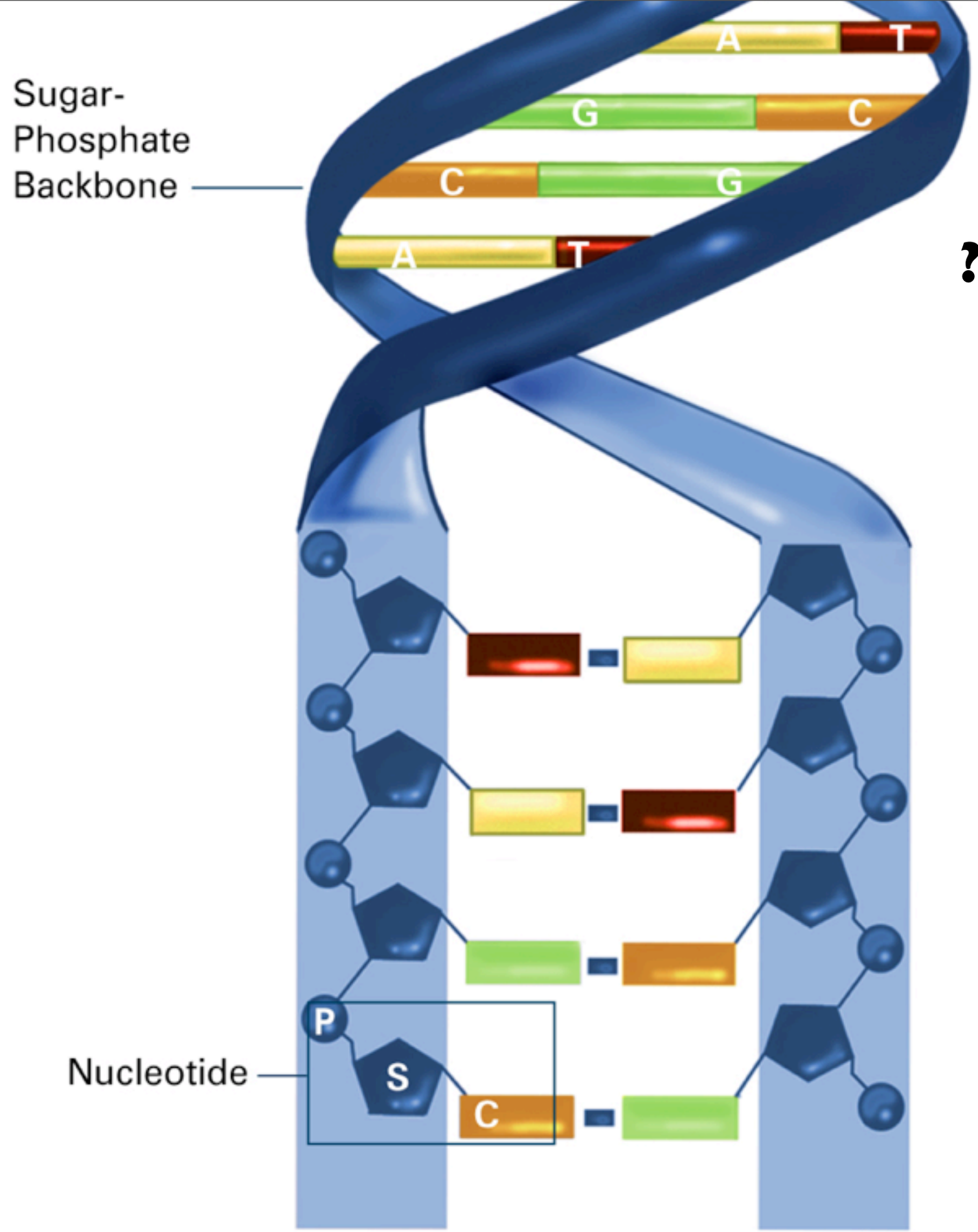
Complimentary





Complimentary

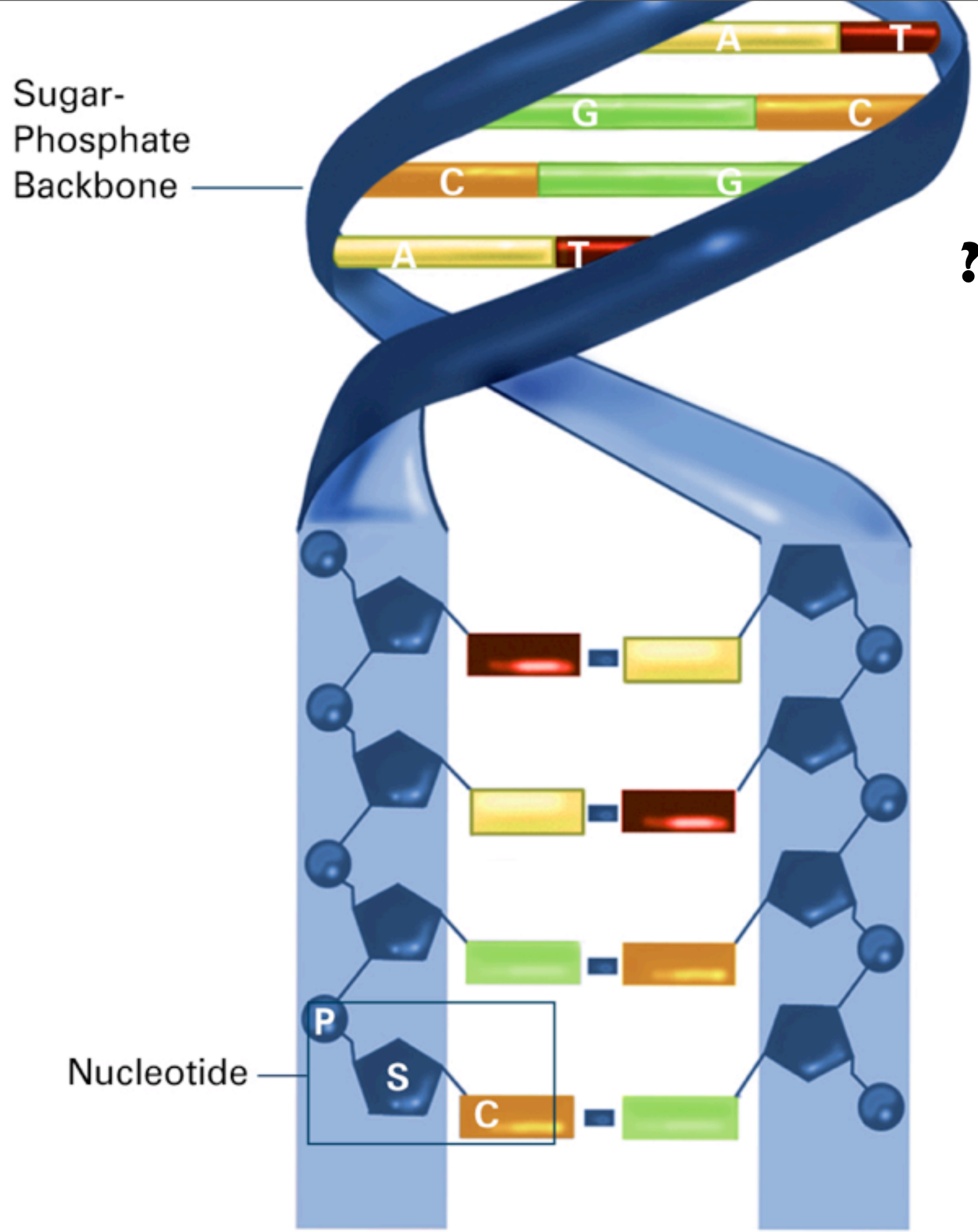
5'-AGGTCCG-3'



Complimentary

5'-AGGTCCG-3'

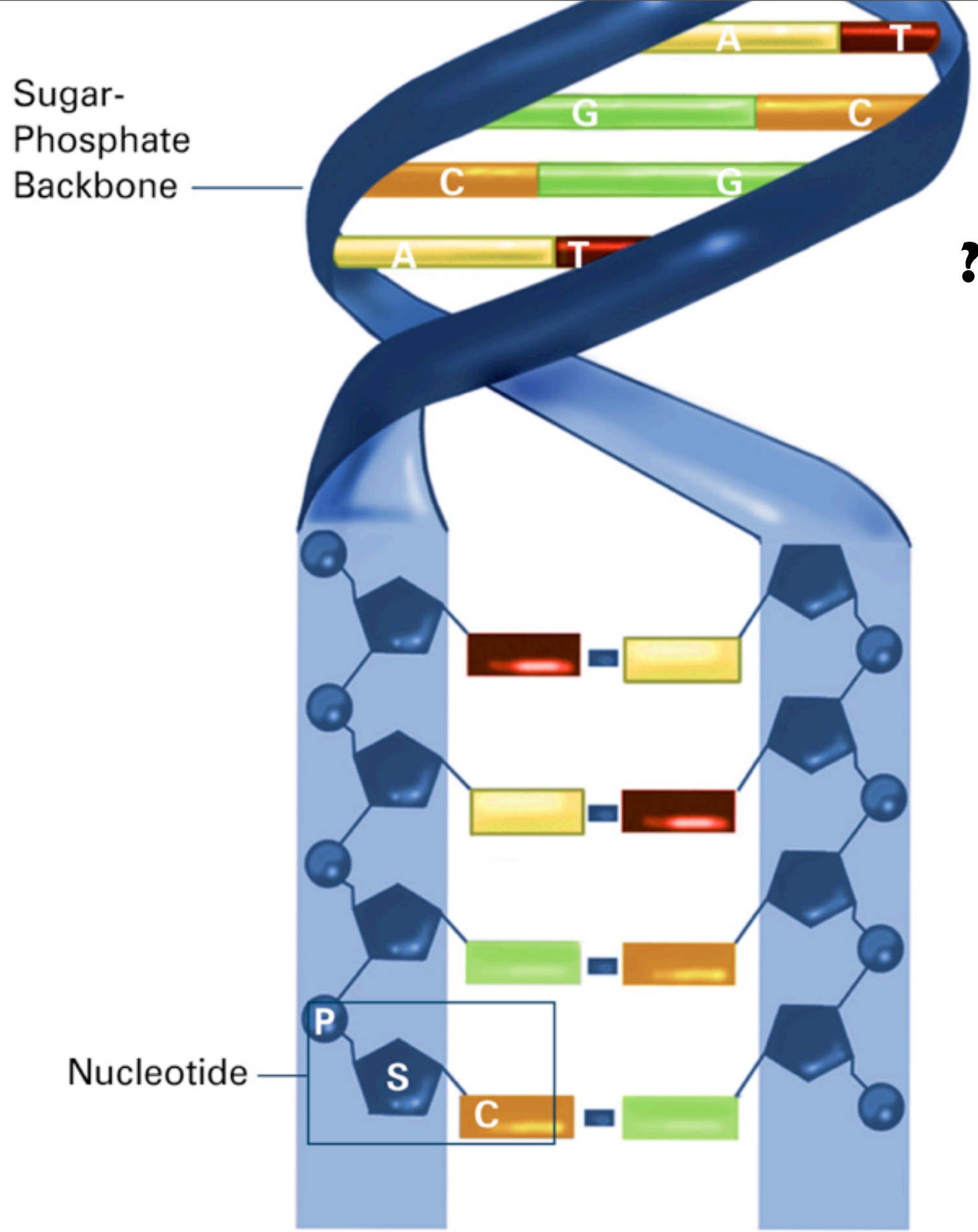
?



Complimentary

5’-AGGTCCG-3’

? 3’-TCCAGGC-5’



Complimentary

5'-AGGTCCG-3'

? 3'-TCCAGGC-5'

this property allows DNA make exact replicas of each DNA molecule

Essential knowledge 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.

a. Structure and function of polymers are derived from the way their monomers are assembled.

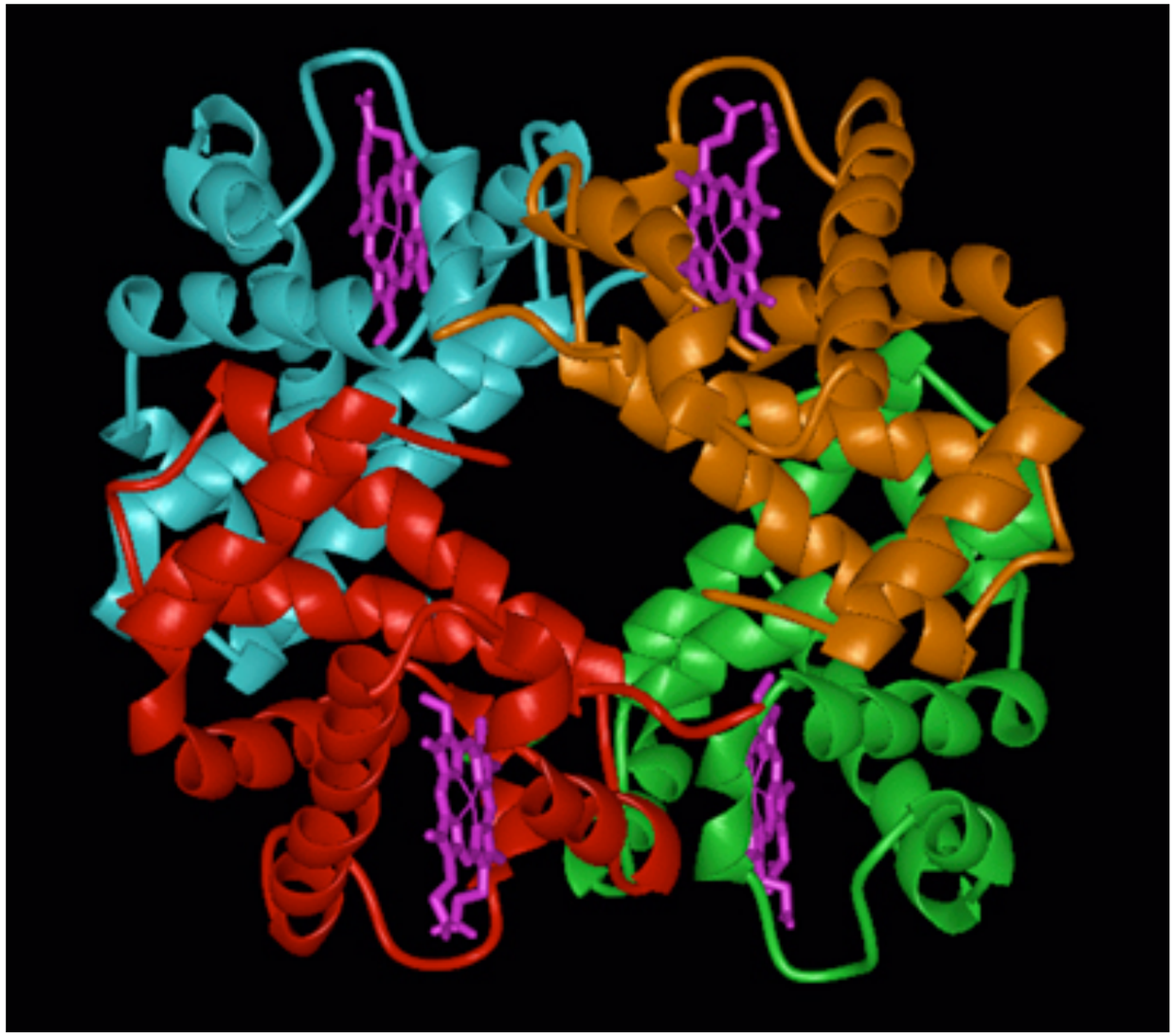
Evidence of student learning is a demonstrated understanding of each of the following:

2. In proteins, the specific order of amino acids in a polypeptide (primary structure) interacts with the environment to determine the overall shape of the protein, which also involves secondary tertiary and quaternary structure and, thus, its function. The R group of an amino acid can be categorized by chemical properties (hydrophobic, hydrophilic and ionic), and the interactions of these R groups determine structure and function of that region of the protein. [See also **1.D.1, 2.A.3, 2.B.1**]

✘✘ *The molecular structure of specific amino acids is beyond the scope of the course and the AP Exam.*

Main Idea: Proteins have the most sophisticated structures and make up over 50% of every cells biomass.

Main Idea: Proteins play a role in virtually every vital process important to life, they have the widest diversity of functions.



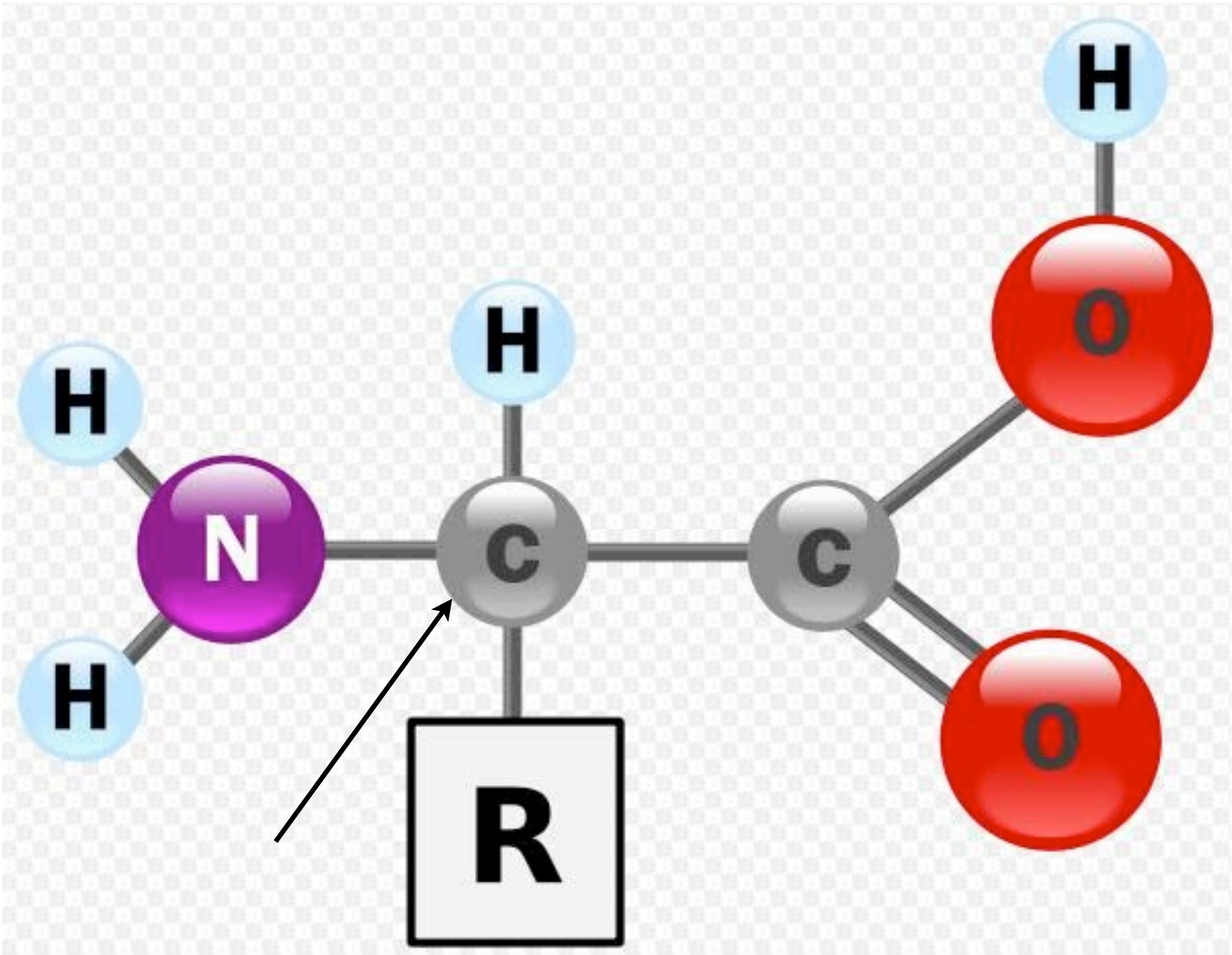
PROTEINS INCLUDE A DIVERSITY OF STRUCTURES, RESULTING IN A WIDE RANGE OF FUNCTIONS

- Humans have tens of thousands of differently shaped proteins, each with its unique role or function.
- Proteins are the main building blocks of life and proteins control life's necessary functions.

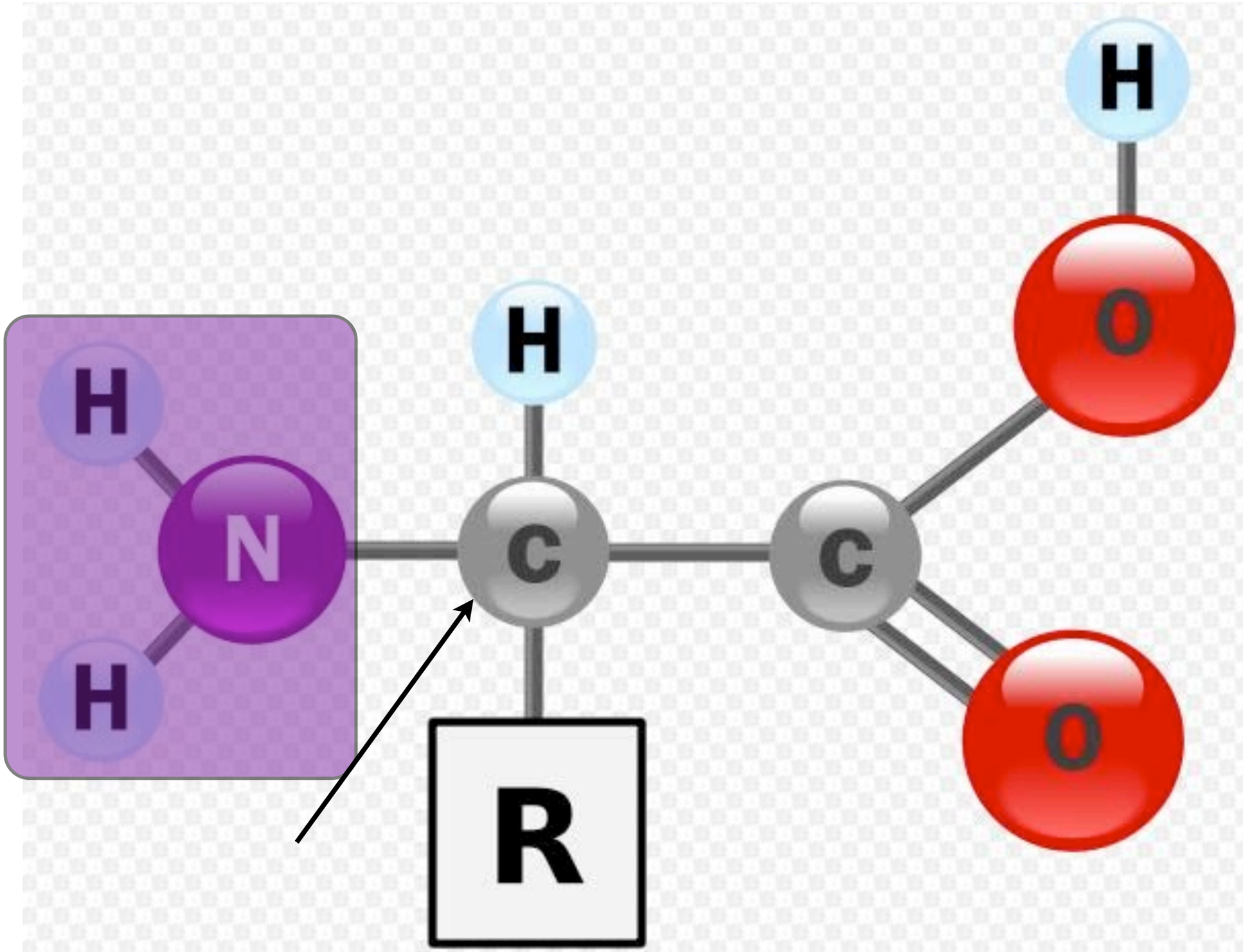
Polypeptides (aka proteins)

- Proteins are true polymers constructed from 20 different monomers called *amino acids*.

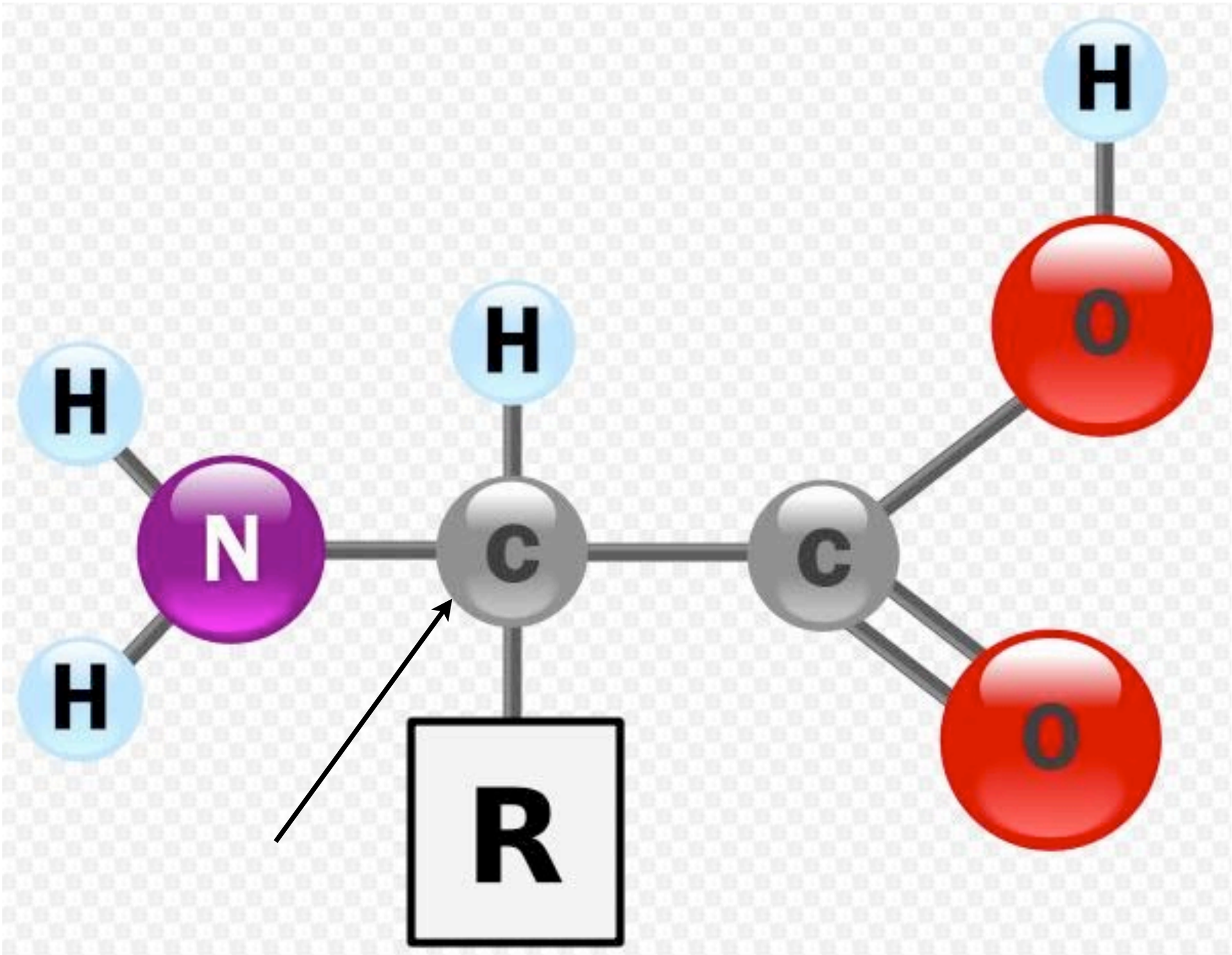
Amino Acid monomers (The amino acid below is non-ionized (dry))



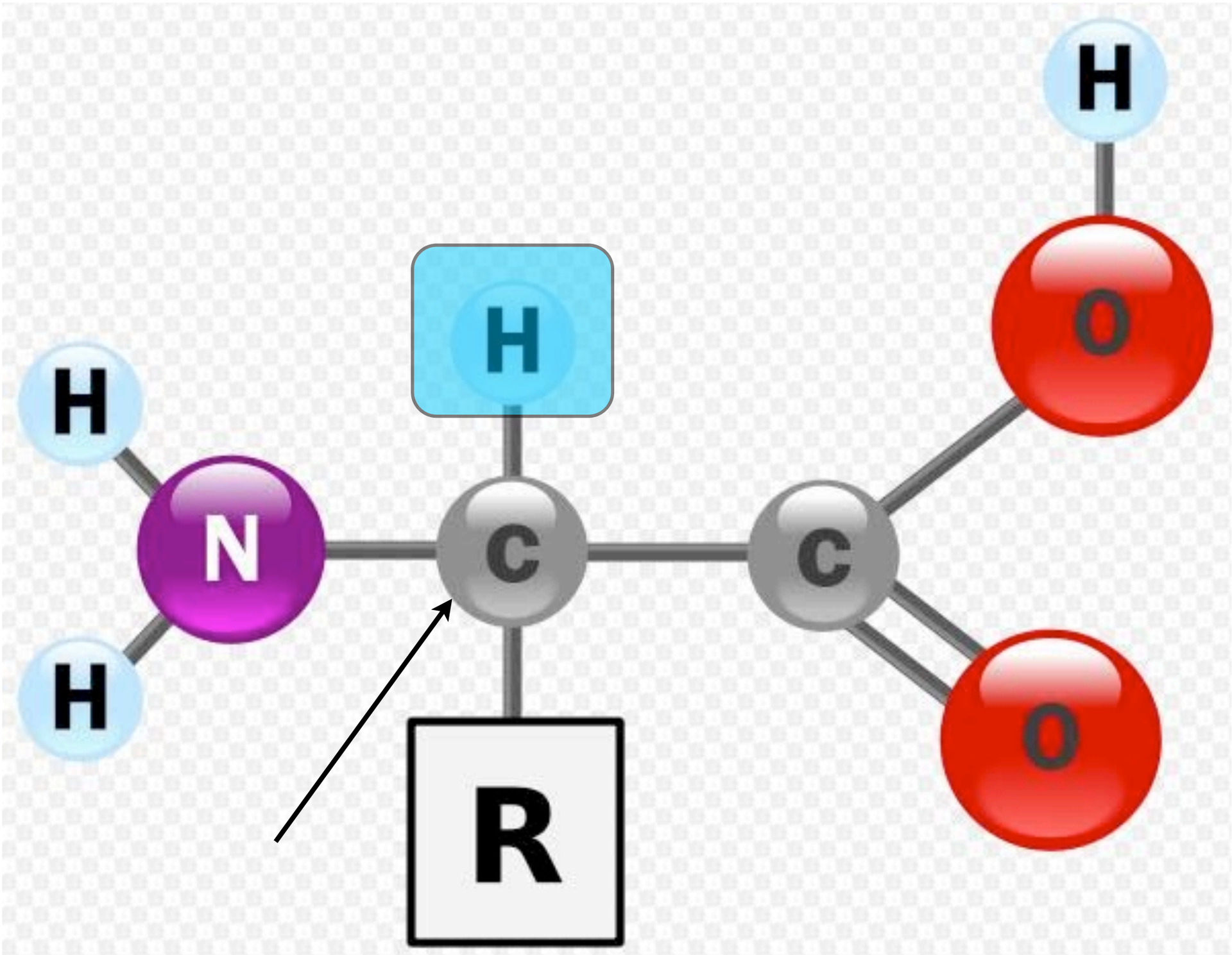
Amino Acid monomers (The amino acid below is non-ionized (dry))



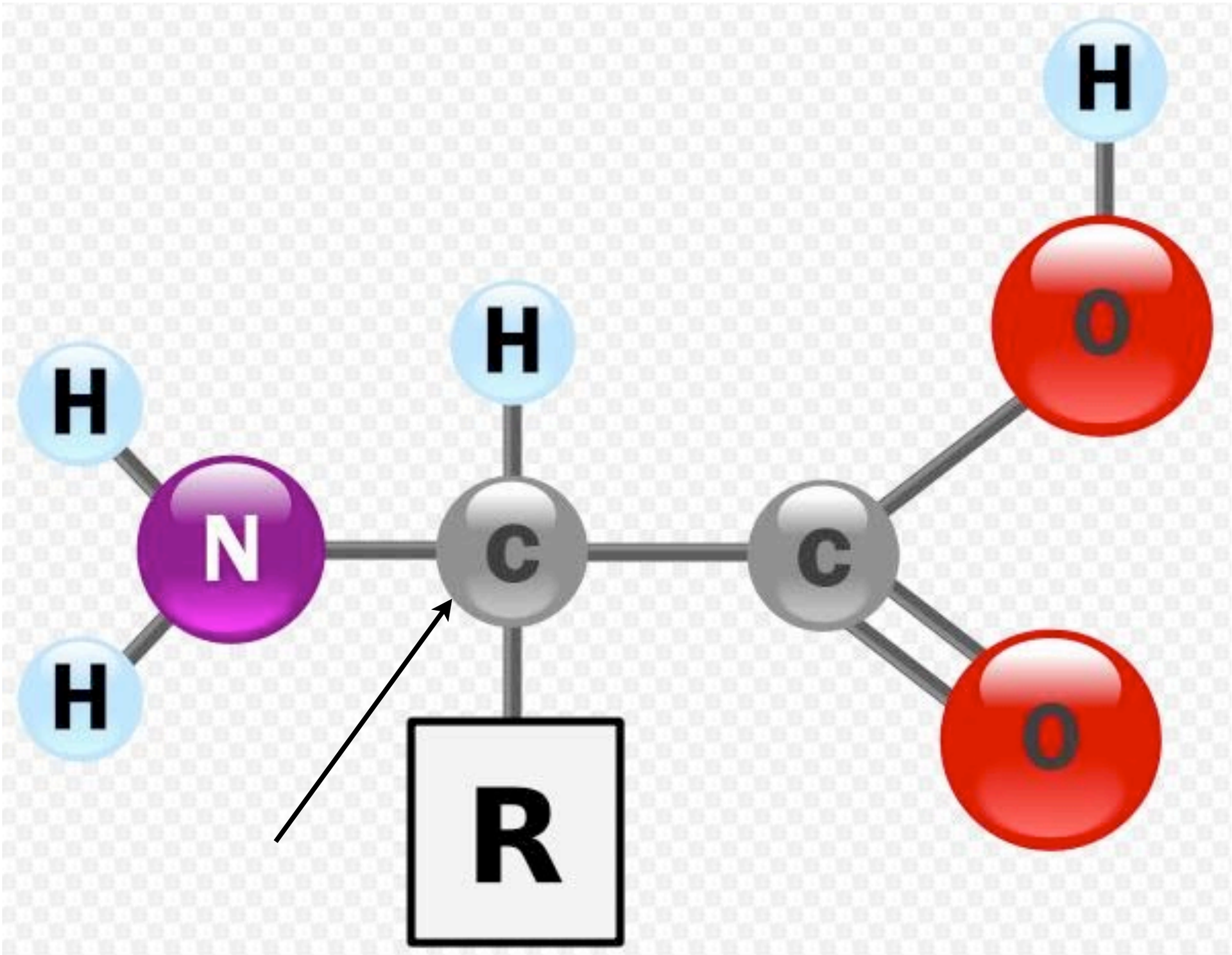
Amino Acid monomers (The amino acid below is non-ionized (dry))



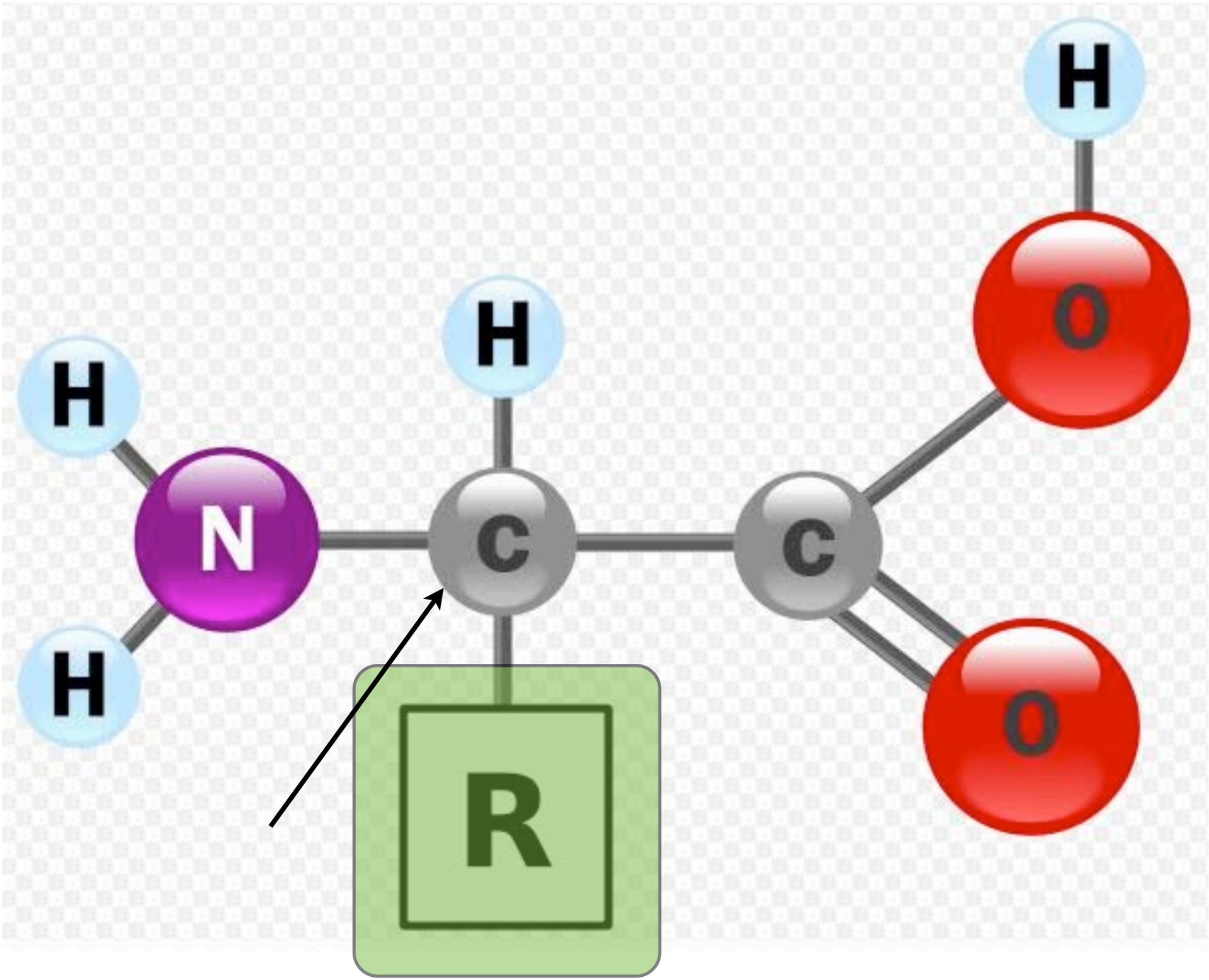
Amino Acid monomers (The amino acid below is non-ionized (dry))



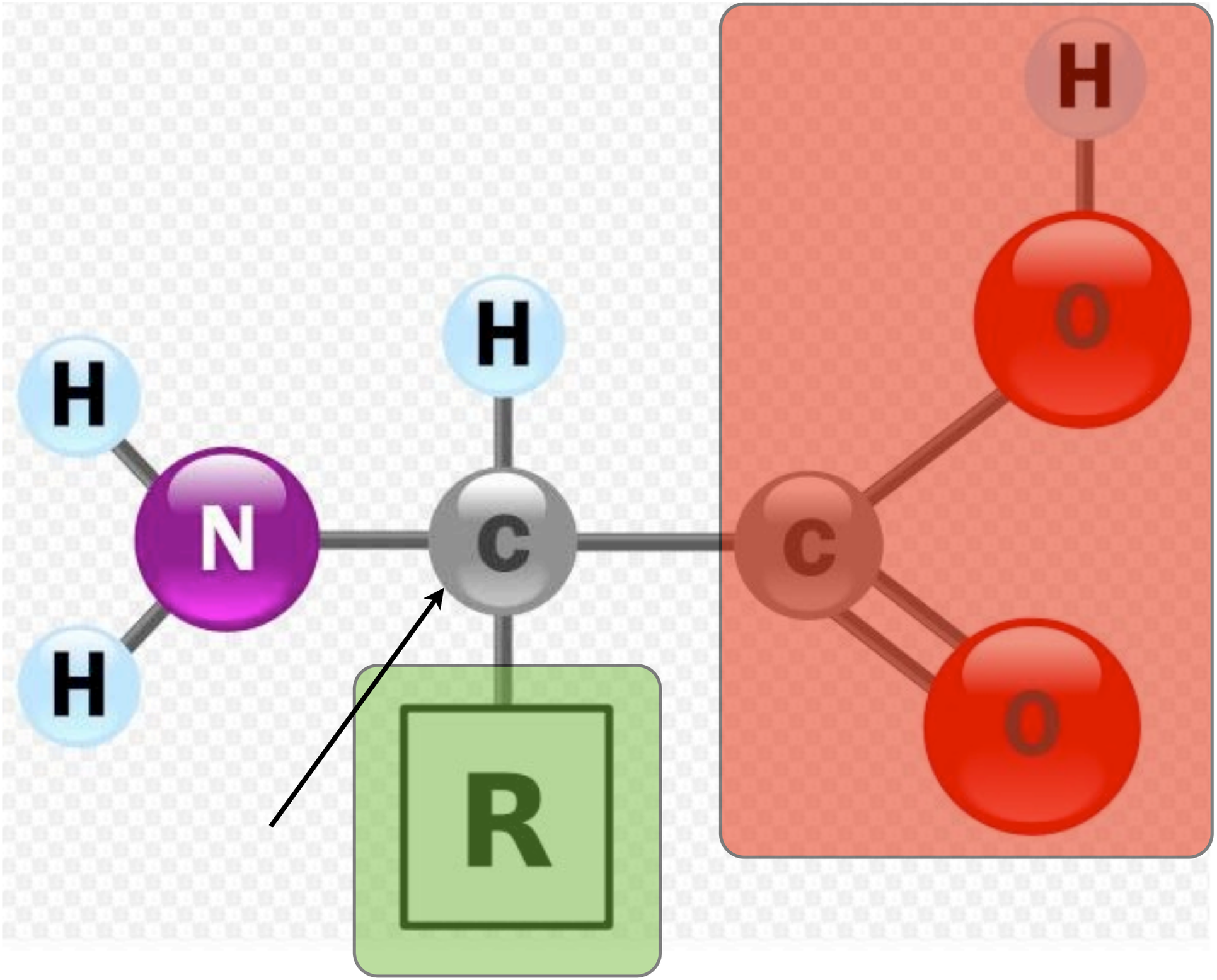
Amino Acid monomers (The amino acid below is non-ionized (dry))



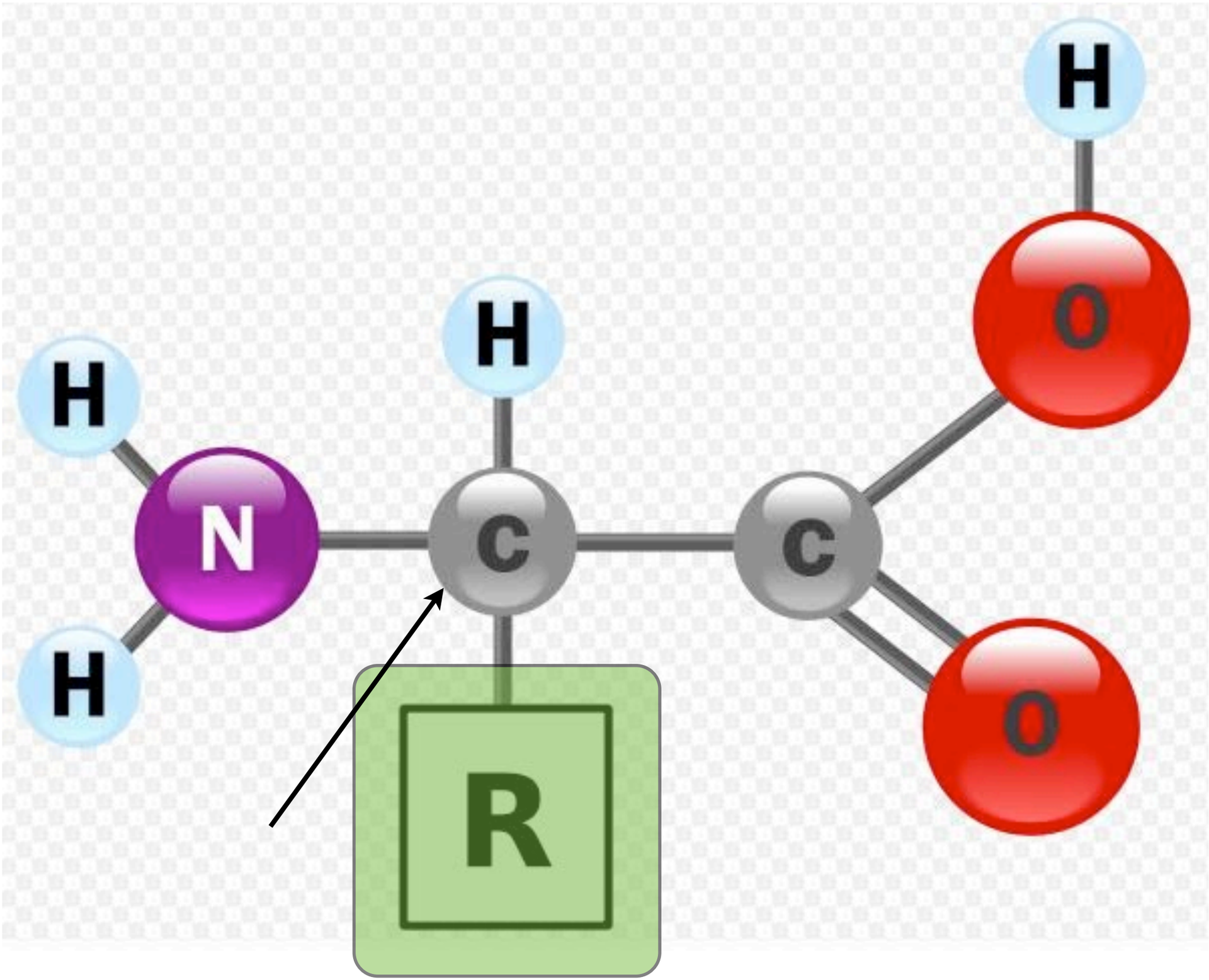
Amino Acid monomers (The amino acid below is non-ionized (dry))



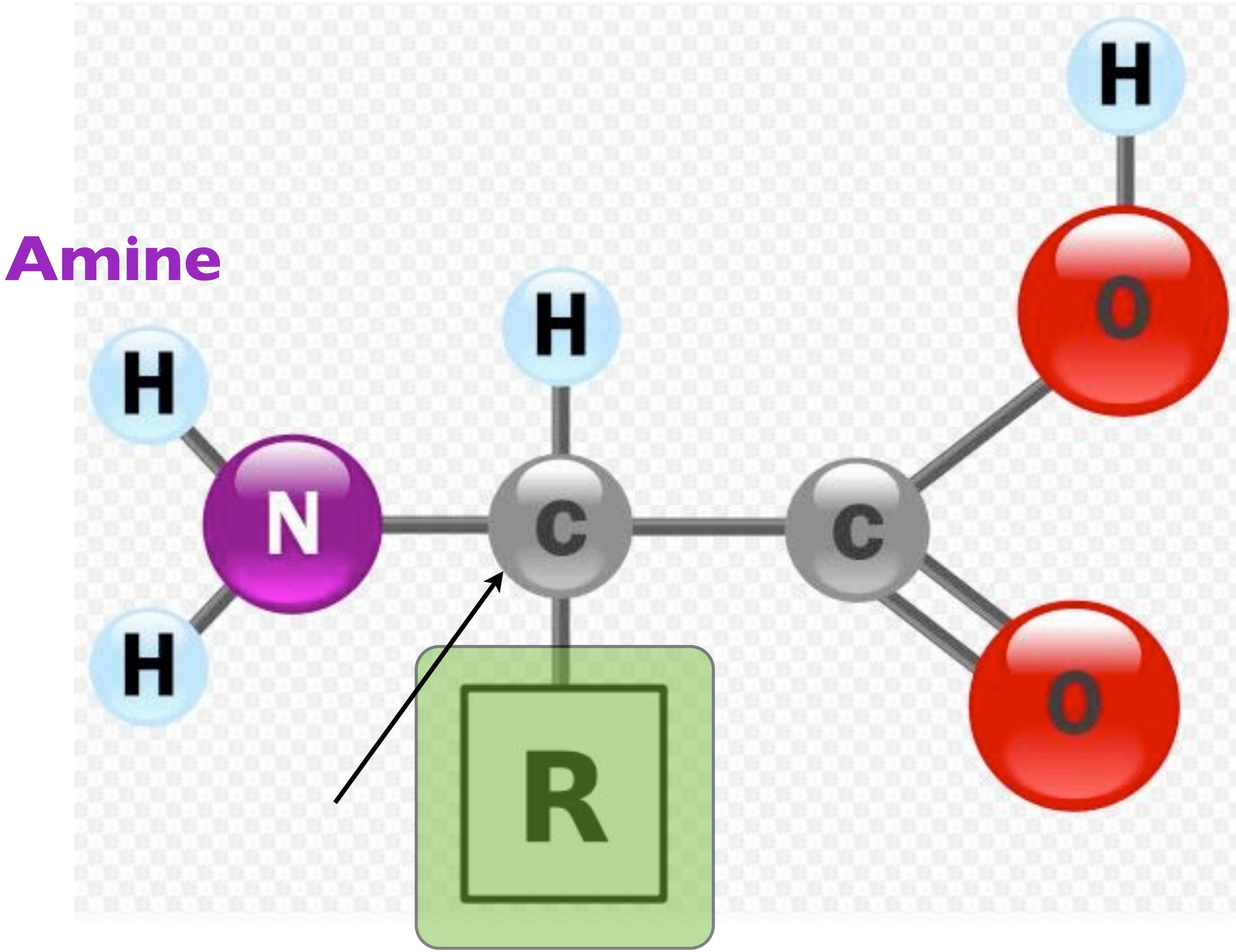
Amino Acid monomers (The amino acid below is non-ionized (dry))



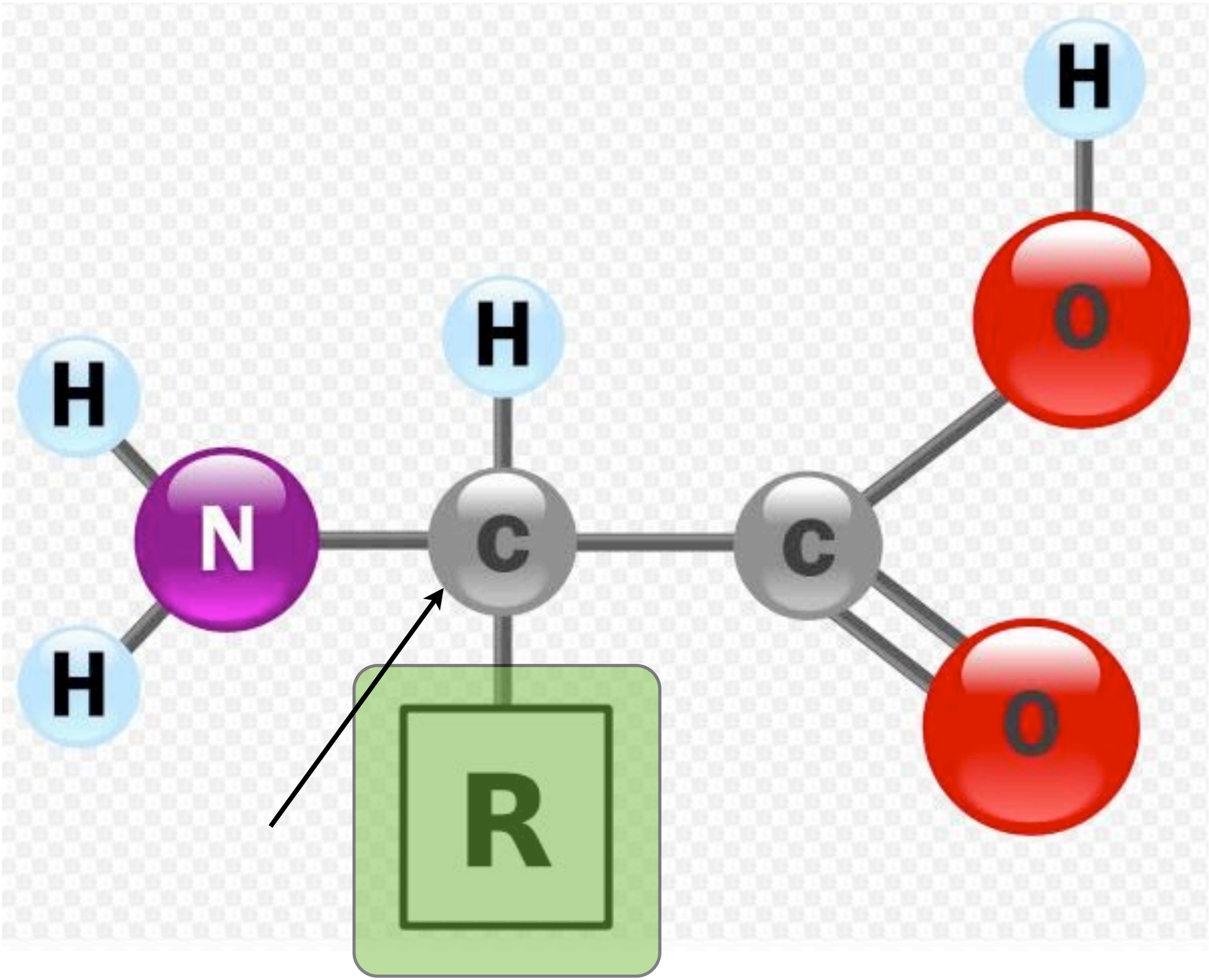
Amino Acid monomers (The amino acid below is non-ionized (dry))



