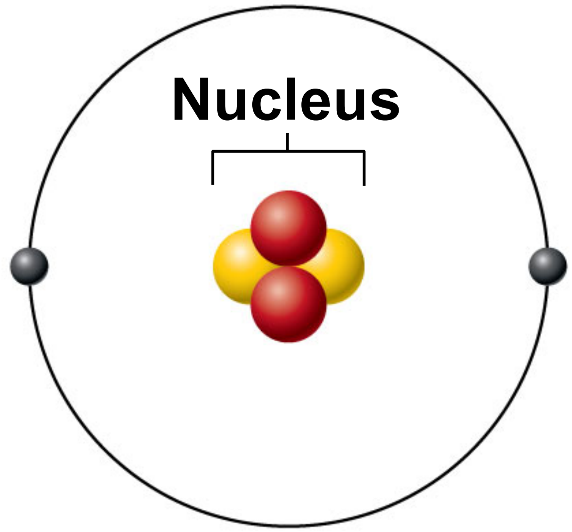
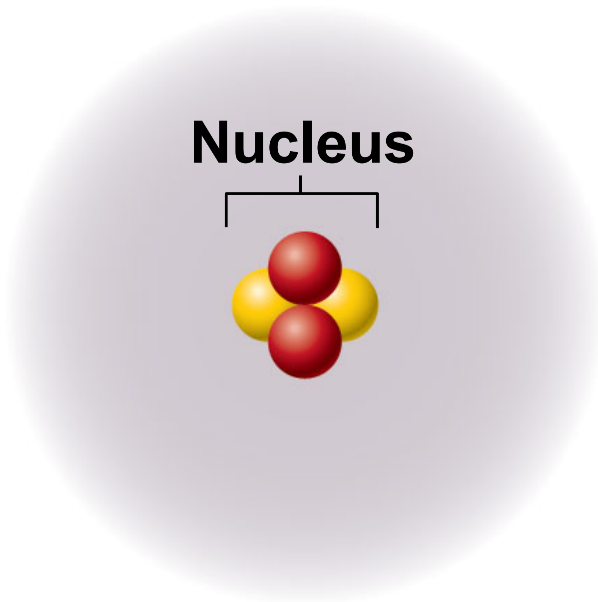


Helium atom

2 protons (p^+)
2 neutrons (n^0)
2 electrons (e^-)

(a) Planetary model

KEY:
Proton
Electron
Neutron

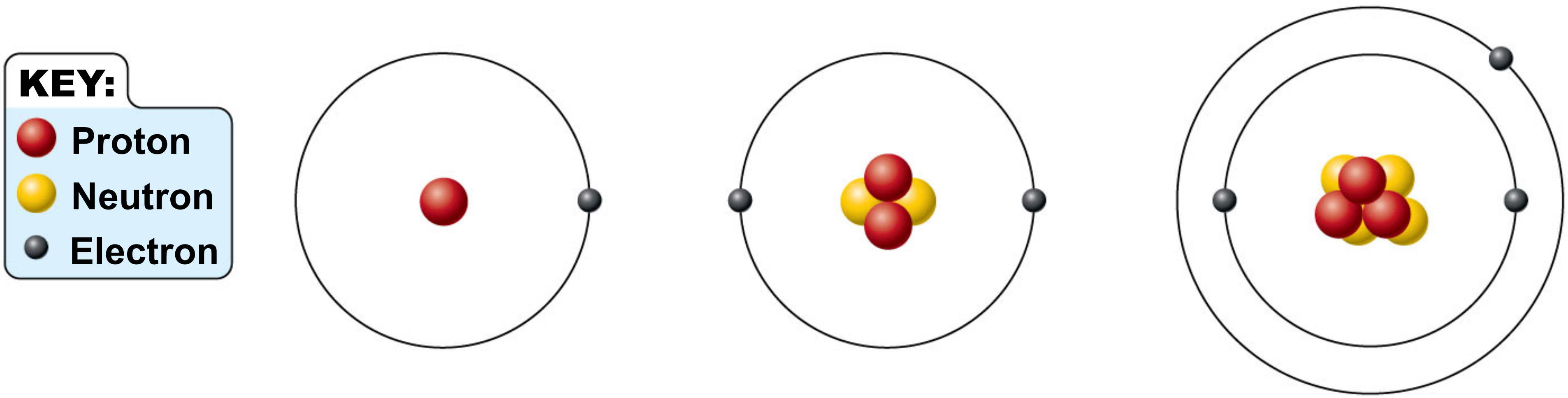


Helium atom

2 protons (p^+)
2 neutrons (n^0)
2 electrons (e^-)

(b) Orbital model

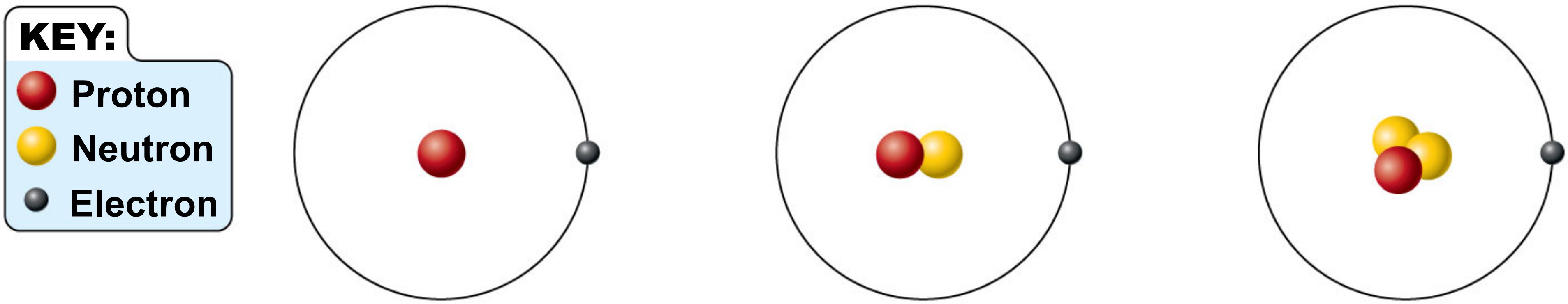
KEY:
Proton
Neutron
Electron cloud



(a) Hydrogen (H)
($1p^+$; $0n^0$; $1e^-$)

(b) Helium (He)
($2p^+$; $2n^0$; $2e^-$)

(c) Lithium (Li)
($3p^+$; $4n^0$; $3e^-$)



Hydrogen (^{1}H)
($1p^{+}$; $0n^{0}$; $1e^{-}$)

Deuterium (^{2}H)
($1p^{+}$; $1n^{0}$; $1e^{-}$)

Tritium (^{3}H)
($1p^{+}$; $2n^{0}$; $1e^{-}$)

Table 2.3 Atomic Structures of the Most Abundant Elements in the Body

Element	Symbol	Atomic number (# of p)	Mass number (# of p + n)	Atomic weight	Electrons in valence shell
Calcium	Ca	20	40	40.078	2
Carbon	C	6	12	12.011	4
Chlorine	Cl	17	35	35.453	7
Hydrogen	H	1	1	1.008	1
Iodine	I	53	127	126.905	7
Iron	Fe	26	56	55.847	2
Magnesium	Mg	12	24	24.305	2
Nitrogen	N	7	14	14.007	5
Oxygen	O	8	16	15.999	6
Phosphorus	P	15	31	30.974	5
Sodium	Na	11	23	22.989	1
Sulfur	S	16	32	32.064	6

Sodium (silvery metal)

+