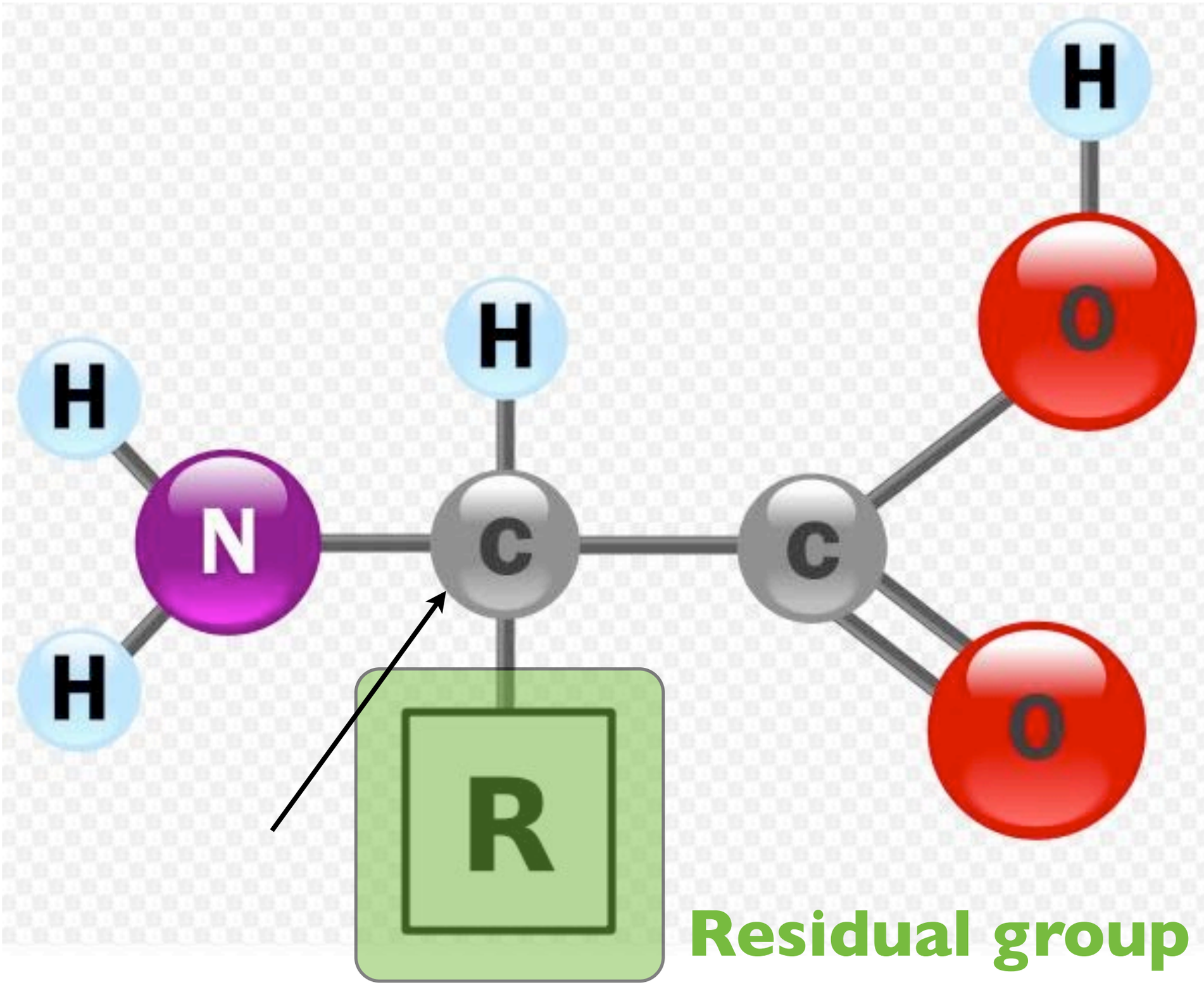
Amino Acid monomers (The amino acid below is non-ionized (dry))



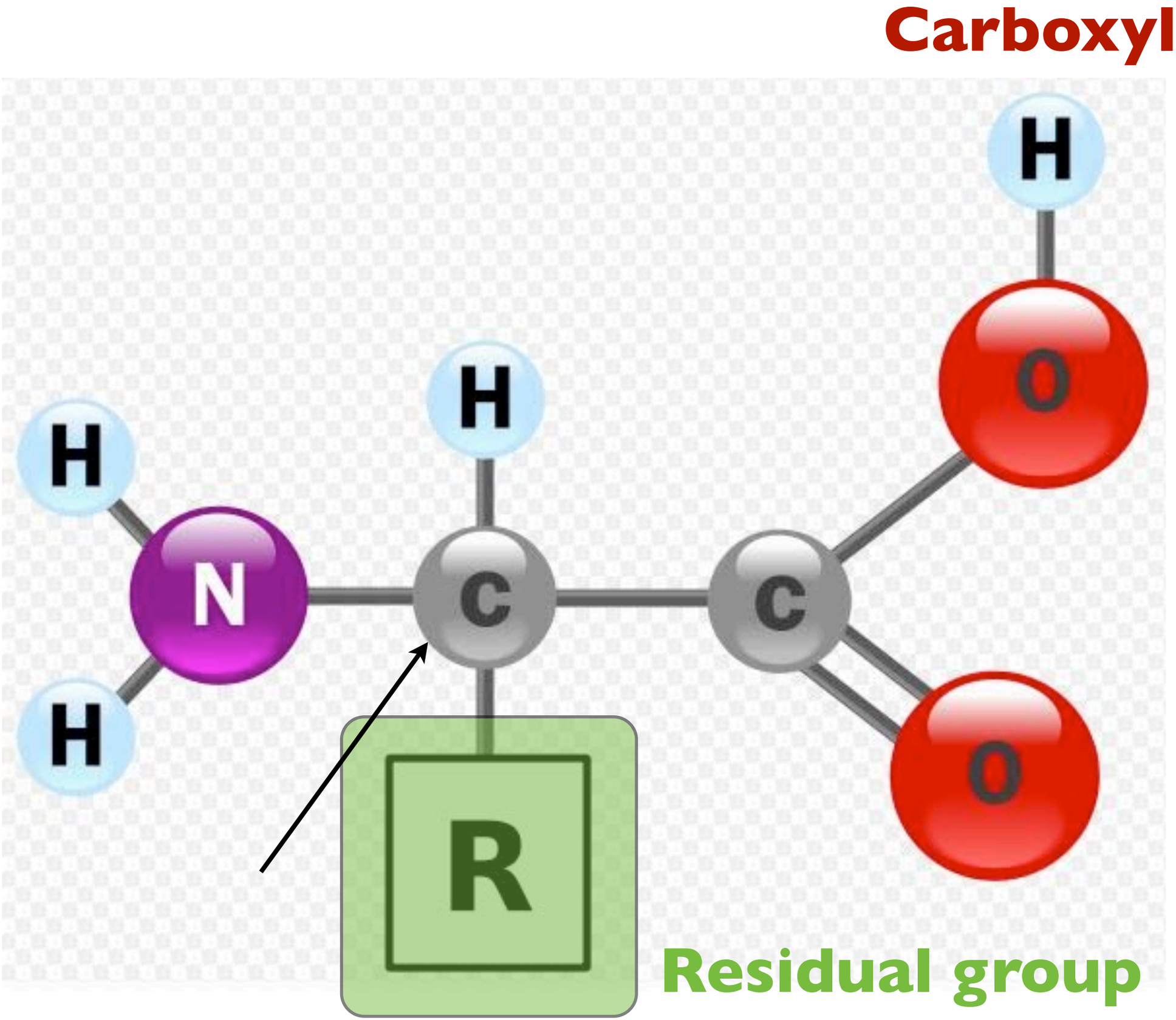
Amino Acid monomers (The amino acid below is non-ionized (dry))



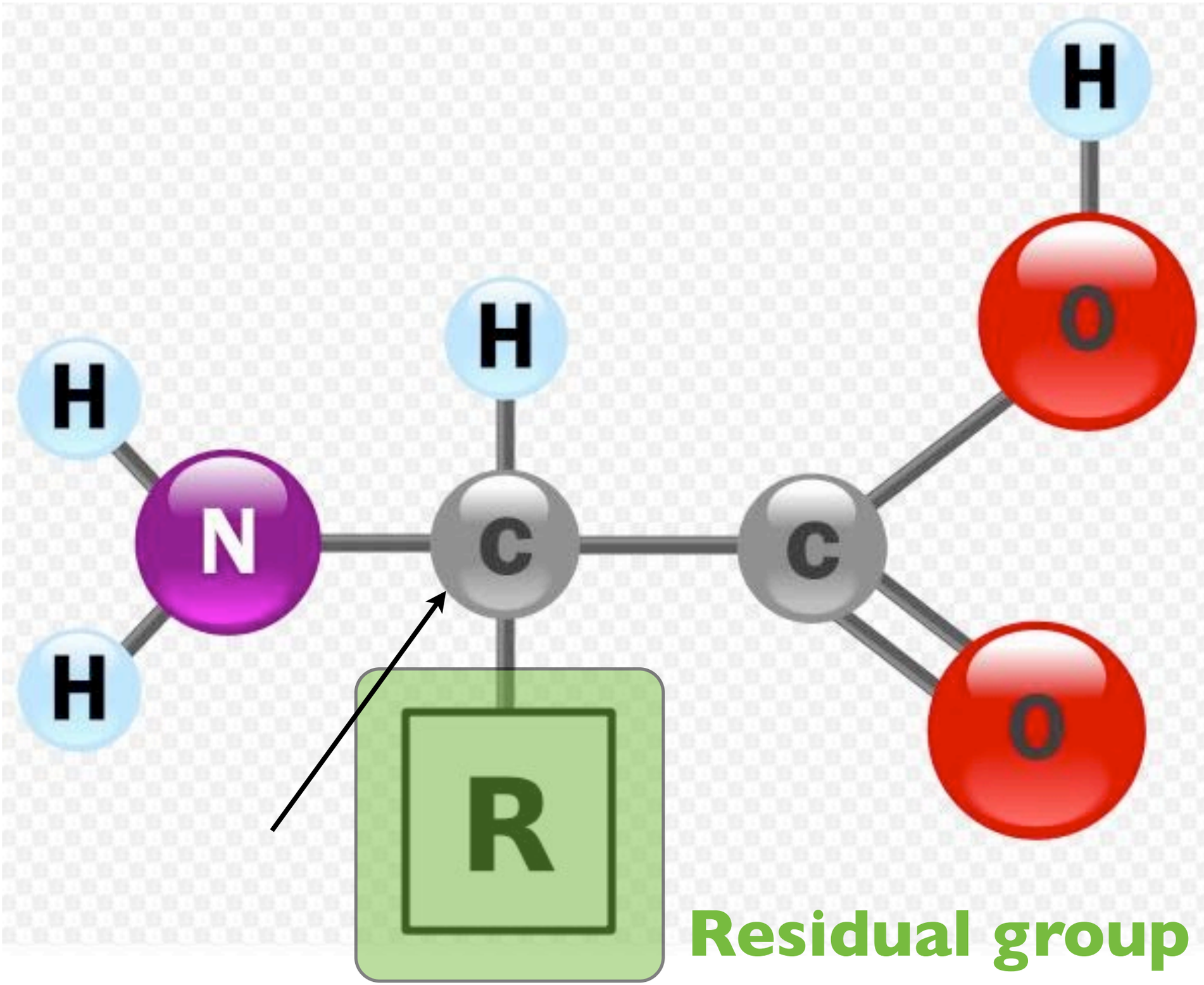
Amino Acid monomers (The amino acid below is non-ionized (dry))



Amino Acid monomers (The amino acid below is non-ionized (dry))

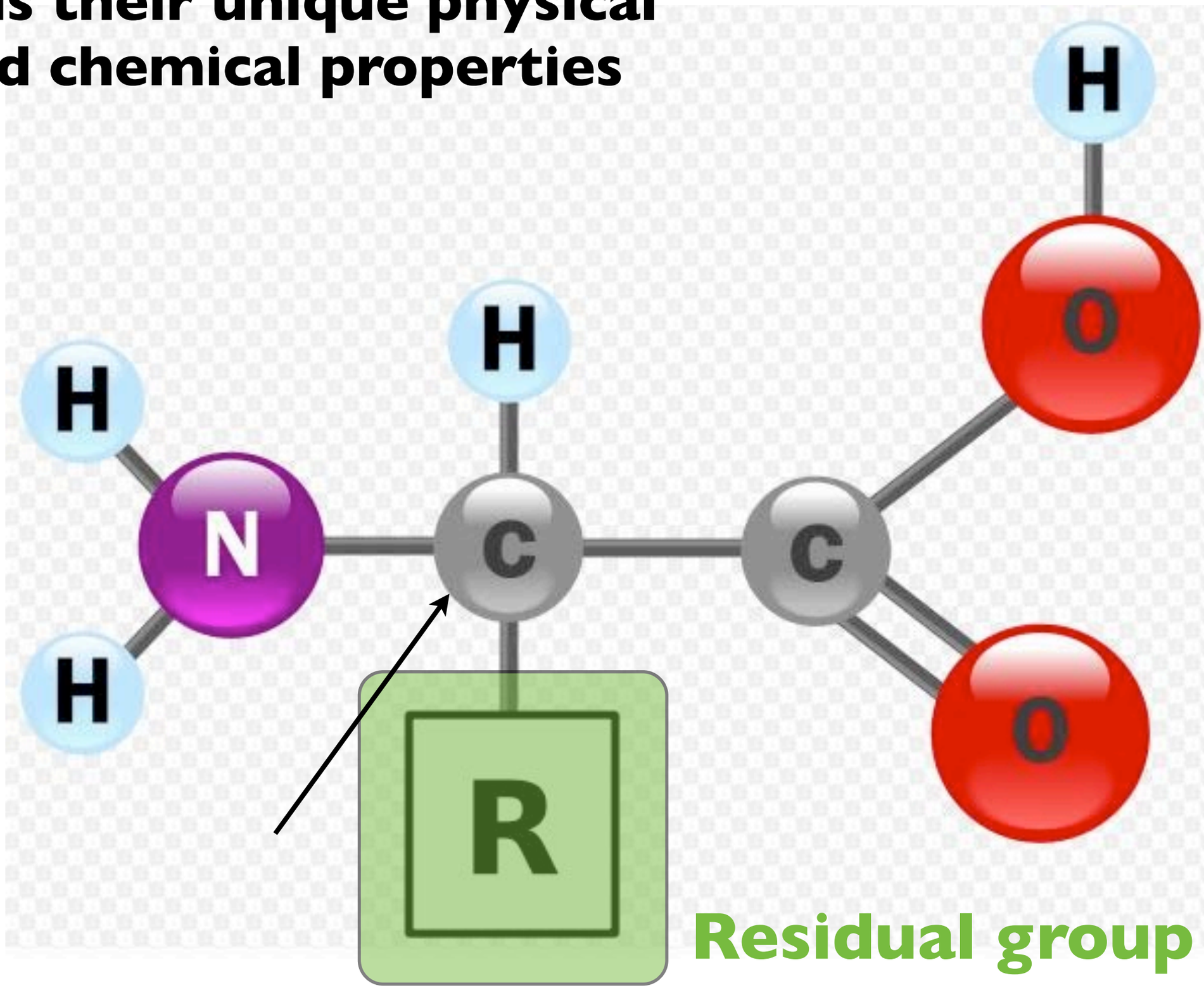


Amino Acid monomers (The amino acid below is non-ionized (dry))



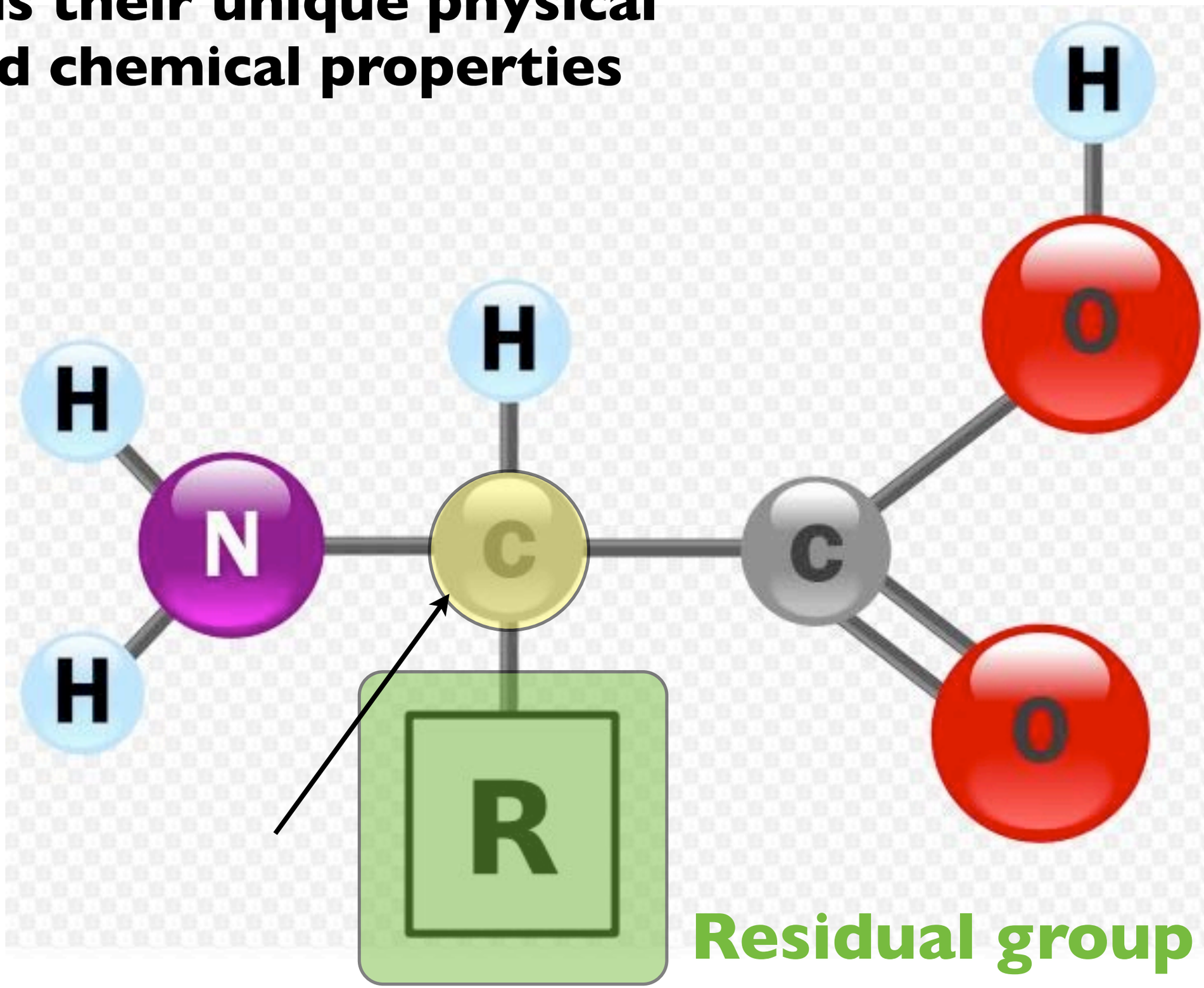
Amino Acid monomers (The amino acid below is non-ionized (dry))

This "R" group gives amino acids their unique physical and chemical properties



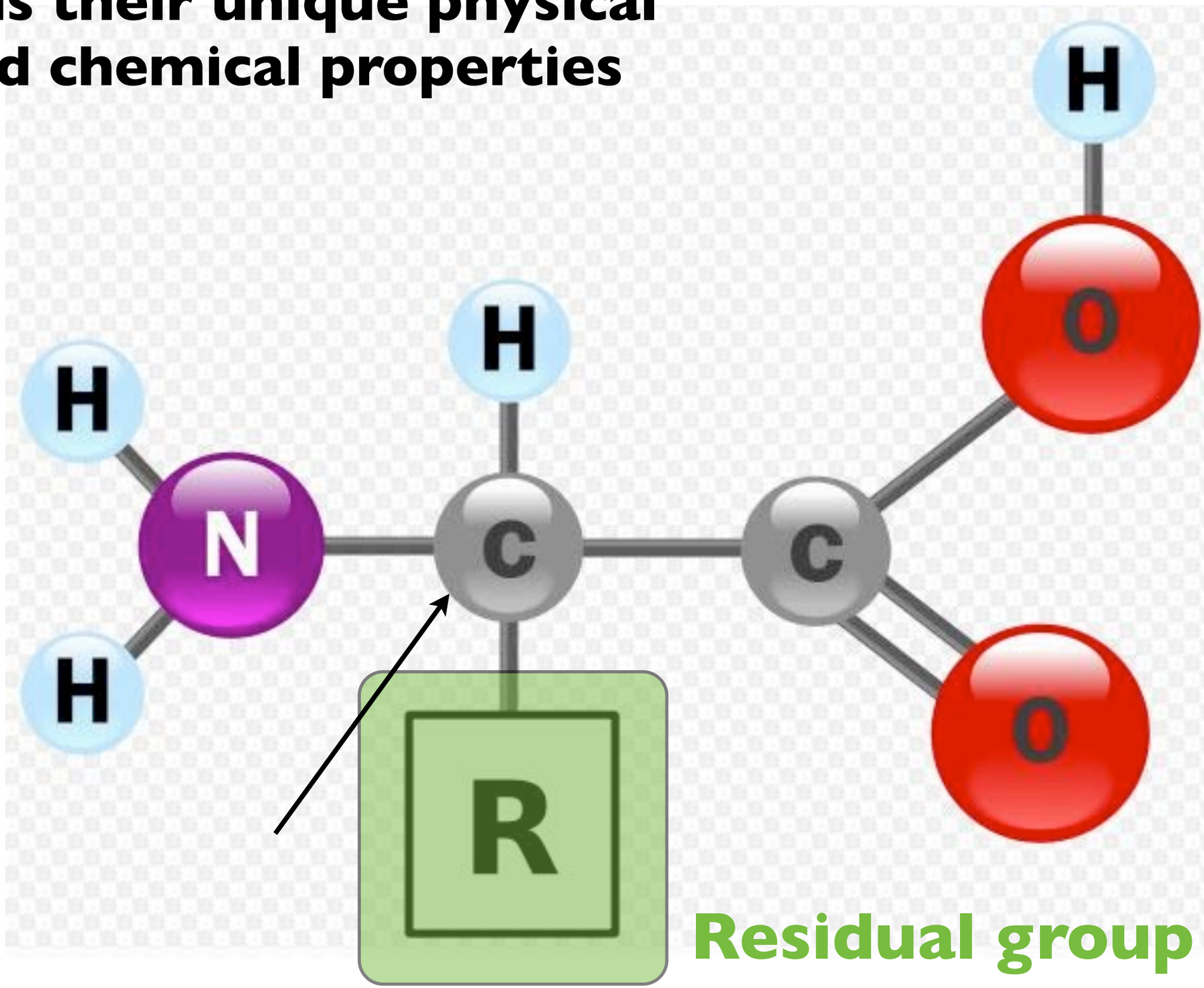
Amino Acid monomers (The amino acid below is non-ionized (dry))

This "R" group gives amino acids their unique physical and chemical properties



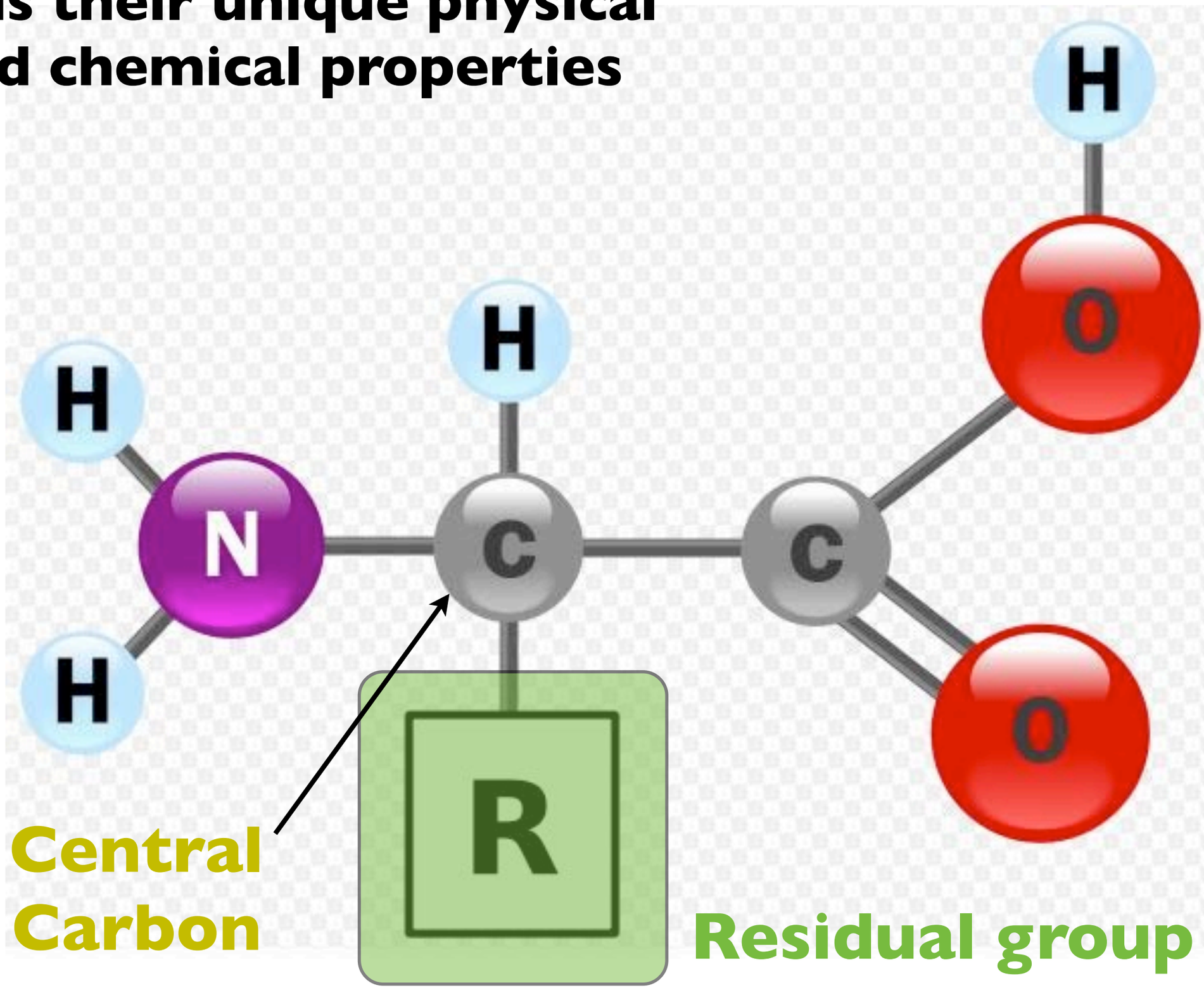
Amino Acid monomers (The amino acid below is non-ionized (dry))

This "R" group gives amino acids their unique physical and chemical properties



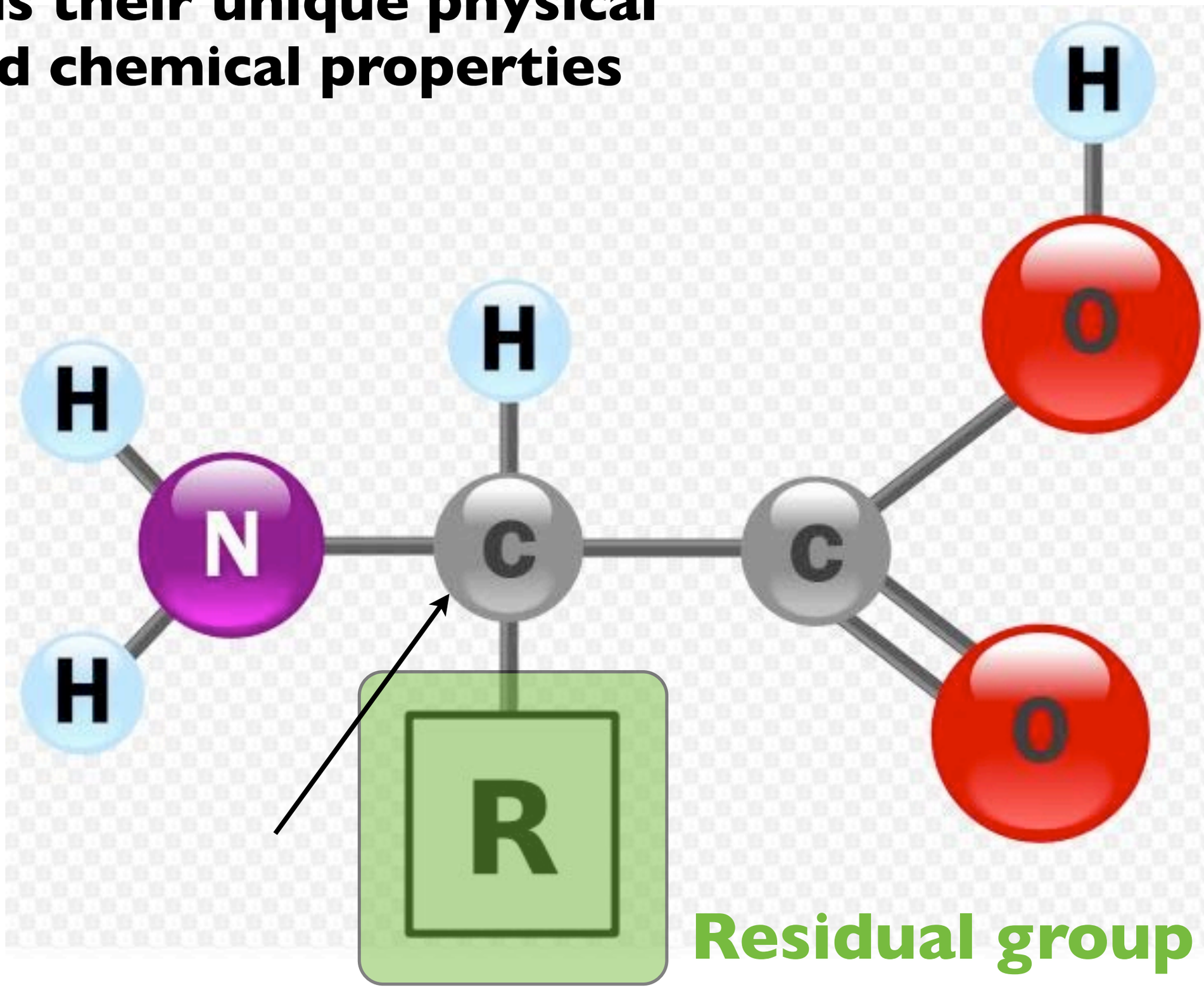
Amino Acid monomers (The amino acid below is non-ionized (dry))

This "R" group gives amino acids their unique physical and chemical properties



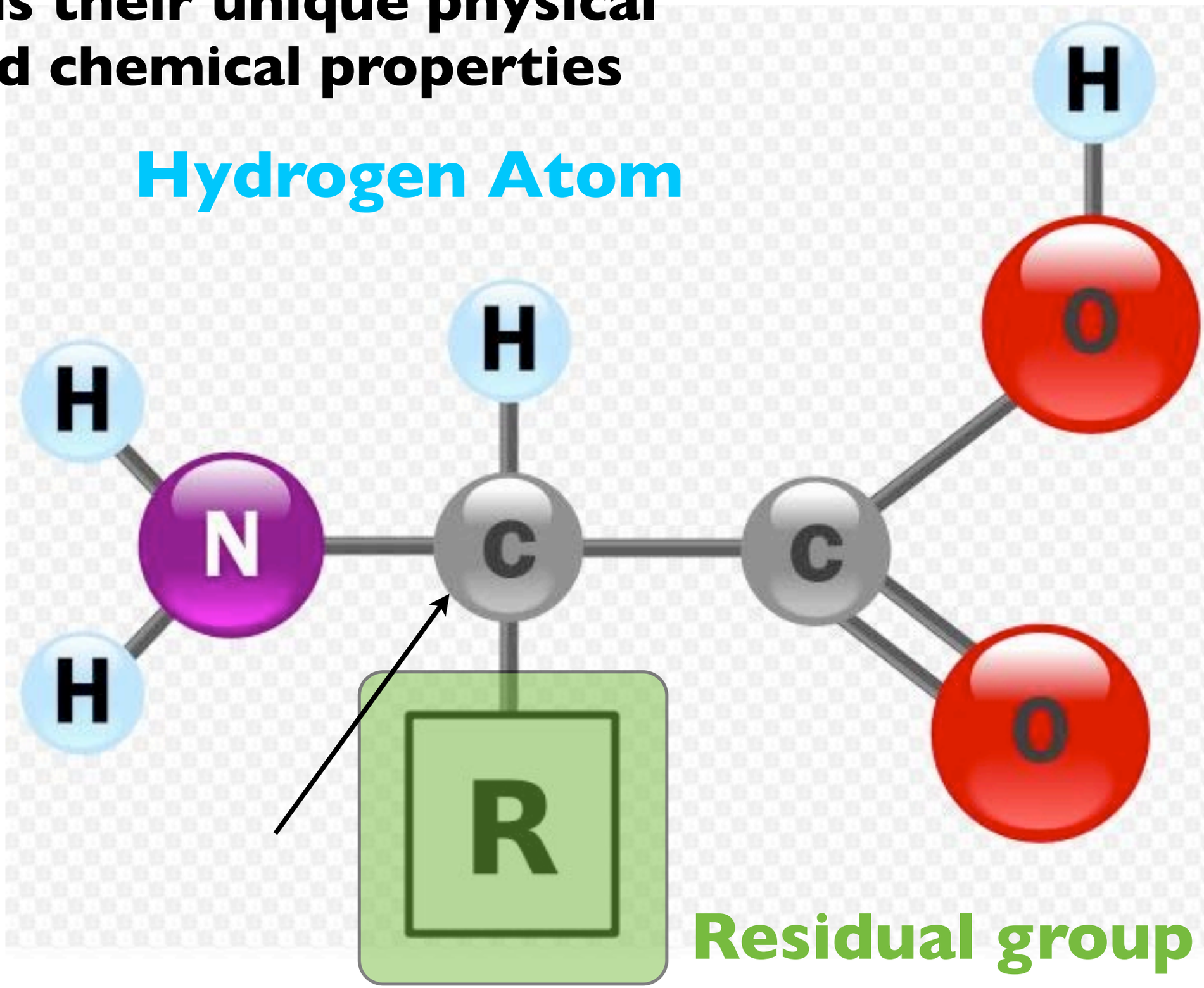
Amino Acid monomers (The amino acid below is non-ionized (dry))

This "R" group gives amino acids their unique physical and chemical properties



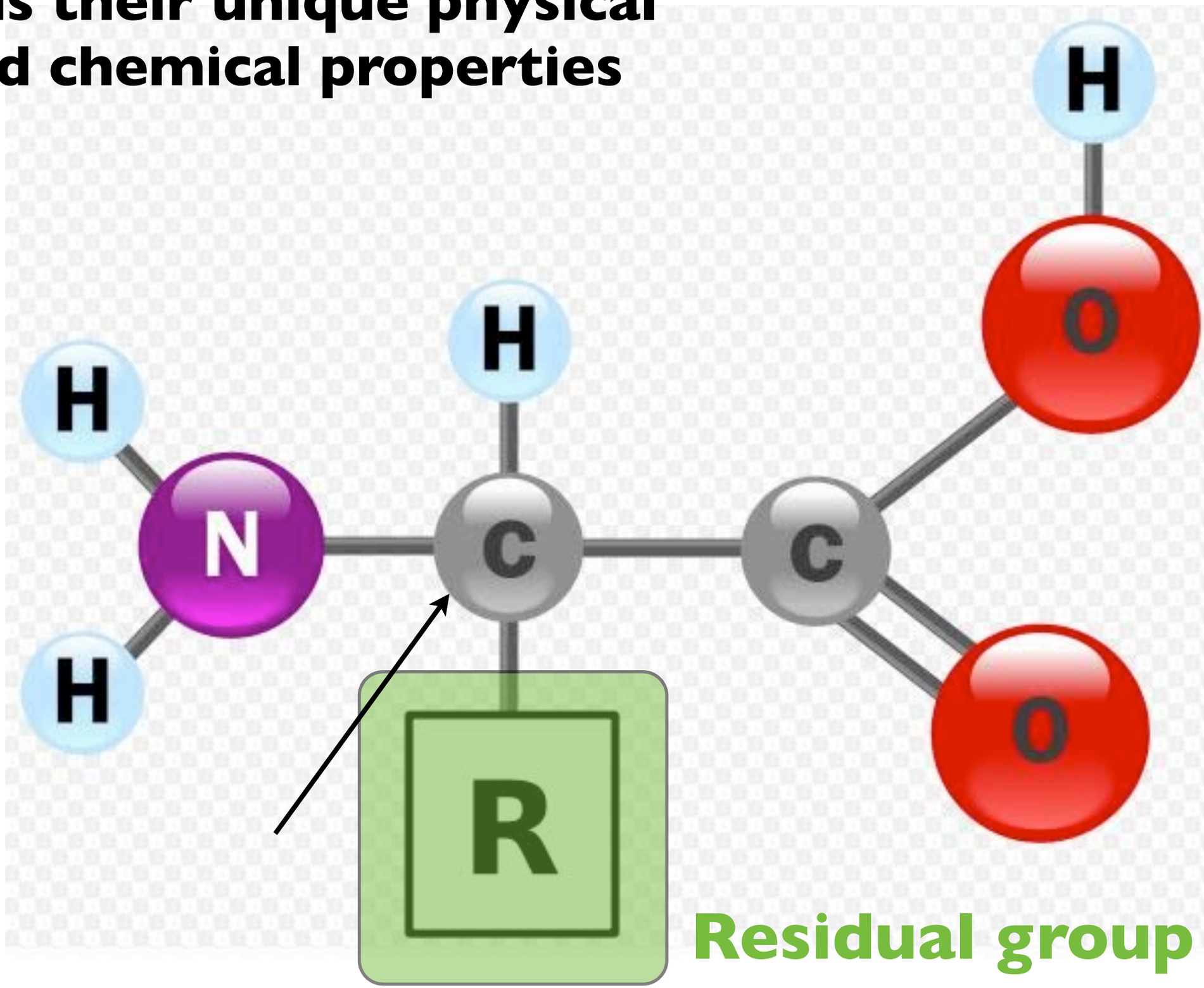
Amino Acid monomers (The amino acid below is non-ionized (dry))

This "R" group gives amino acids their unique physical and chemical properties

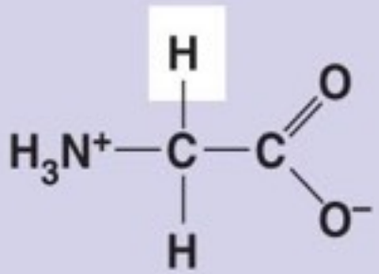


Amino Acid monomers (The amino acid below is non-ionized (dry))

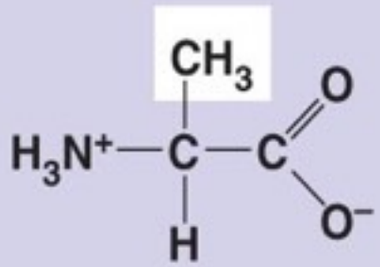
This "R" group gives amino acids their unique physical and chemical properties



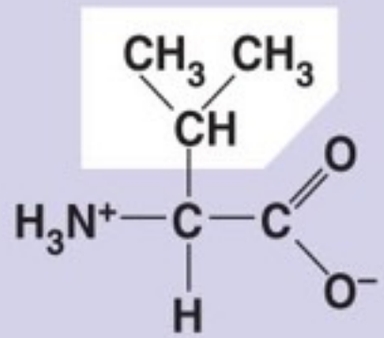
Nonpolar



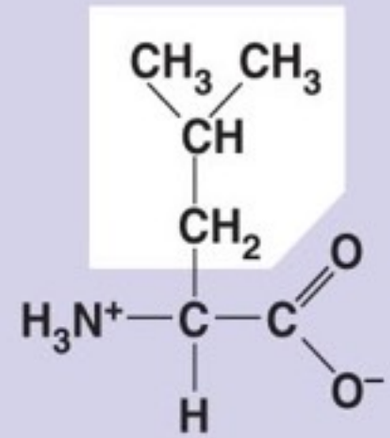
Glycine
(Gly or G)



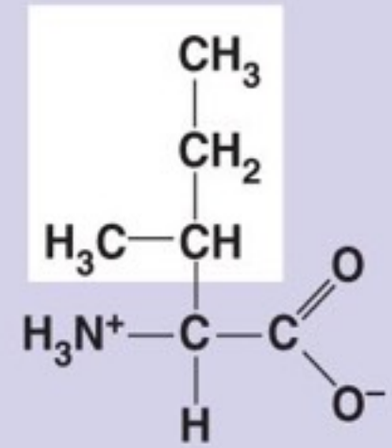
Alanine
(Ala or A)



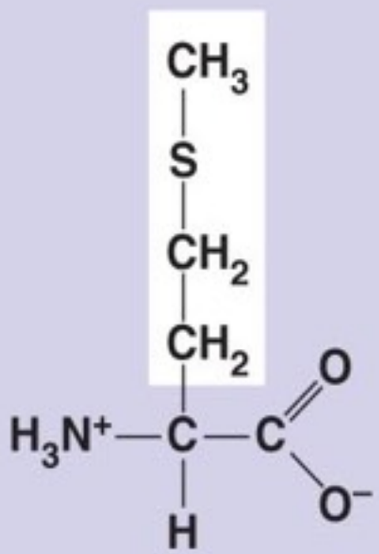
Valine
(Val or V)



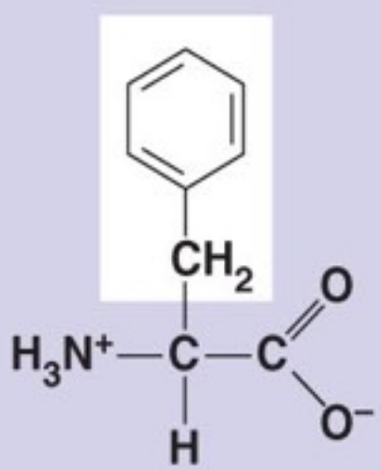
Leucine
(Leu or L)



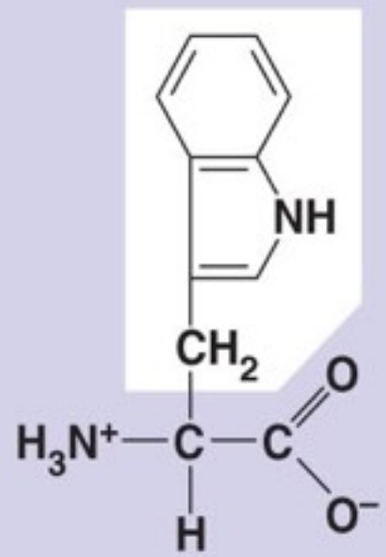
Isoleucine
(Ile or I)



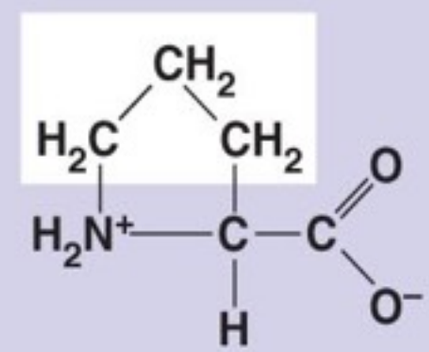
Methionine
(Met or M)



Phenylalanine
(Phe or F)

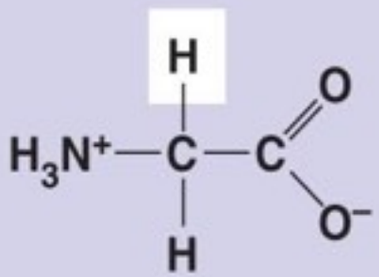


Tryptophan
(Trp or W)

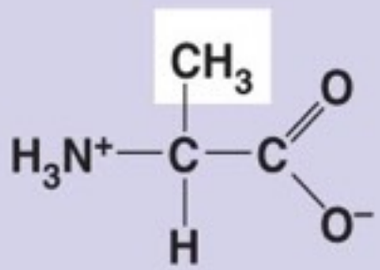


Proline
(Pro or P)

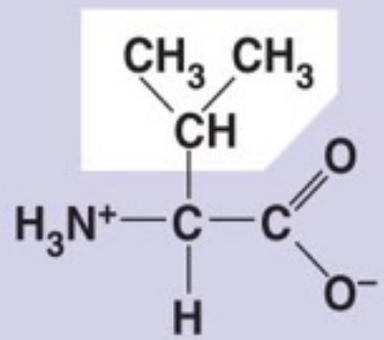
Nonpolar



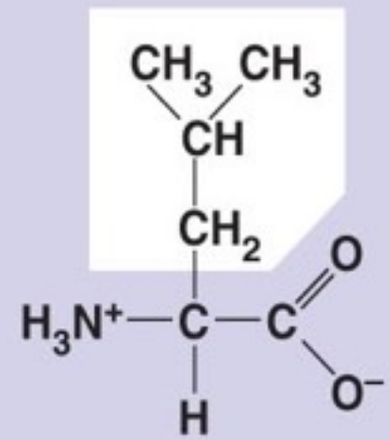
Glycine
(Gly or G)



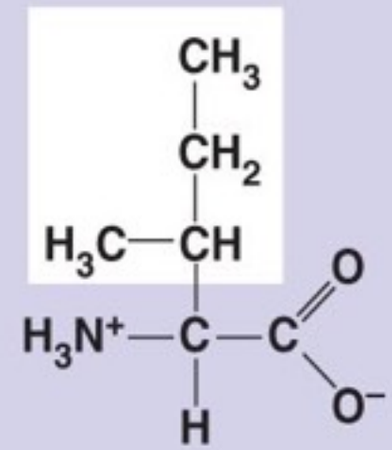
Alanine
(Ala or A)



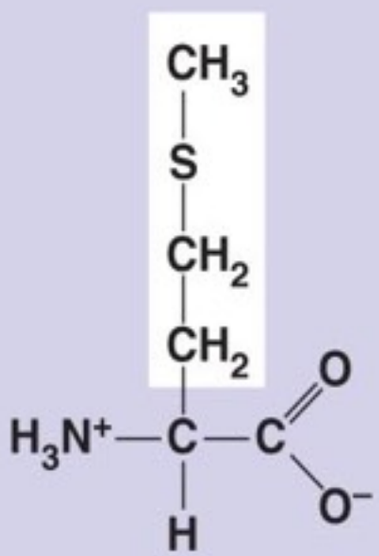
Valine
(Val or V)



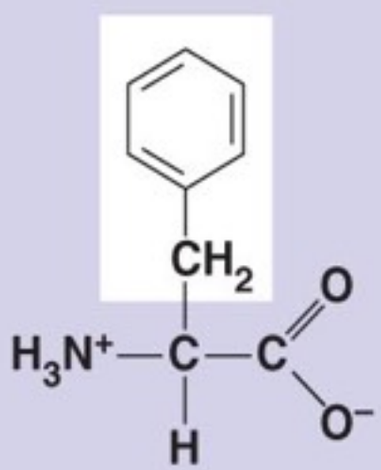
Leucine
(Leu or L)



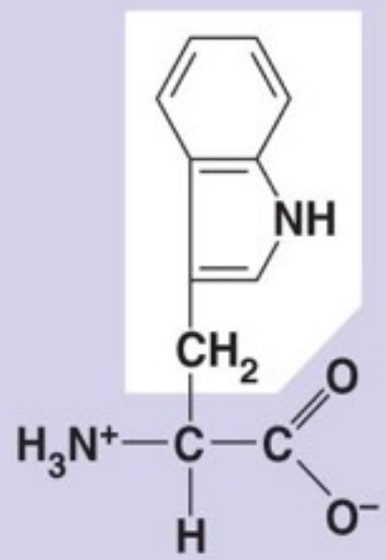
Isoleucine
(Ile or I)



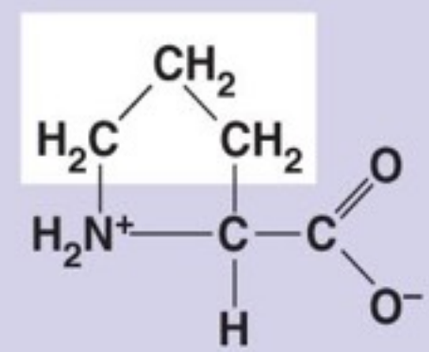
Methionine
(Met or M)



Phenylalanine
(Phe or F)



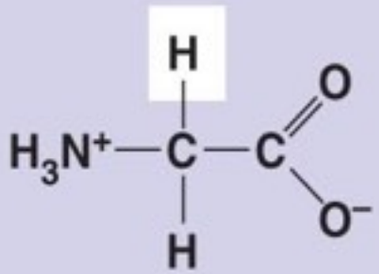
Tryptophan
(Trp or W)



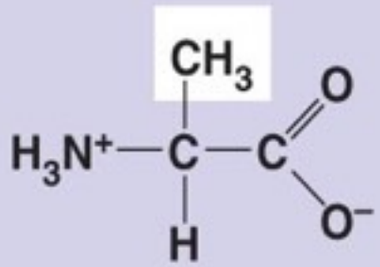
Proline
(Pro or P)

What is different about these side groups?

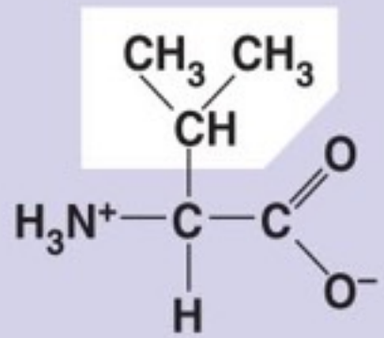
Nonpolar



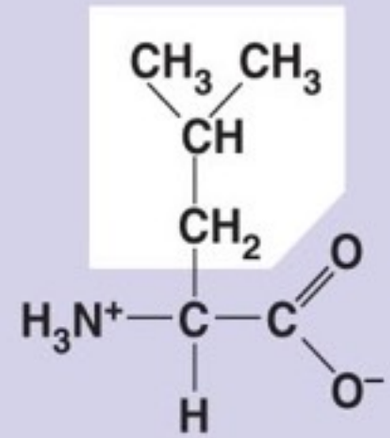
Glycine
(Gly or G)



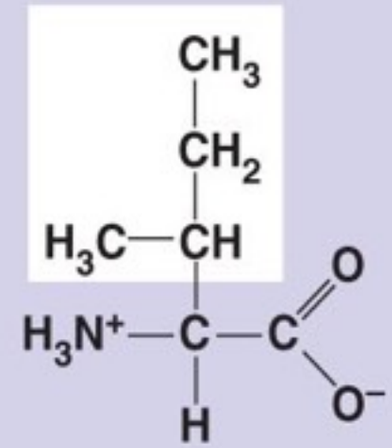
Alanine
(Ala or A)



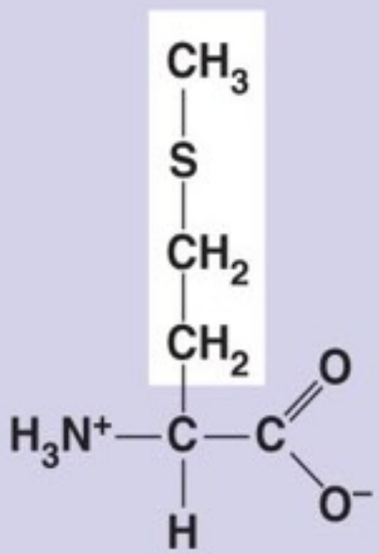
Valine
(Val or V)



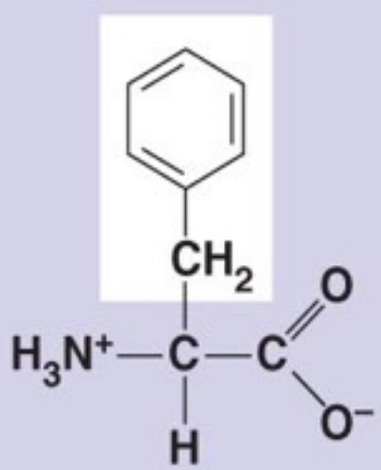
Leucine
(Leu or L)



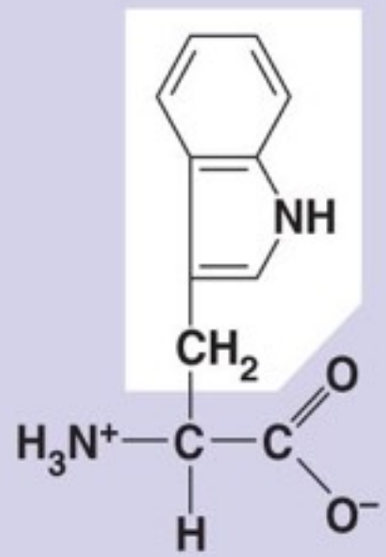
Isoleucine
(Ile or I)



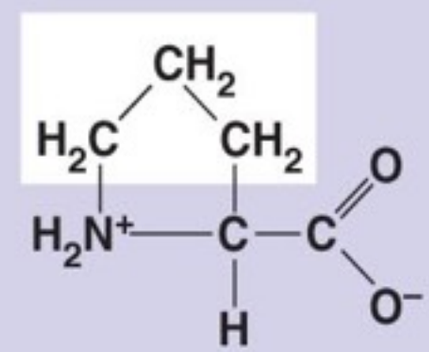
Methionine
(Met or M)



Phenylalanine
(Phe or F)



Tryptophan
(Trp or W)

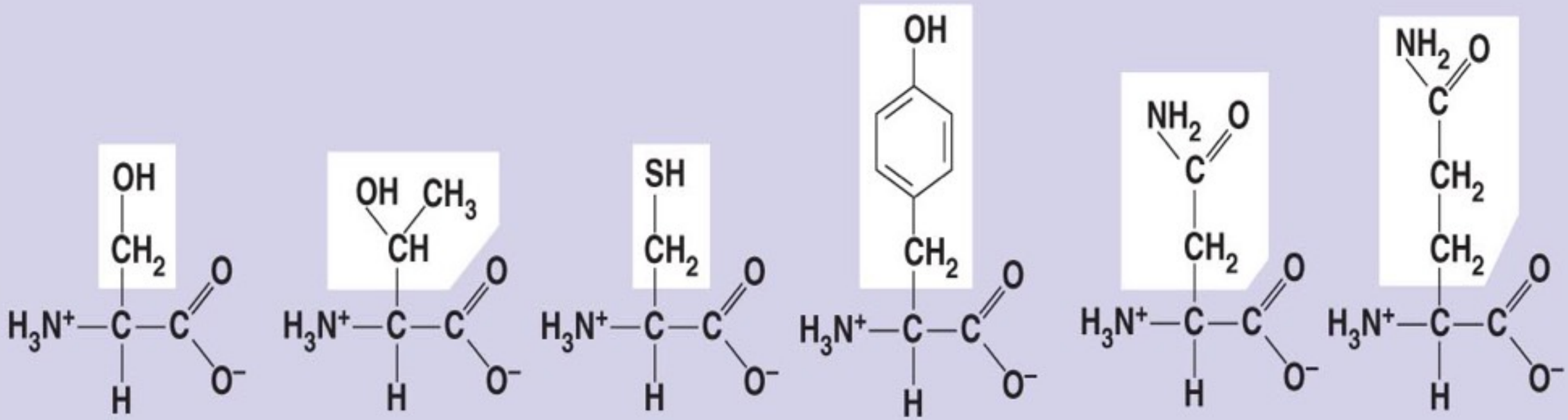


Proline
(Pro or P)

What is different about these side groups?

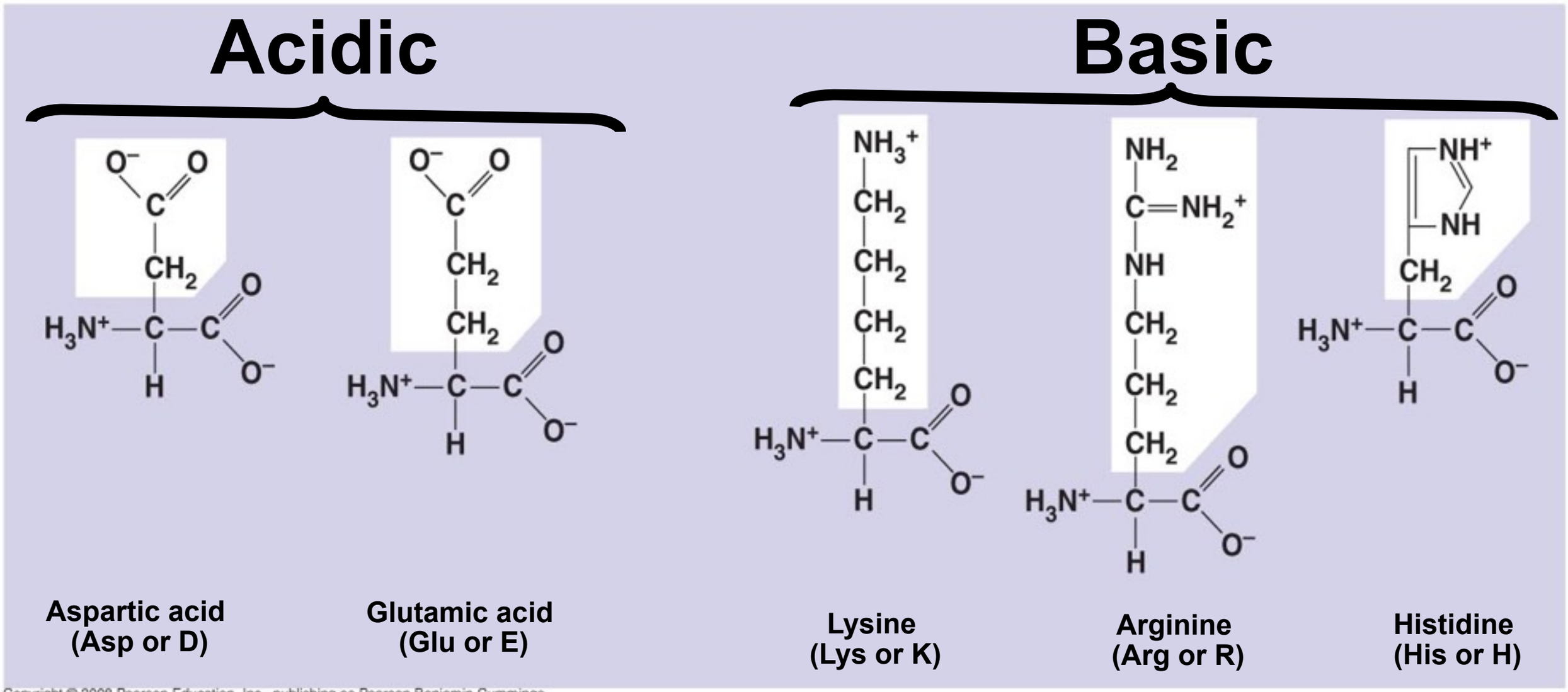
Ionized

Polar



Serine (Ser or S) | **Threonine (Thr or T)** | **Cysteine (Cys or C)** | **Tyrosine (Tyr or Y)** | **Asparagine (Asn or N)** | **Glutamine (Gln or Q)**

Electrically charged



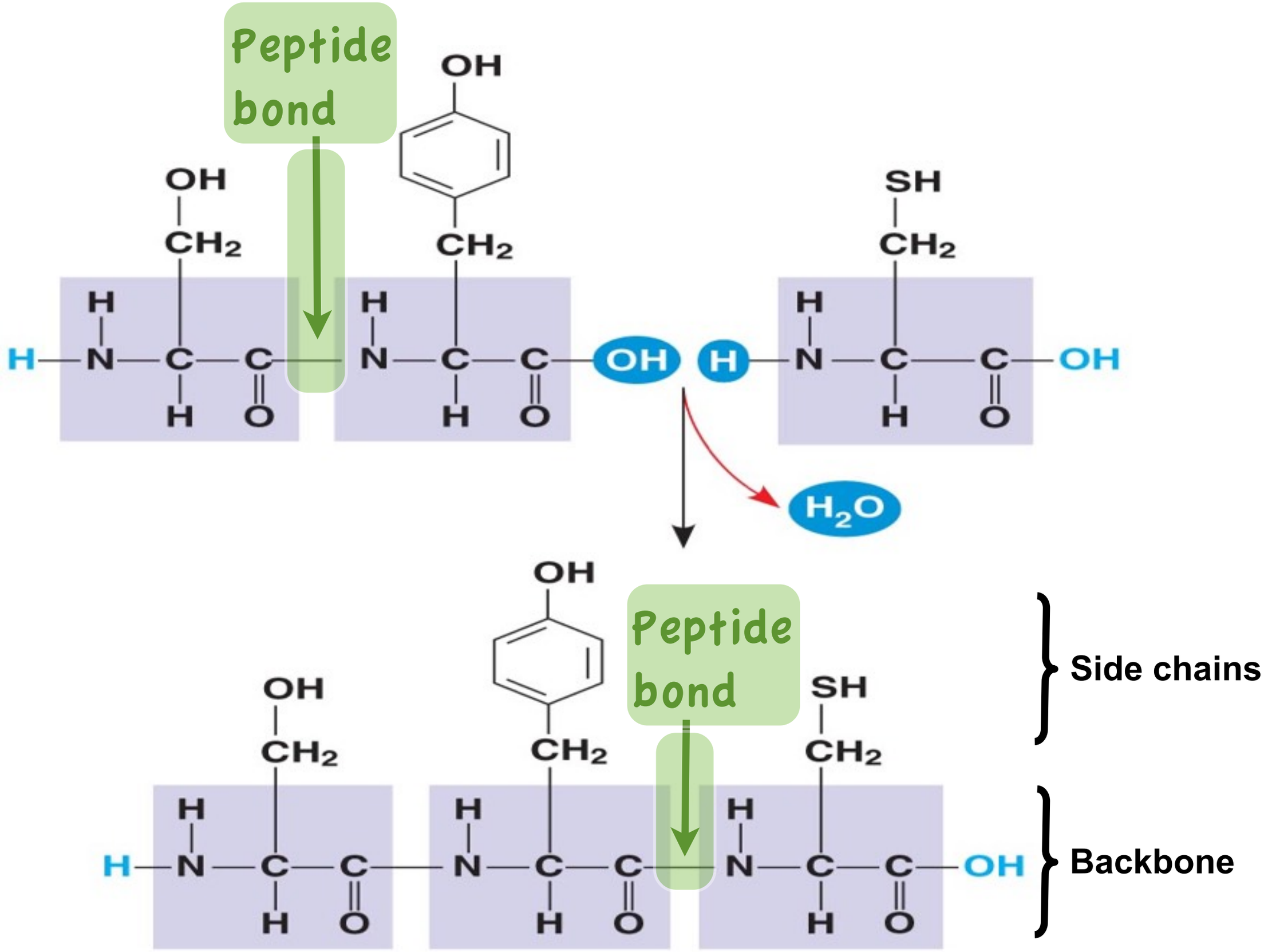
Essential knowledge 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.

b. Directionality influences structure and function of the polymer.

2. Proteins have an amino end and a carboxyl end, and consist of a linear sequence of amino acids connected by the formation of peptide bonds by dehydration synthesis between the amino and carboxyl groups of adjacent monomers.

Amino Acid polymers

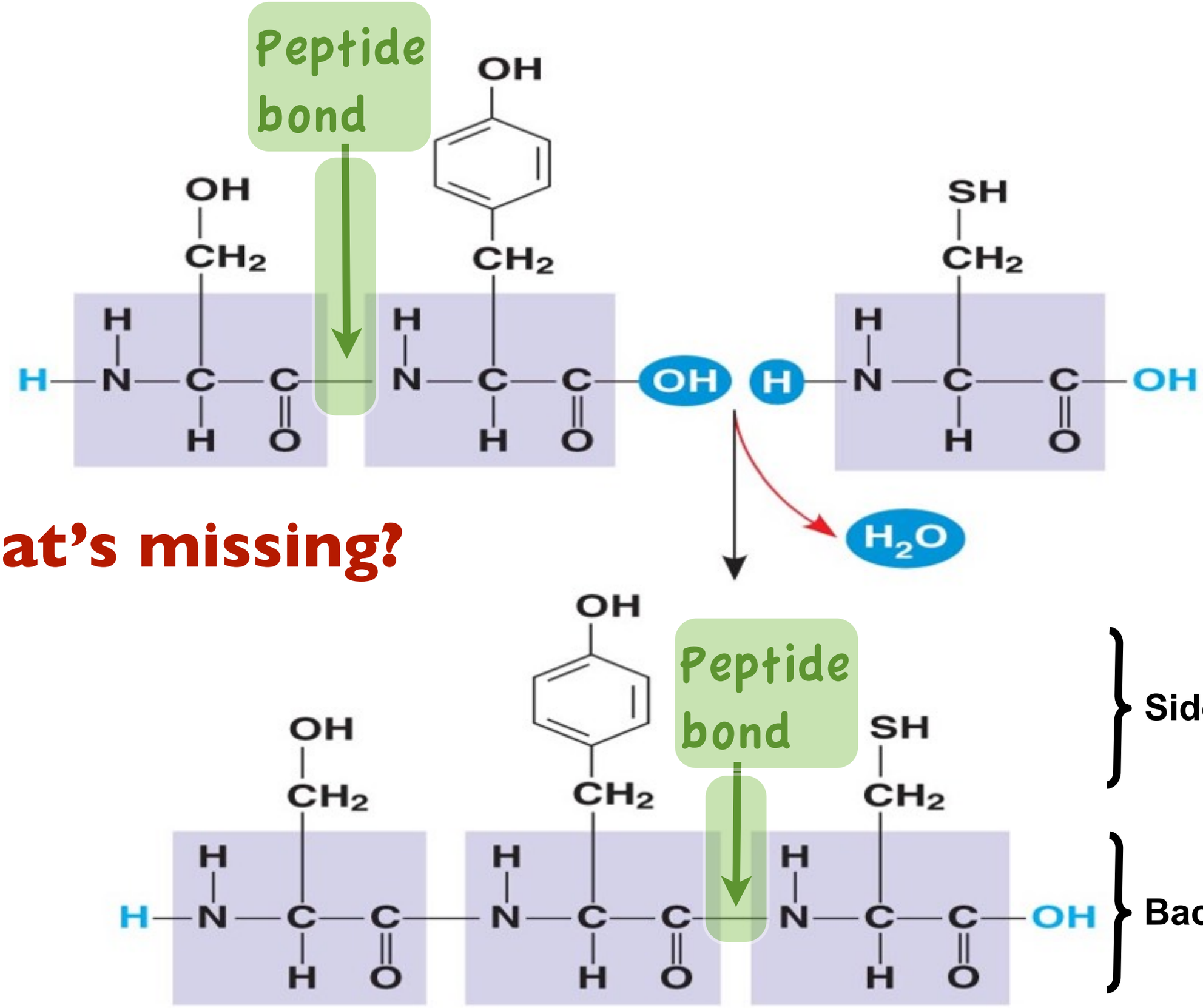
- **The amino acids are joined by <u>dehydration synthesis</u> reactions.**
  - **The resulting bond is a <u>*peptide bond*</u>.**
- **This process repeated over and over yields a <u>polypeptide</u>.**
  - **Polypeptide chains range in length from <u>3 amino acids to 1000's of amino acids</u>**
- **Each protein is unique due to the <u>types</u> of amino acids, the <u>number</u> of amino acids and their <u>order</u>.**



Amino end
(N-terminus)

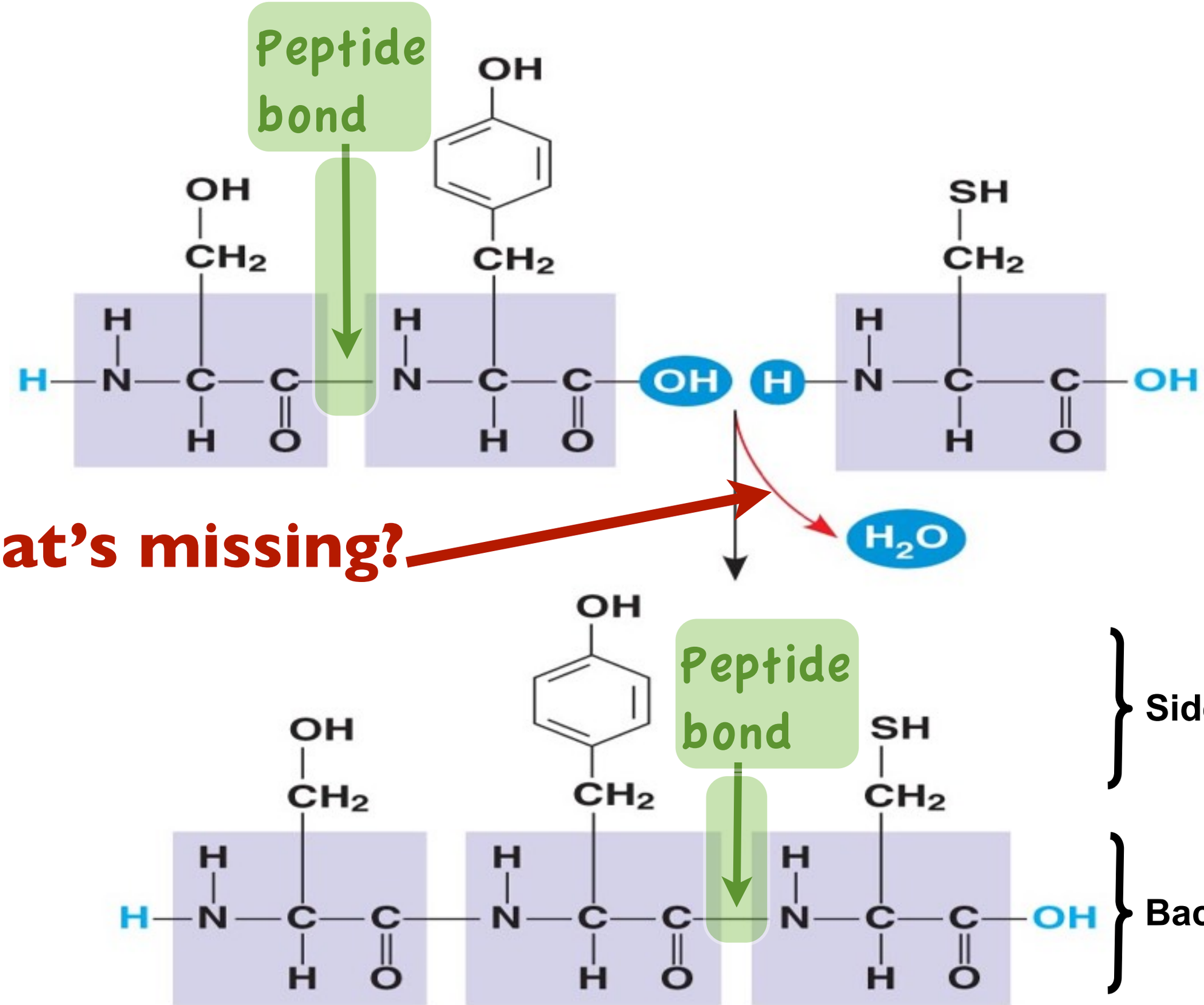
Carboxyl end
(C-terminus)

What's missing?



Amino end
(N-terminus)

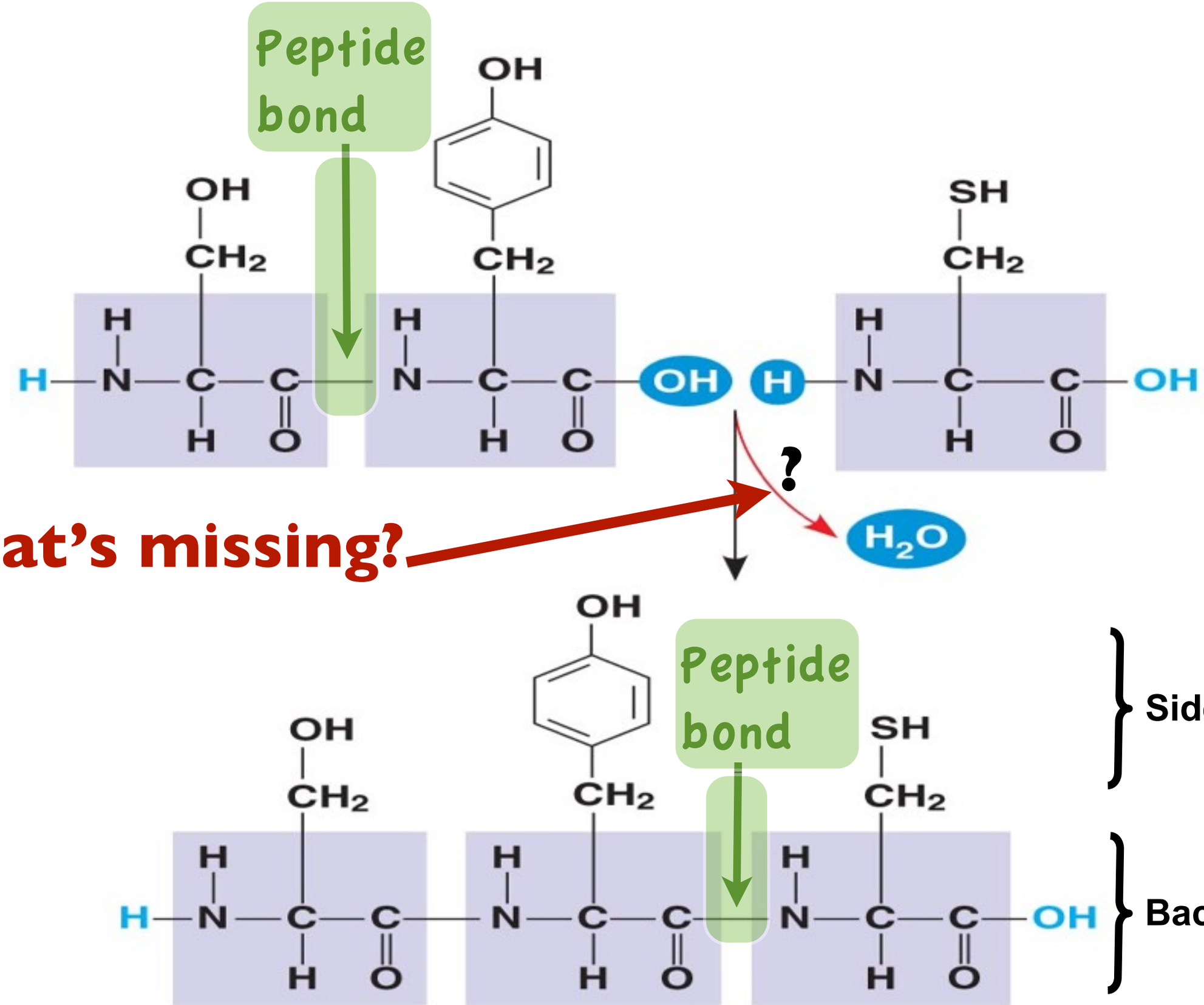
Carboxyl end
(C-terminus)



What's missing?

Amino end
(N-terminus)

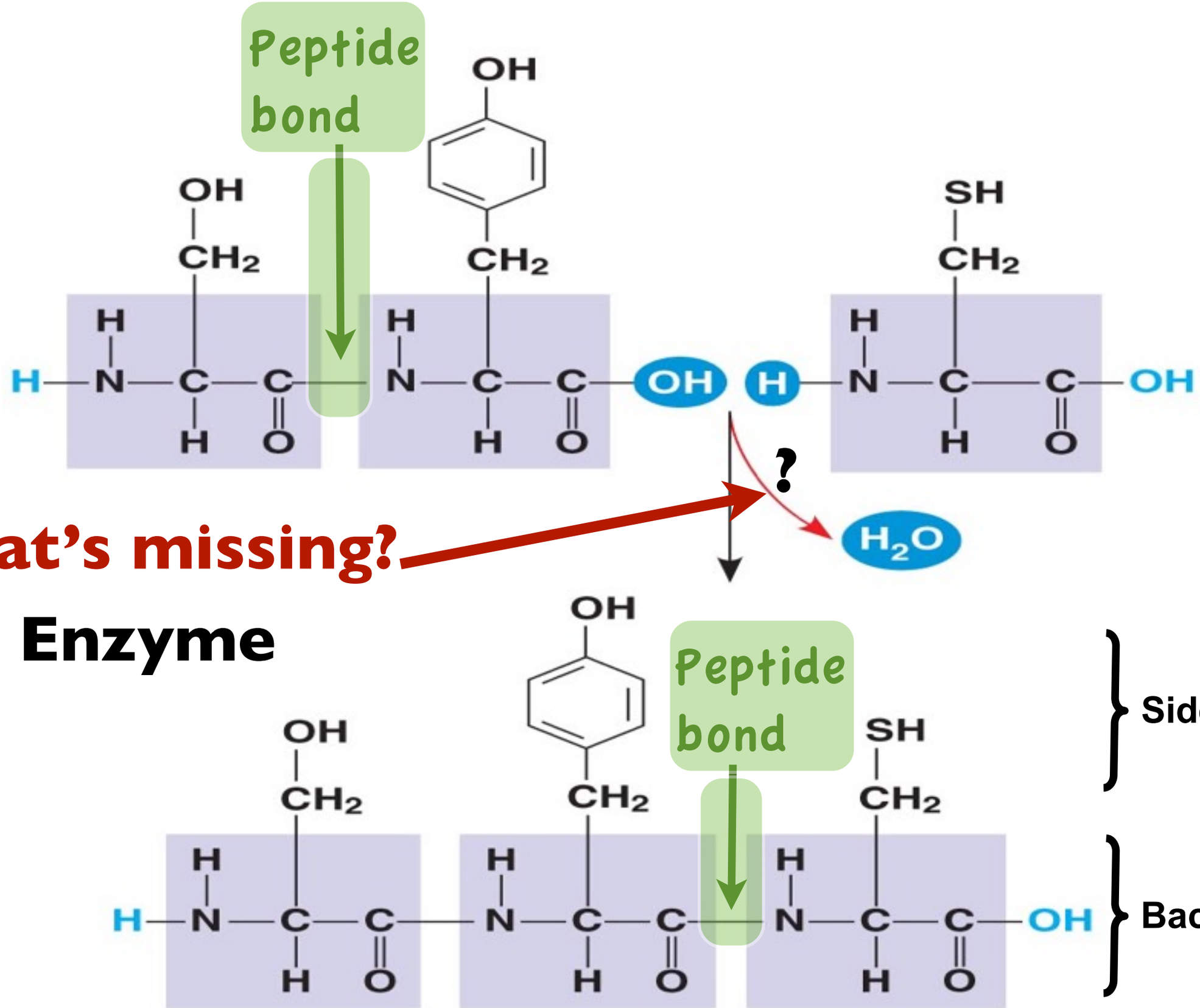
Carboxyl end
(C-terminus)



What's missing?

Amino end
(N-terminus)

Carboxyl end
(C-terminus)



What's missing?

An Enzyme

Amino end
(N-terminus)

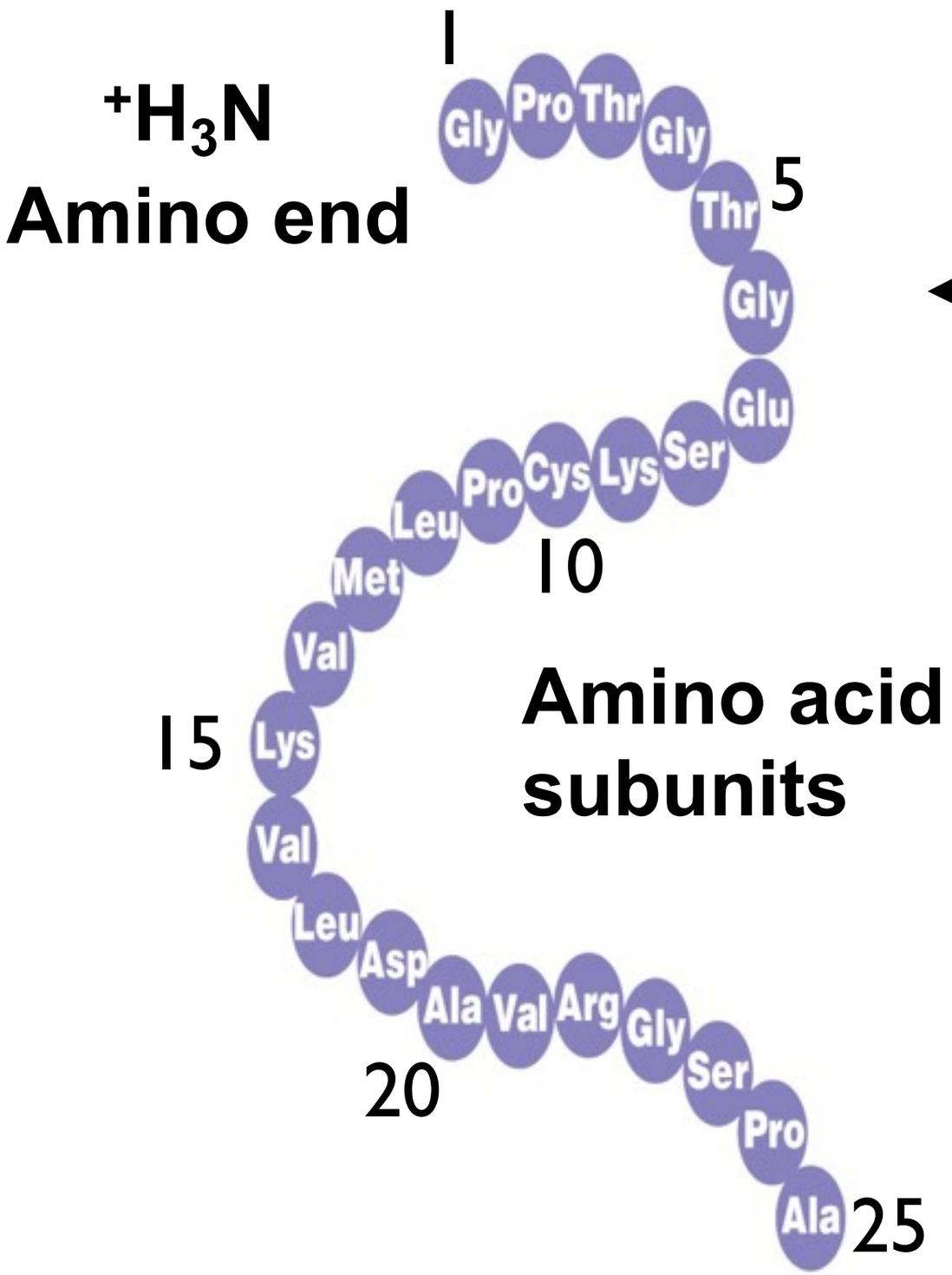
Carboxyl end
(C-terminus)

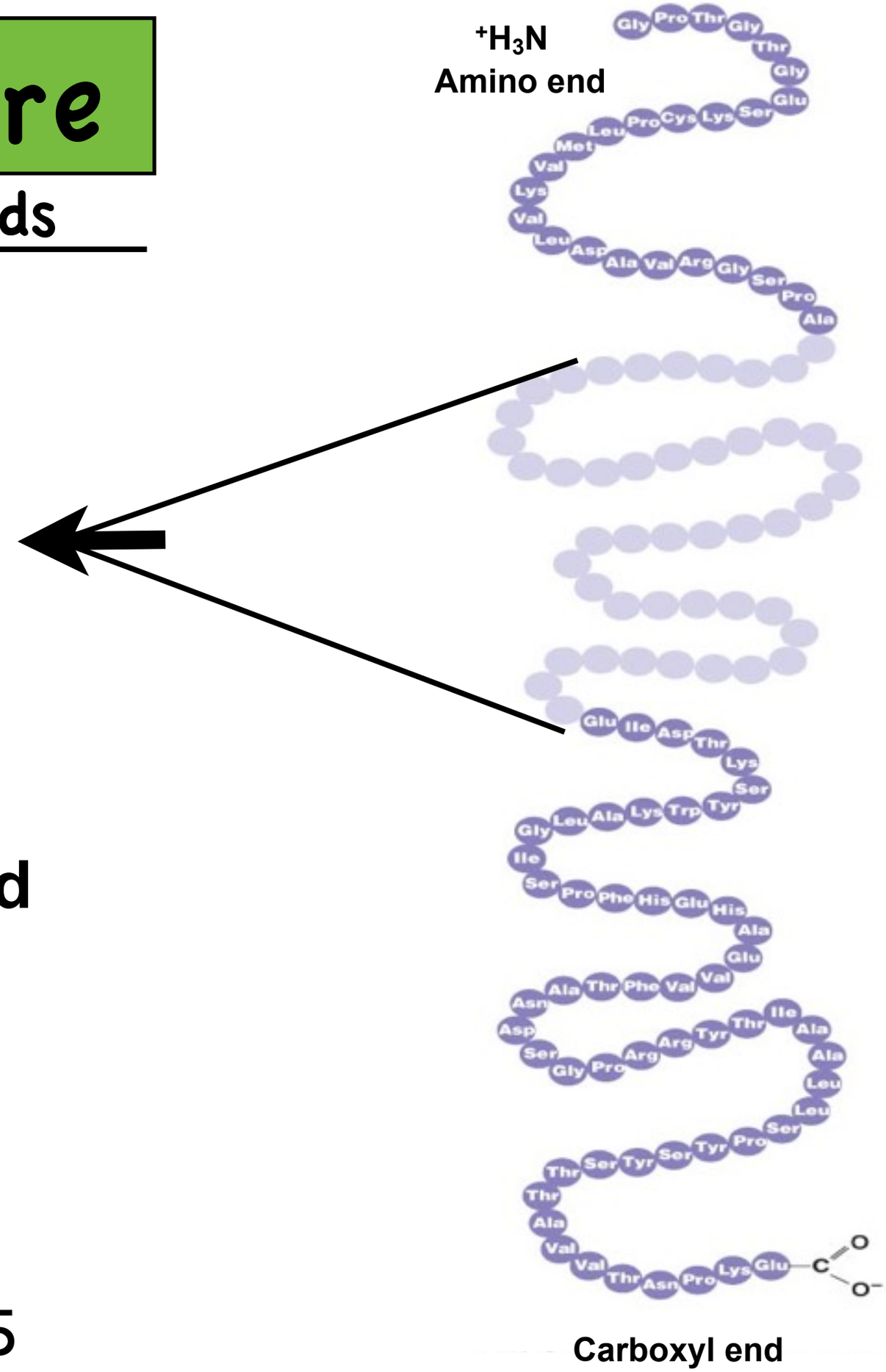
Protein Structure and Function

- Functions of proteins depend on their architecture.
  - This architecture is dependent upon the amino acid sequence.
- Proteins are more than just a polypeptide chain, proteins must be twisted, folded and coiled into a specific shape.
- The twisting, folding and coiling is held in place by a variety of bonds between the groups on the amino acids.
- Proteins generally take one of two shapes:
  - Round... *globular proteins*
  - Linear... *fibrous proteins*
- In almost every case the function of a protein depends on its ability to recognize and bind with some other molecule.

Primary Structure

Linear Chain of Amino Acids

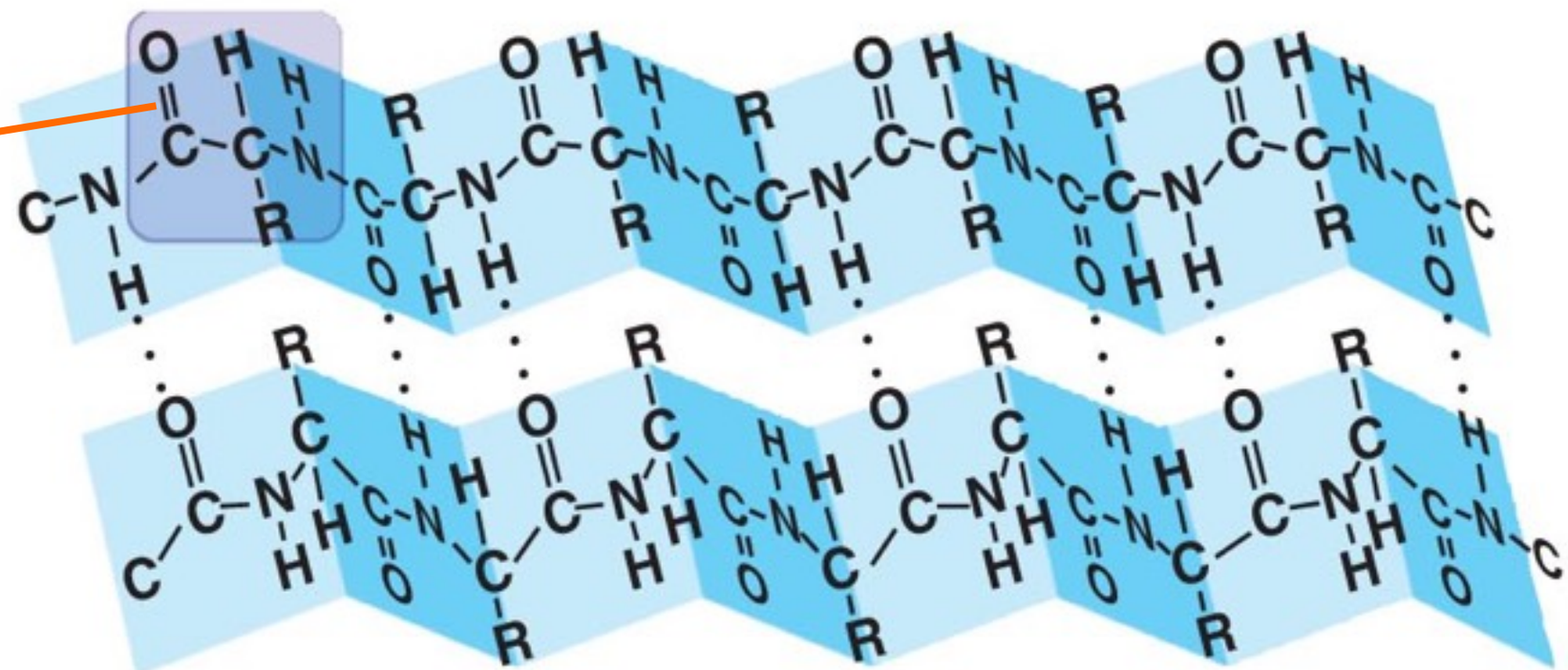




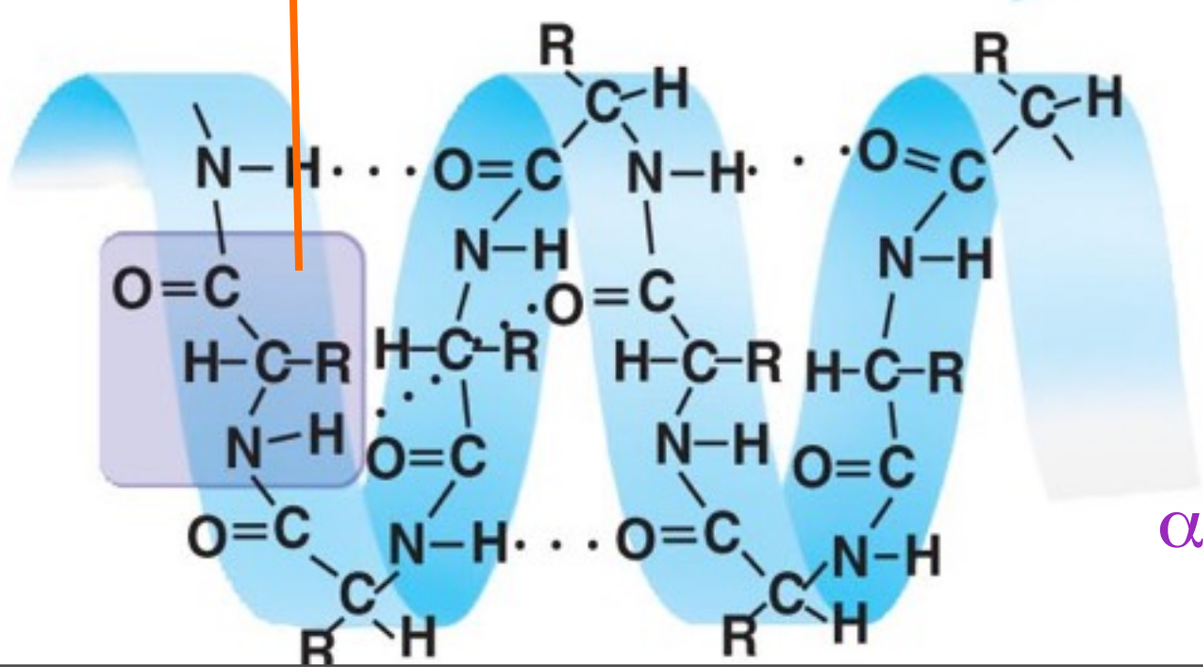
Secondary Structure

Regions stabilized by hydrogen bonds between polypeptide chains

Examples of amino acid subunits



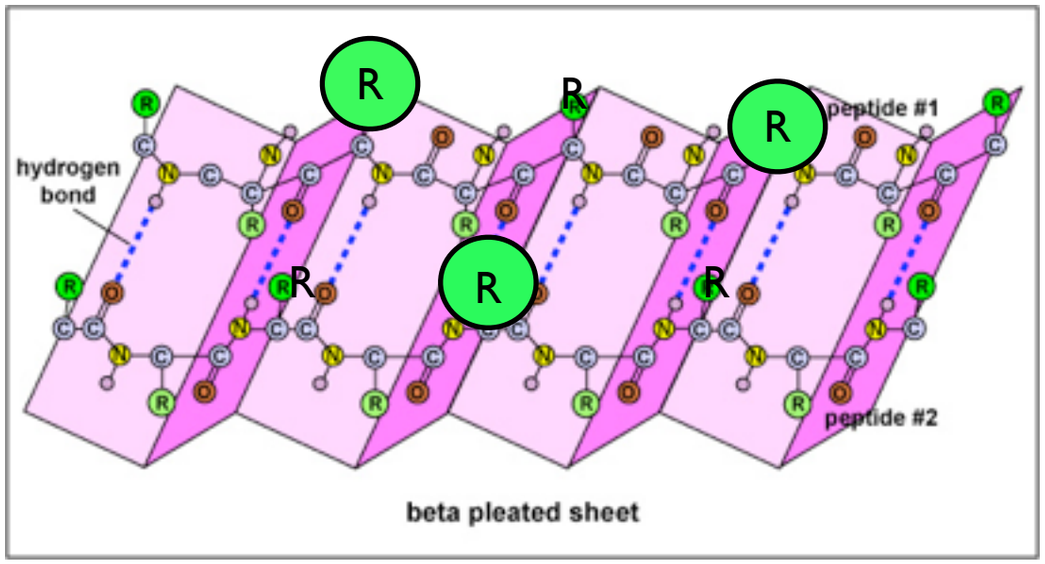
β pleated sheet



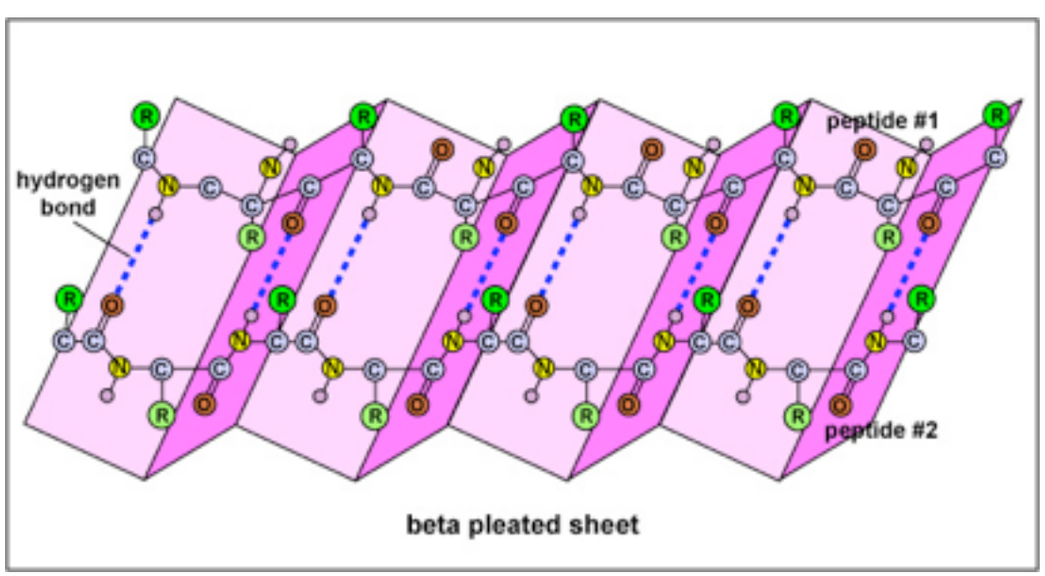
α helix

Abdominal glands of the spider secrete silk fibers made of a structural protein containing b pleated sheets.

The radiating (base) strands, made of dry silk fibers, maintain the shape of the web.

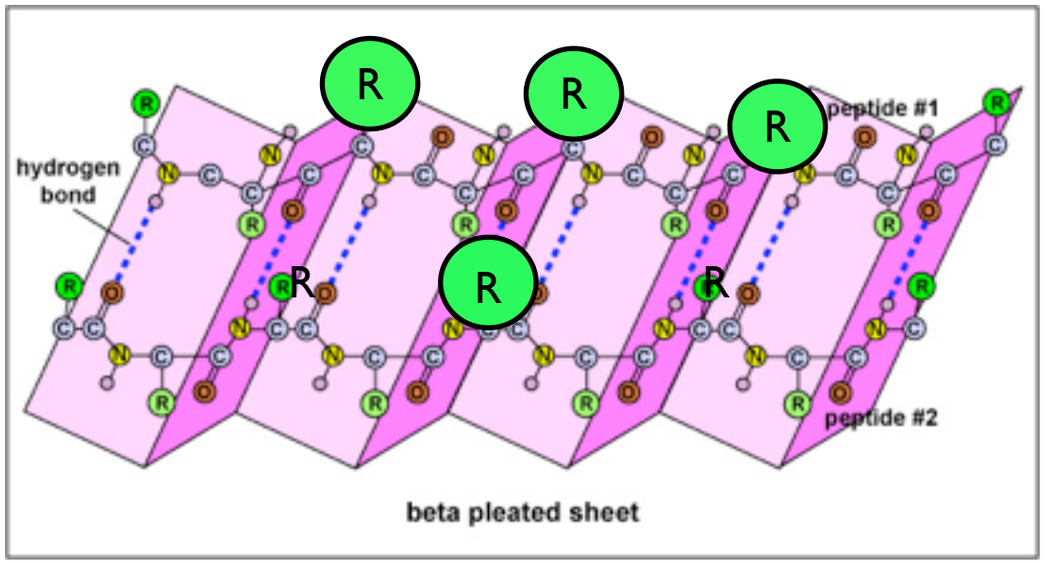


The spiral (viscid)strands (capture strands) are elastic, stretching in response to wind, rain, and the touch of insects.

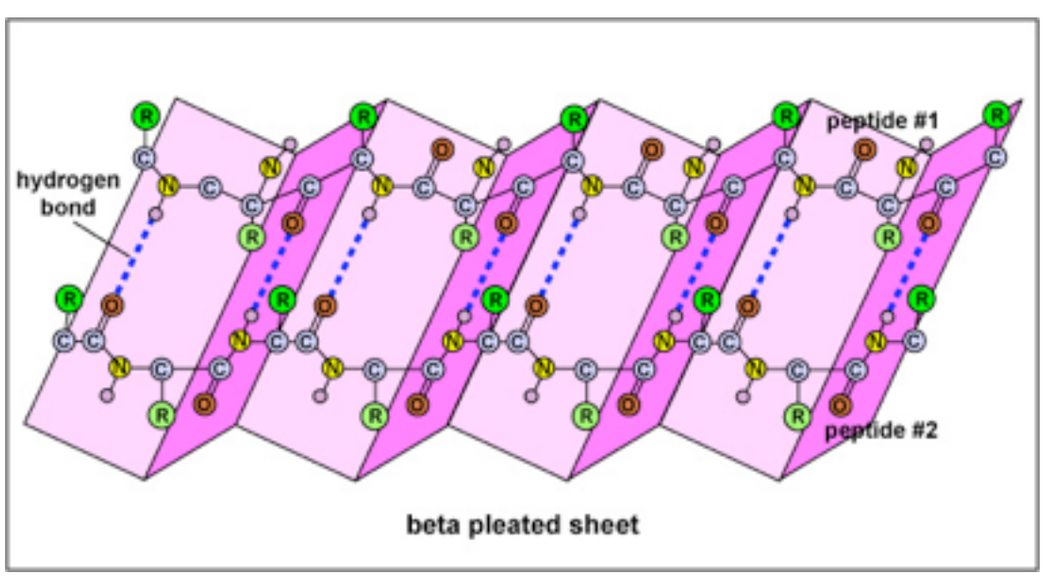


Abdominal glands of the spider secrete silk fibers made of a structural protein containing b pleated sheets.

The radiating (base) strands, made of dry silk fibers, maintain the shape of the web.

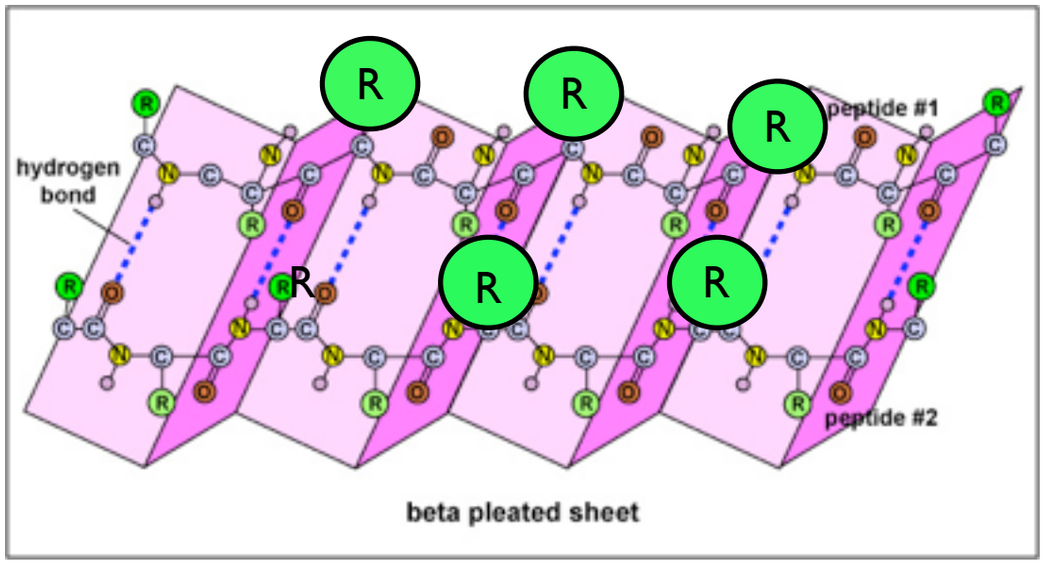


The spiral (viscid)strands (capture strands) are elastic, stretching in response to wind, rain, and the touch of insects.

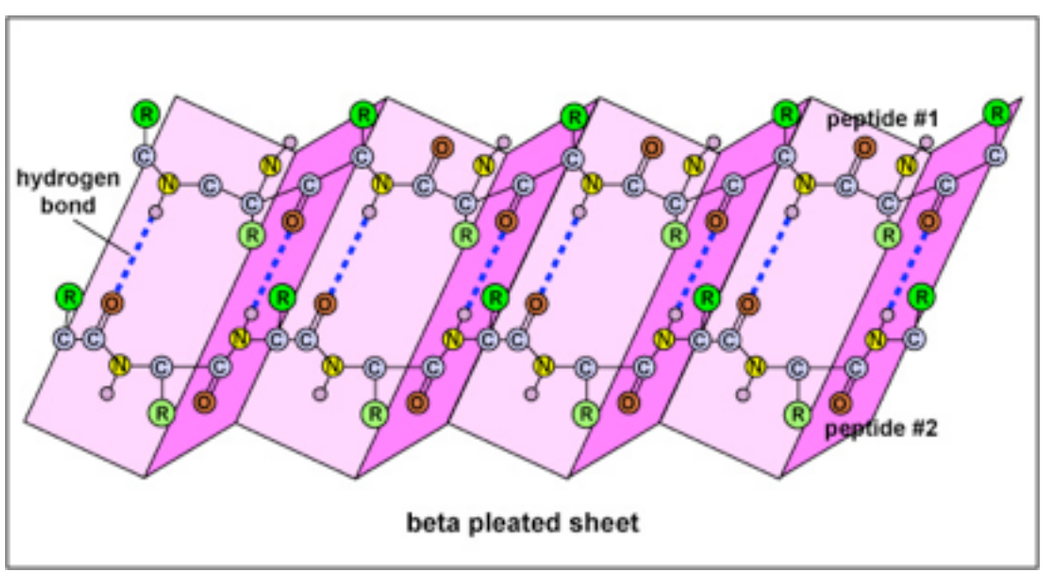


Abdominal glands of the spider secrete silk fibers made of a structural protein containing b pleated sheets.

The radiating (base) strands, made of dry silk fibers, maintain the shape of the web.

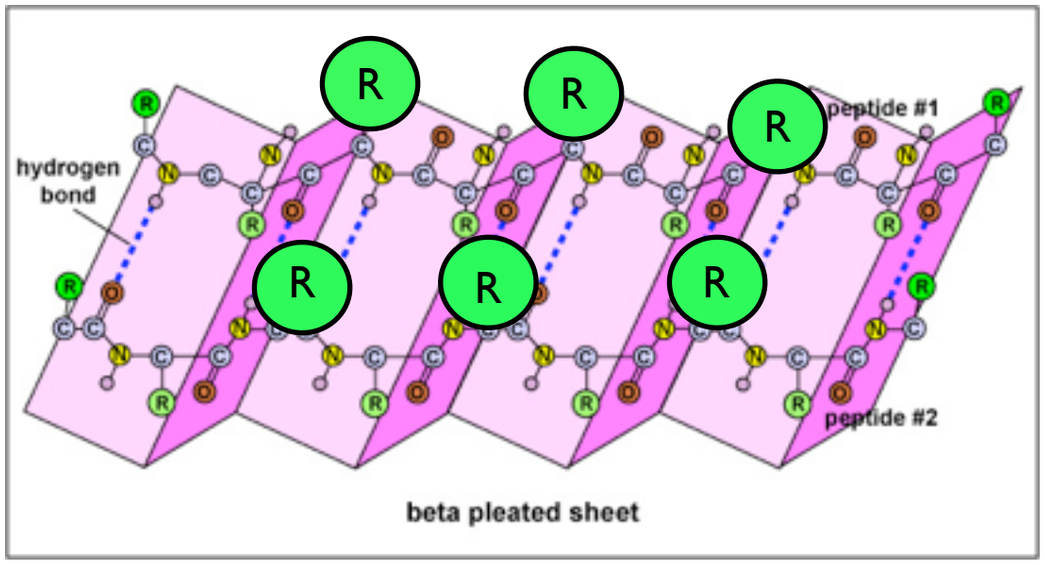


The spiral (viscid)strands (capture strands) are elastic, stretching in response to wind, rain, and the touch of insects.

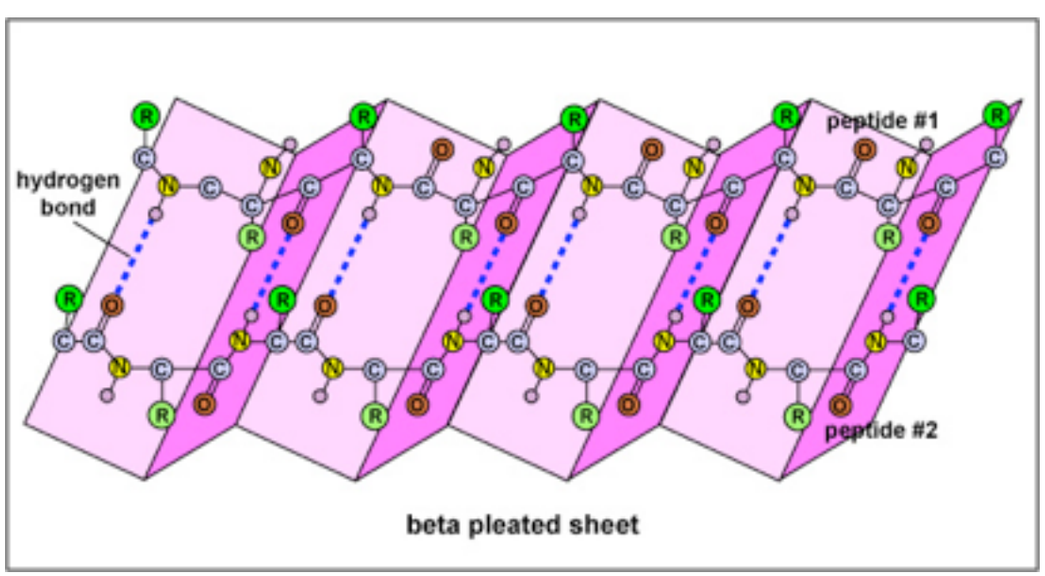


Abdominal glands of the spider secrete silk fibers made of a structural protein containing b pleated sheets.

The radiating (base) strands, made of dry silk fibers, maintain the shape of the web.

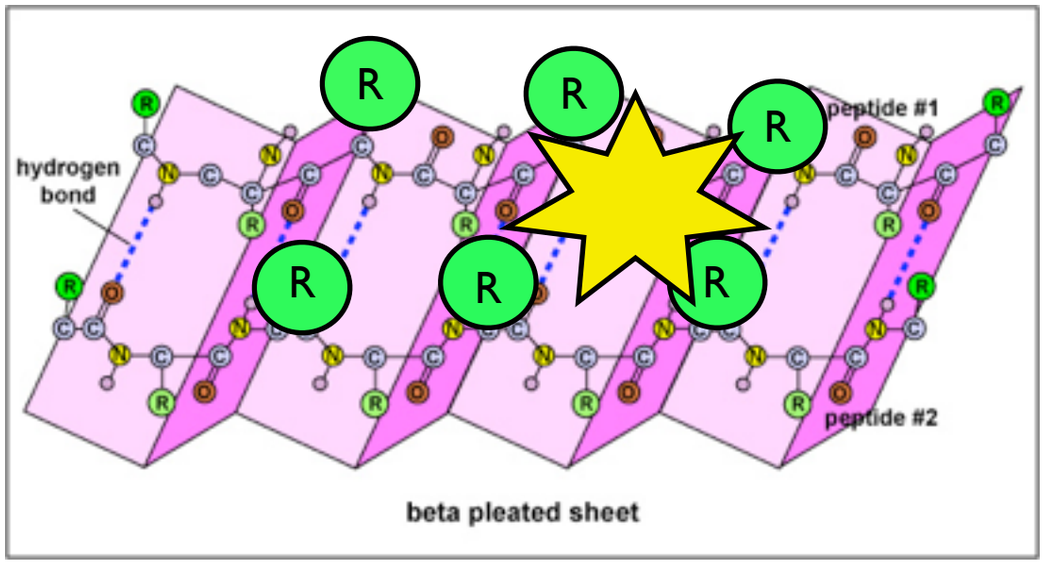


The spiral (viscid)strands (capture strands) are elastic, stretching in response to wind, rain, and the touch of insects.

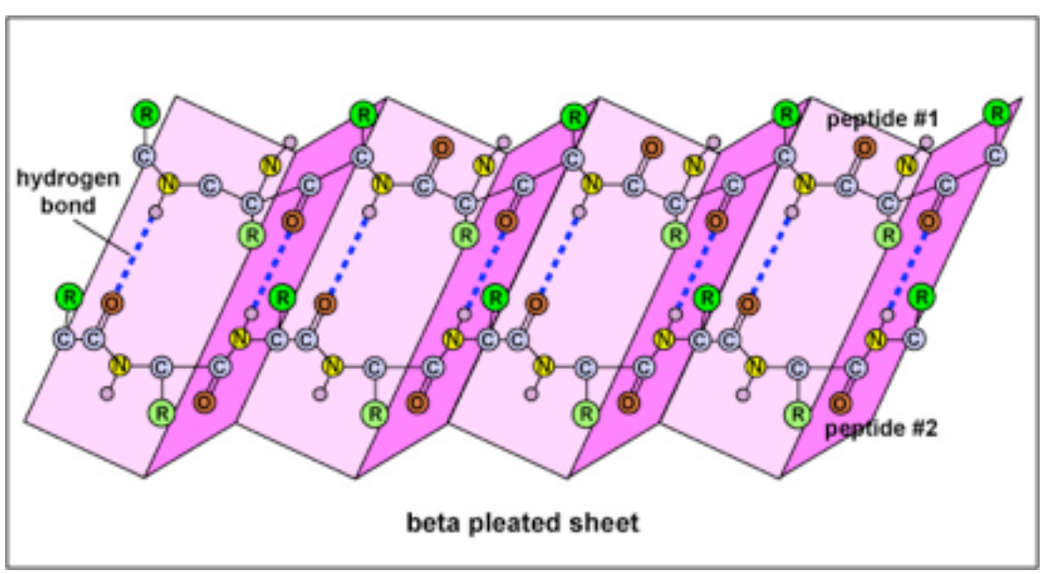


Abdominal glands of the spider secrete silk fibers made of a structural protein containing b pleated sheets.

The radiating (base) strands, made of dry silk fibers, maintain the shape of the web.

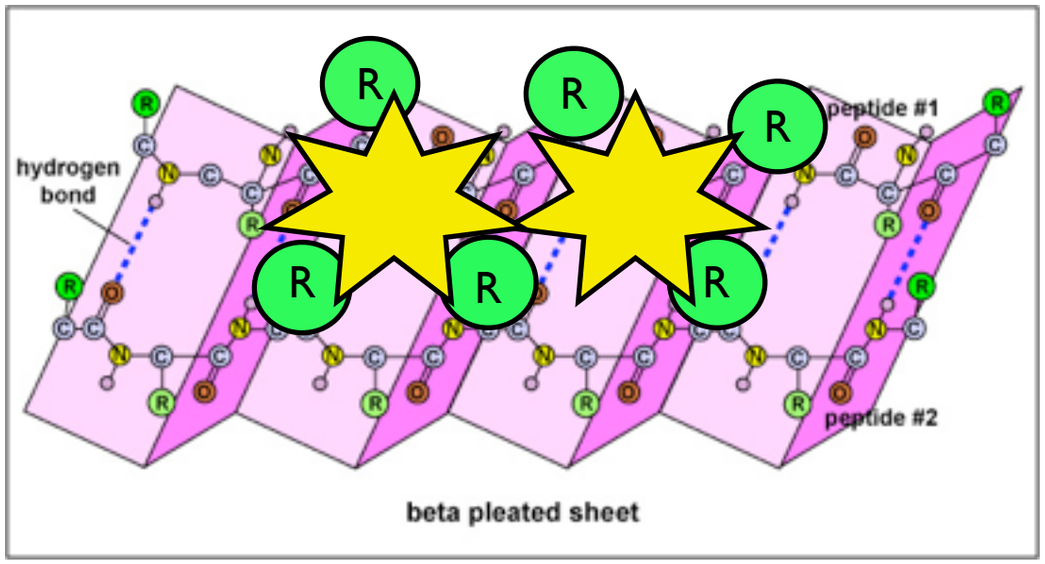


The spiral (viscid)strands (capture strands) are elastic, stretching in response to wind, rain, and the touch of insects.

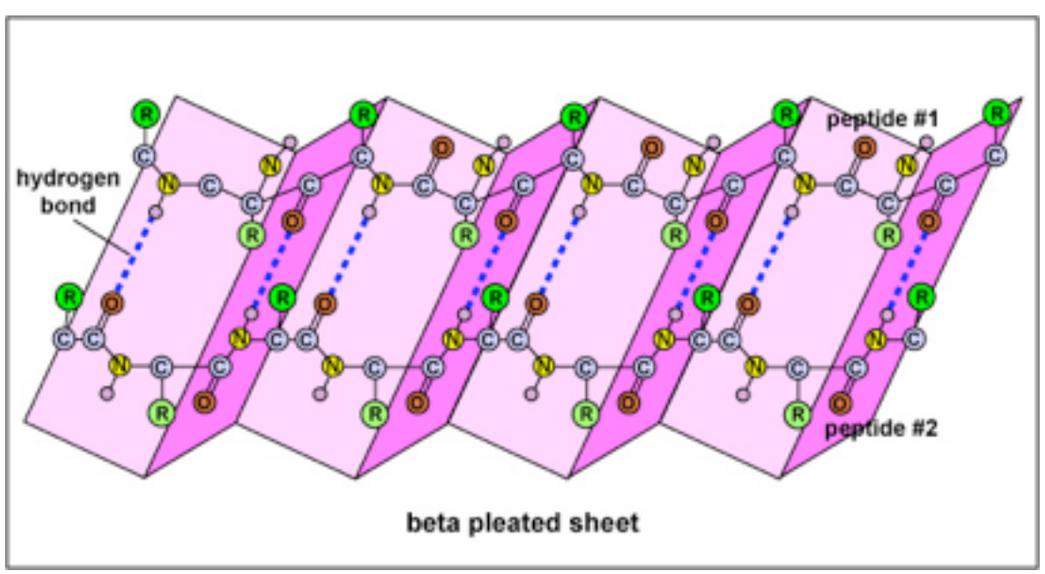


Abdominal glands of the spider secrete silk fibers made of a structural protein containing b pleated sheets.

The radiating (base) strands, made of dry silk fibers, maintain the shape of the web.

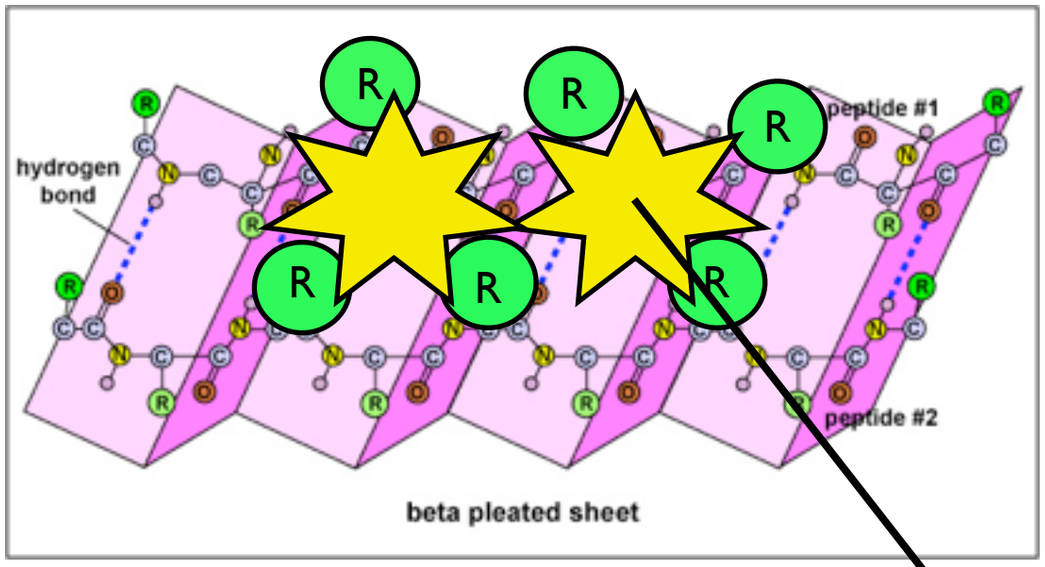


The spiral (viscid)strands (capture strands) are elastic, stretching in response to wind, rain, and the touch of insects.

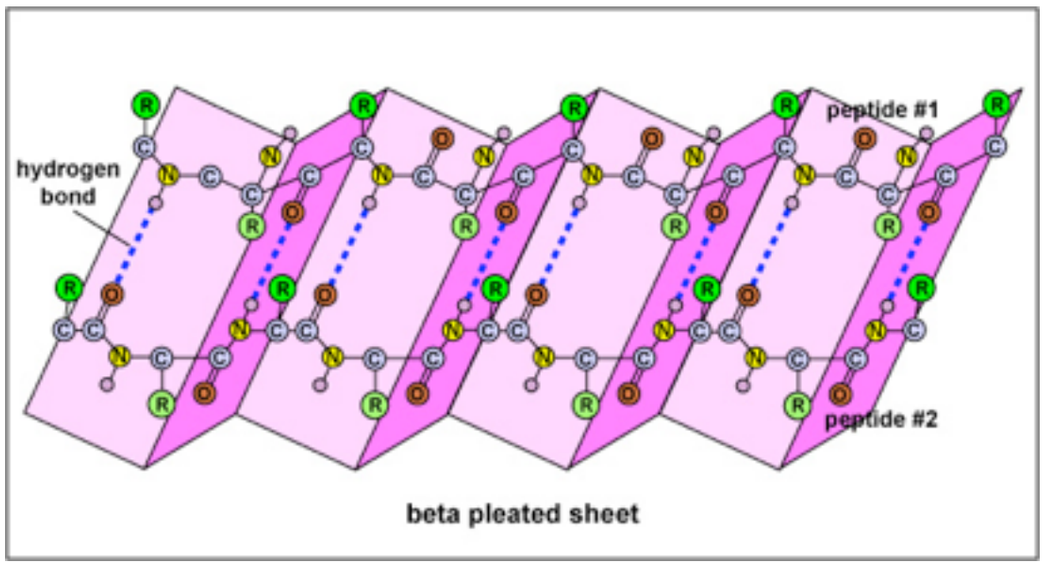


Abdominal glands of the spider secrete silk fibers made of a structural protein containing b pleated sheets.

The radiating (base) strands, made of dry silk fibers, maintain the shape of the web.

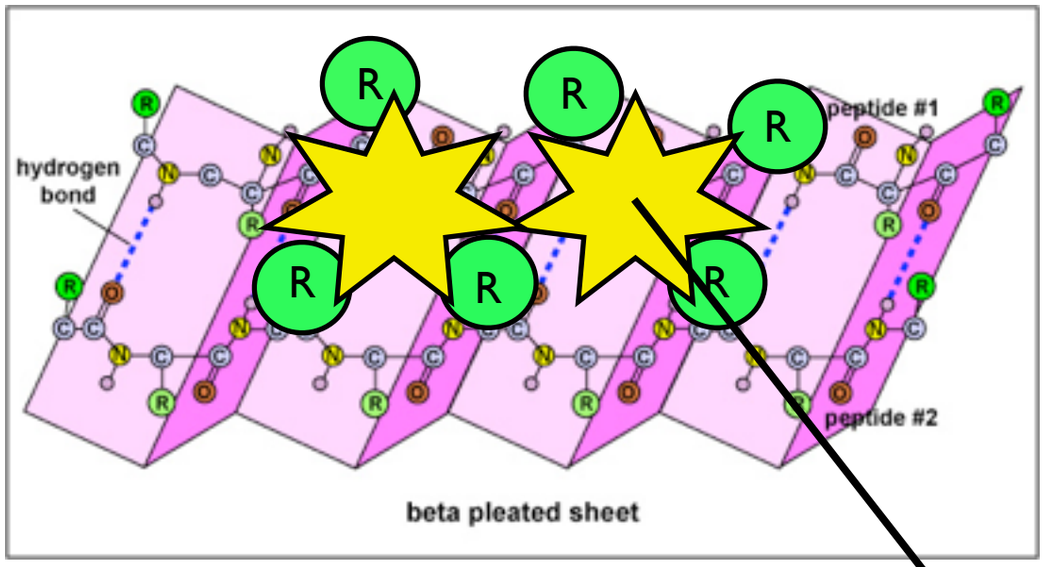


The spiral (viscid)strands (capture strands) are elastic, stretching in response to wind, rain, and the touch of insects.

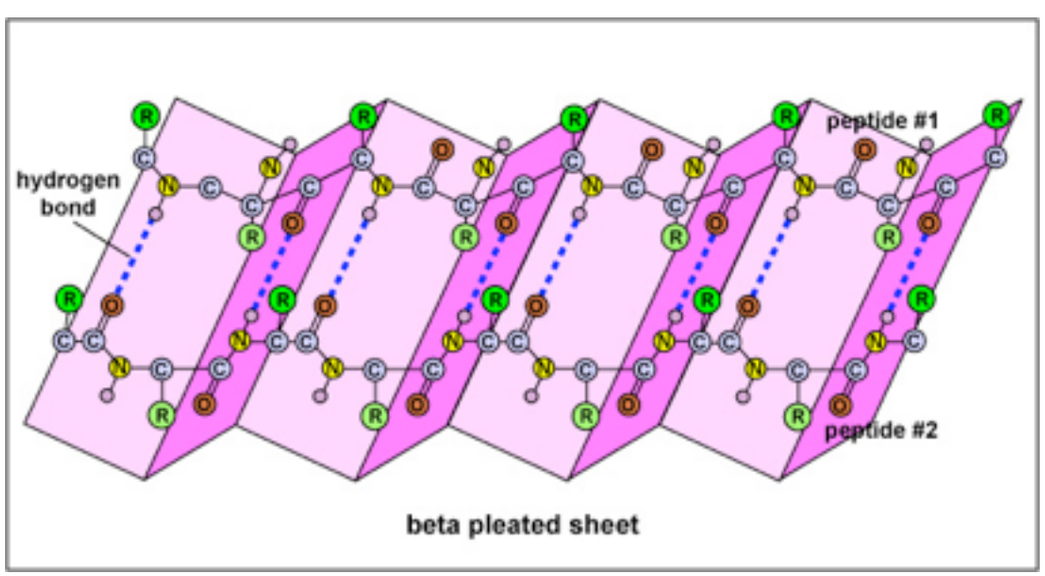


Abdominal glands of the spider secrete silk fibers made of a structural protein containing b pleated sheets.

The radiating (base) strands, made of dry silk fibers, maintain the shape of the web.



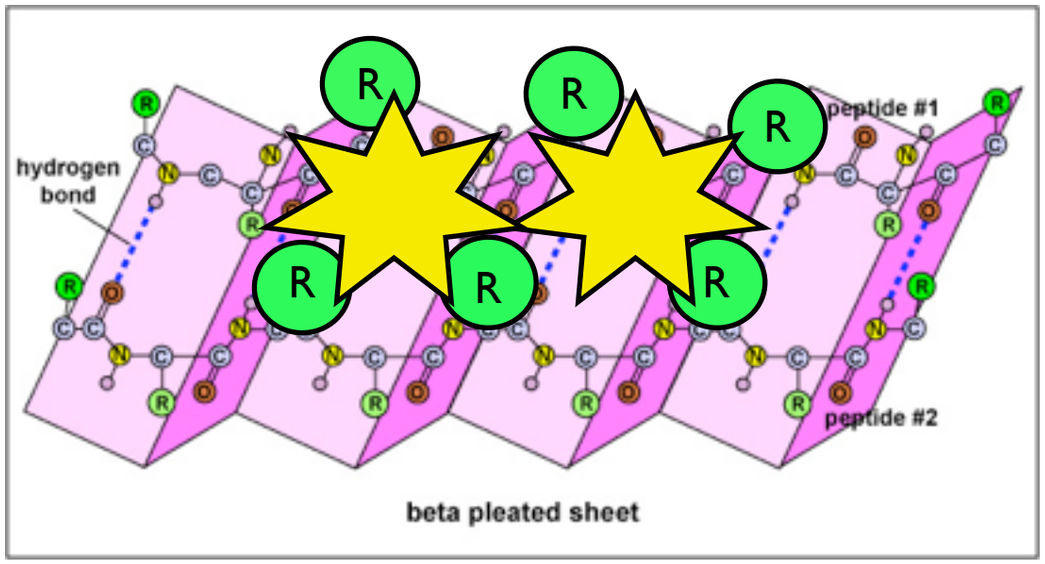
The spiral (viscid)strands (capture strands) are elastic, stretching in response to wind, rain, and the touch of insects.



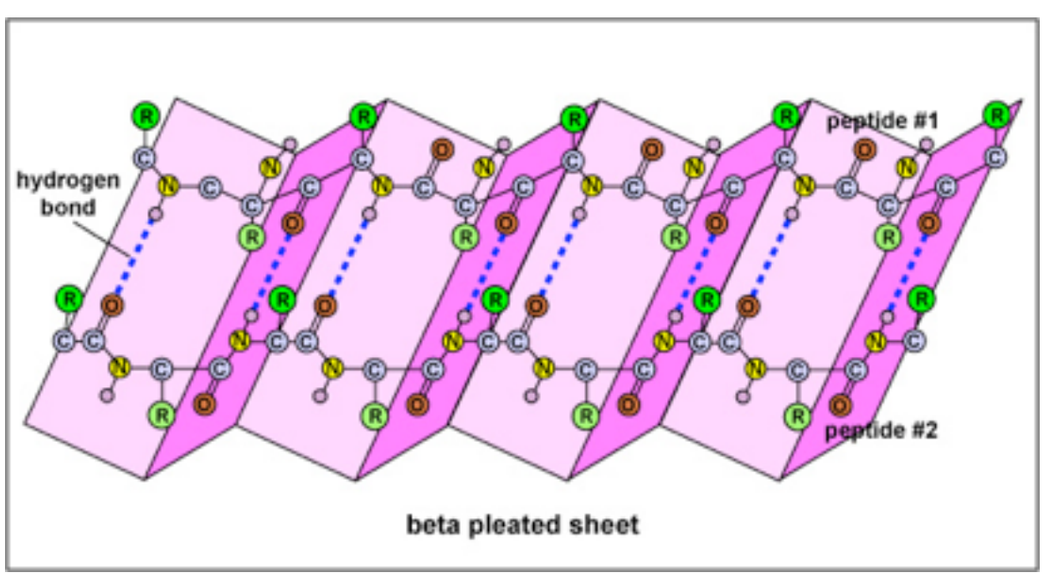
Large "R" groups help to capture crystals which in turn decrease the pleated sheets ability to expand

Abdominal glands of the spider secrete silk fibers made of a structural protein containing b pleated sheets.

The radiating (base) strands, made of dry silk fibers, maintain the shape of the web.



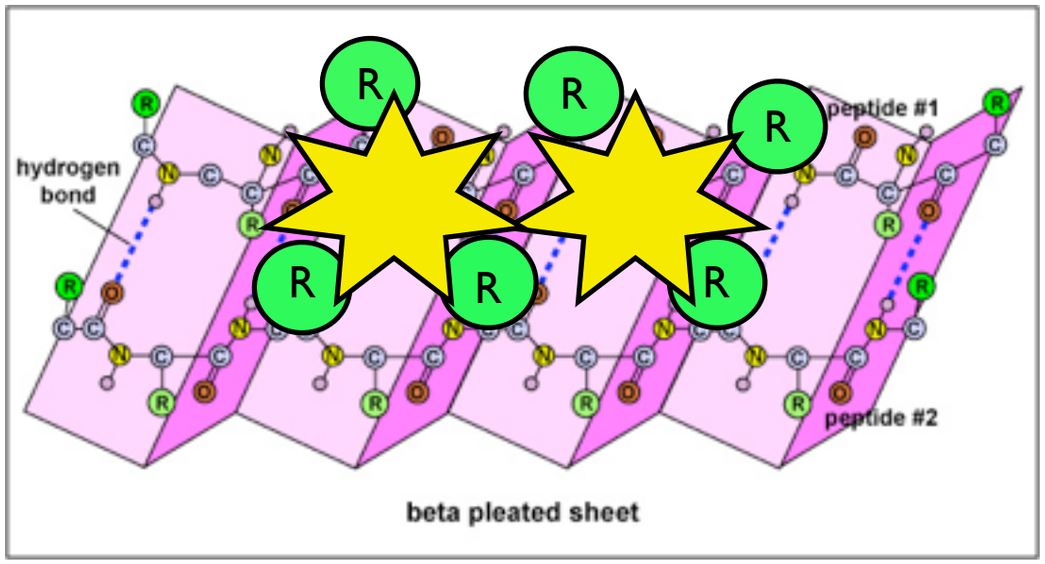
The spiral (viscid)strands (capture strands) are elastic, stretching in response to wind, rain, and the touch of insects.



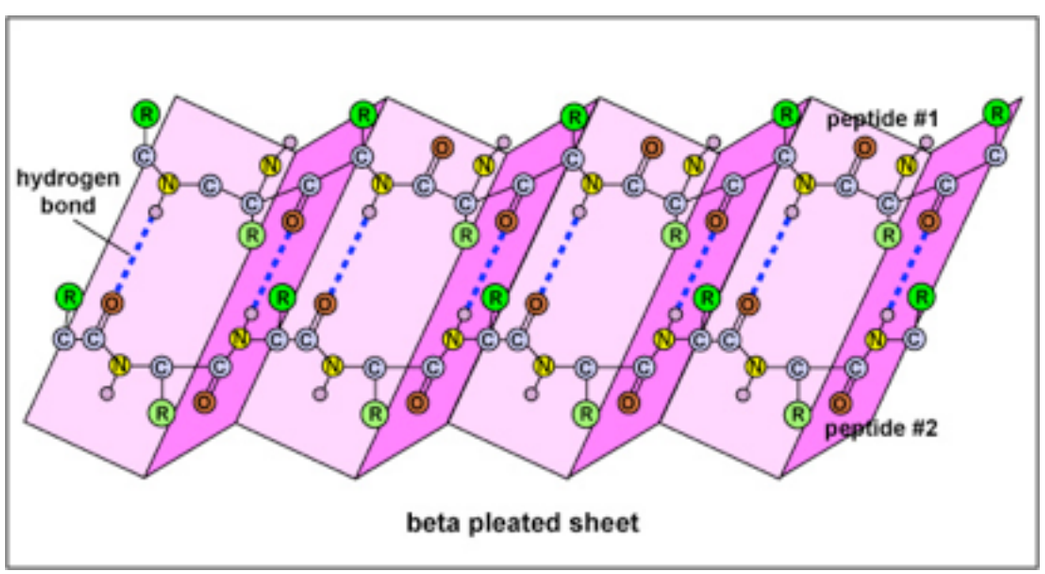
Large "R" groups help to capture crystals which in turn decrease the pleated sheets ability to expand

Abdominal glands of the spider secrete silk fibers made of a structural protein containing b pleated sheets.

The radiating (base) strands, made of dry silk fibers, maintain the shape of the web.

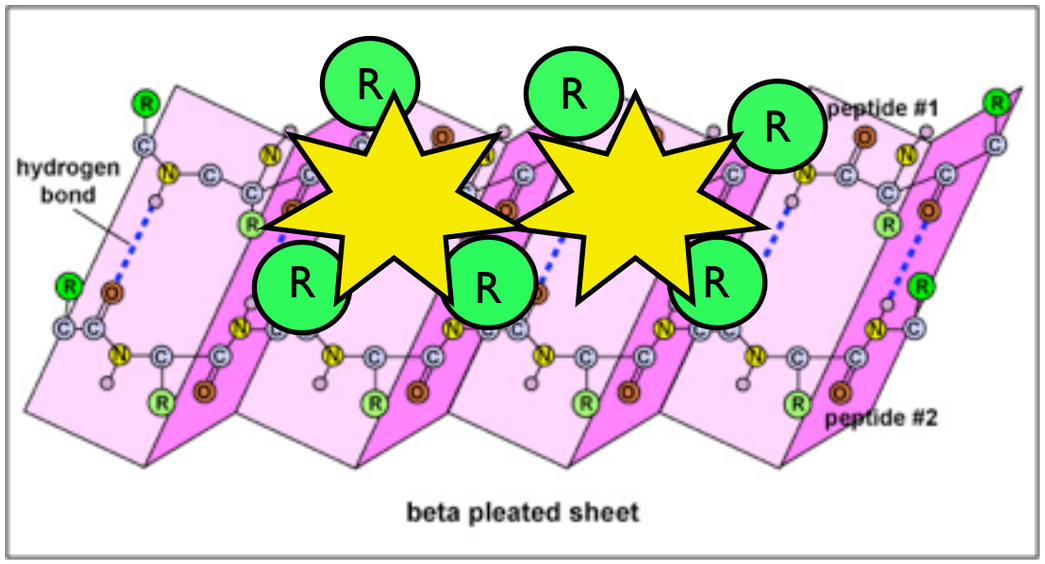


The spiral (viscid)strands (capture strands) are elastic, stretching in response to wind, rain, and the touch of insects.

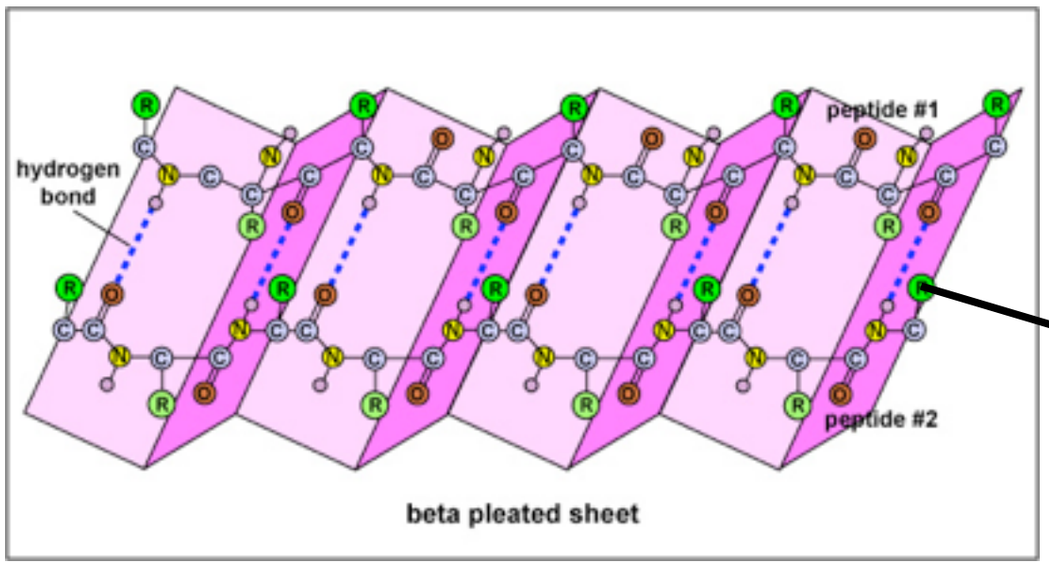


Abdominal glands of the spider secrete silk fibers made of a structural protein containing b pleated sheets.

The radiating (base) strands, made of dry silk fibers, maintain the shape of the web.

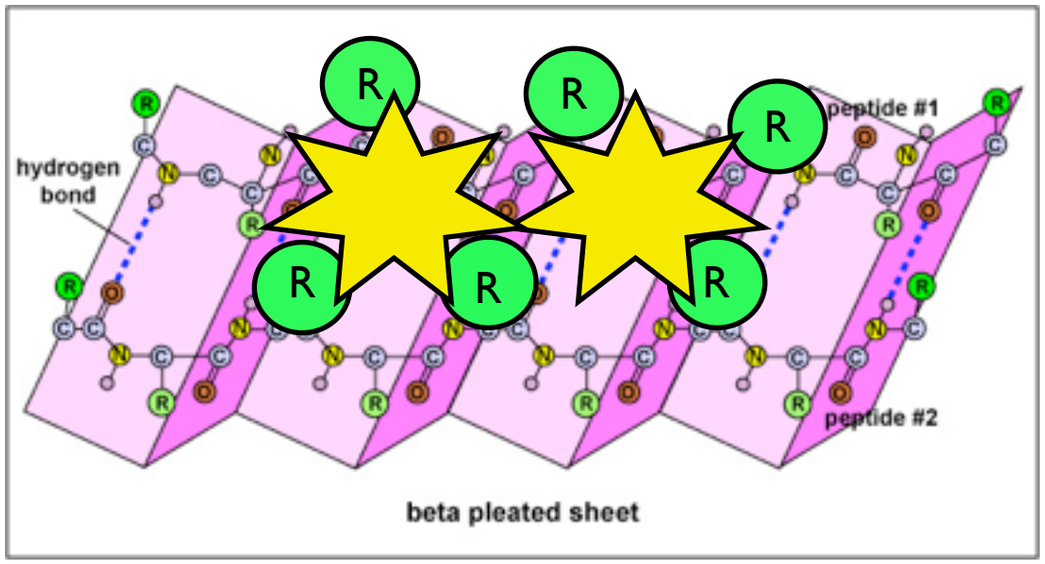


The spiral (viscid)strands (capture strands) are elastic, stretching in response to wind, rain, and the touch of insects.

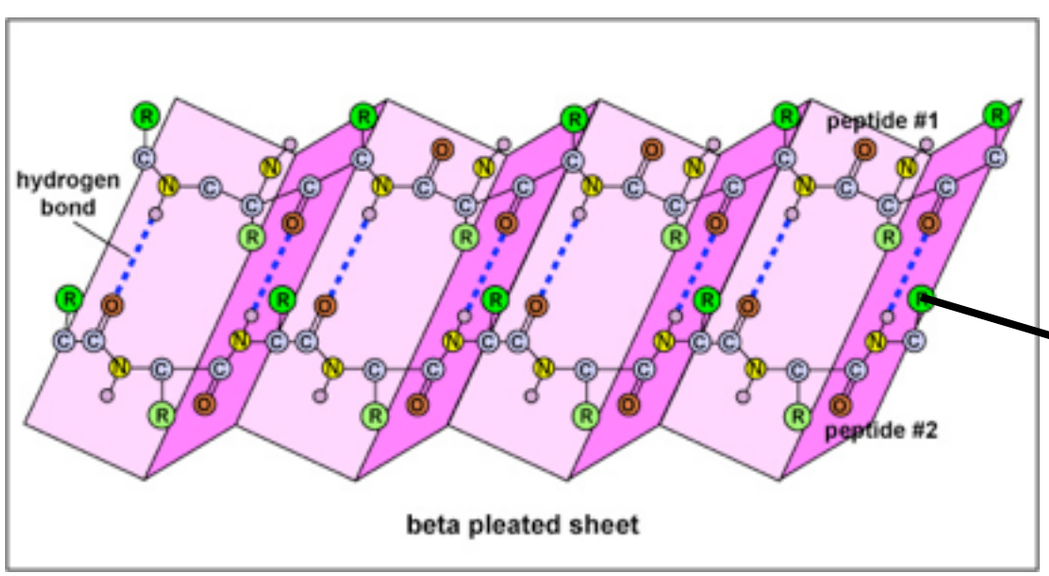


Abdominal glands of the spider secrete silk fibers made of a structural protein containing b pleated sheets.

The radiating (base) strands, made of dry silk fibers, maintain the shape of the web.



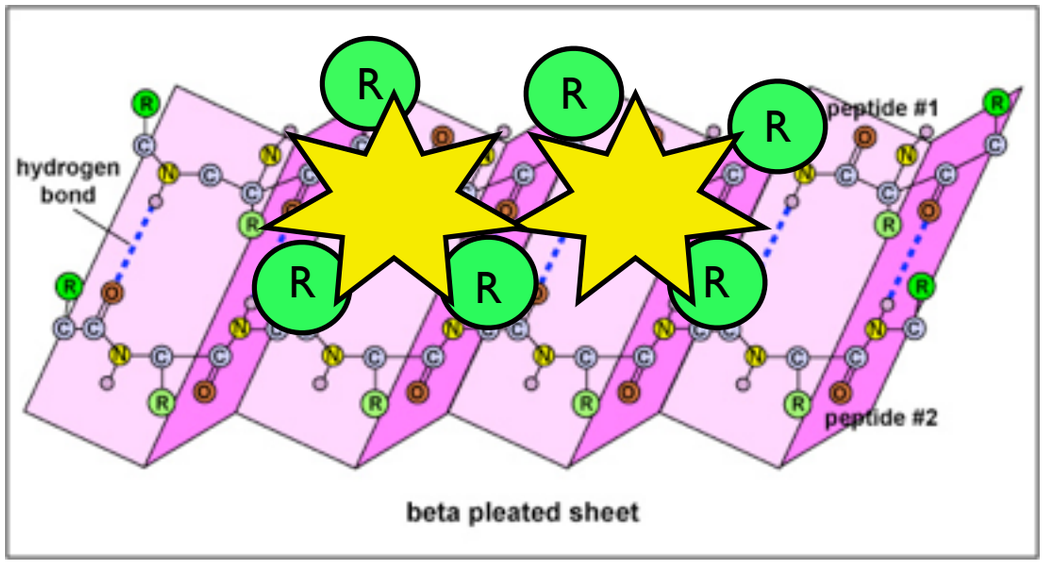
The spiral (viscid)strands (capture strands) are elastic, stretching in response to wind, rain, and the touch of insects.



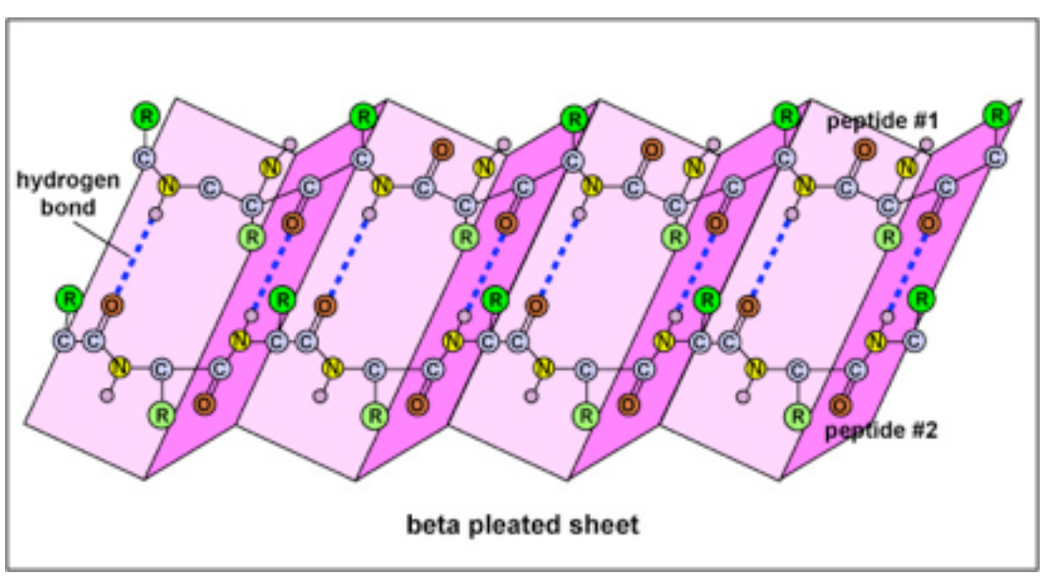
Small "R" groups can not capture crystals which in turn allows the pleated sheets to expand and have flexibility

Abdominal glands of the spider secrete silk fibers made of a structural protein containing b pleated sheets.

The radiating (base) strands, made of dry silk fibers, maintain the shape of the web.



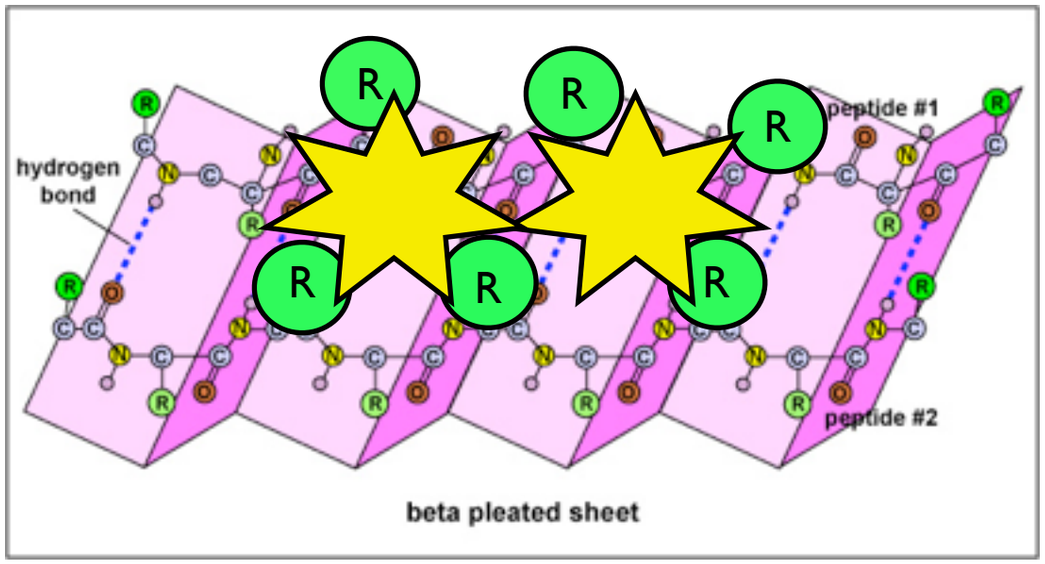
The spiral (viscid)strands (capture strands) are elastic, stretching in response to wind, rain, and the touch of insects.



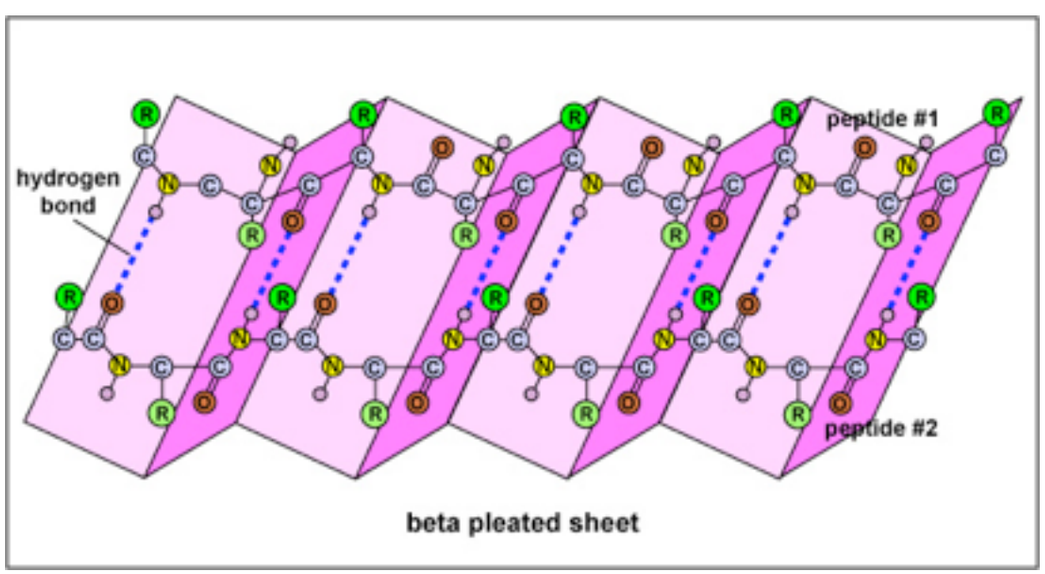
Small "R" groups can not capture crystals which in turn allows the pleated sheets to expand and have flexibility

Abdominal glands of the spider secrete silk fibers made of a structural protein containing b pleated sheets.

The radiating (base) strands, made of dry silk fibers, maintain the shape of the web.

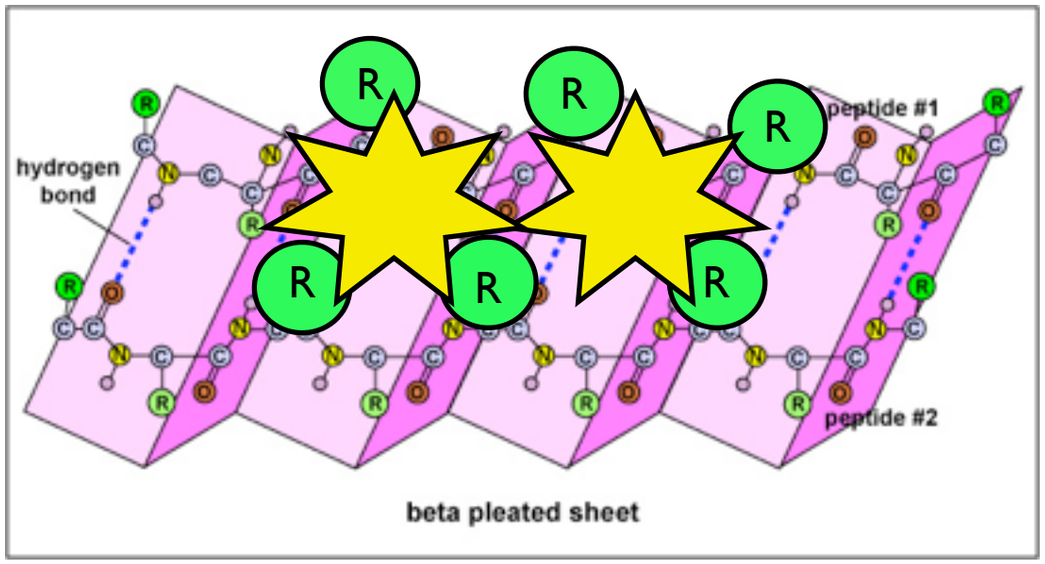


The spiral (viscid)strands (capture strands) are elastic, stretching in response to wind, rain, and the touch of insects.



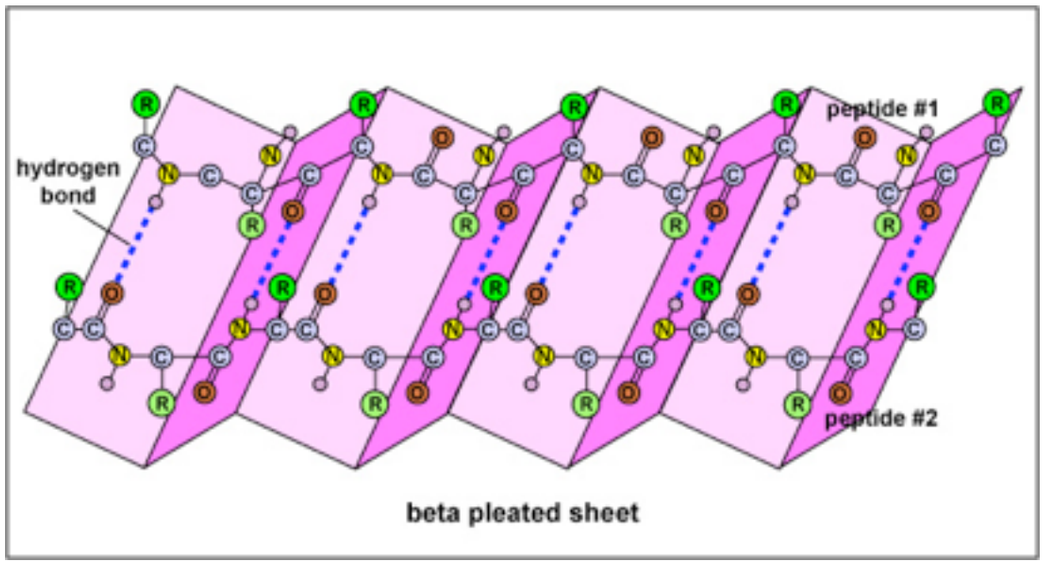
Abdominal glands of the spider secrete silk fibers made of a structural protein containing b pleated sheets.

The radiating (base) strands, made of dry silk fibers, maintain the shape of the web.



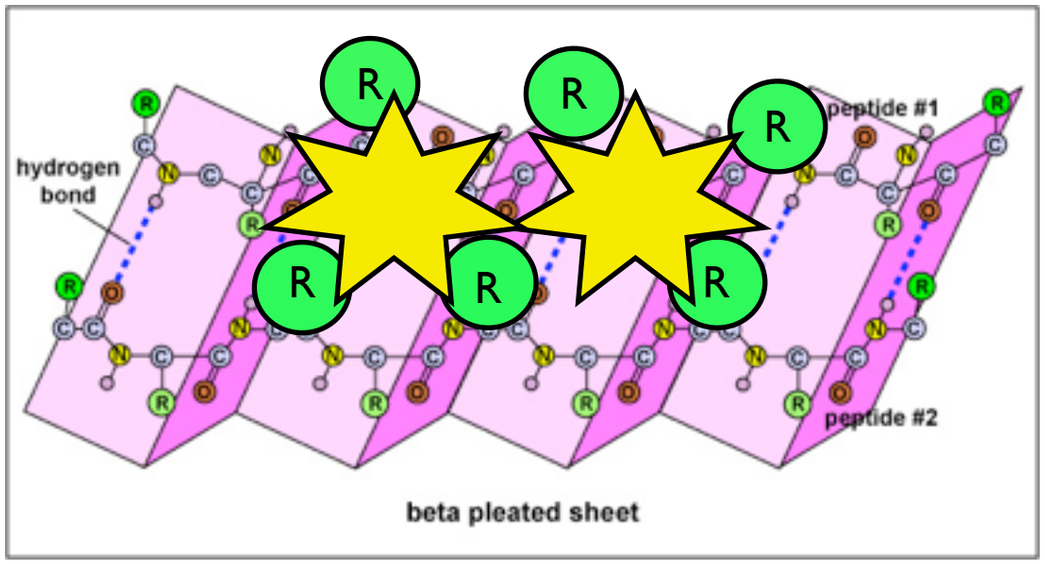
Rigid

The spiral (viscid)strands (capture strands) are elastic, stretching in response to wind, rain, and the touch of insects.



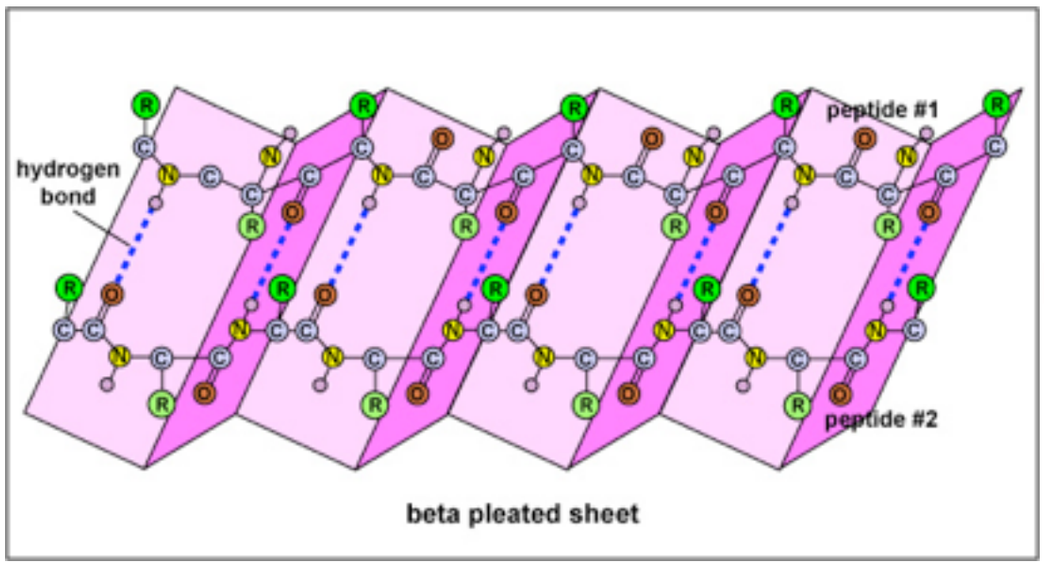
Abdominal glands of the spider secrete silk fibers made of a structural protein containing b pleated sheets.

The radiating (base) strands, made of dry silk fibers, maintain the shape of the web.



Rigid

The spiral (viscid)strands (capture strands) are elastic, stretching in response to wind, rain, and the touch of insects.



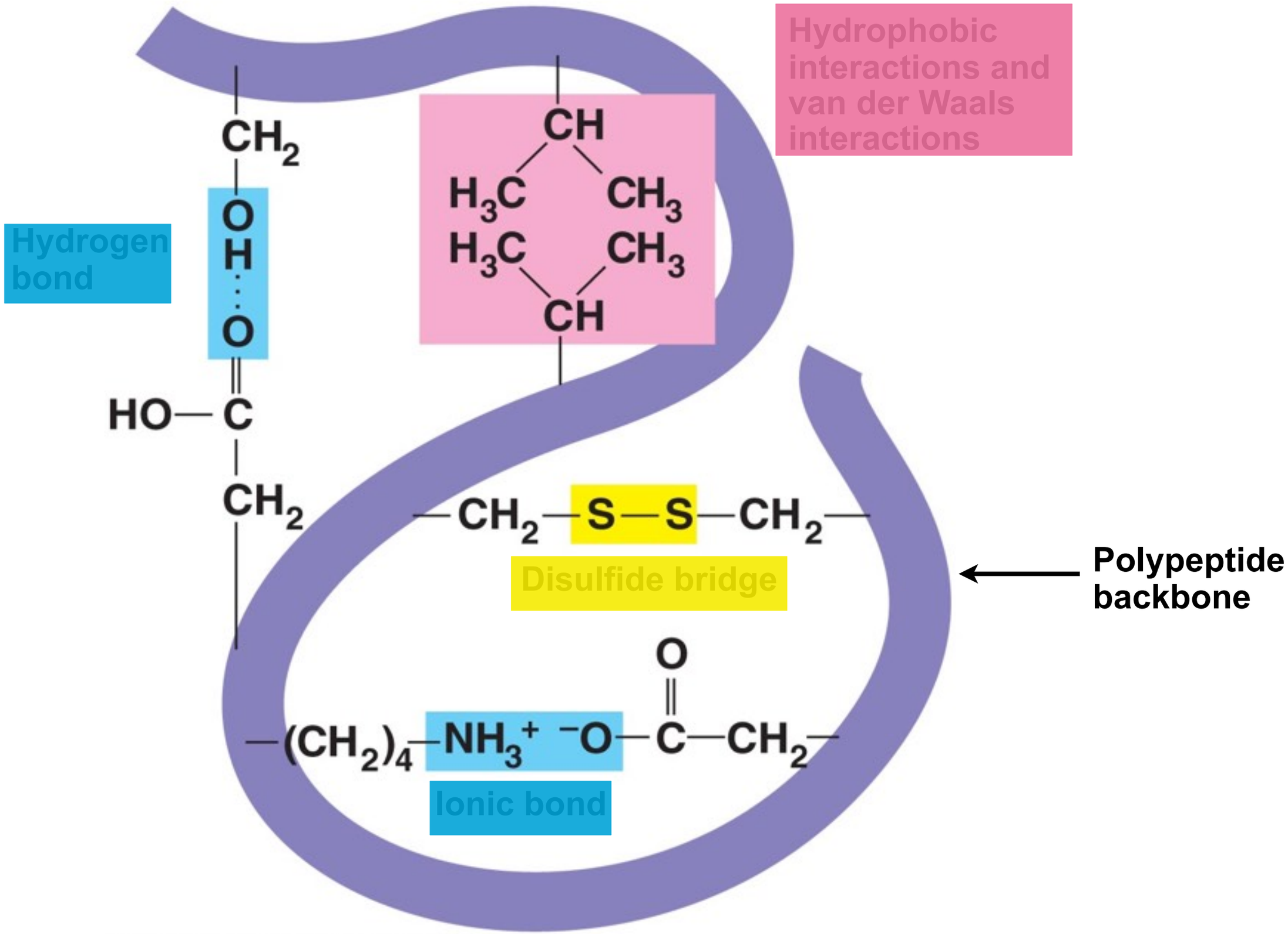
Flexible

If these webs were 3 cm diameter, it could stop in 747 during flight.

If these webs were 3 cm diameter, it could stop in 747 during flight.

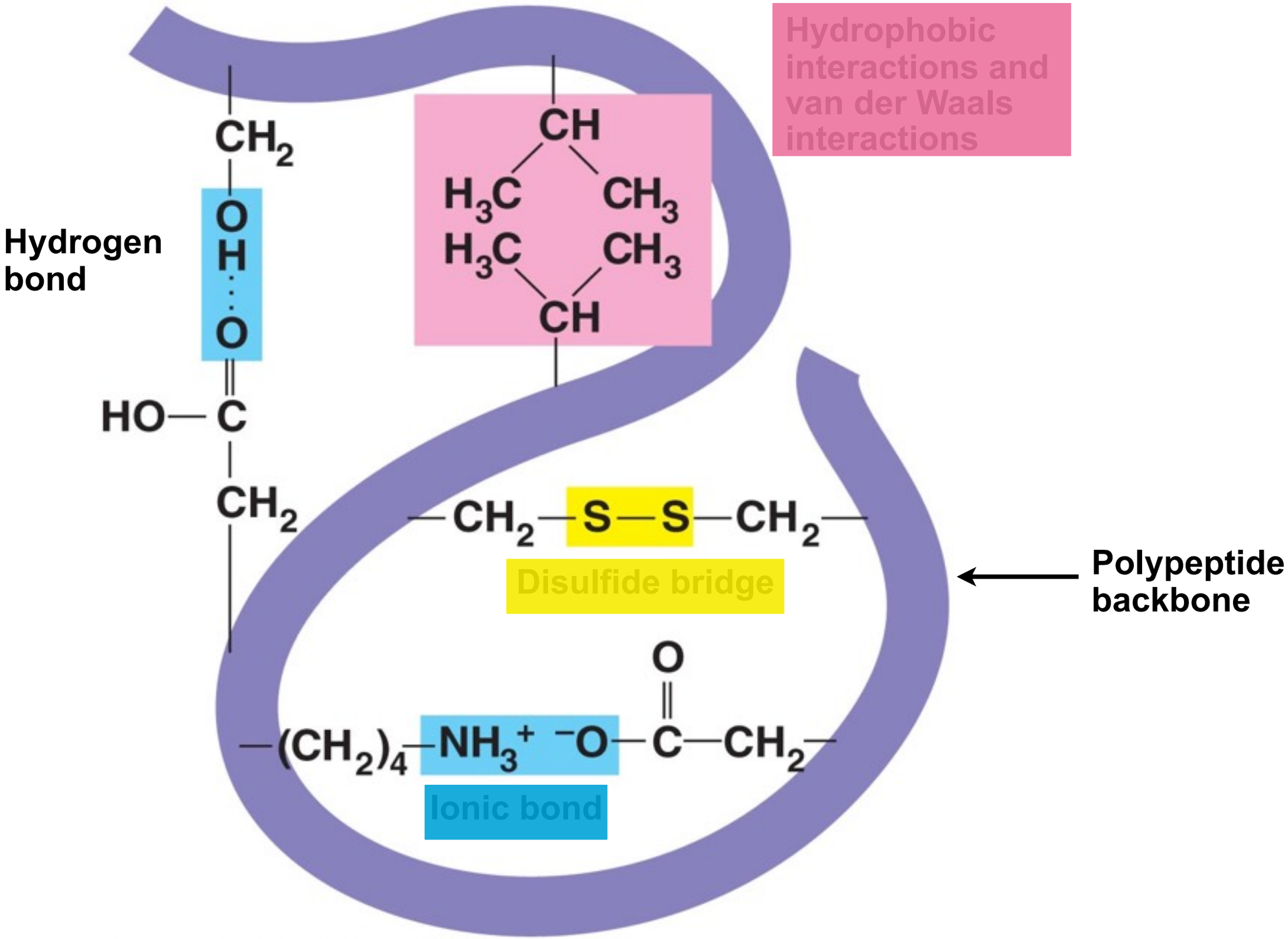
Tertiary Structure

Overall 3-D Shape



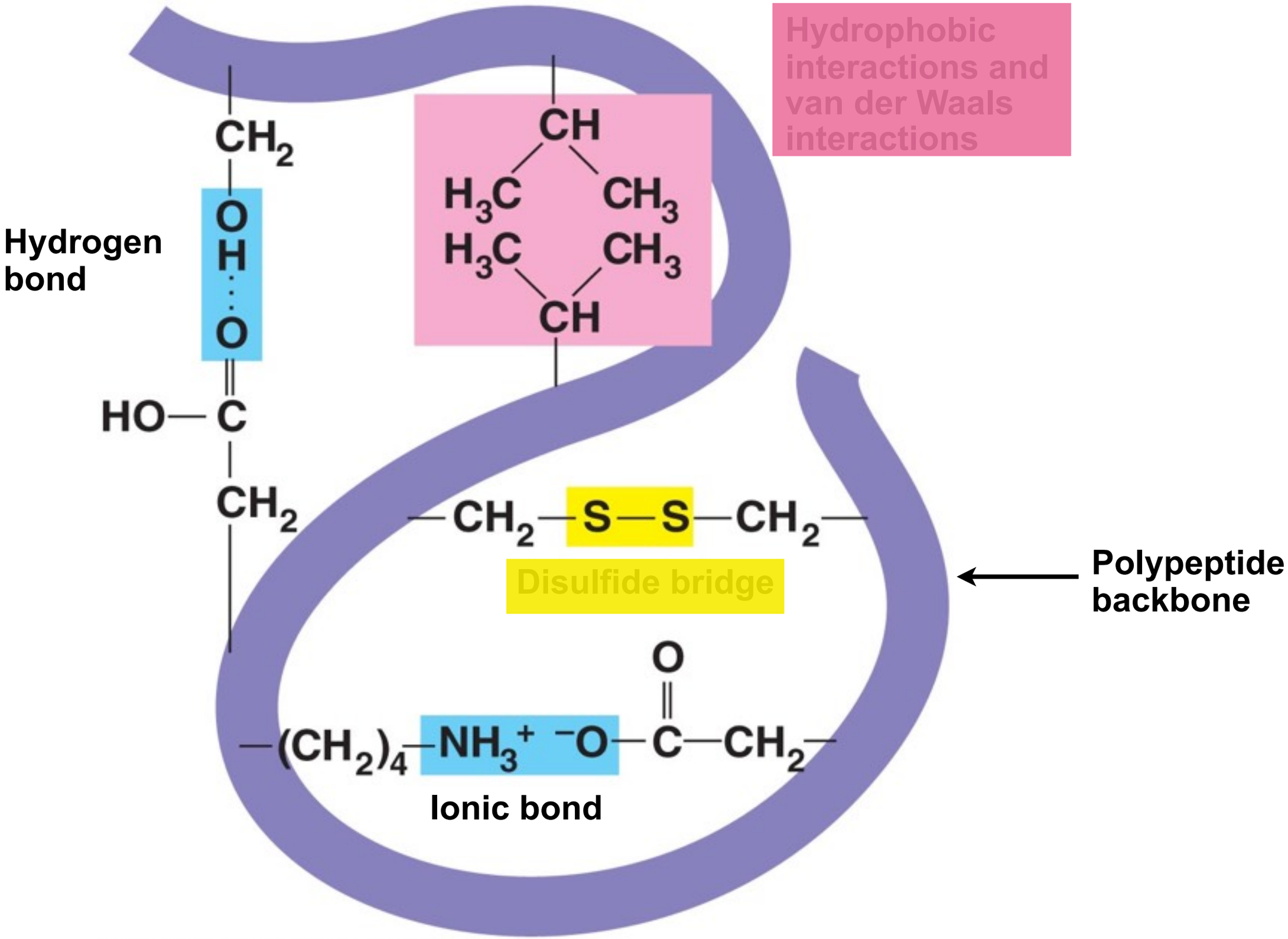
Tertiary Structure

Overall 3-D Shape



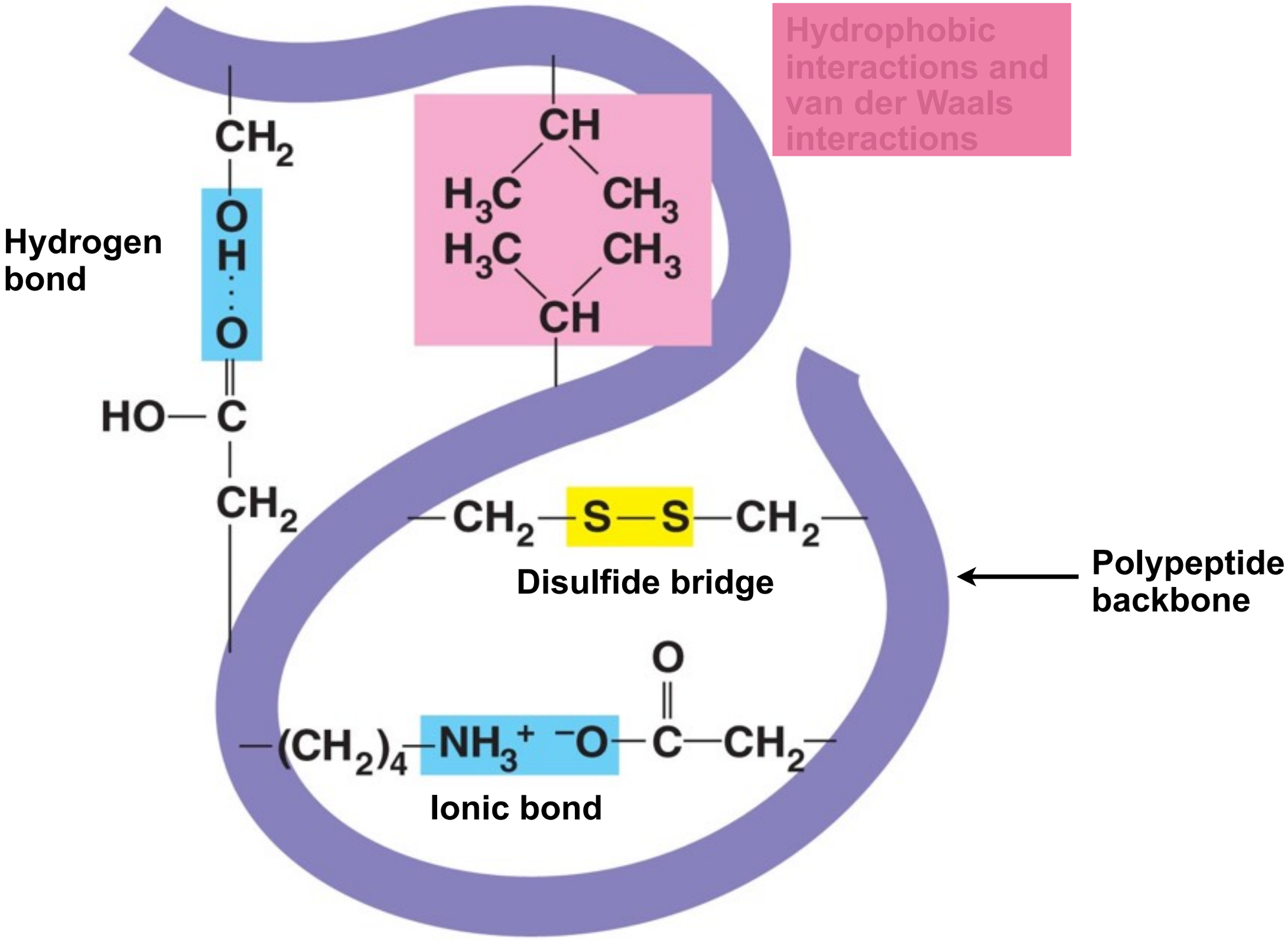
Tertiary Structure

Overall 3-D Shape



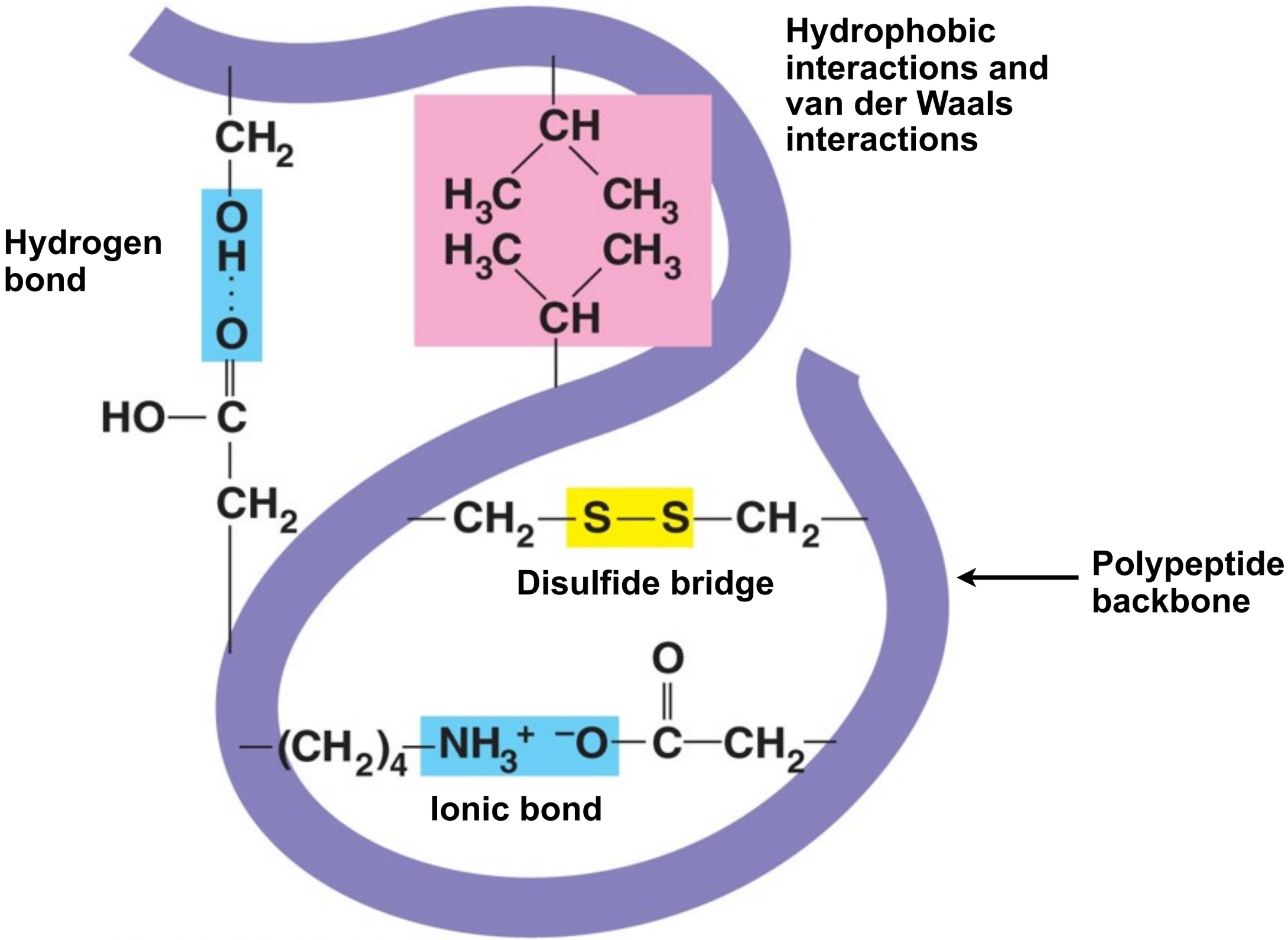
Tertiary Structure

Overall 3-D Shape



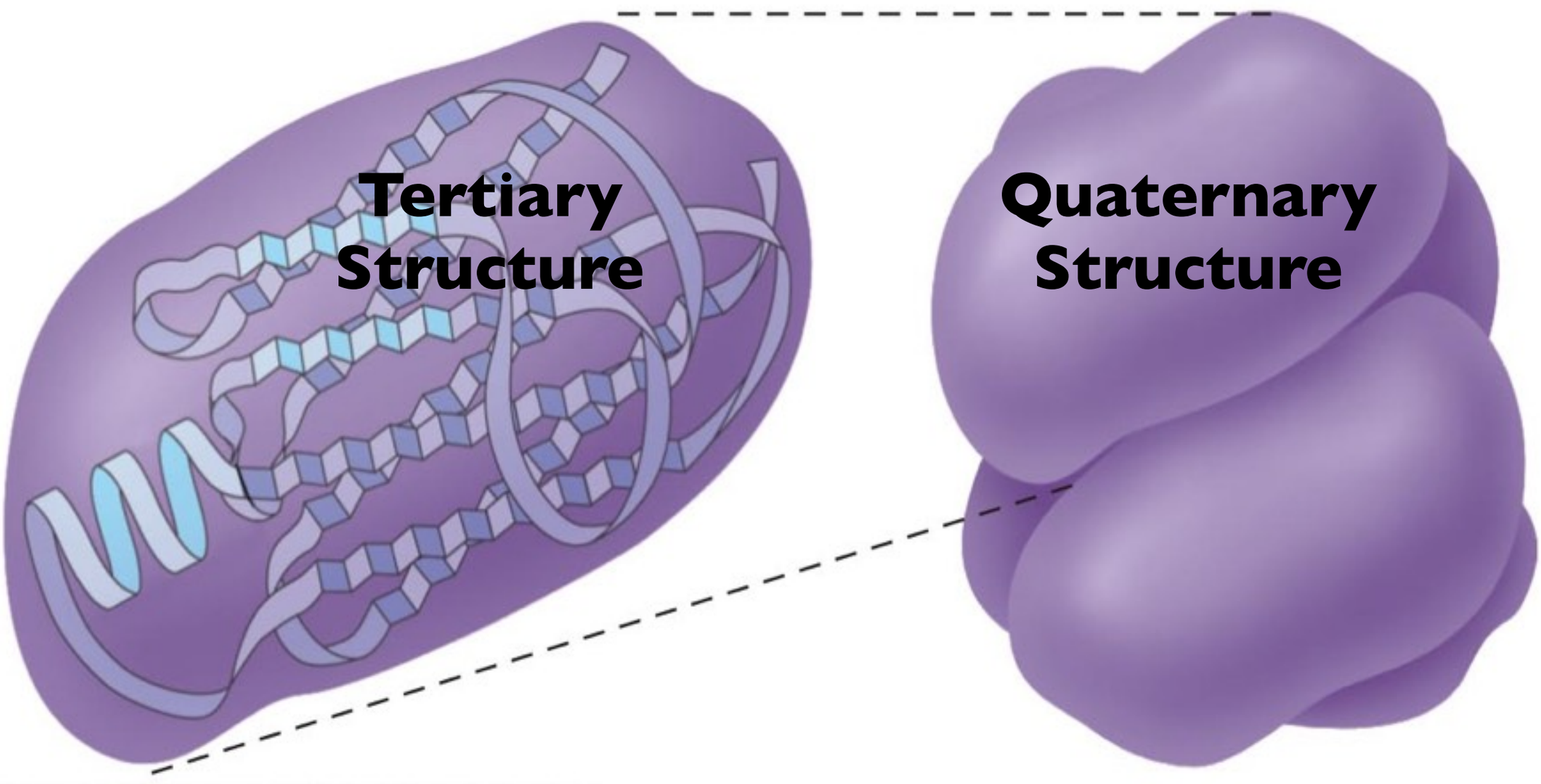
Tertiary Structure

Overall 3-D Shape



Tertiary Structure

Some tertiary proteins come together and form larger proteins

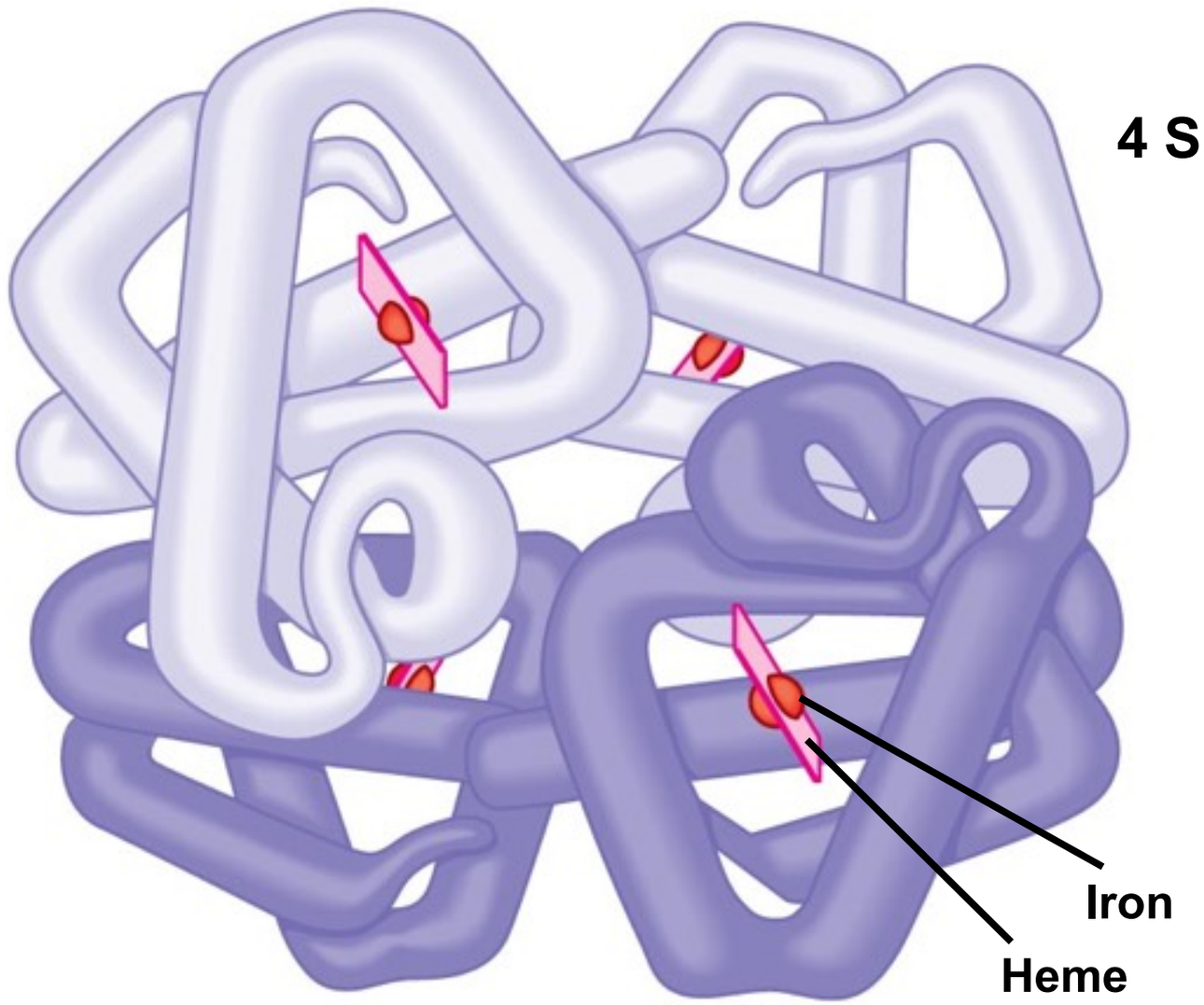


Quaternary Structure

Association of multiple polypeptides forming a functional protein

Polypeptide chains

Collagen



Hemoglobin

Quaternary Structure

Association of multiple polypeptides forming a functional protein

Polypeptide chains

Collagen

Quaternary Structure

Association of multiple polypeptides forming a functional protein

Polypeptide chains

Collagen

Quaternary Structure

Association of multiple polypeptides forming a functional protein

Polypeptide chains

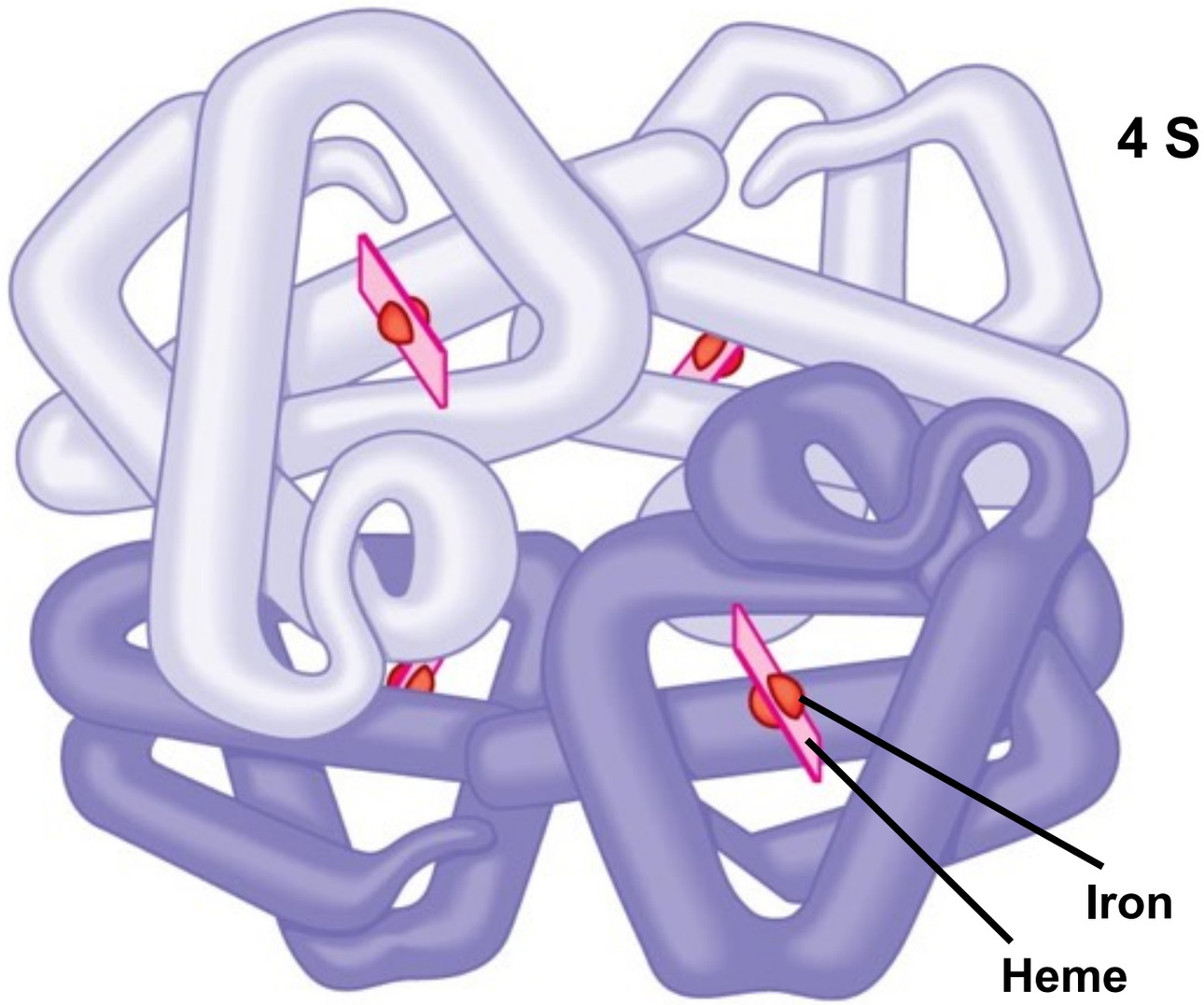
Collagen

Quaternary Structure

Association of multiple polypeptides forming a functional protein

Polypeptide chains

Collagen

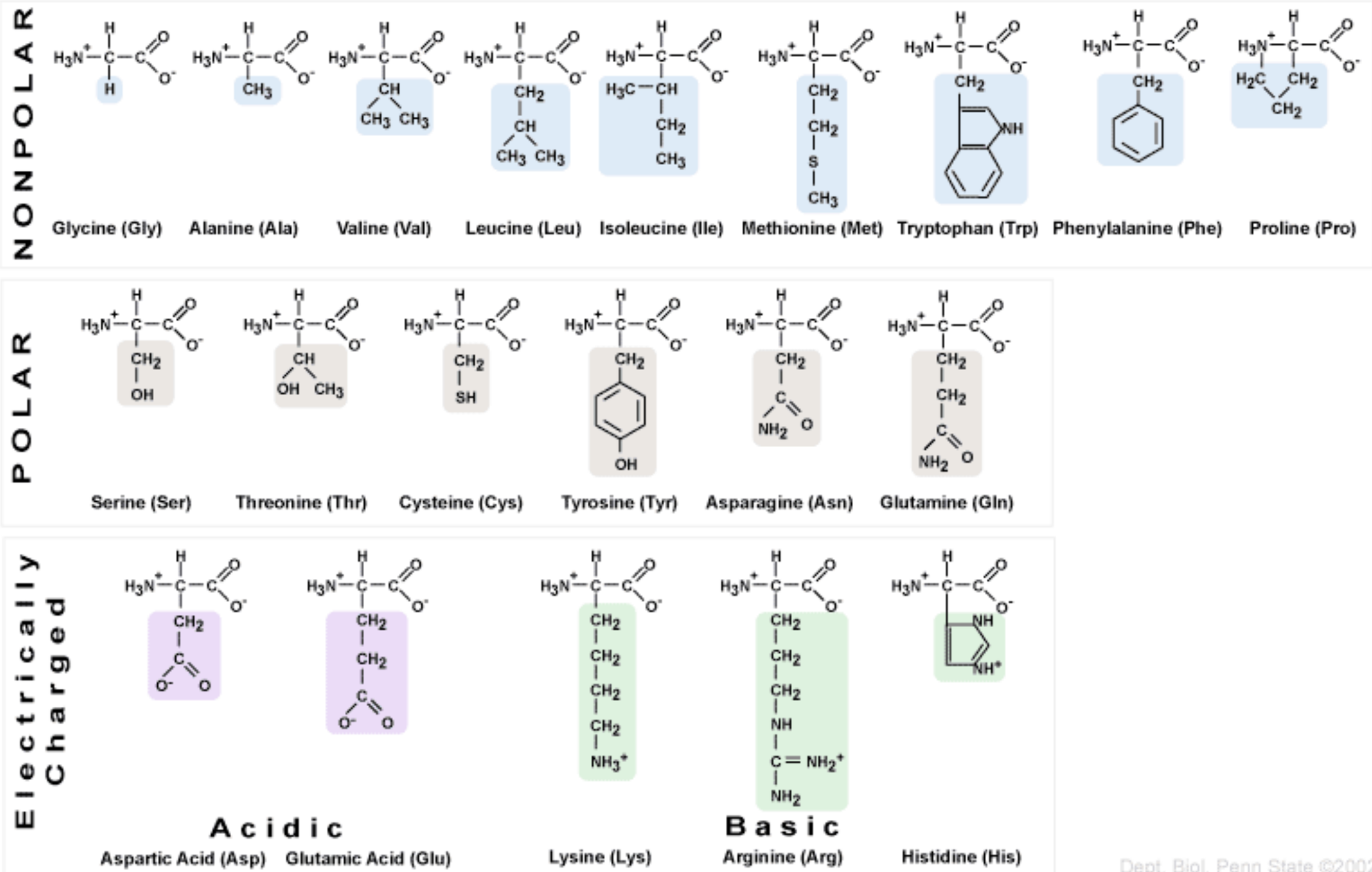


Hemoglobin

In almost every case the function of a protein depends on its ability to recognize and bind with some other molecule.

Amino Acids

"Our Cast of Characters"



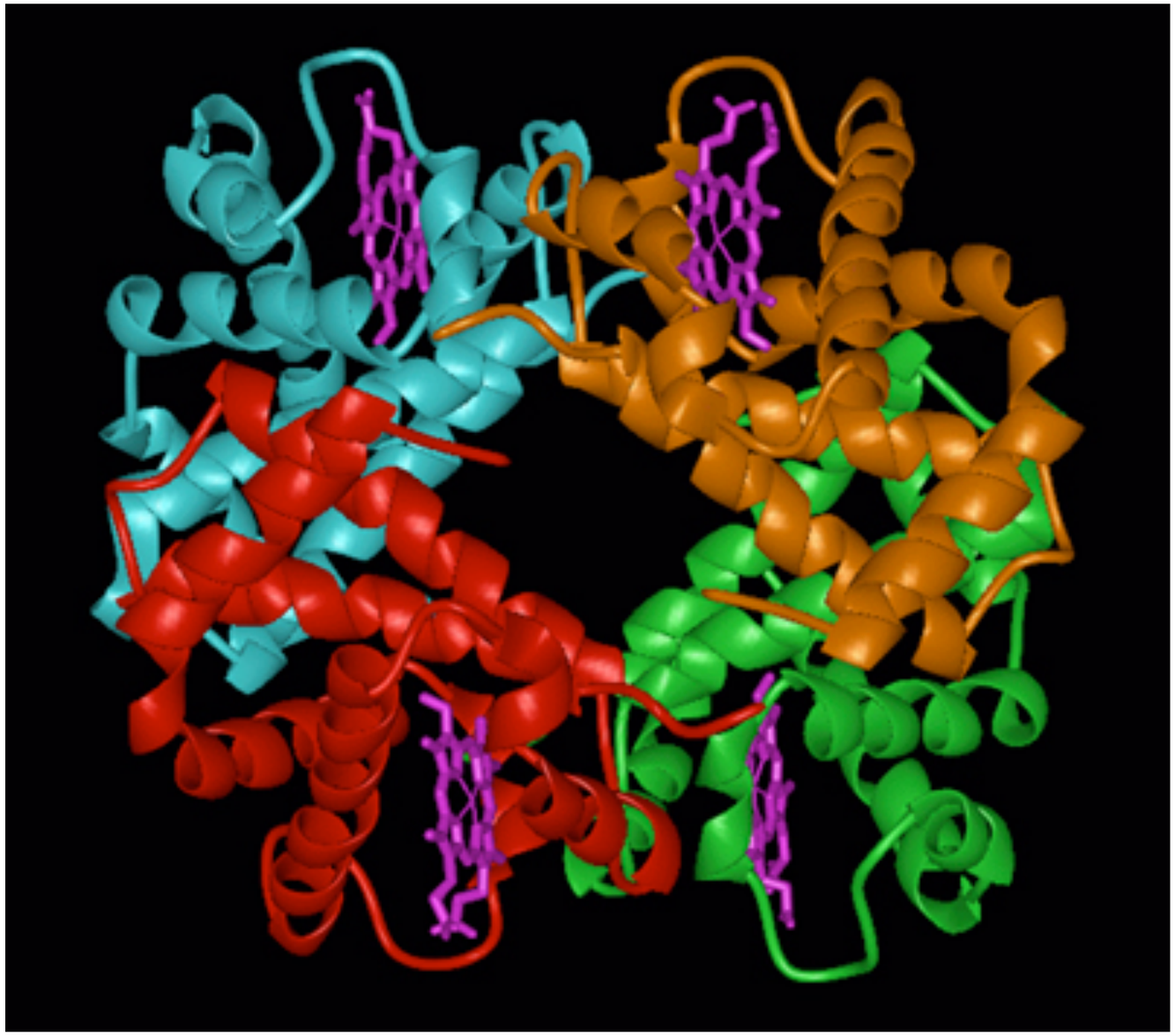
Essential knowledge 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.

3. In general, lipids are nonpolar; however, phospholipids exhibit structural properties, with polar regions that interact with other polar molecules such as water, and with nonpolar regions where differences in saturation determine the structure and function of lipids. [See also **1.D.1, 2.A.3, 2. B.1**]

✘✘ *The molecular structure of specific lipids is beyond the scope of the course and the AP Exam.*

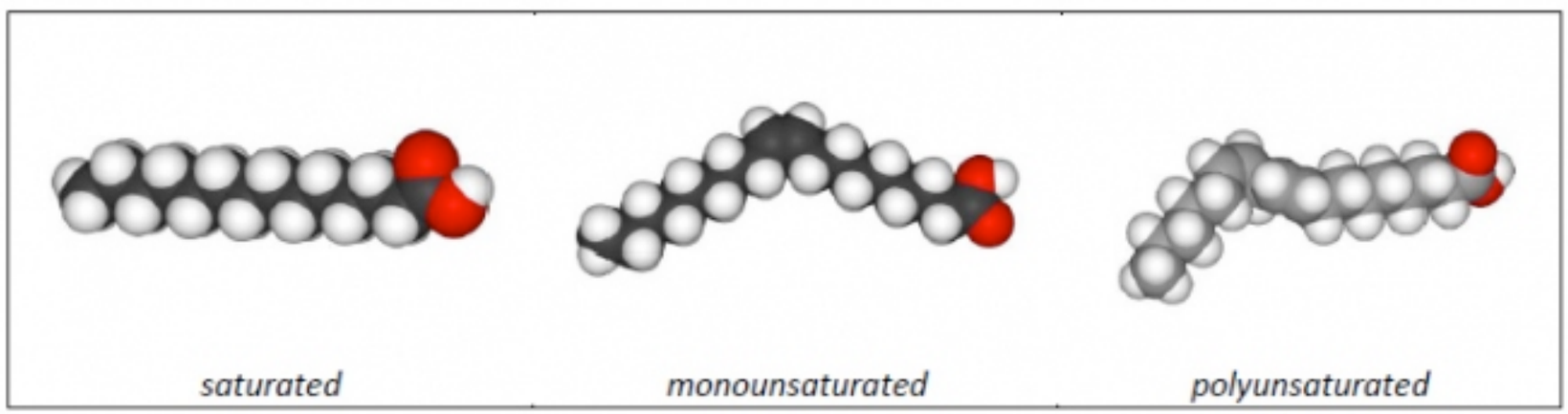
Main Idea: Lipids are a structurally diverse group of hydrophobic molecules and they smaller than the other macromolecules.

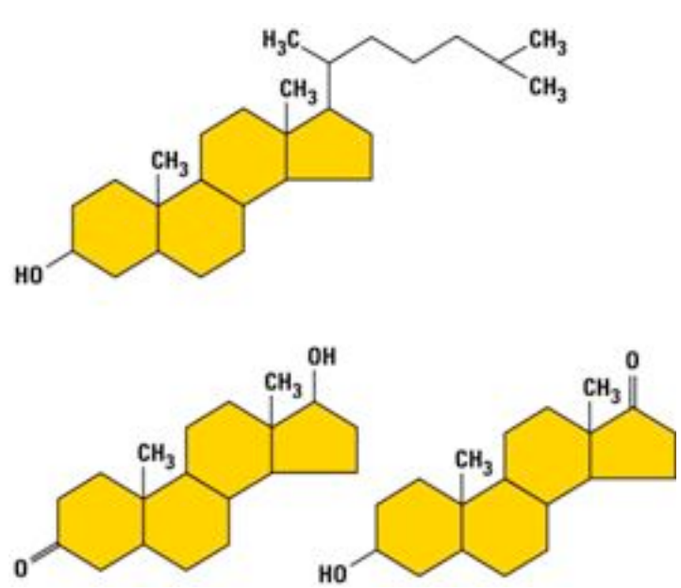
Main Idea: Lipids are functionally as diverse, they are used as energy molecules, structural molecules and chemical messengers.

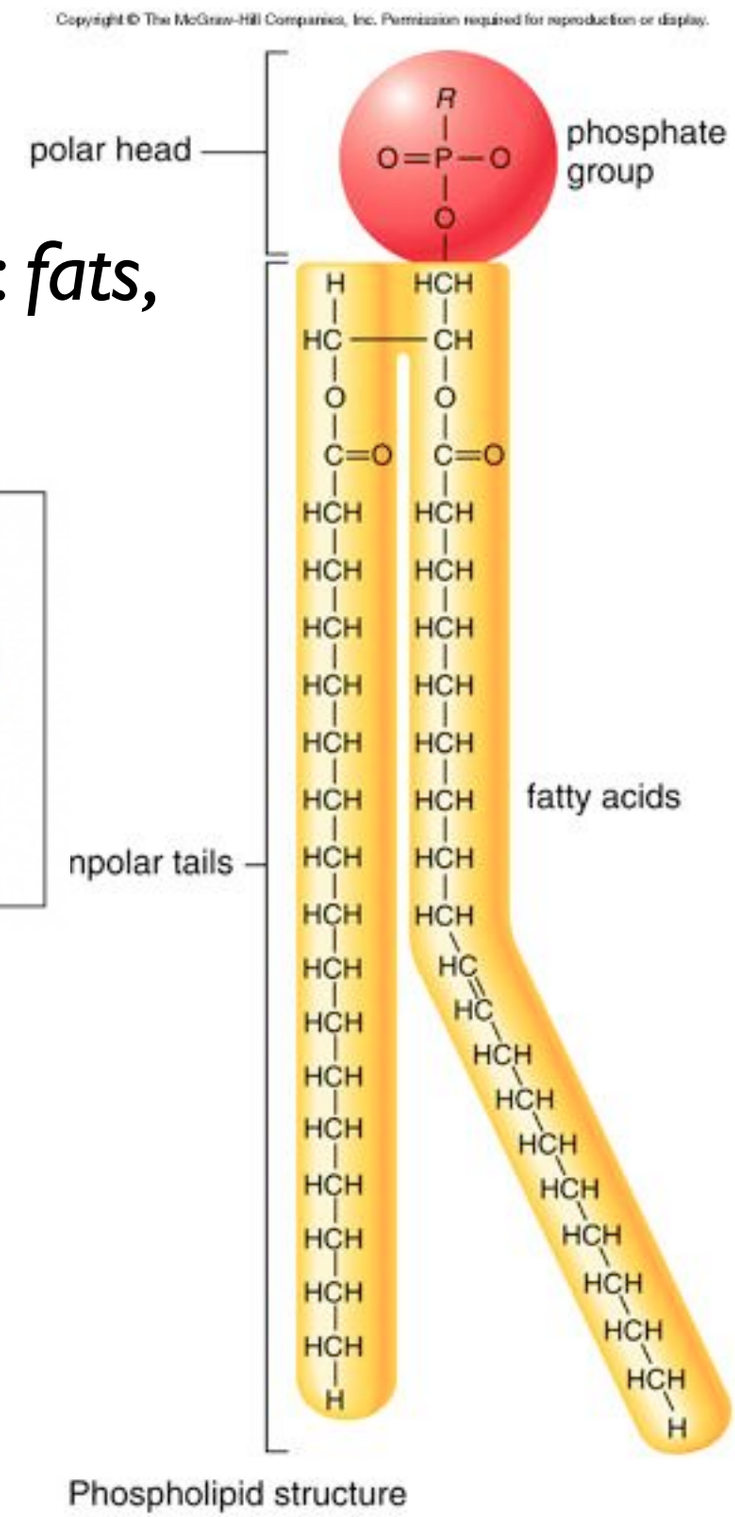


LIPIDS ARE A DIVERSE GROUP OF HYDROPHOBIC MOLECULES

- They are not true polymers.
- The most biologically important lipids include: *fats*, *phospholipids* and *steroids*.



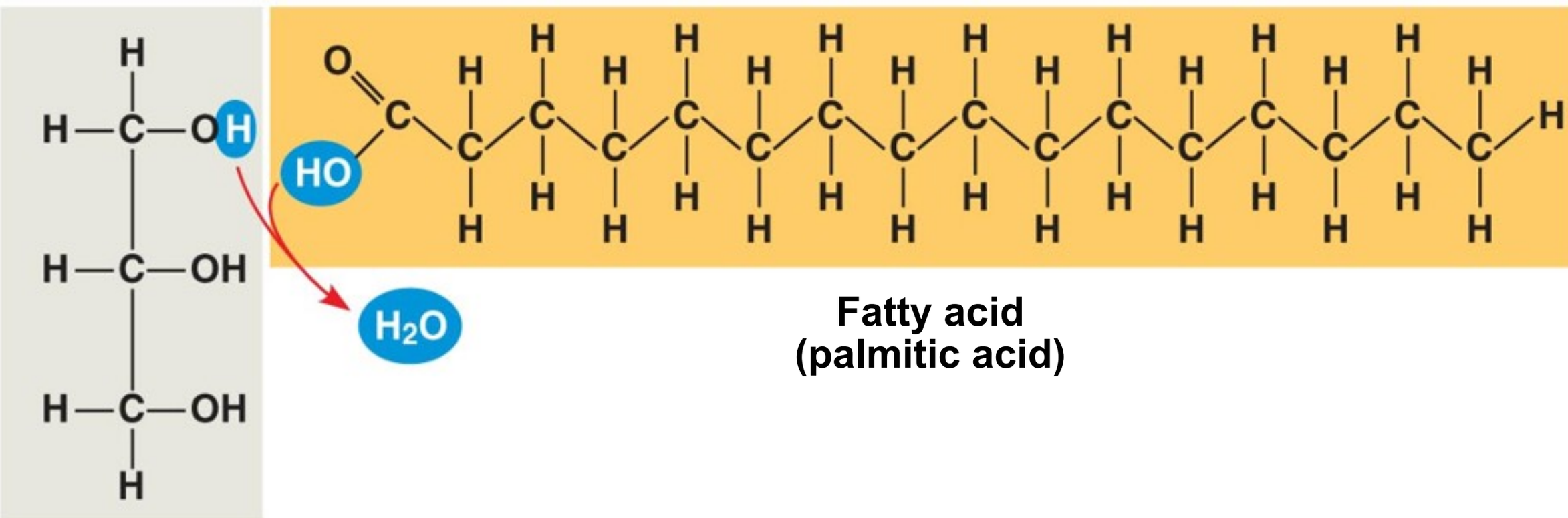




Fats

- A fat has two parts: *a Glycerol backbone and a fatty acid(s)*
- They are hydrophobic.

Dehydration reaction in the synthesis of a fat



Fatty acid
(palmitic acid)

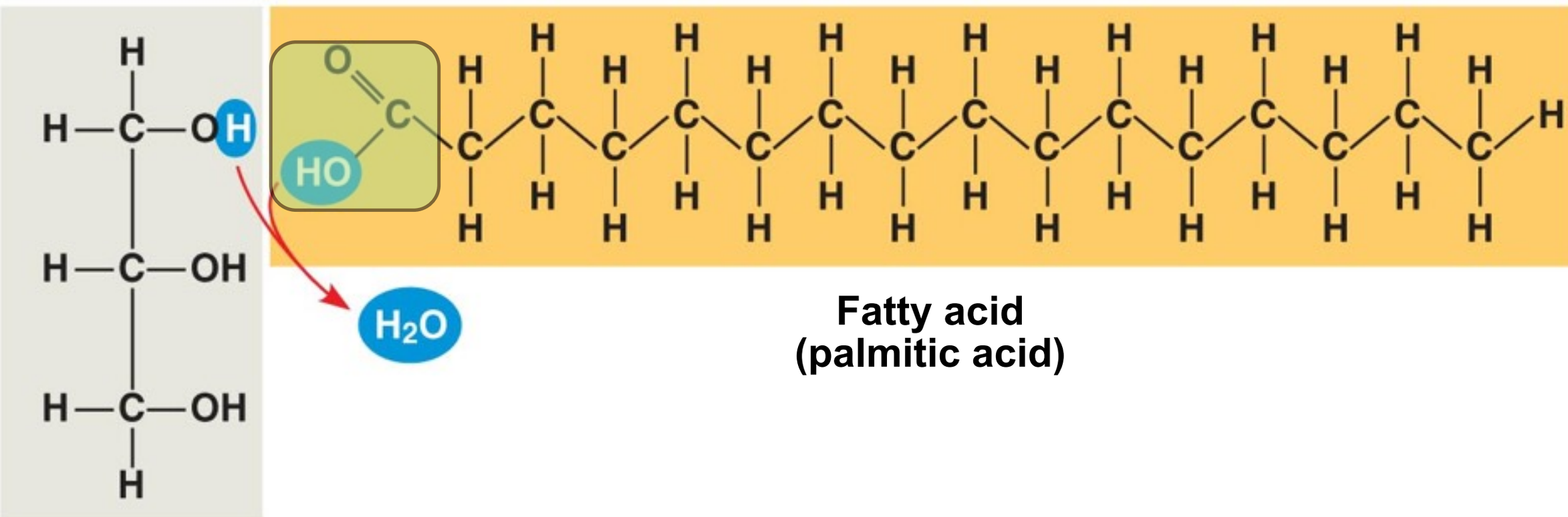
Glycerol

(An Alcohol)

Fats

- A fat has two parts: *a Glycerol backbone and a fatty acid(s)*
- They are hydrophobic.

Dehydration reaction in the synthesis of a fat



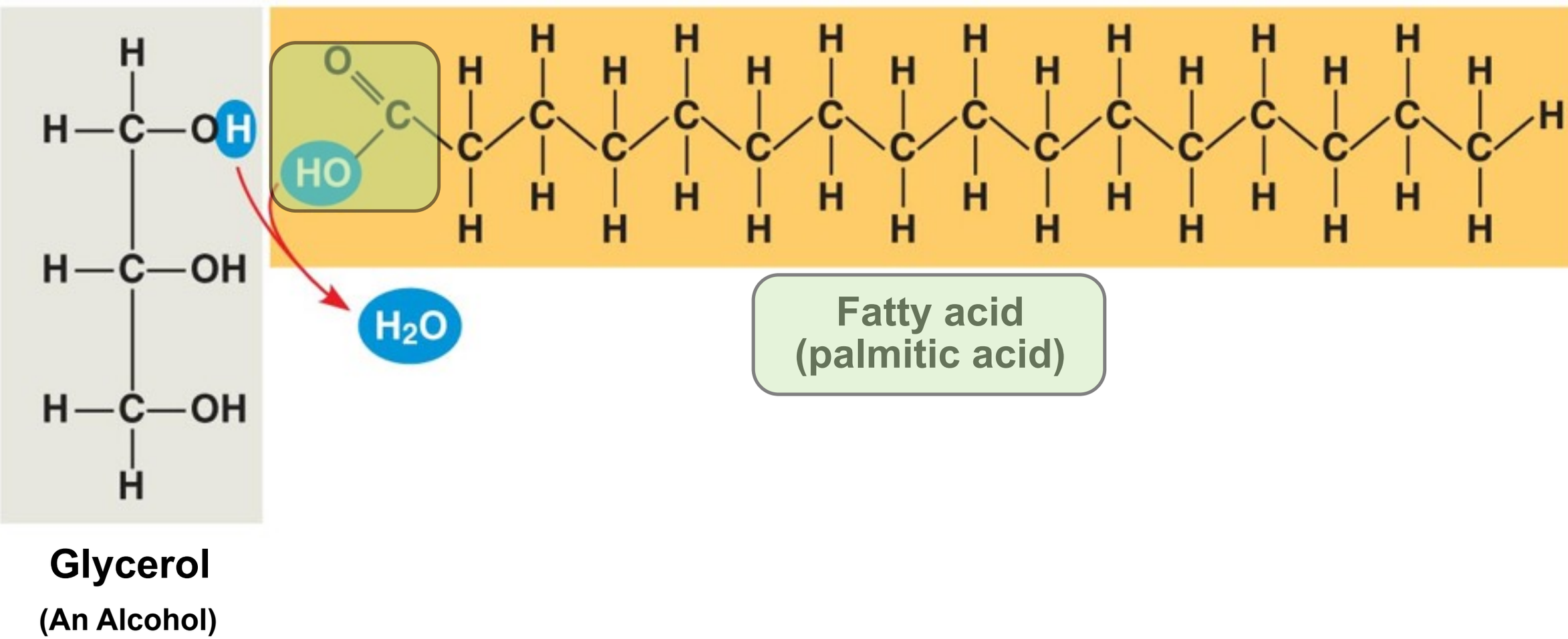
Fatty acid
(palmitic acid)

Glycerol
(An Alcohol)

Fats

- A fat has two parts: *a Glycerol backbone and a fatty acid(s)*
- They are hydrophobic.

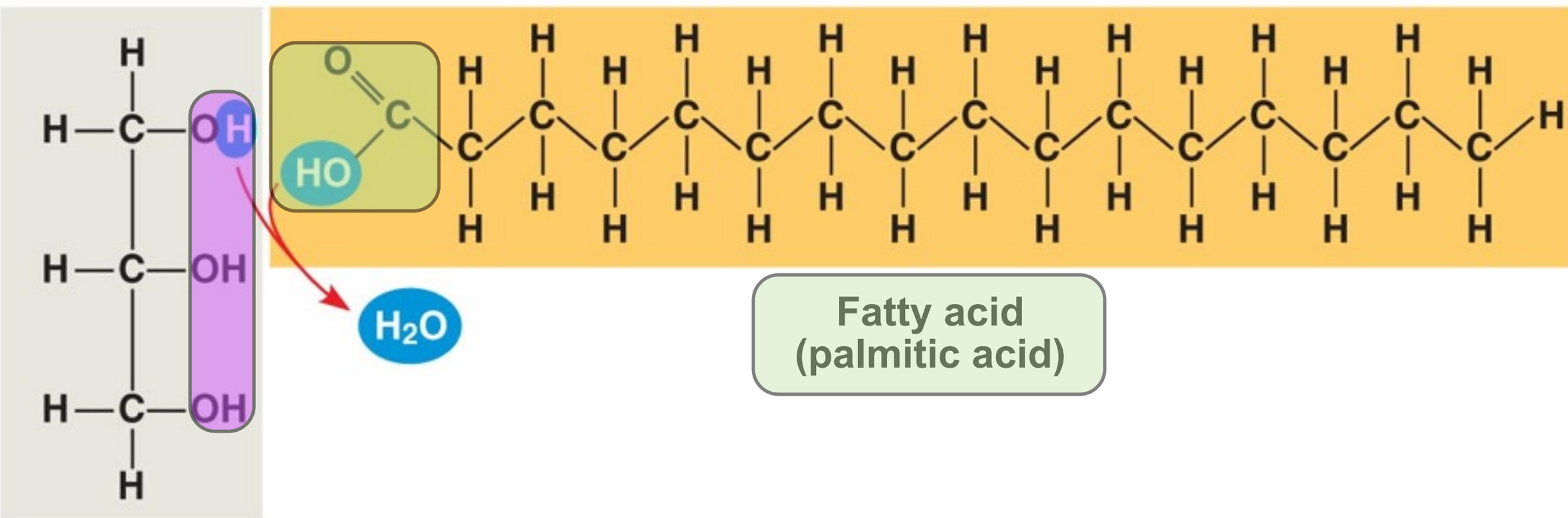
Dehydration reaction in the synthesis of a fat



Fats

- A fat has two parts: *a Glycerol backbone and a fatty acid(s)*
- They are hydrophobic.

Dehydration reaction in the synthesis of a fat



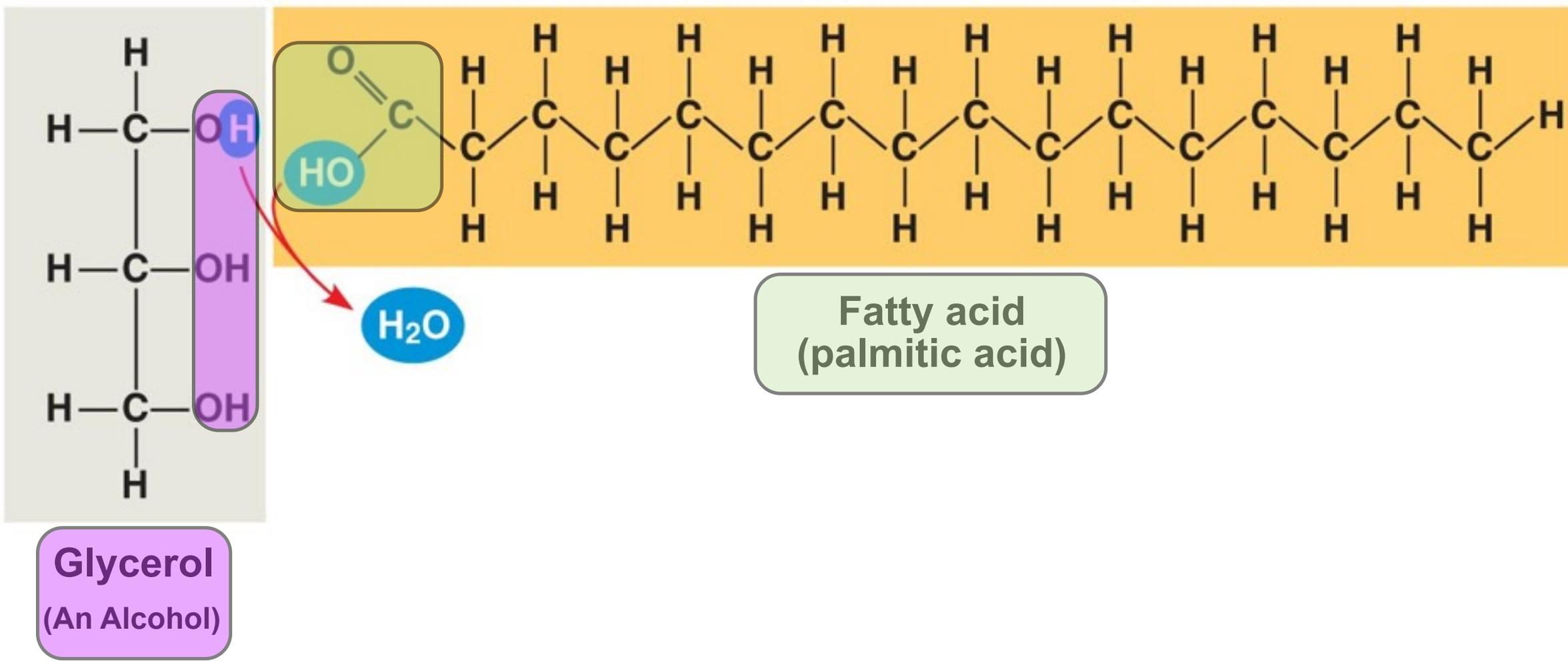
Glycerol

(An Alcohol)

Fats

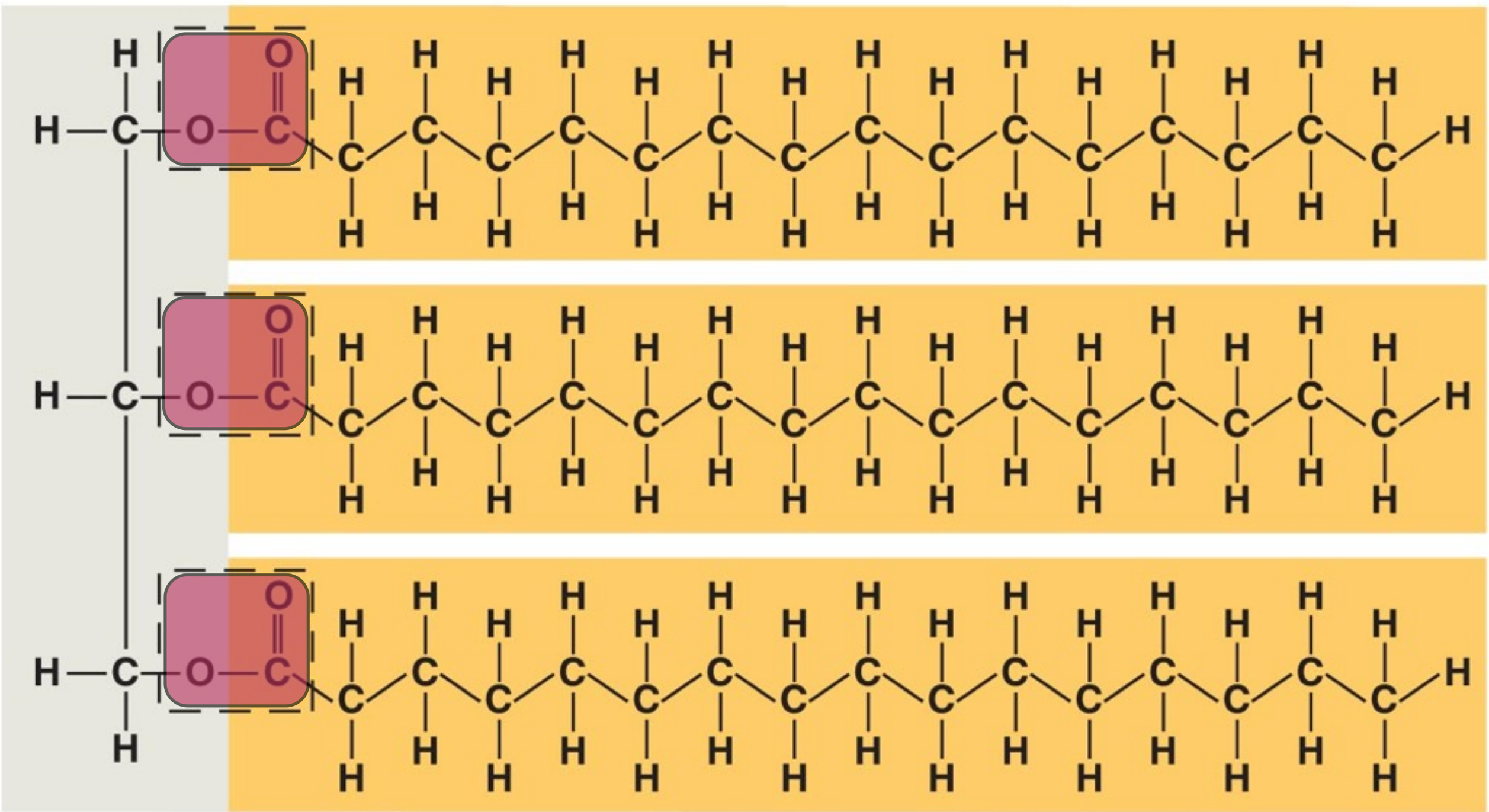
- A fat has two parts: *a Glycerol backbone and a fatty acid(s)*
- They are hydrophobic.

Dehydration reaction in the synthesis of a fat



Fatty acids can same or each can be different

Usually 16-18 carbons in length



Fat molecule (triacylglycerol)

saturated fats

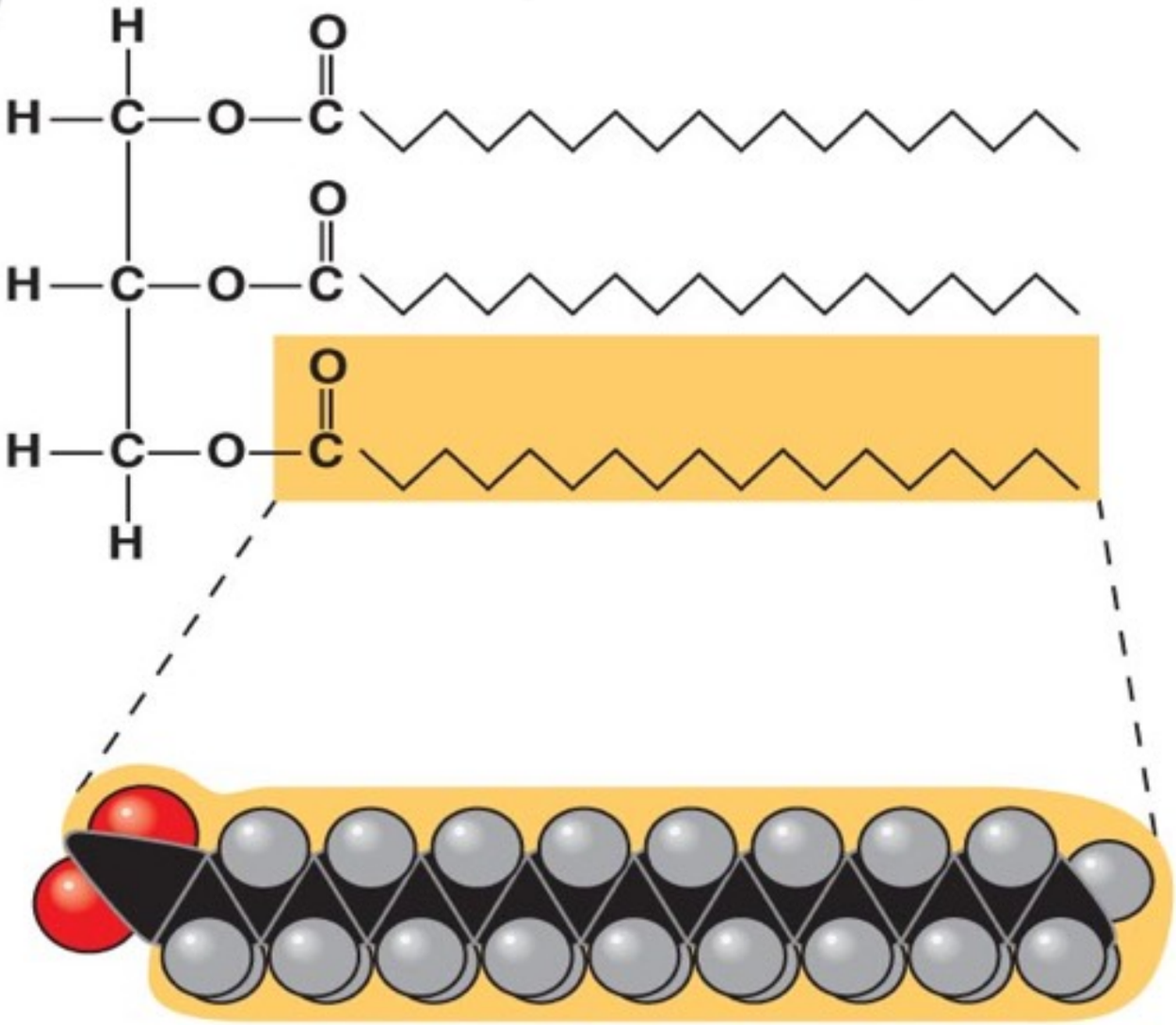
-no double bonds

-packs tightly together

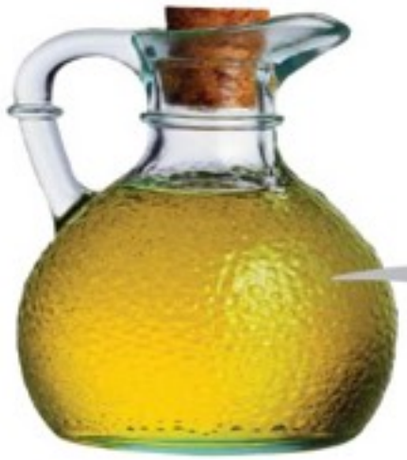
Solid at room temp

Contributes to cardiovascular disease

Animal fats

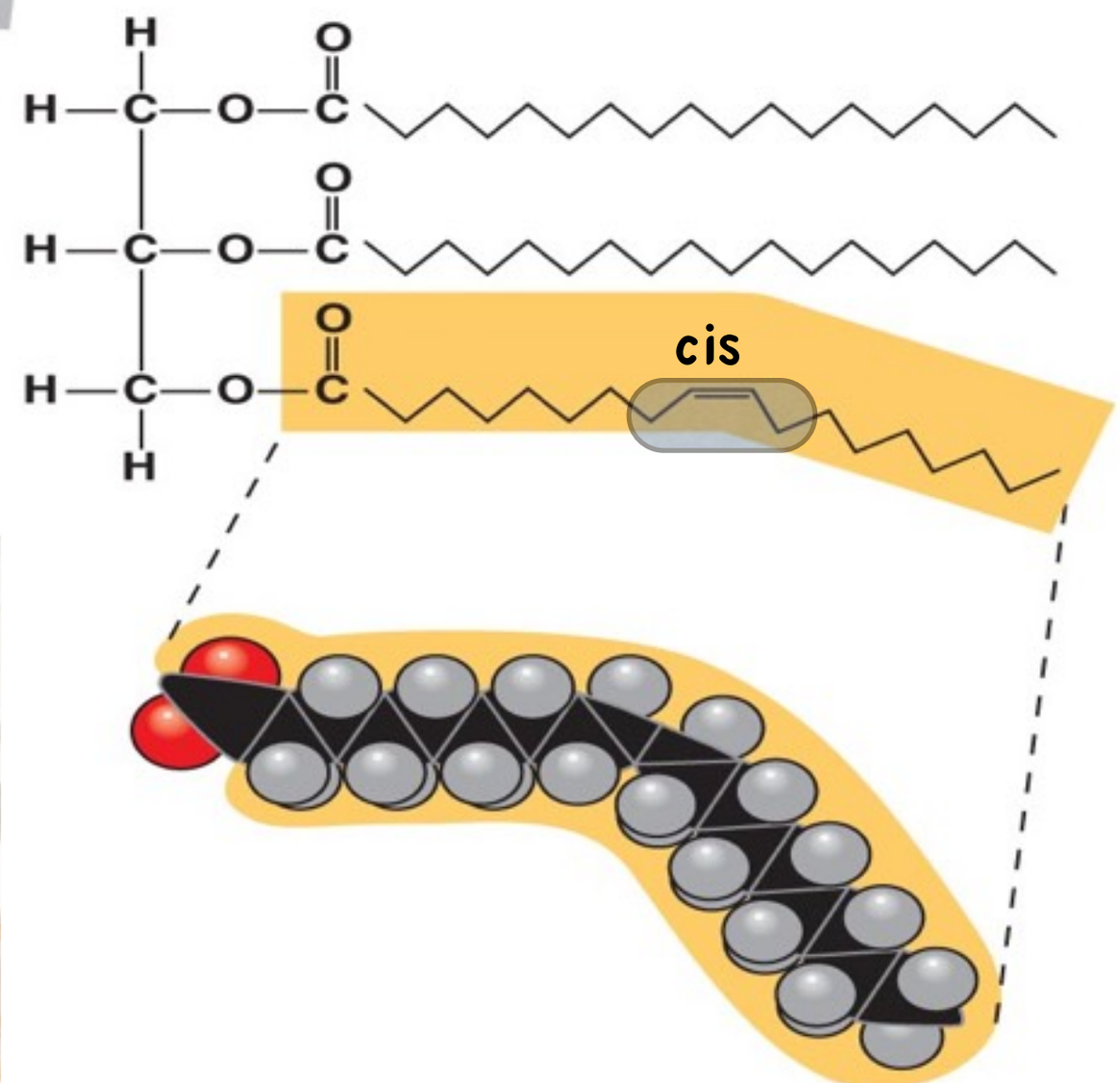


unsaturated fats



-one or more double bonds

-packs less tightly together



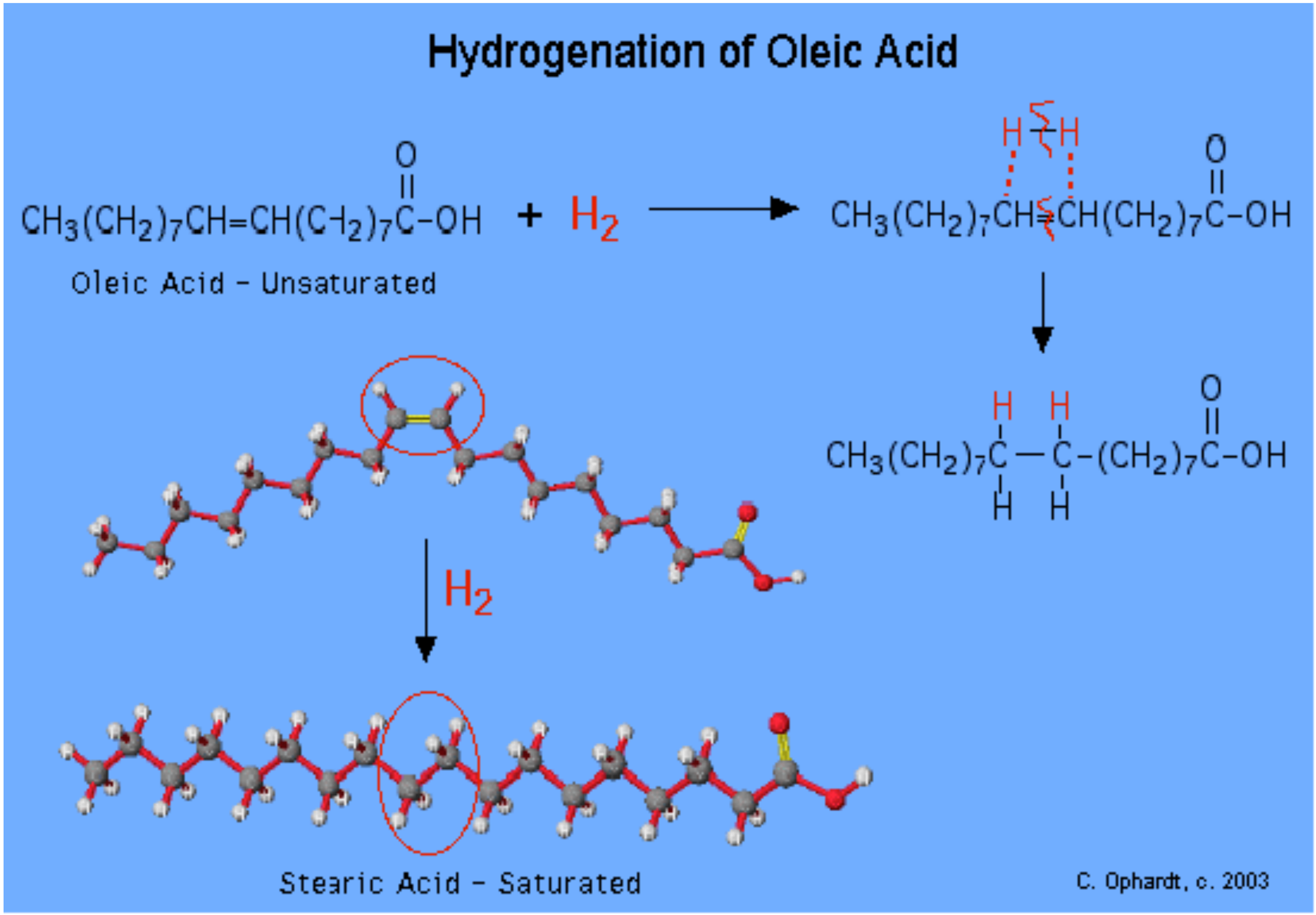
Liquid at room temp

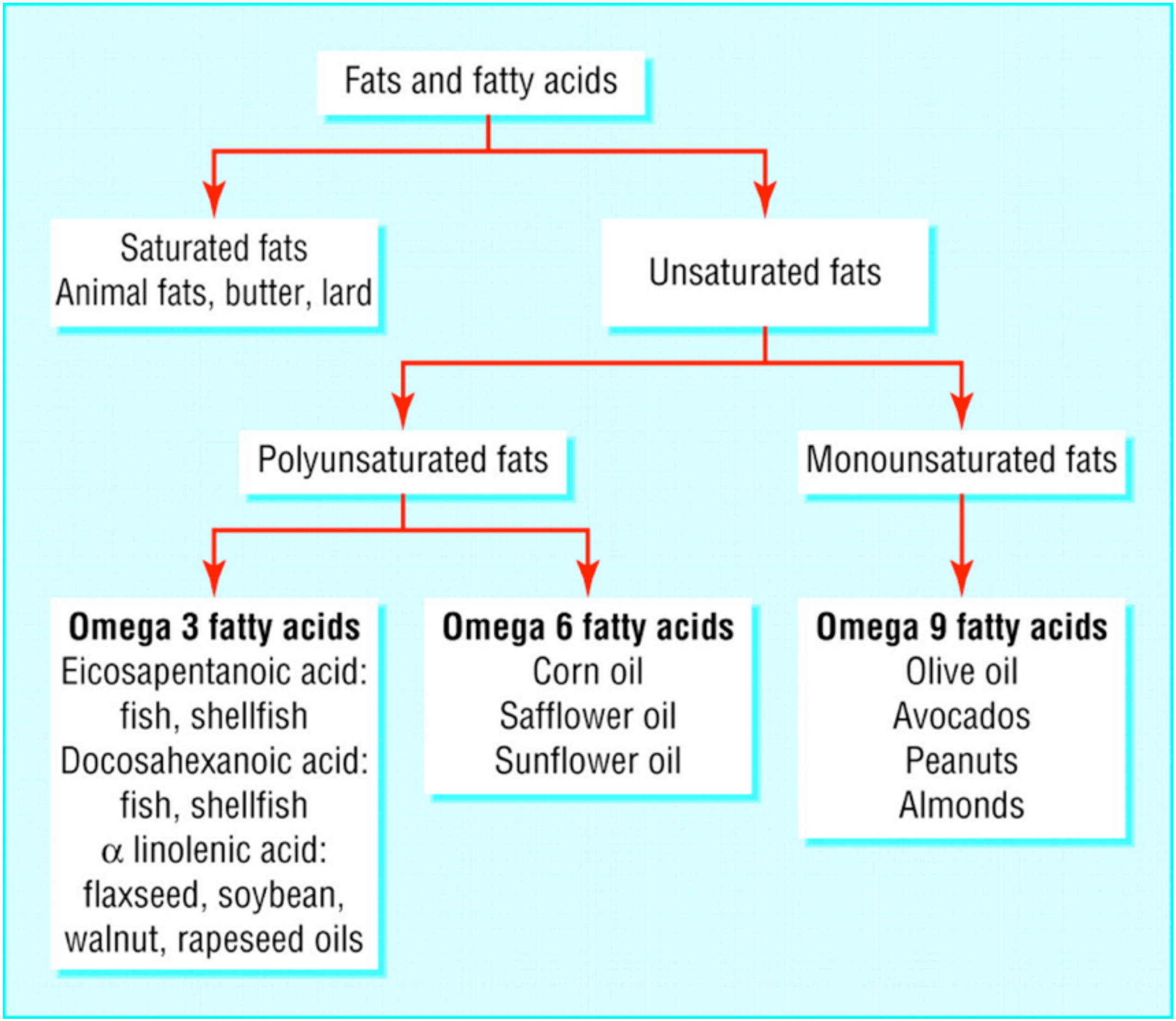
Helps eliminate "bad" fats

Fish & Plant fats

hydrogenated oils

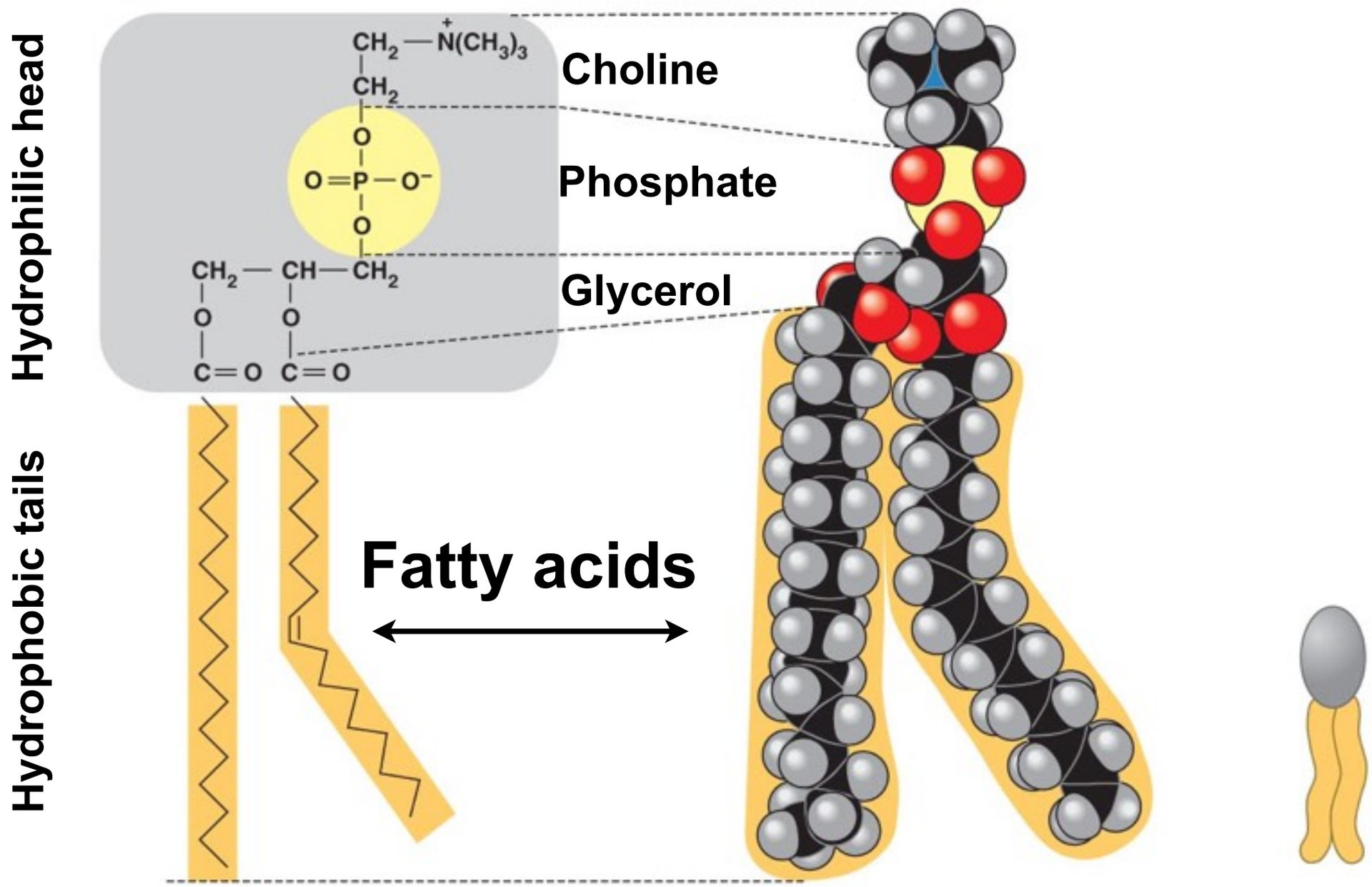
aka...trans-fats




Fats and fatty acids
Saturated fats
Animal fats, butter, lard
Unsaturated fats
Polyunsaturated fats
Monounsaturated fats
Omega 3 fatty acids
Eicosapentanoic acid:
fish, shellfish
Docosahexanoic acid:
fish, shellfish
α linolenic acid:
flaxseed, soybean,
walnut, rapeseed oils
Omega 6 fatty acids
Corn oil
Safflower oil
Sunflower oil
Omega 9 fatty acids
Olive oil
Avocados
Peanuts
Almonds

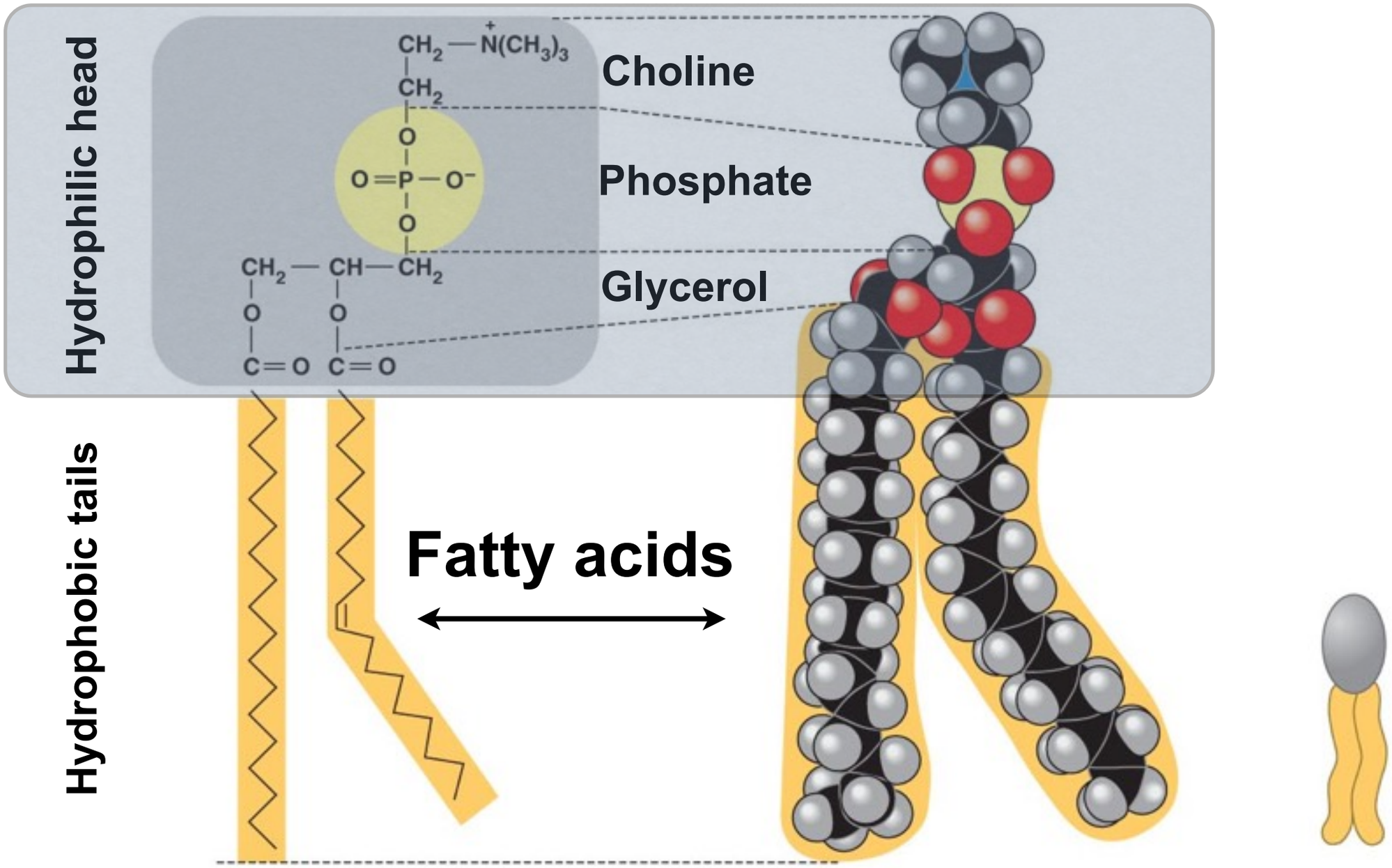
Phospholipids

- *Phospholipids* are essential, they make up membranes
- A fat has two parts: *Hydrophilic head* and *Hydrophobic tail*



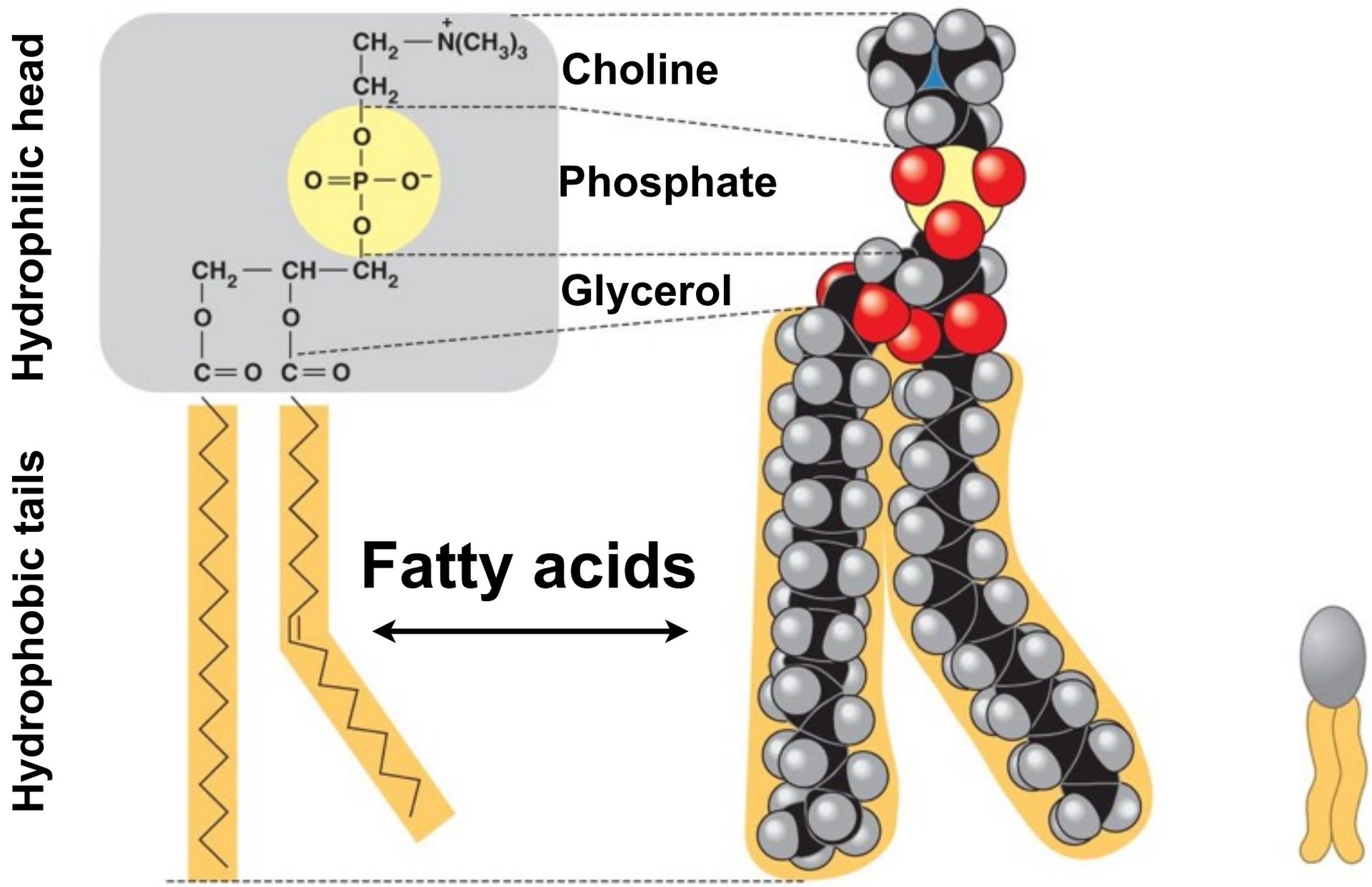
Phospholipids

- *Phospholipids* are essential, they make up membranes
- A fat has two parts: *Hydrophilic head* and *Hydrophobic tail*



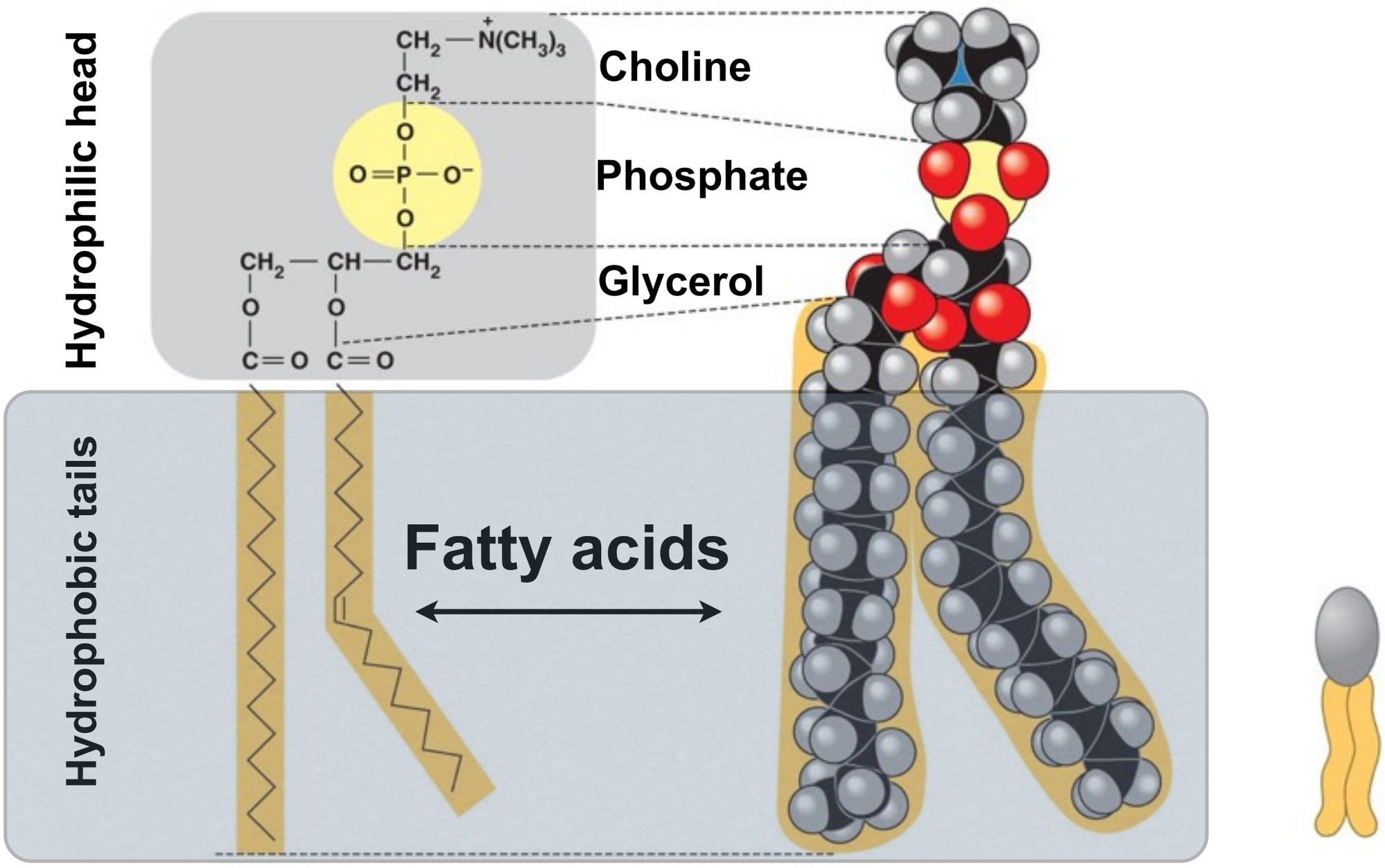
Phospholipids

- *Phospholipids* are essential, they make up membranes
- A fat has two parts: *Hydrophilic head* and *Hydrophobic tail*



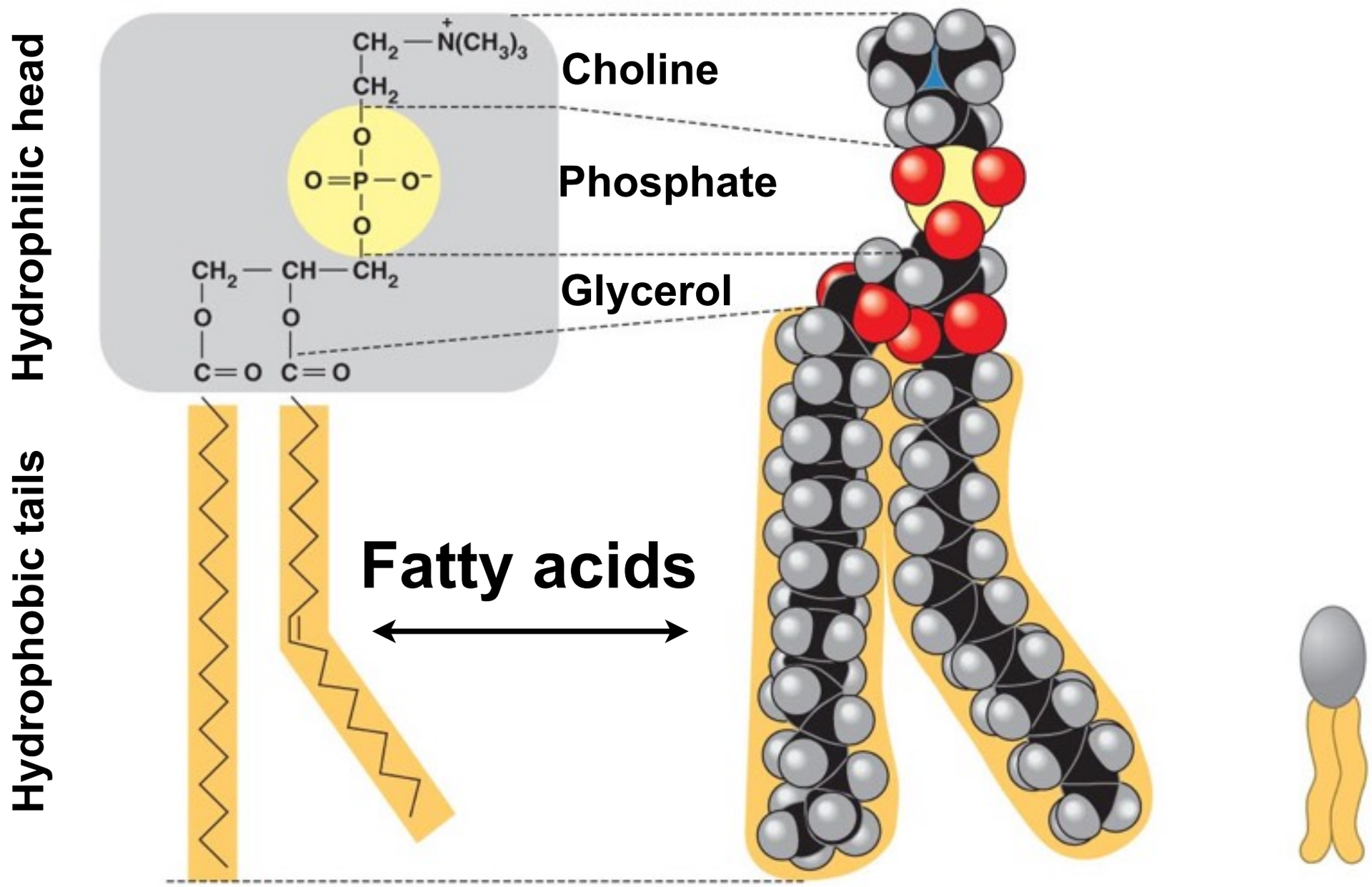
Phospholipids

- *Phospholipids* are essential, they make up membranes
- A fat has two parts: *Hydrophilic head* and *Hydrophobic tail*



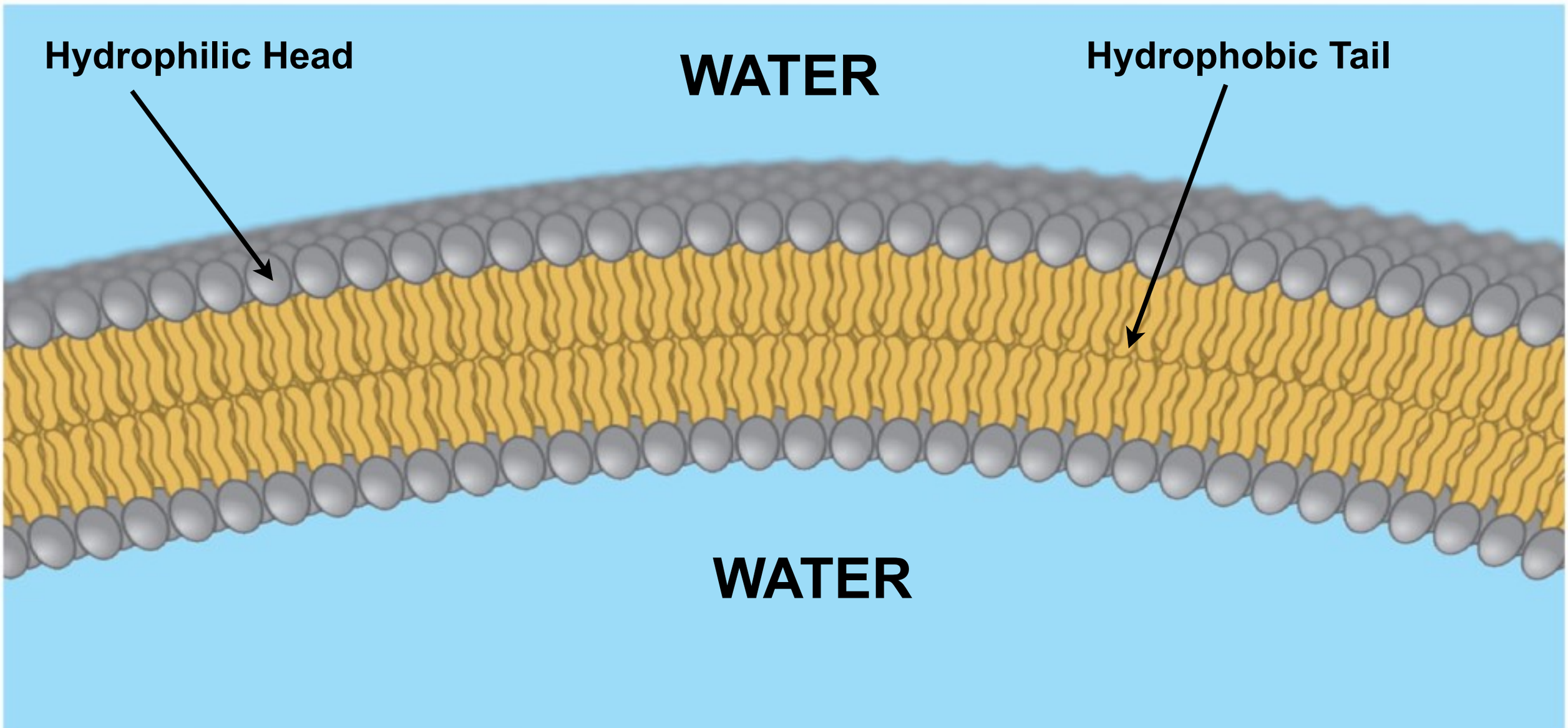
Phospholipids

- *Phospholipids* are essential, they make up membranes
- A fat has two parts: *Hydrophilic head* and *Hydrophobic tail*



Phospholipids

- *Phospholipids* are essential, they make up membranes
- A fat has two parts: *Hydrophilic head* and *Hydrophobic tail*
- ***Membranes separate internal from external environments, cells could not exist without them***



Steroids

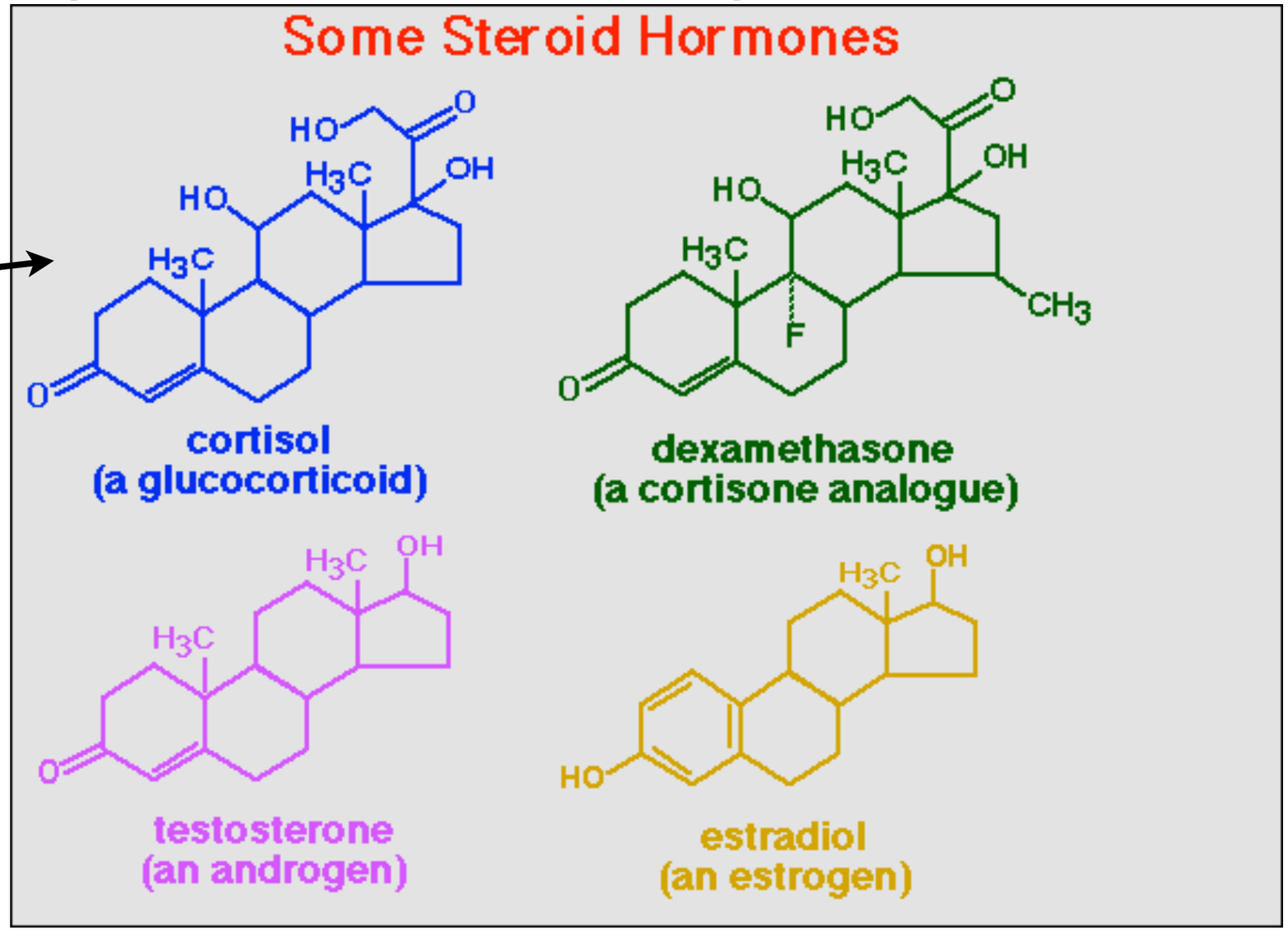
- *Steroids* are lipids, they are made of 4 fused rings
- Steroids include: Cholesterol and Sex Hormones
- They play an important role in membrane structure and function
- They are also important precursors to other organic molecules

Cortisol

-increasing blood sugar through gluconeogenesis

-suppressing the immune system

-aiding in fat, protein, and carbohydrate metabolism



Functions of Lipids

- They are major fuel source for cellular work
  - Lipids are used indirectly to power cellular processes, ATP is the direct cellular fuel
- They act as building blocks for membranes
- They cushion and insulate
- They are chemical messengers (hormones)

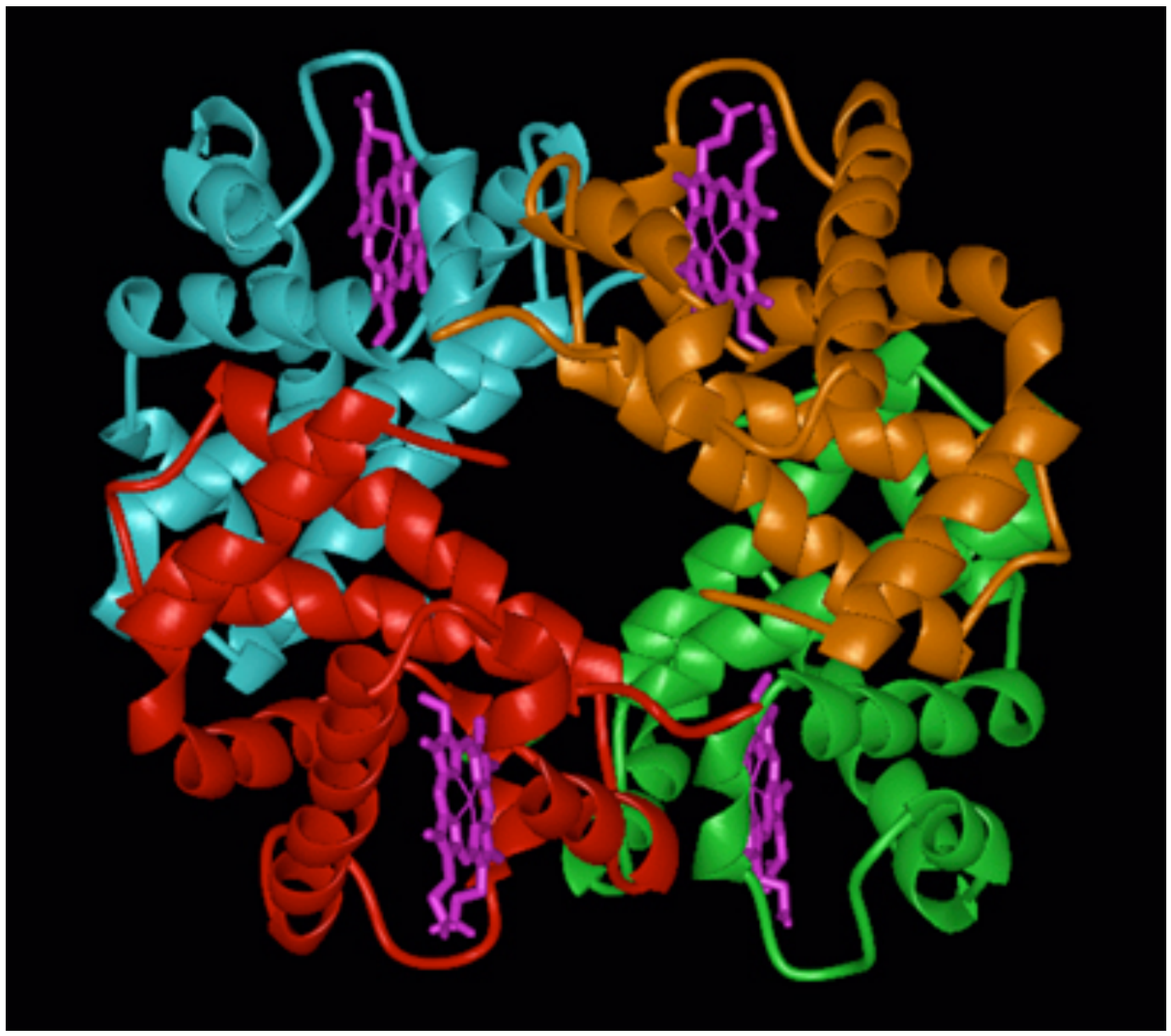
Essential knowledge 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.

4. Carbohydrates are composed of sugar monomers whose structures and bonding with each other by dehydration synthesis determine the properties and functions of the molecules. Illustrative examples include: cellulose versus starch.

✘✘ *The molecular structure of specific carbohydrate polymers is beyond the scope of the course and the AP Exam.*

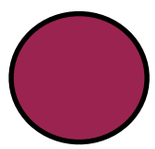
Main Idea: Carbohydrates' structure consists of atoms of carbon, hydrogen and oxygen, in a 1:2:1 ratio ($C_1H_2O_1$).

Main Idea: Carbohydrates function as a fuel source and building material.

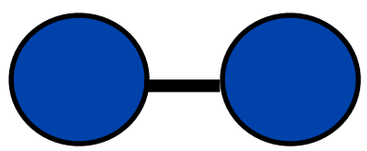


CARBOHYDRATES SERVE AS FUEL AND BUILDING MATERIAL

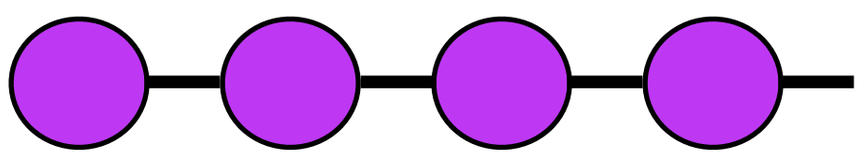
- *Carbohydrates* include both simple sugars and polymers of sugars.
  - *Monosaccharides;* simple monomers of sugars

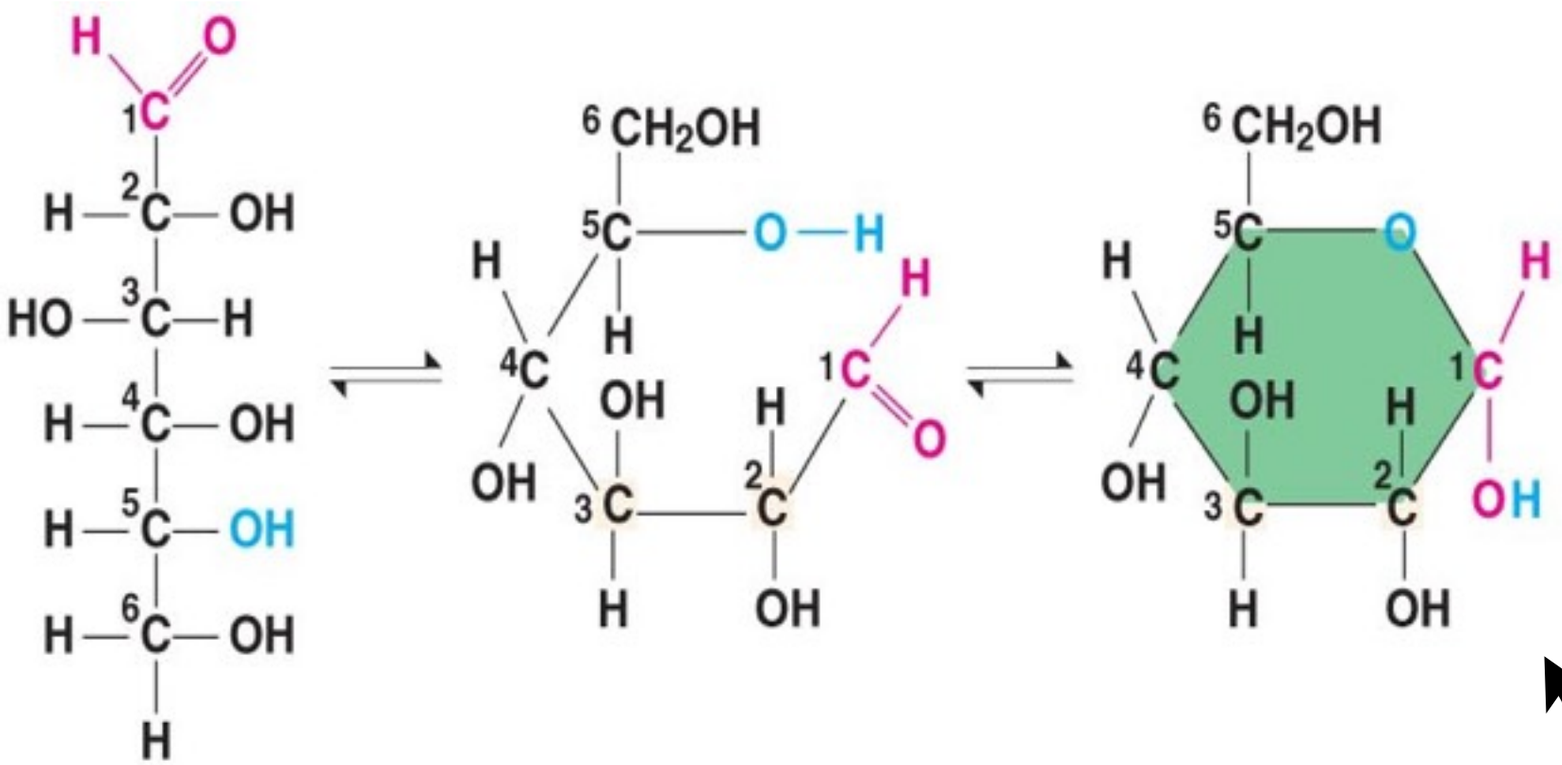


  - *Disaccharides;* two monomers of sugar bonded together

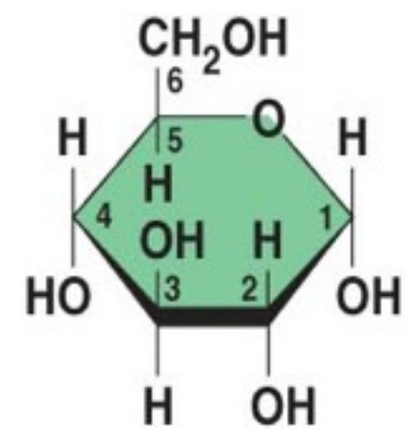


  - *Polysaccharides;* monomers of sugars bonded together





(c) Abbreviated ring structure



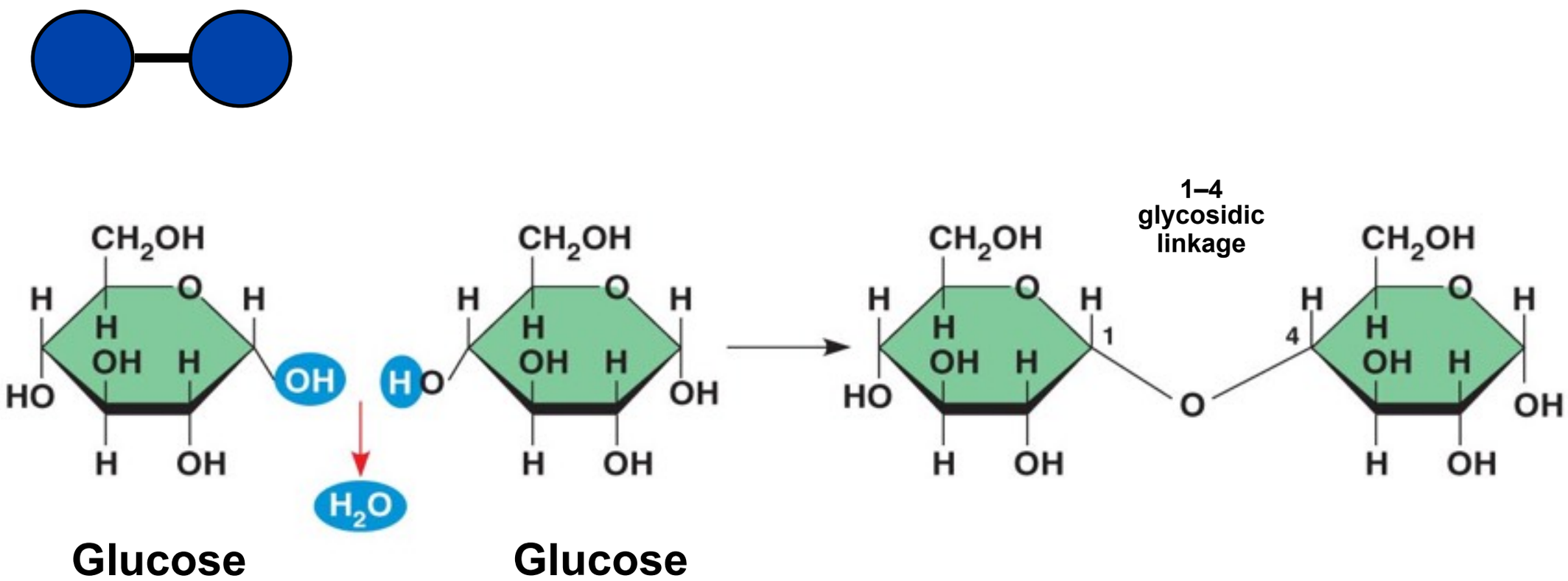
(b) ring forms

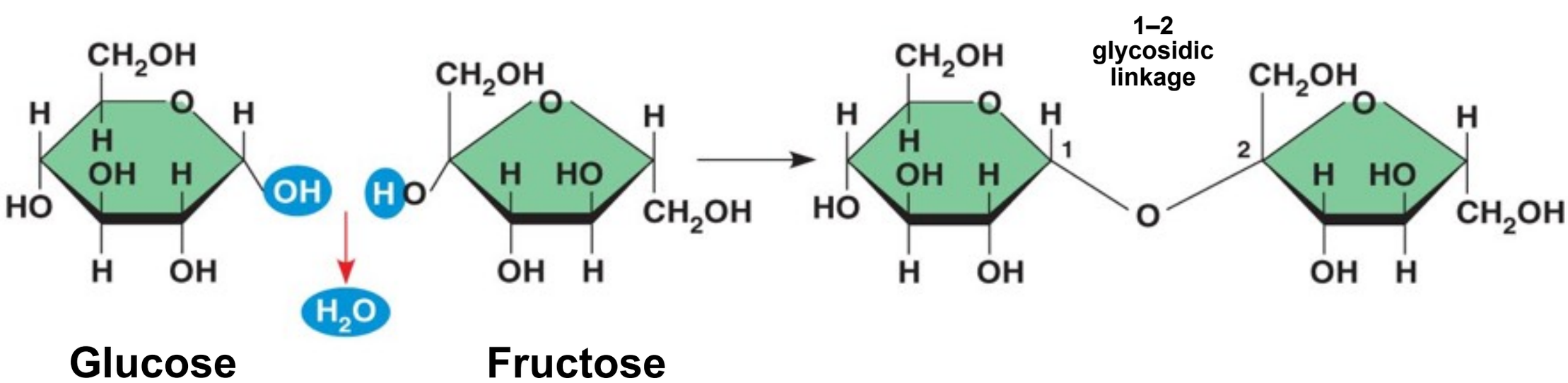
Wet (in cells)

(a) Linear

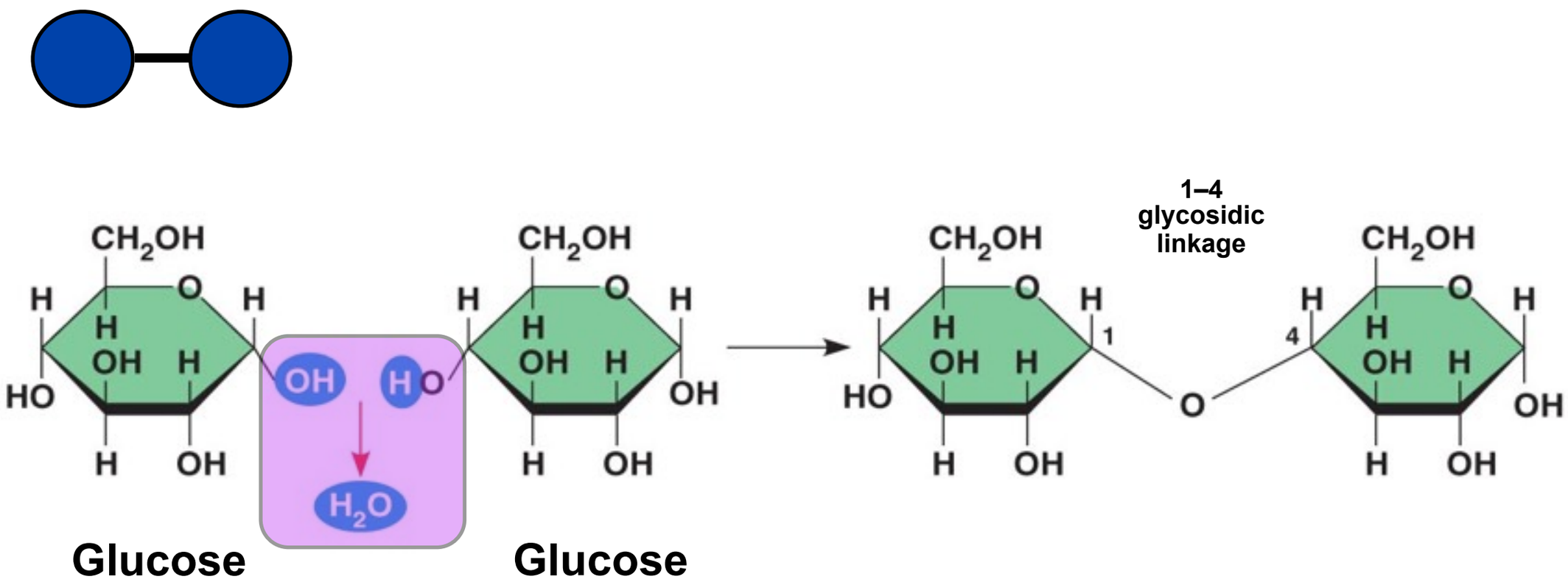
Dry (on lab bench)

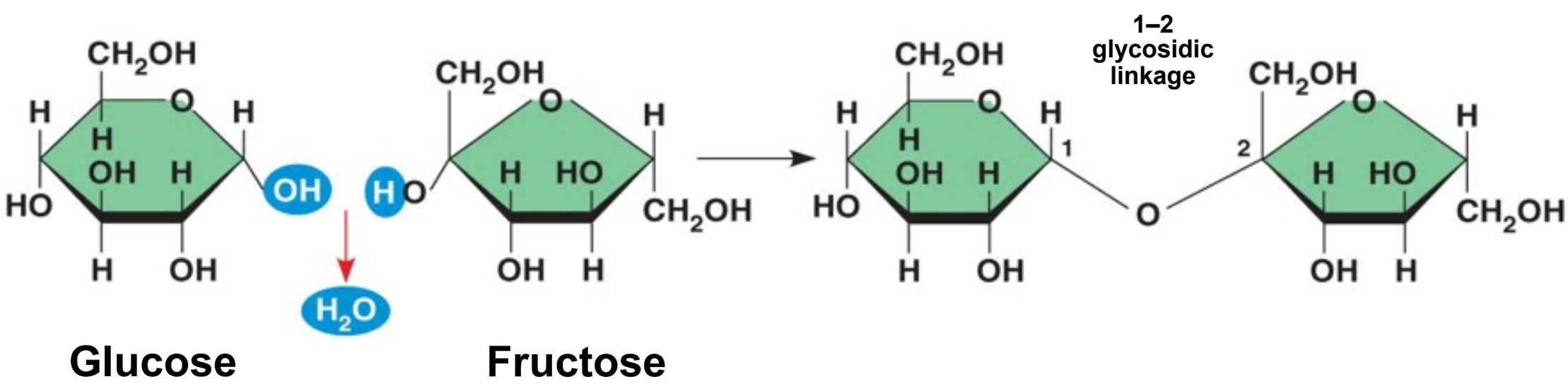
- *Disaccharides;* two monomers of sugar bonded together



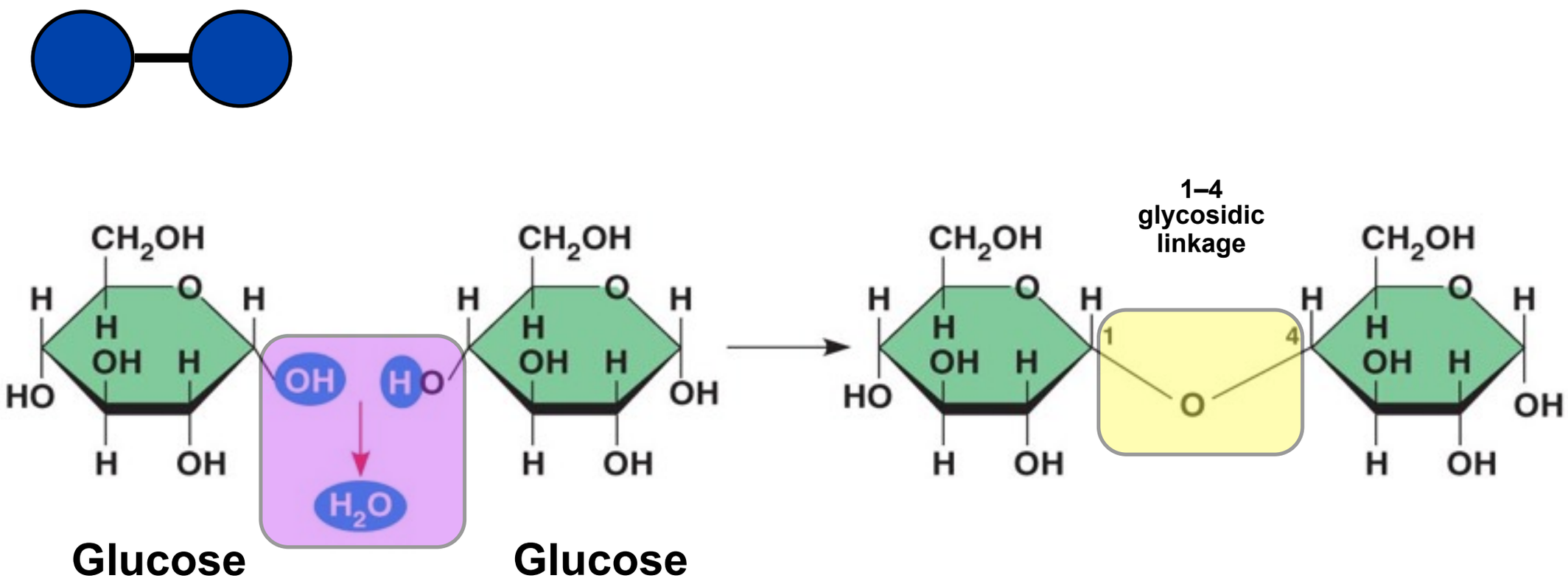


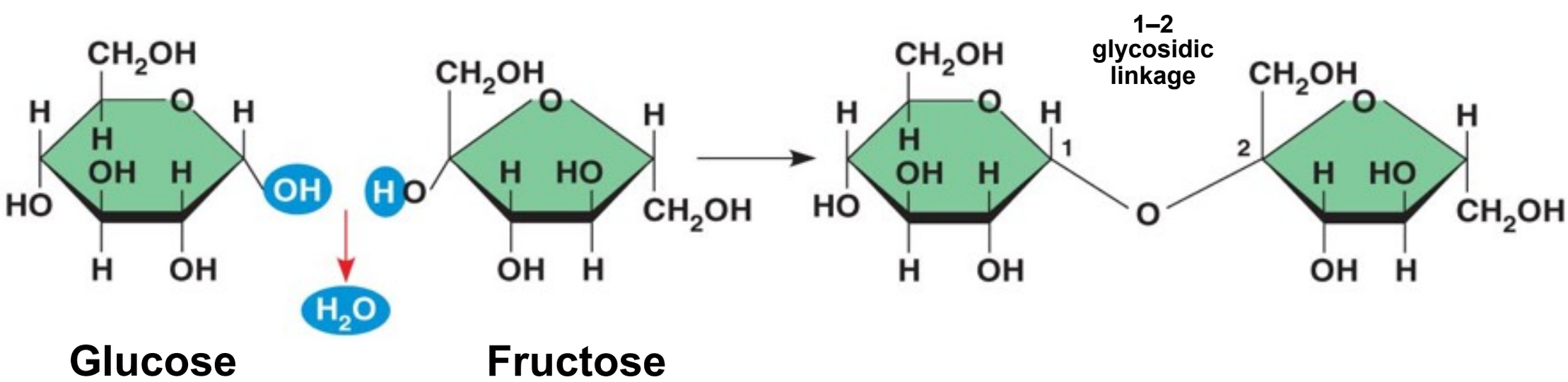
- *Disaccharides;* two monomers of sugar bonded together



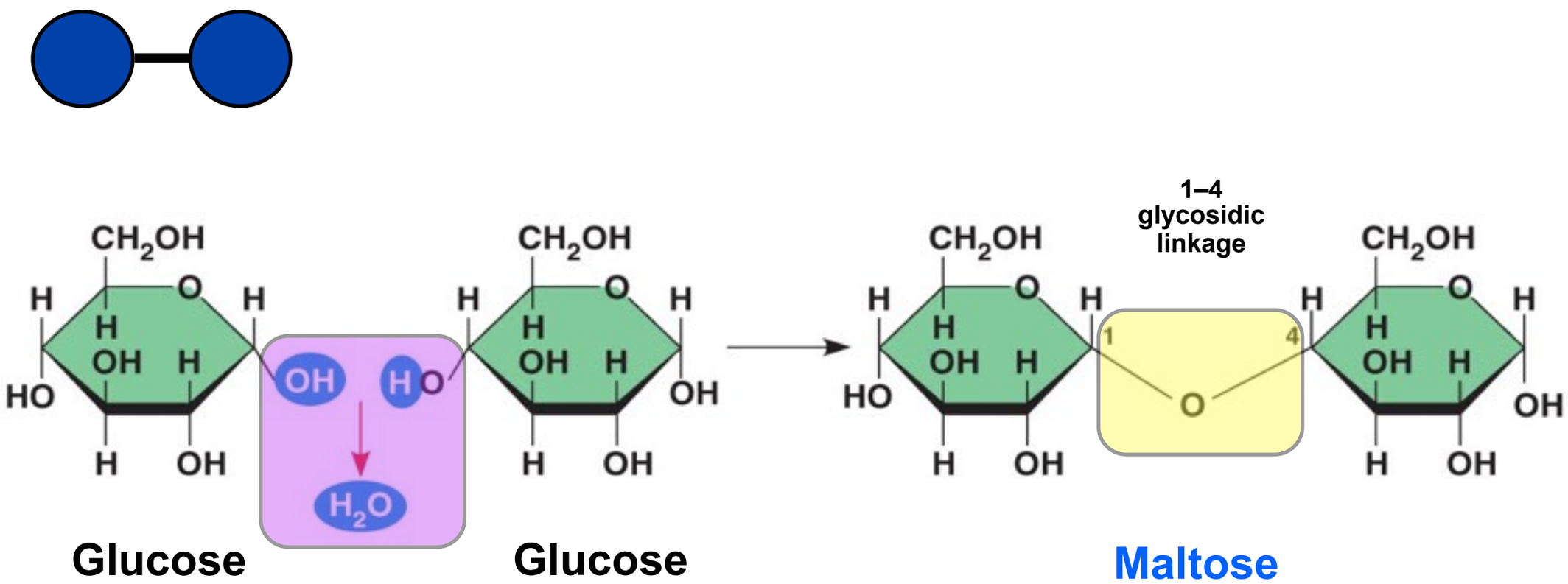


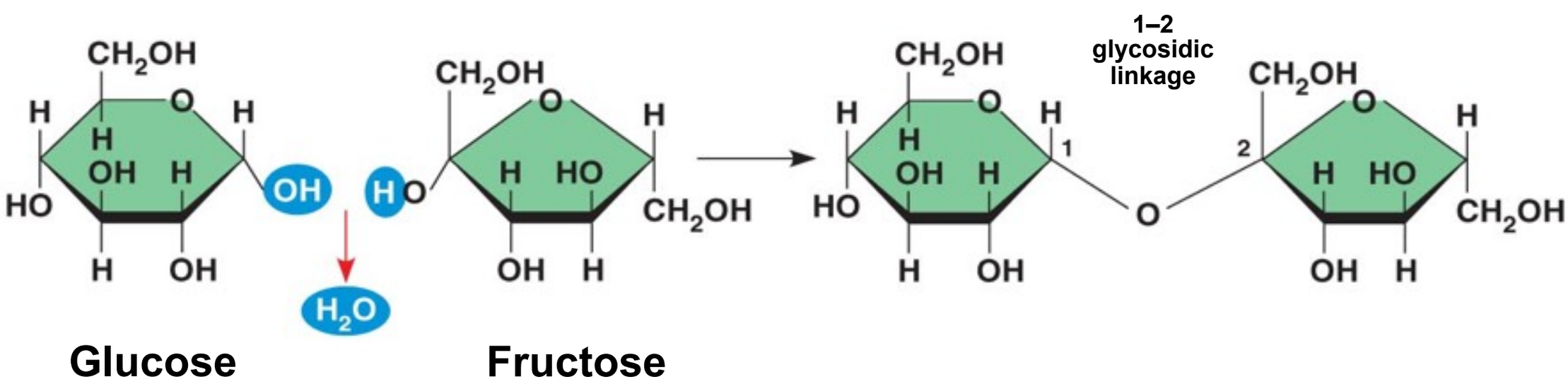
- *Disaccharides;* two monomers of sugar bonded together



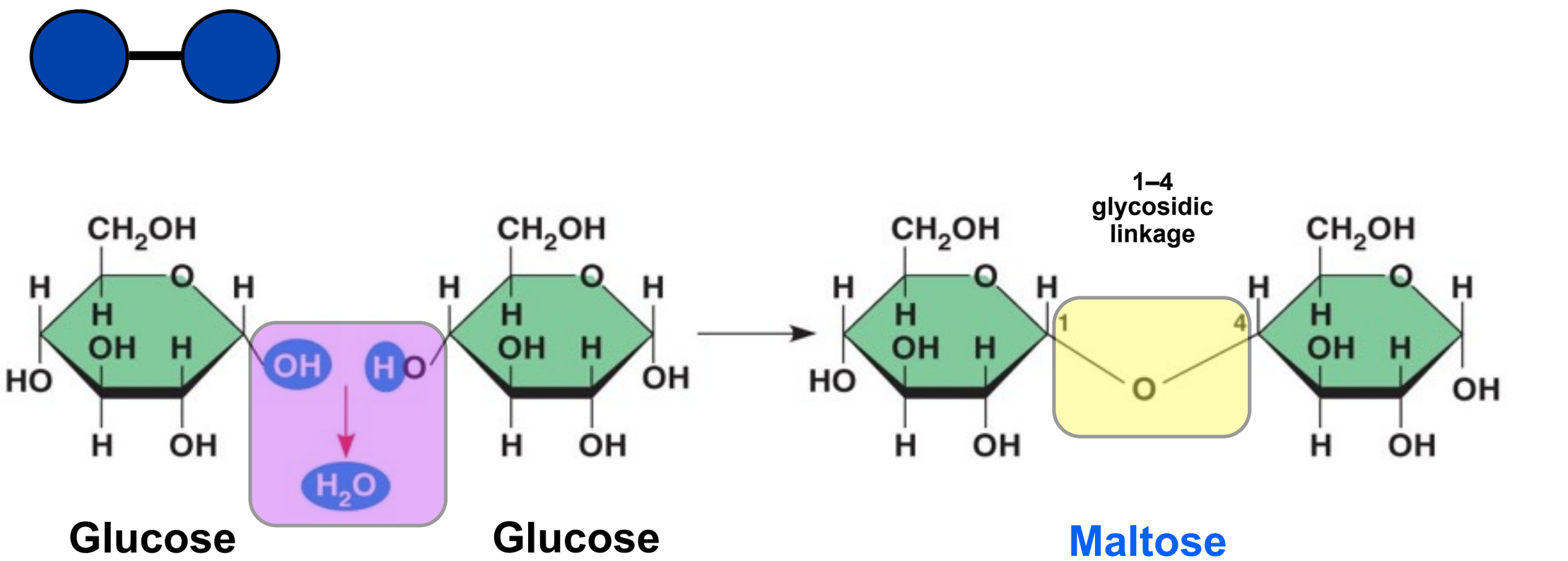


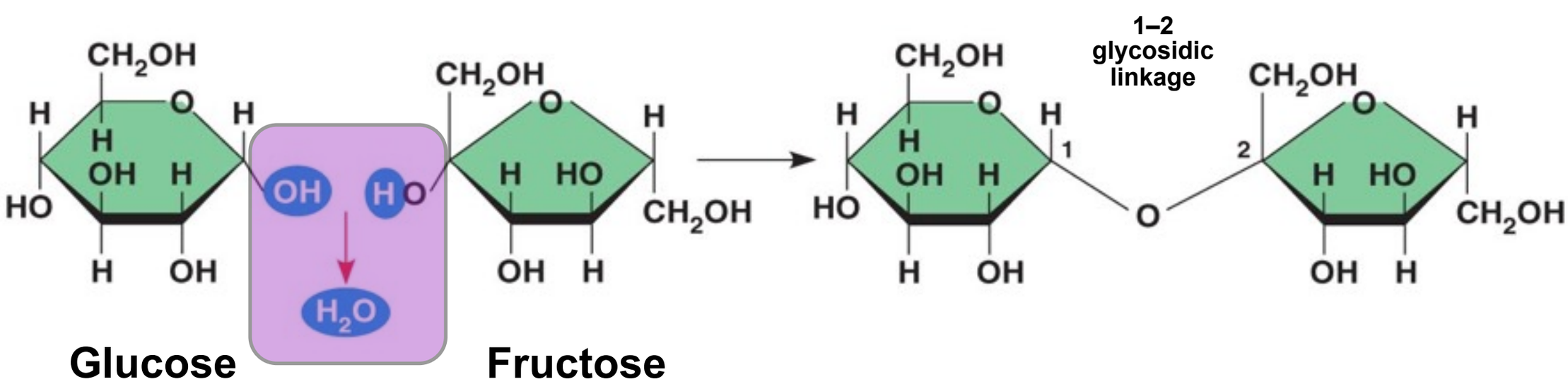
- *Disaccharides;* two monomers of sugar bonded together



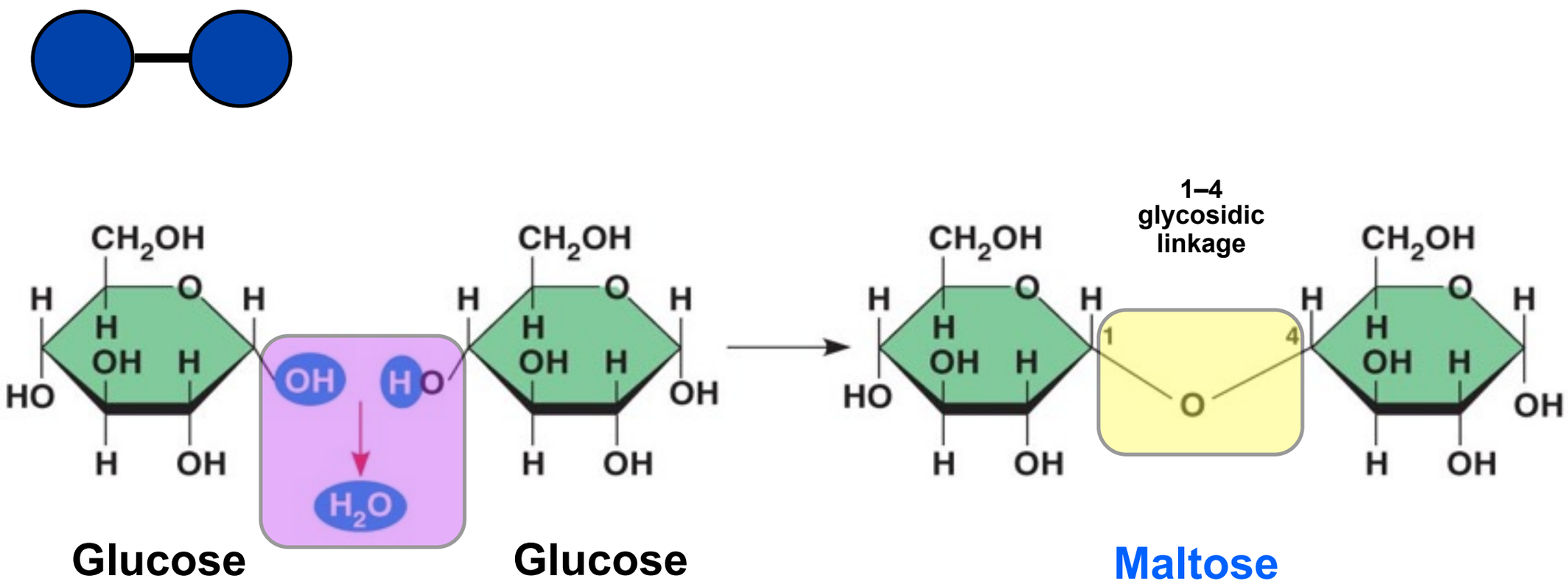


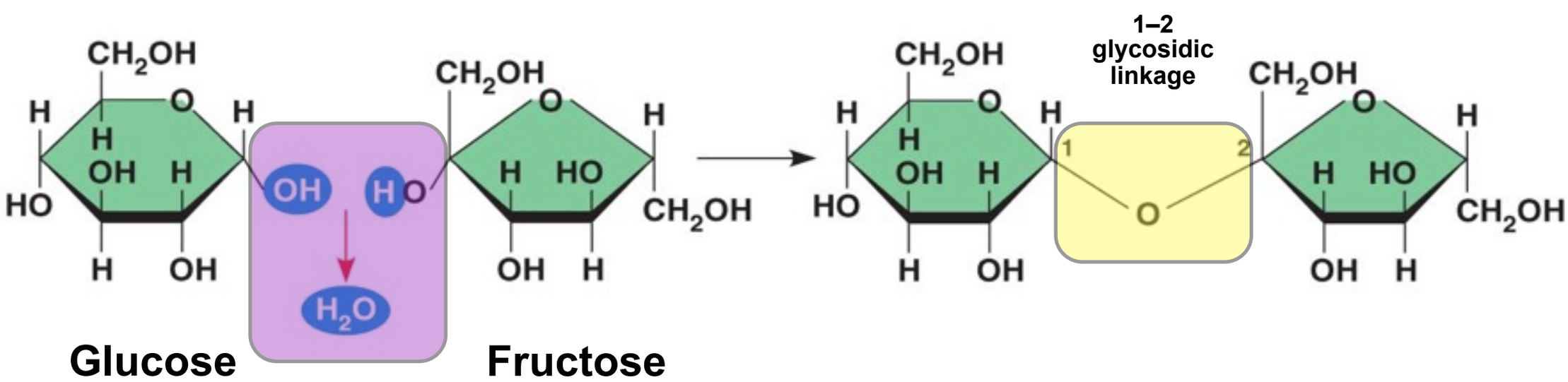
- *Disaccharides;* two monomers of sugar bonded together



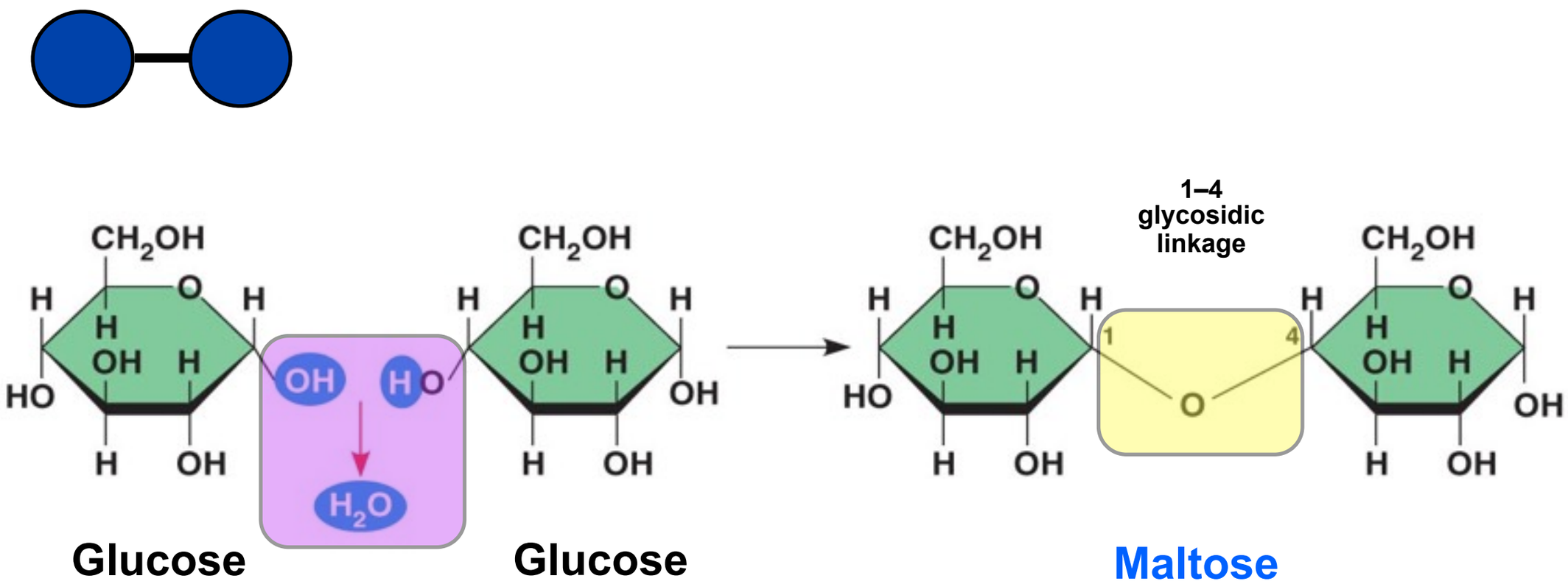


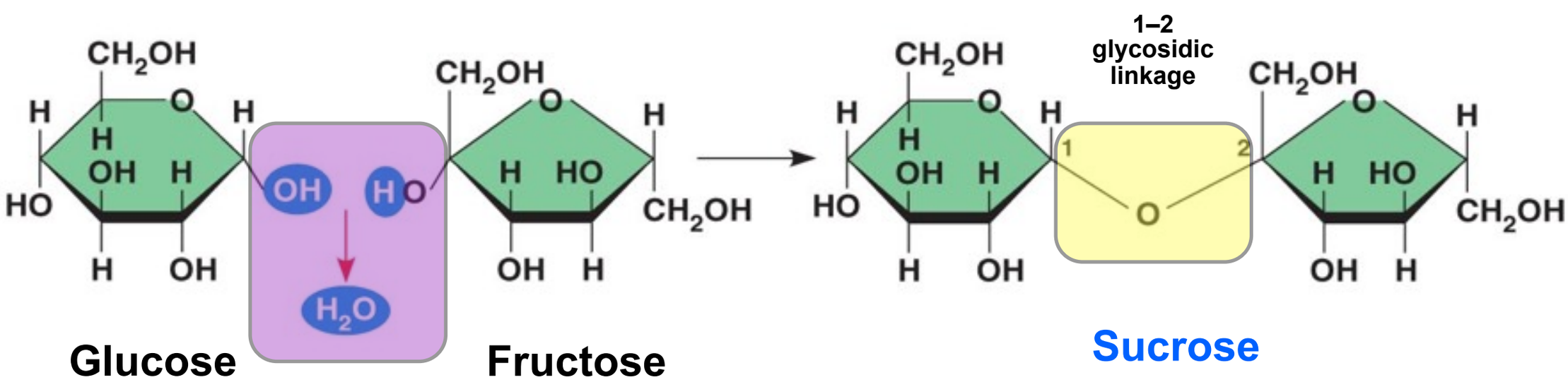
- *Disaccharides;* two monomers of sugar bonded together



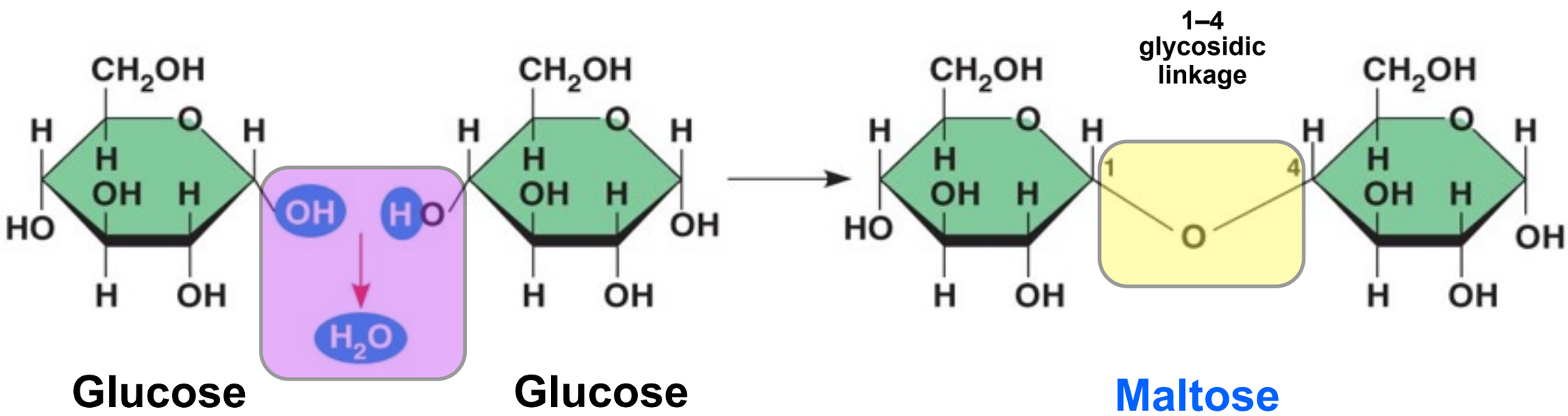


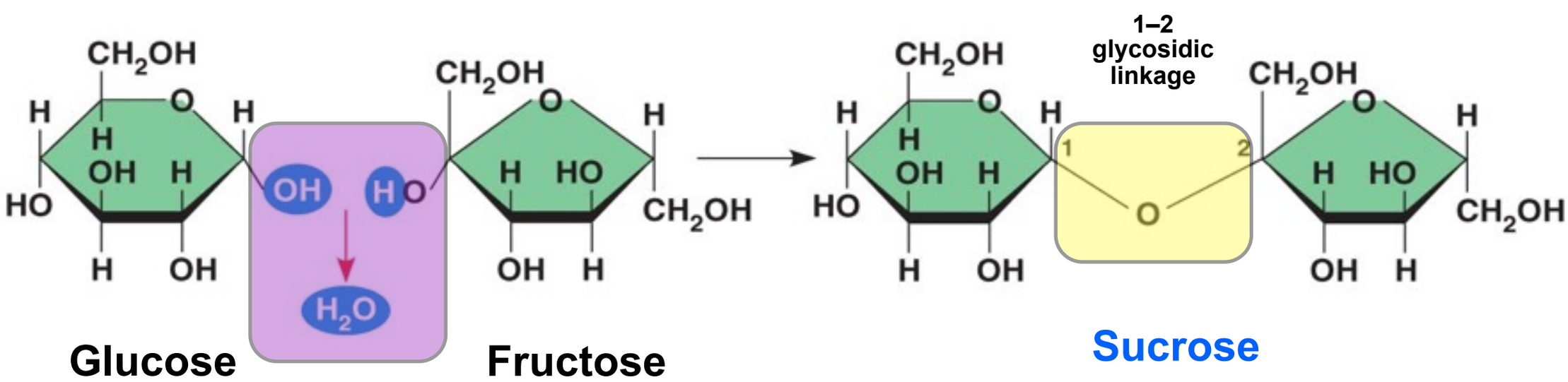
- *Disaccharides;* two monomers of sugar bonded together





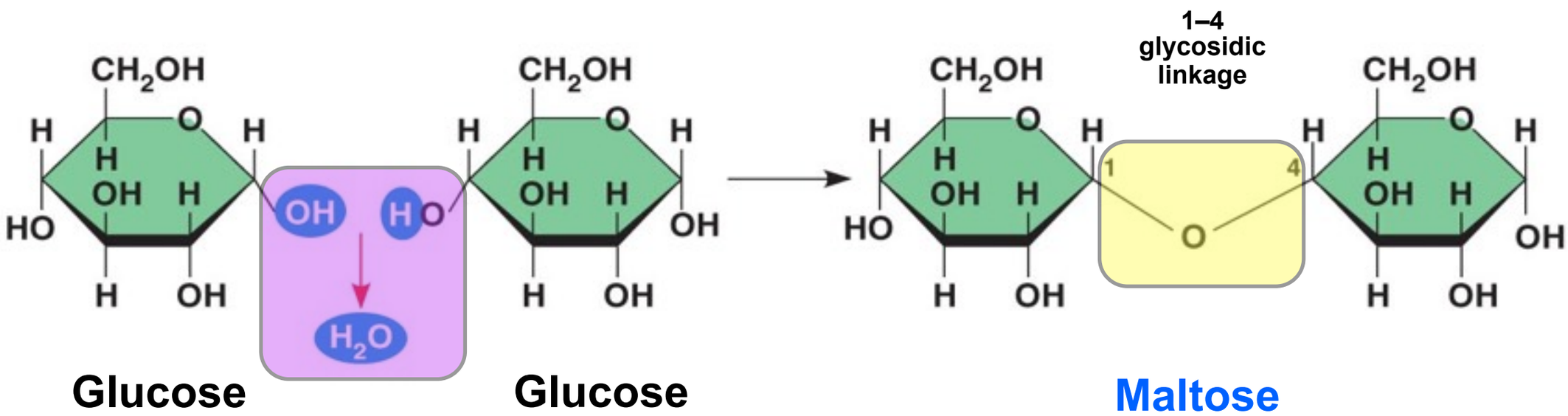
- *Disaccharides;* two monomers of sugar bonded together

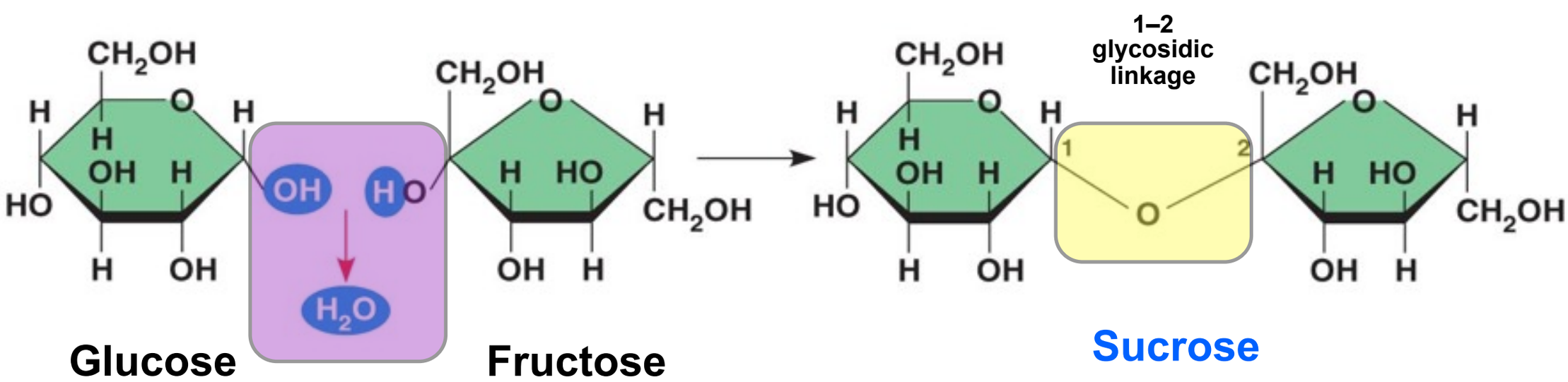




Glucose + Galactose = ?

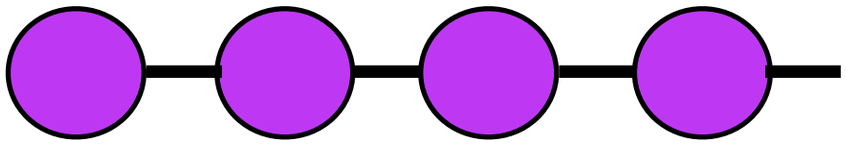
- *Disaccharides;* two monomers of sugar bonded together





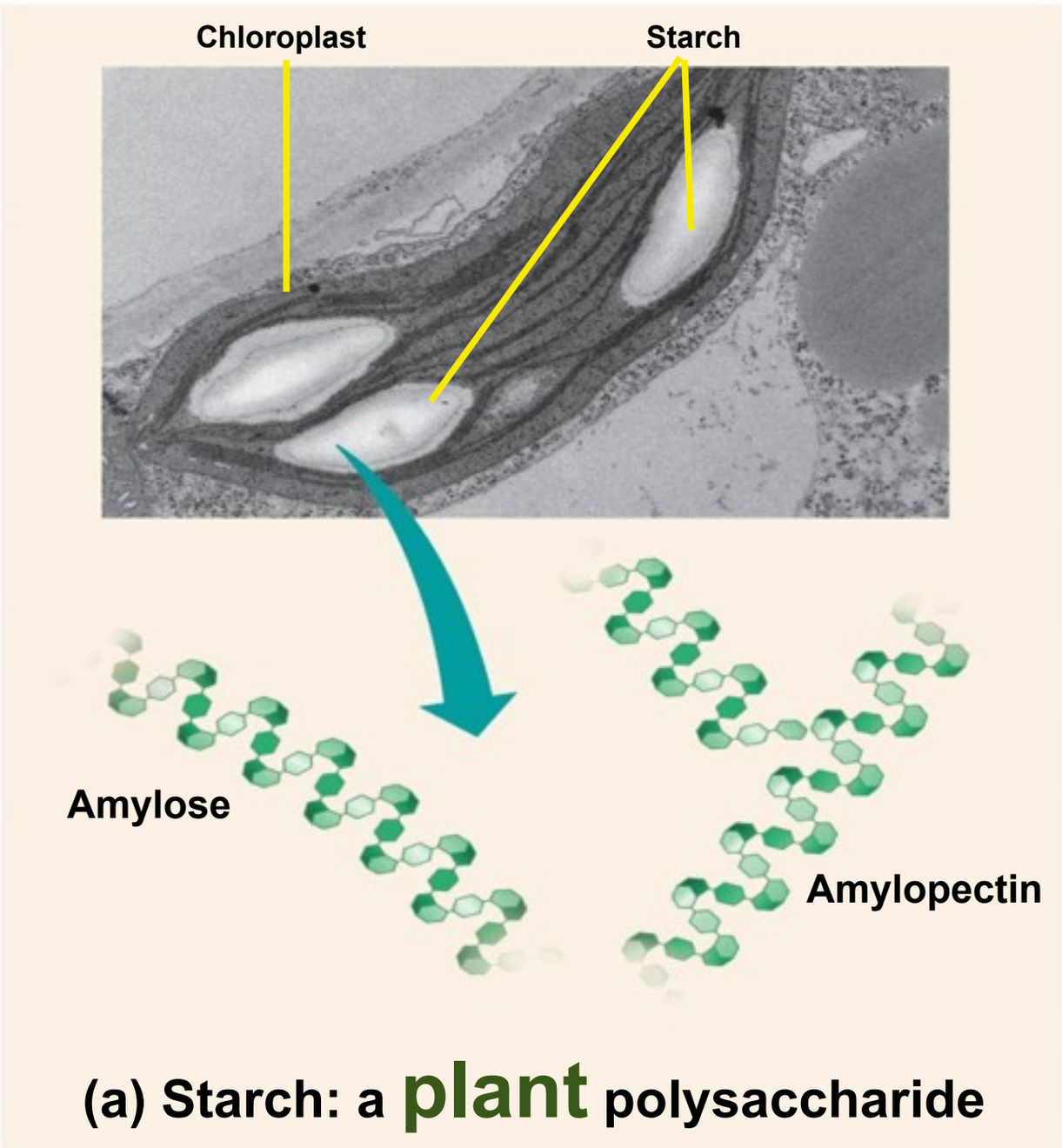
Glucose + Galactose = ? **Lactose**

- *Polysaccharides;* monomers of sugars bonded together

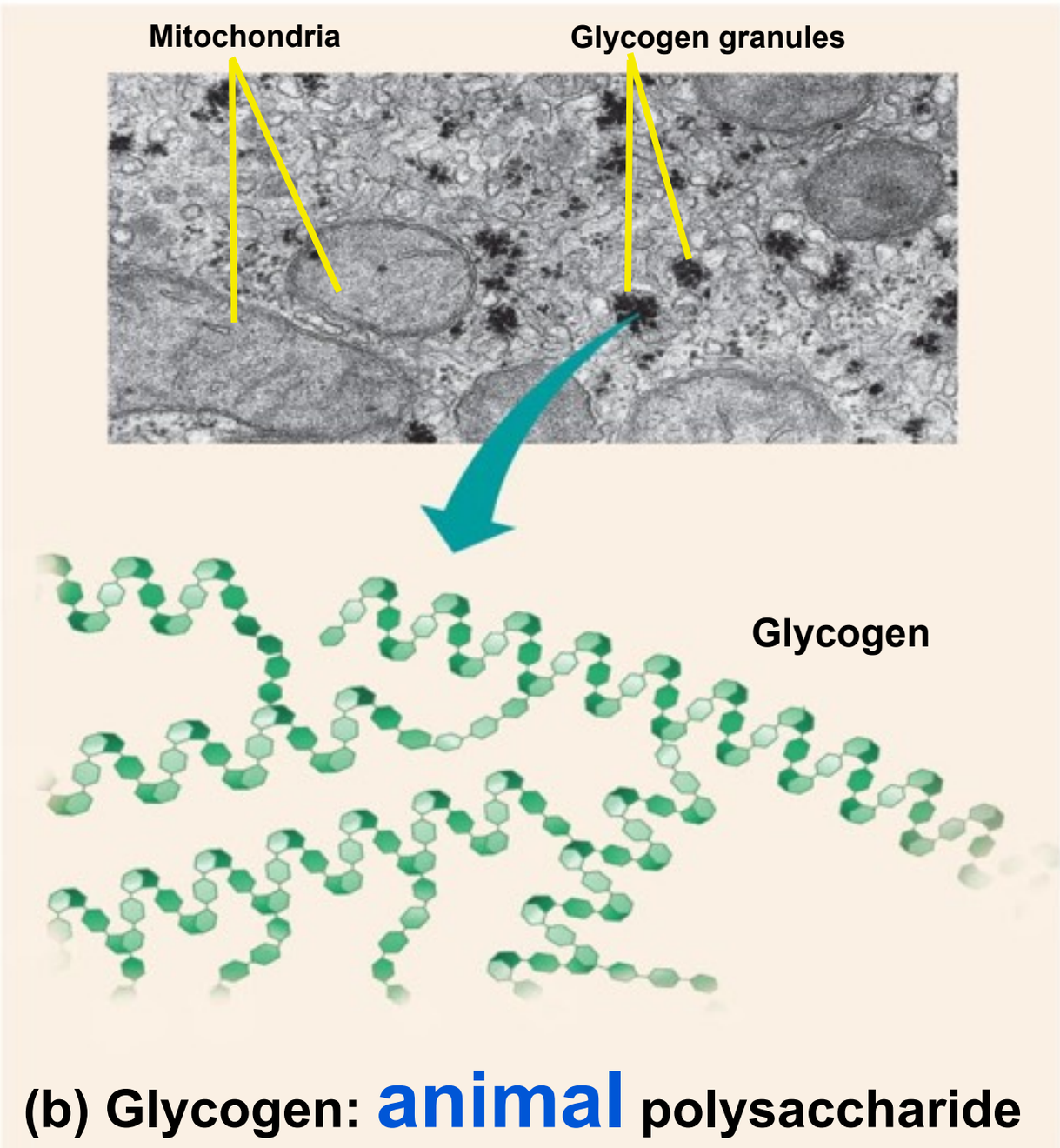


a few hundred to a few thousand

Storage Polysaccharides



(a) Starch: a **plant** polysaccharide



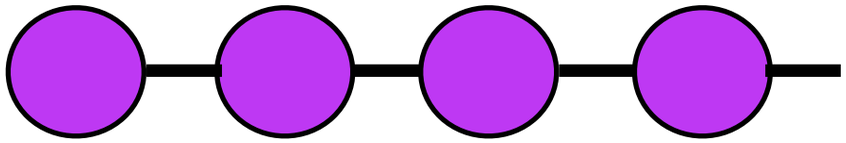
(b) Glycogen: **animal** polysaccharide

Essential knowledge 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.

b. Directionality influences structure and function of the polymer.

3. The nature of the bonding between carbohydrate subunits determines their relative orientation in the carbohydrate, which then determines the secondary structure of the carbohydrate.

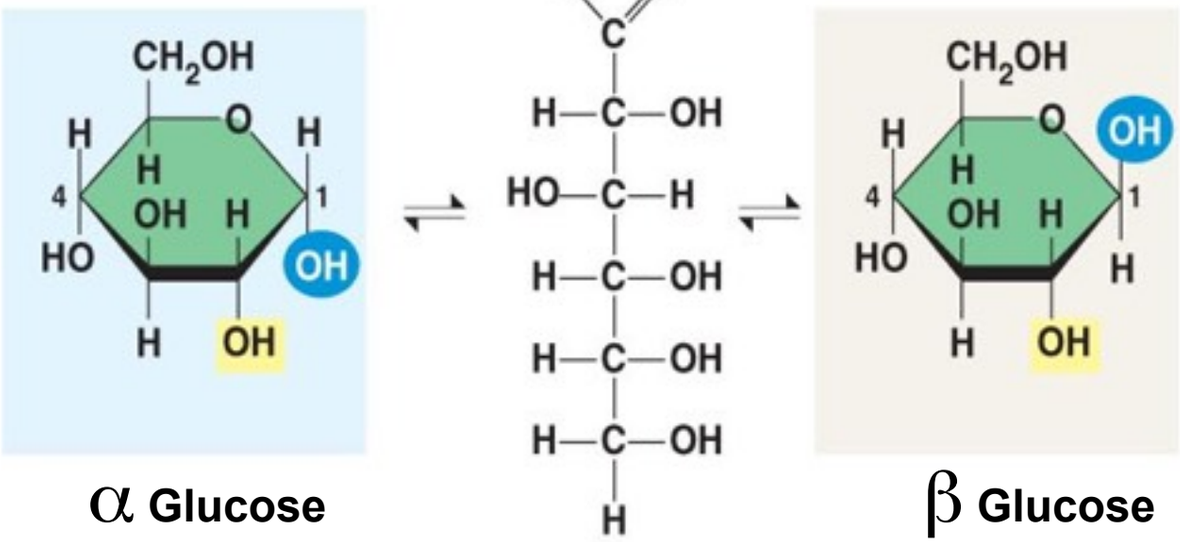
- *Polysaccharides;* monomers of sugars bonded together

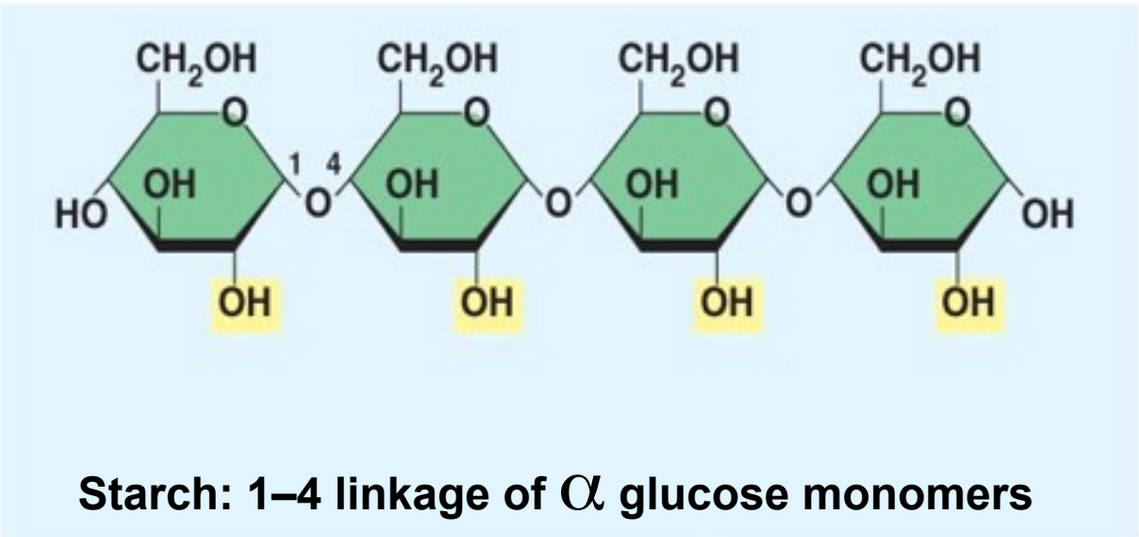


a few hundred to a few thousand

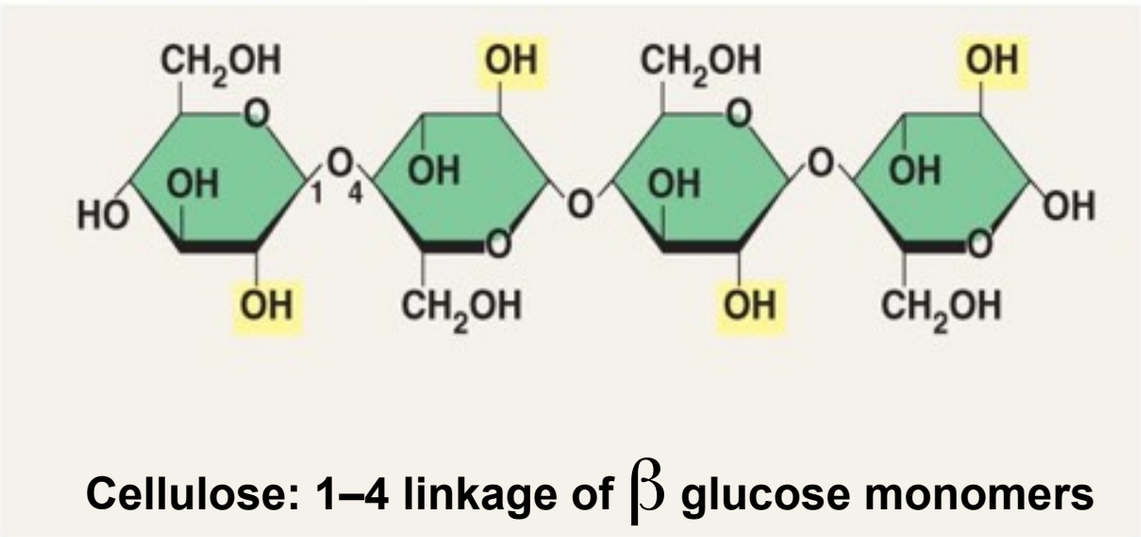
Structural Polysaccharides

α and β glucose ring structures



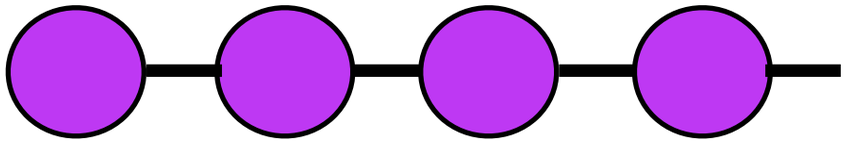


Starch: 1–4 linkage of α glucose monomers



Cellulose: 1–4 linkage of β glucose monomers

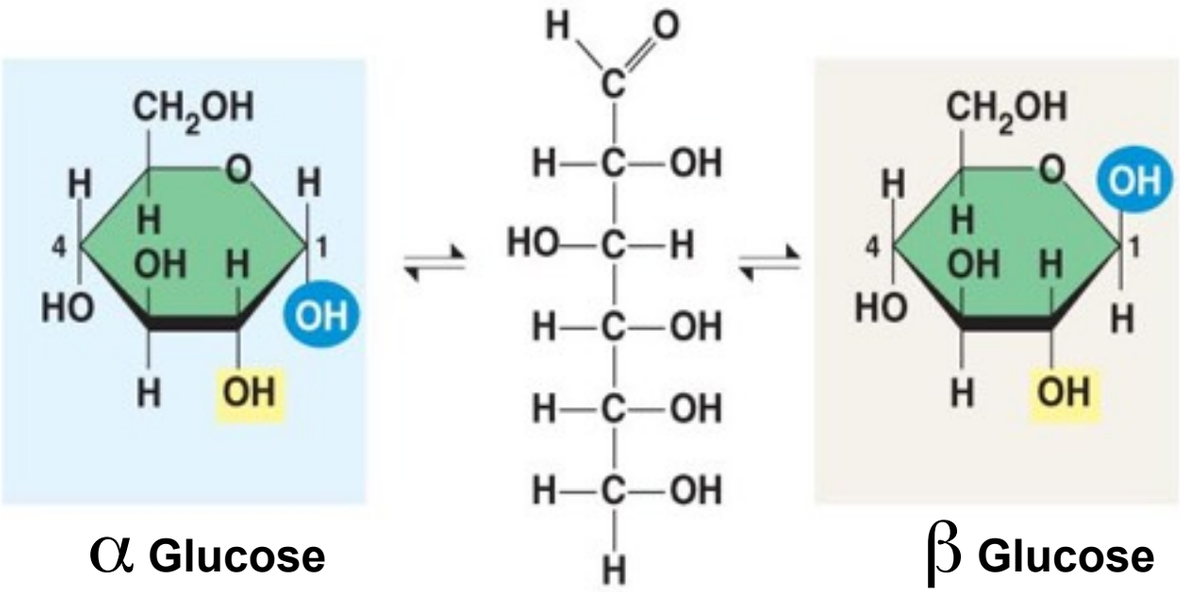
- *Polysaccharides;* monomers of sugars bonded together



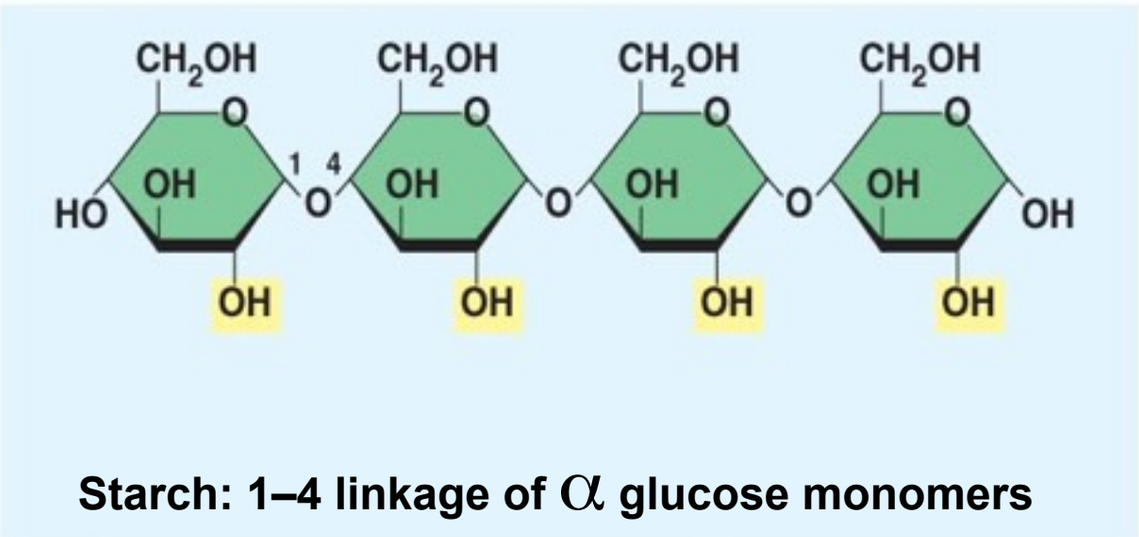
a few hundred to a few thousand

Structural Polysaccharides

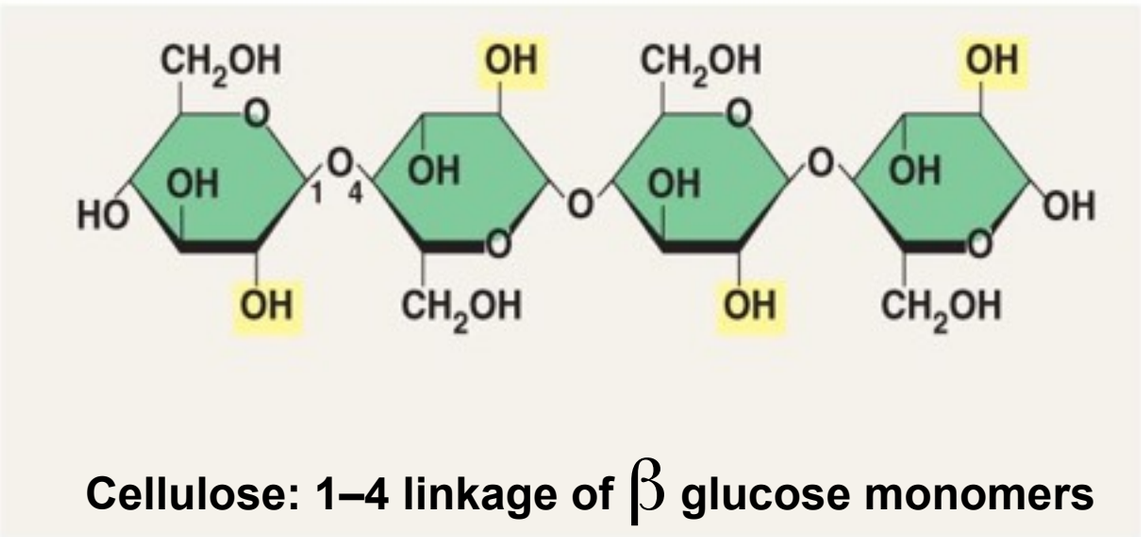
α and β glucose ring structures



Helical

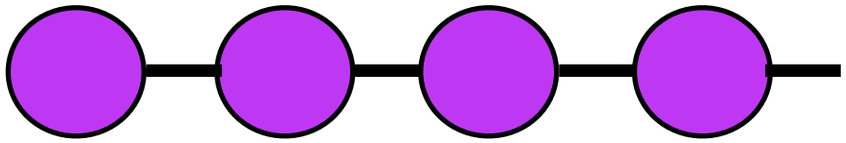


Starch: 1–4 linkage of α glucose monomers



Cellulose: 1–4 linkage of β glucose monomers

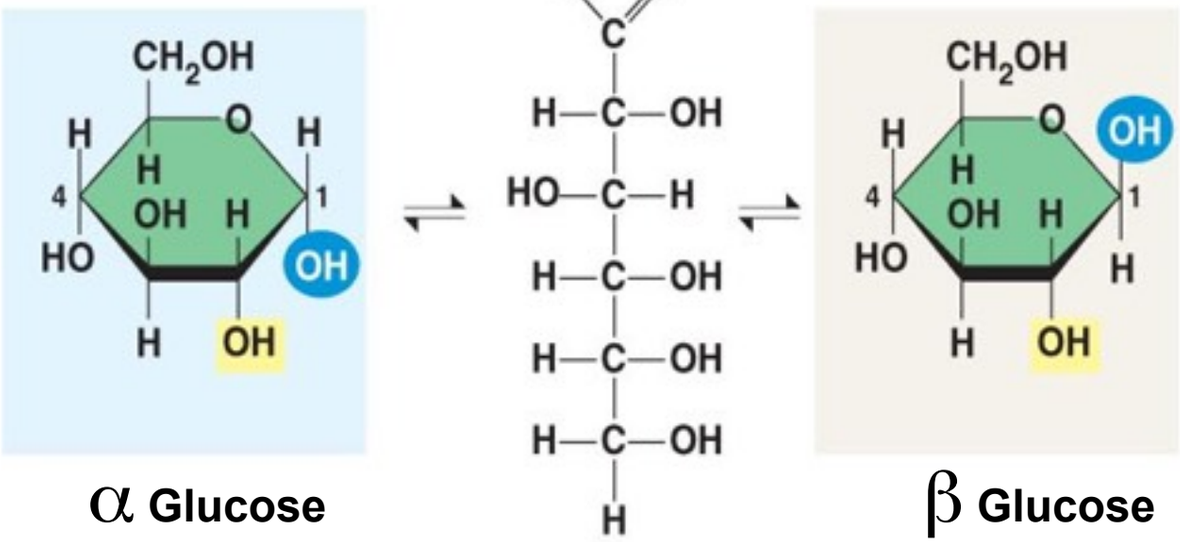
- *Polysaccharides;* monomers of sugars bonded together



a few hundred to a few thousand

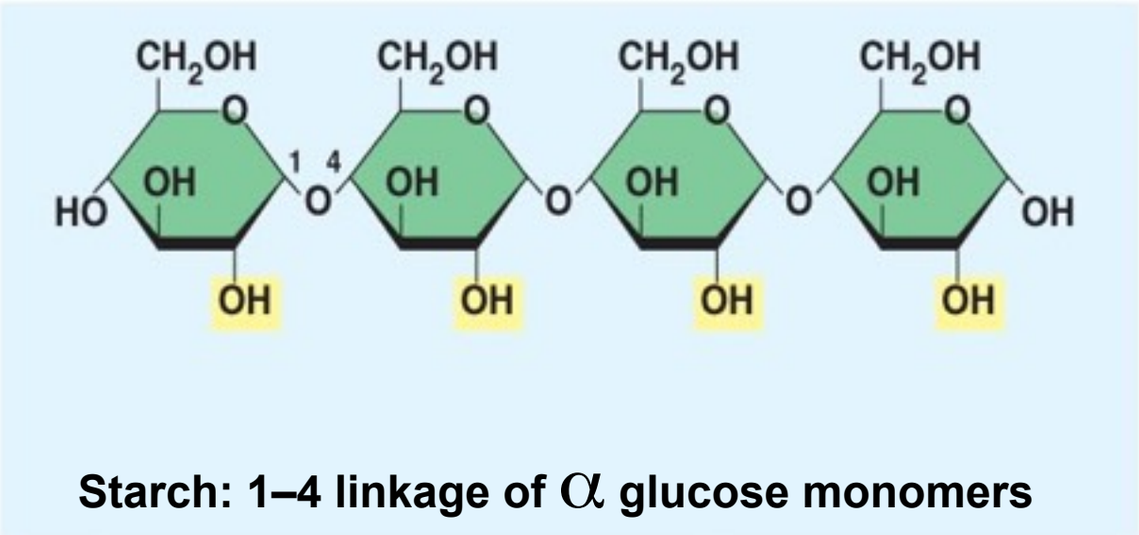
Structural Polysaccharides

α and β glucose ring structures

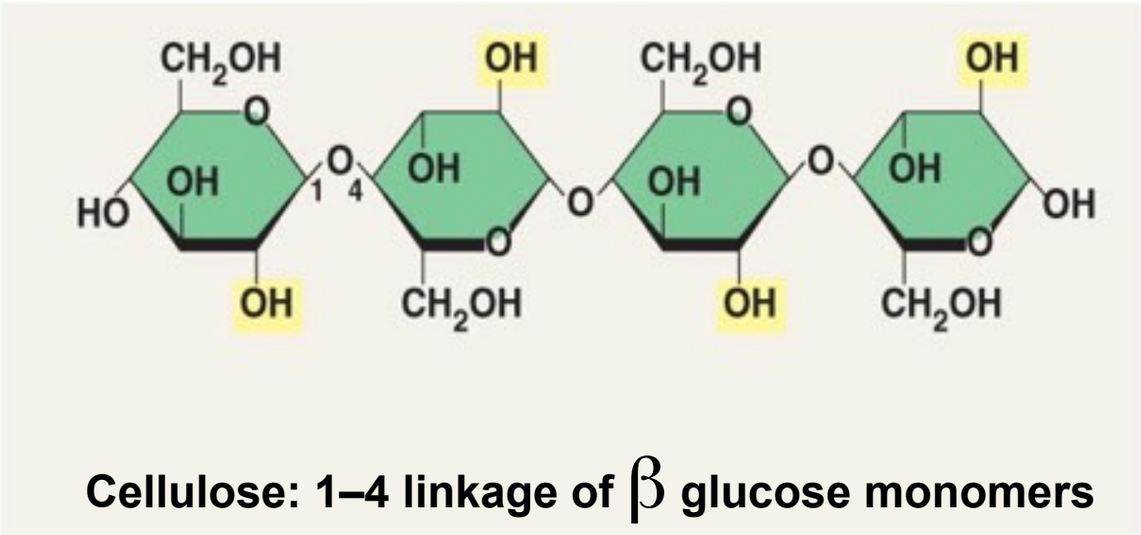


Helical

Straight

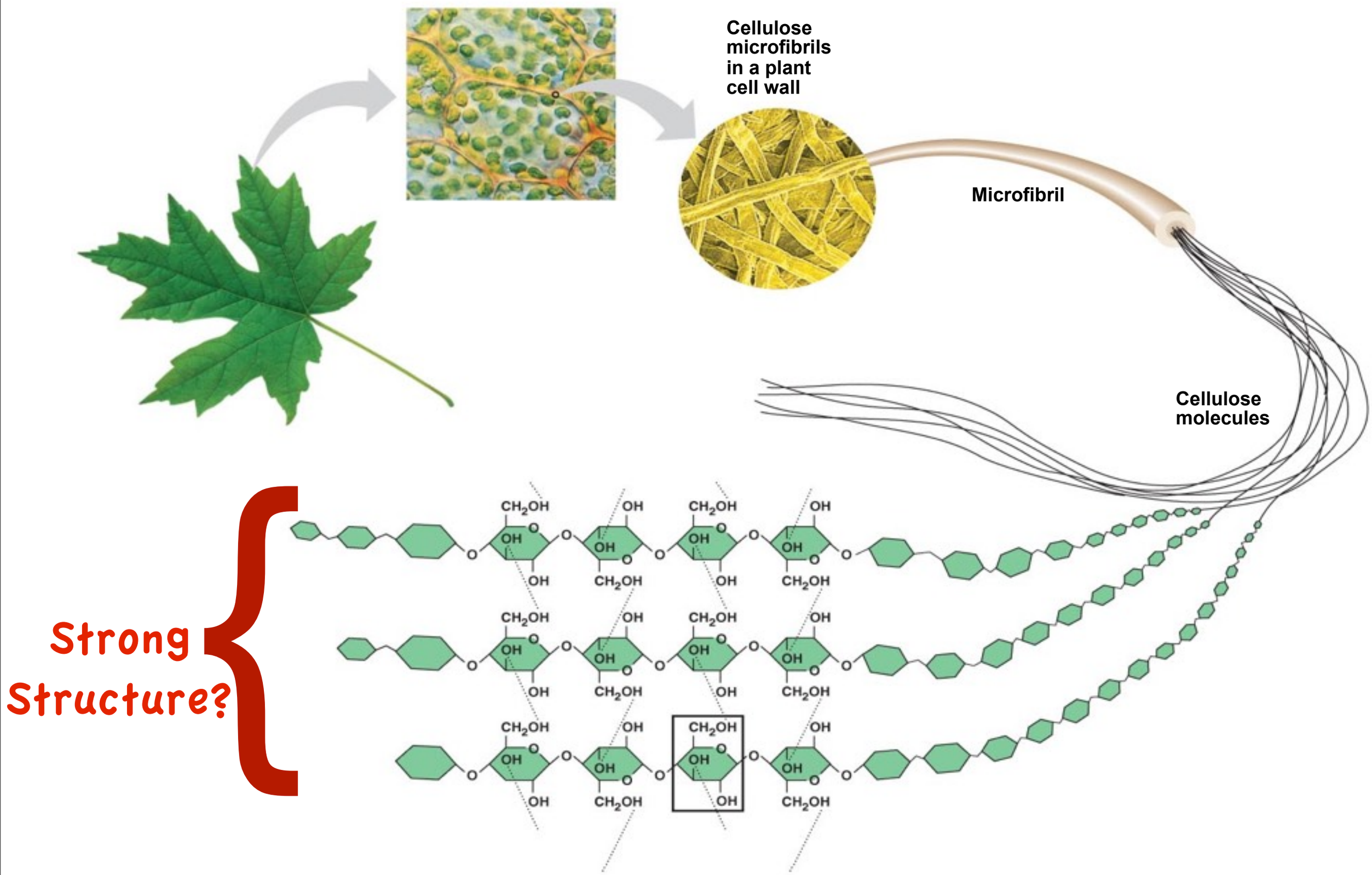


Starch: 1–4 linkage of α glucose monomers



Cellulose: 1–4 linkage of β glucose monomers

Structural Polysaccharides



Cable from Bridge

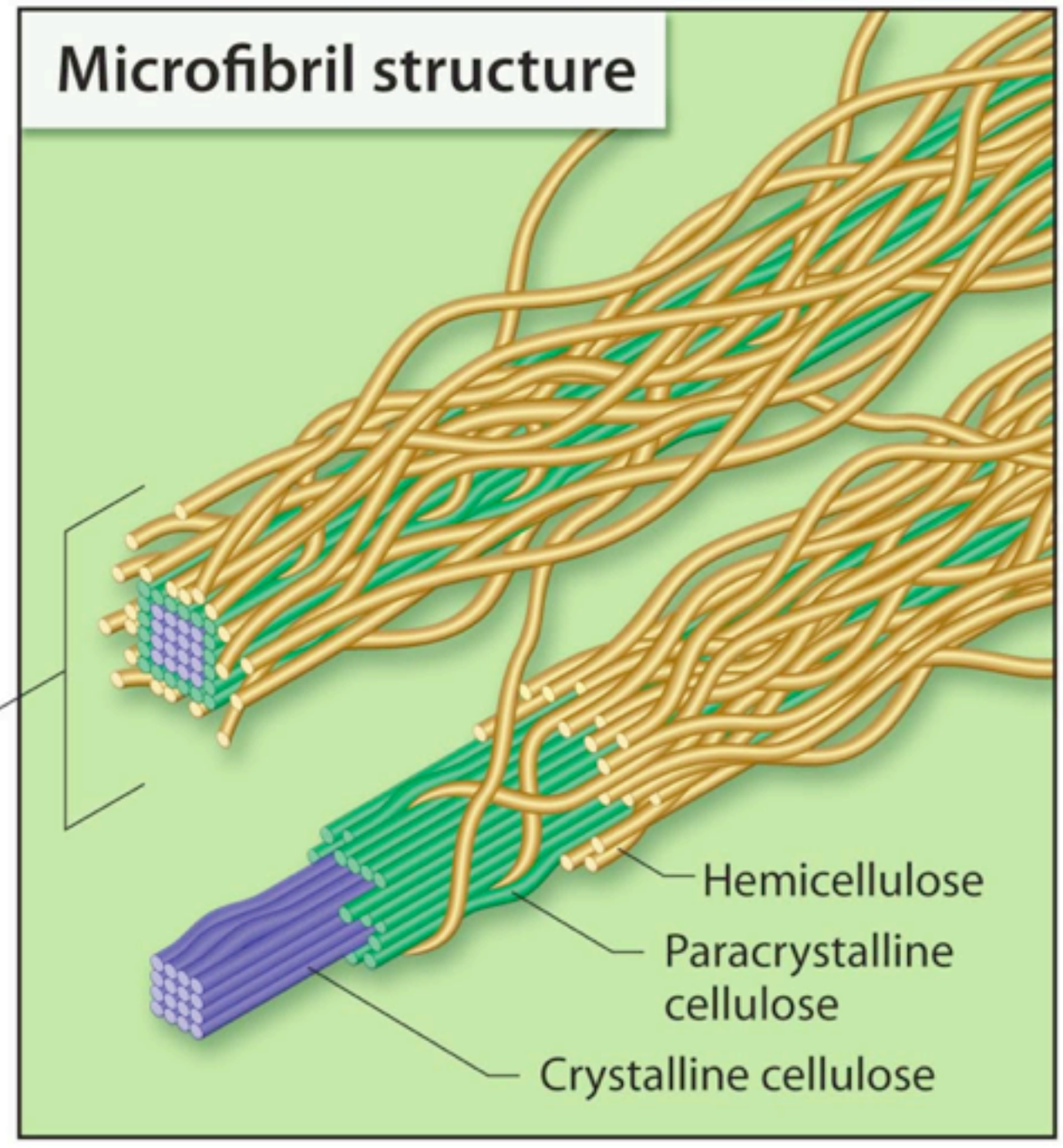

Cable from Bridge
GOLDEN GATE BRIDGE
MAIN SPAN
4200 FEET
LENGTH OF ONE CABLE . . . 7650 FT. (2331.7m)
DIAMETER OF ONE CABLE . . . 36 5/8 IN. (92.4 cm)
WIRES IN EACH CABLE . . . 27,572
TOTAL WIRE USED . . . 80,000 MILES (128,748 km)
WEIGHT OF CABLE . . . 24,500 TONS (22,226 m. tons)
Cable Contractor: John A. Roebling's Sons Co
Trenton & Roebling, New Jersey


GOLDEN GATE BRIDGE
MAIN SPAN
4200 FEET
LENGTH OF ONE CABLE . . . 7650 FT. (2331.7m)
DIAMETER OF ONE CABLE . . . . 36 1/2 IN. (92.4 cm)
WIRES IN EACH CABLE 27,572
TOTAL WIRE USED . . . 80,000 MILES (128,748 km)
WEIGHT OF CABLE | 24,500 TONS (22,226 m. tons)
Cable Contractor: John A. Roebling's Sons Co
Trenton & Roebling, New Jersey
www.micktravels


Roebling's Sons Co
Trenton & Roebling, New Jersey

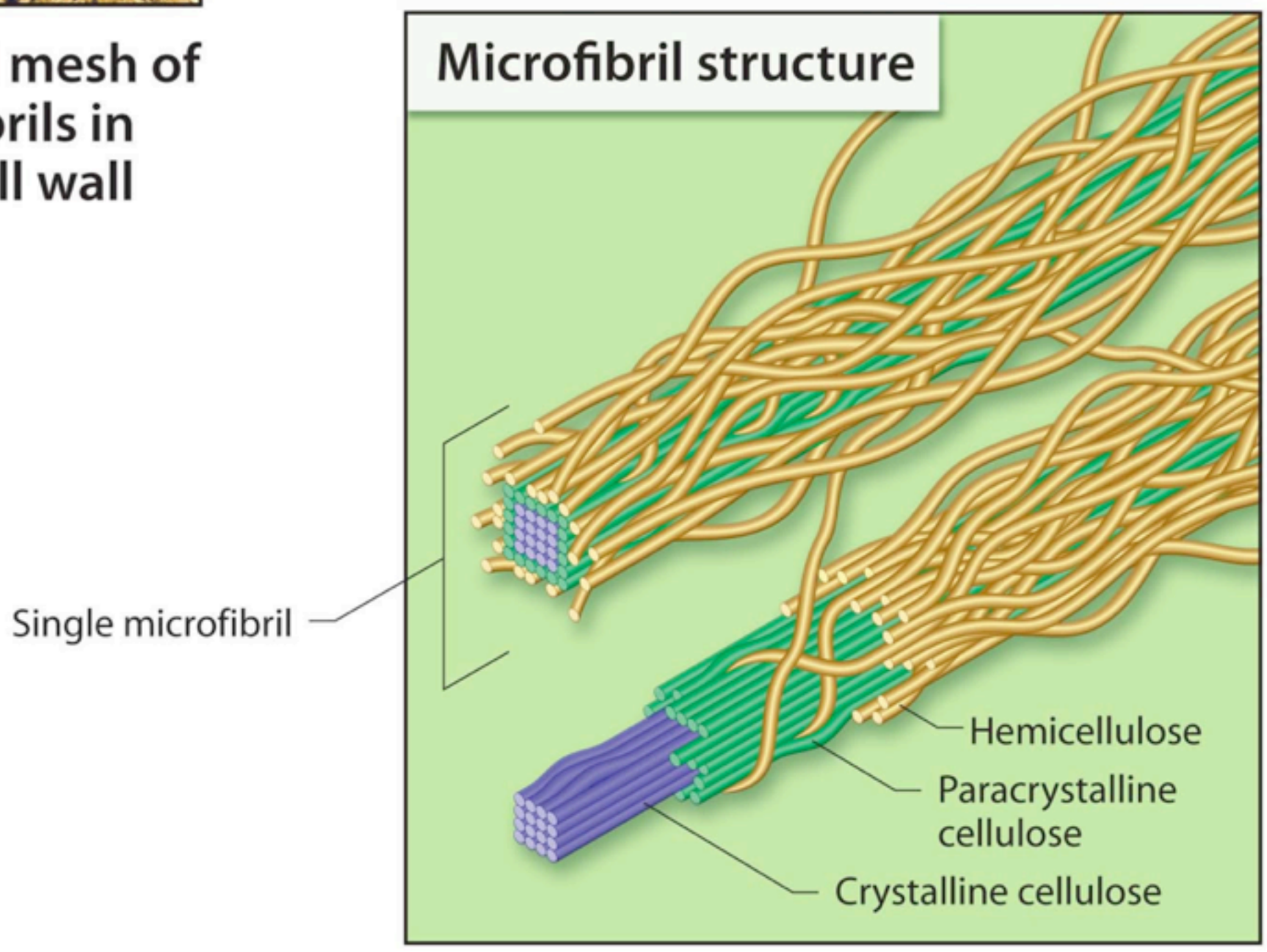

Roebling's Sons Co
Trenton & Roebling, New Jersey

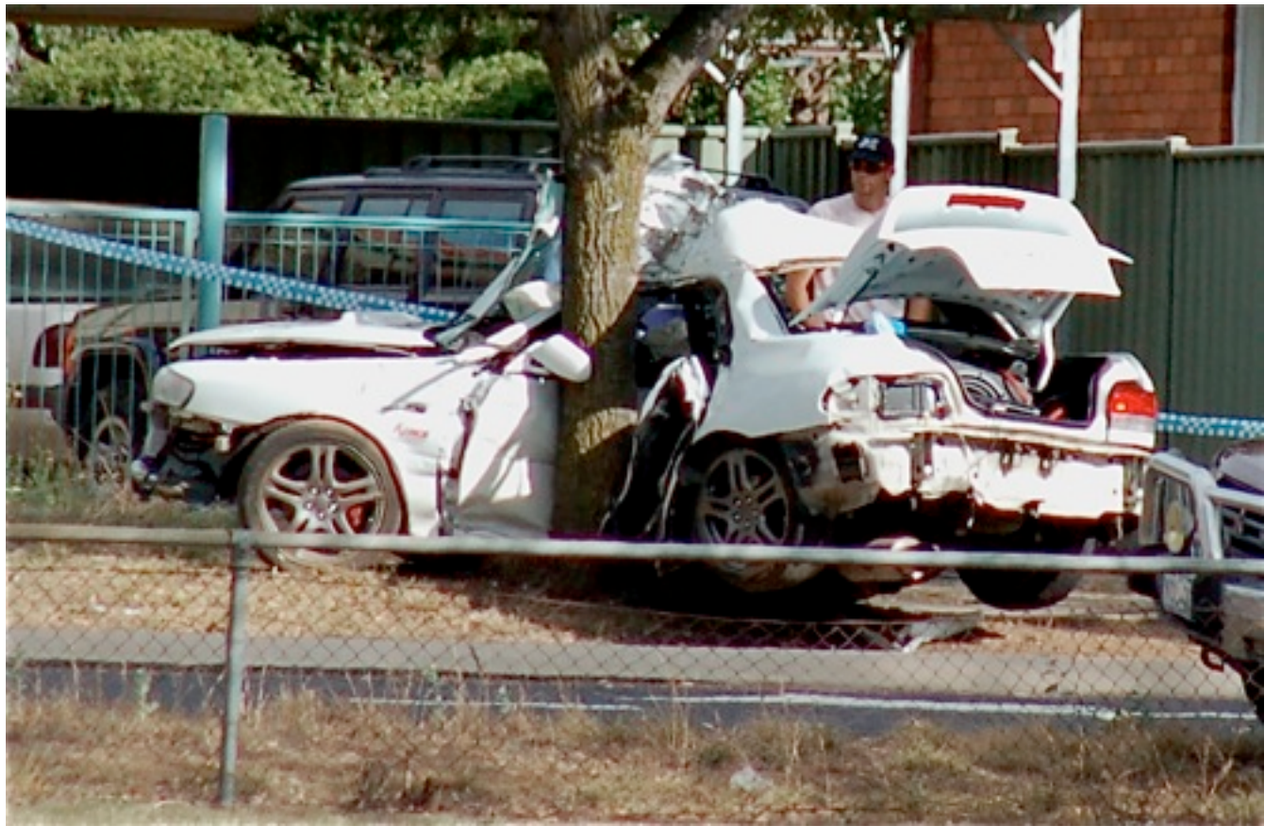
Layered mesh of microfibrils in plant cell wall

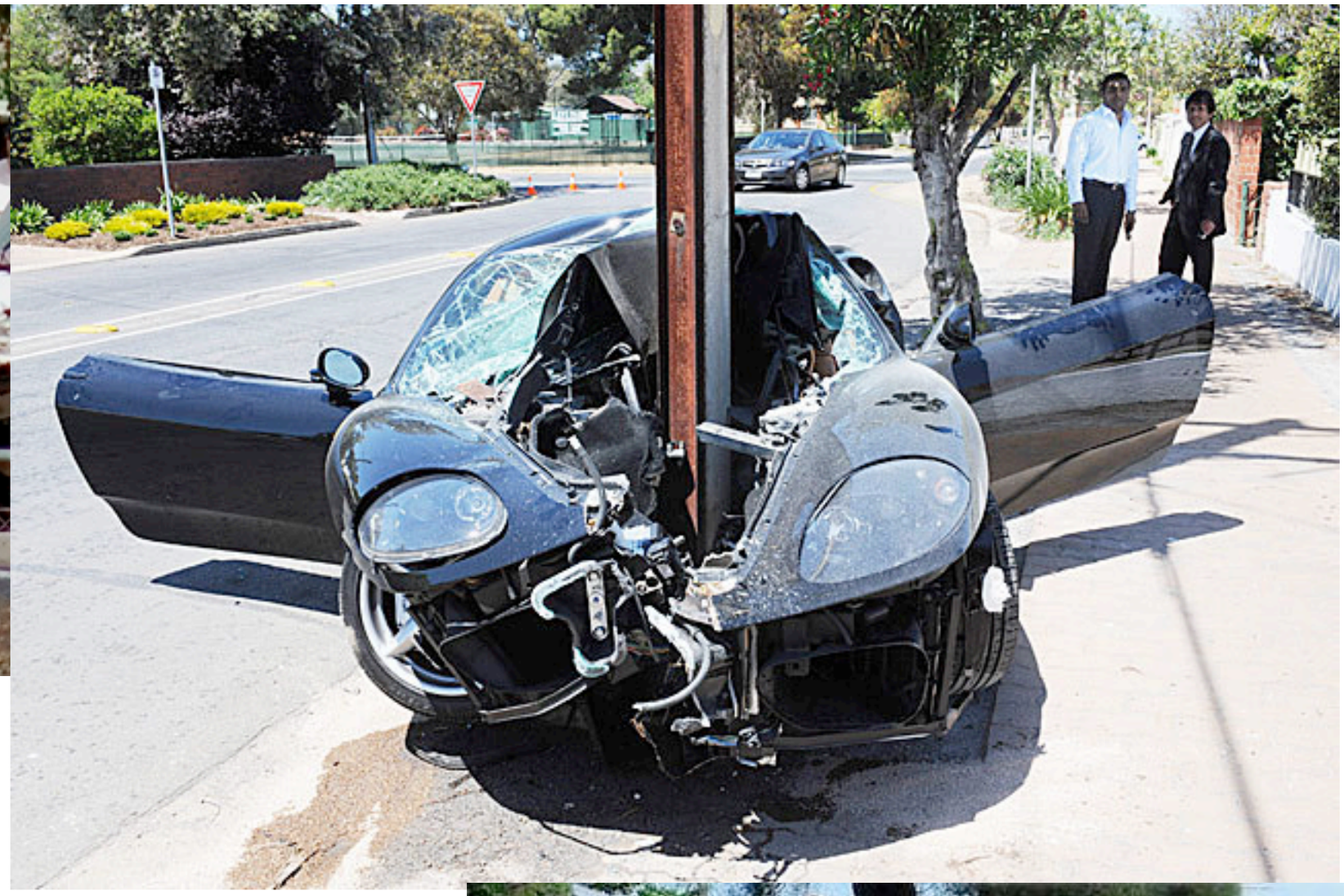


We (humans) copy nature all the time

Layered mesh of microfibrils in plant cell wall



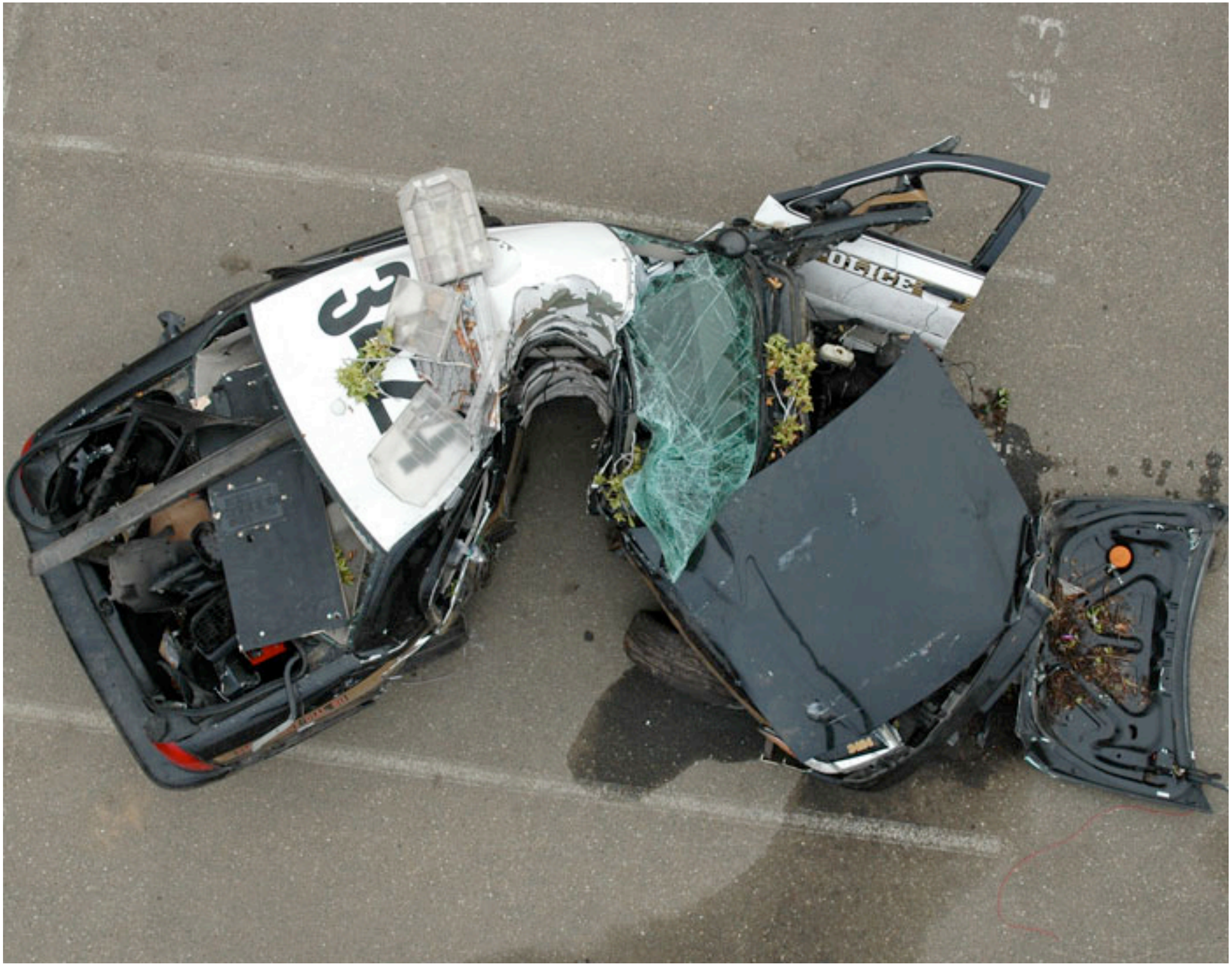





COMMUNITY
PATROL
SUPERVISOR
608

Are still questioning the strength of cellulose?

Are still questioning the strength of cellulose?

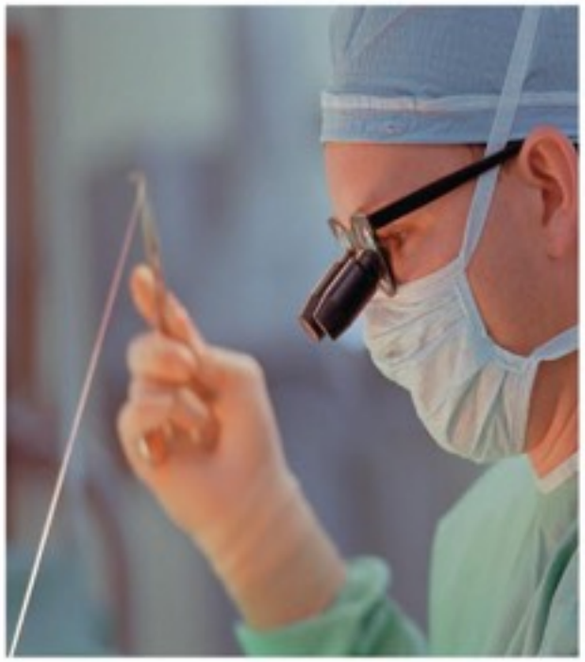


Cellulose

- Major component in plant cell walls
  - It is the most abundant organic compound on earth!
- Few organisms possess the enzyme(s) necessary to digest the β bonds found in cellulose
  - Some prokaryotes & protists
  - Many herbivores, from cows to termites, have symbiotic relationships with these microbes.
- Humans can not digest cellulose and get no energy from these sugars however cellulose is still important in a healthy diet.

Chitin

- Found in arthropods (insects, spiders and crustaceans)
  - Major component in exoskeletons
- Pure Chitin is leathery and flexible
  - Becomes very hard when encrusted with calcium carbonate.
- Fungi build their cell walls from chitin.



Functions of Carbohydrates

- They are major fuel source for cellular work
  - Sugars are used indirectly to power cellular processes, ATP is the direct cellular fuel
- They act as building blocks for other types of organic molecules
  - Sugars are used structurally by organisms
  - Sugars also serve as cellular ID tags

Learning Objectives:

LO 4.1 The student is able to explain the connection between the sequence and the subcomponents of a biological polymer and its properties. [See **SP 7.1**]

LO 4.2 The student is able to refine representations and models to explain how the subcomponents of a biological polymer and their sequence determine the properties of that polymer.

[See **SP 1.3**]

LO 4.3 The student is able to use models to predict and justify that changes in the subcomponents of a biological polymer affect the functionality of the molecule. [See **SP 6.1, 6.4**]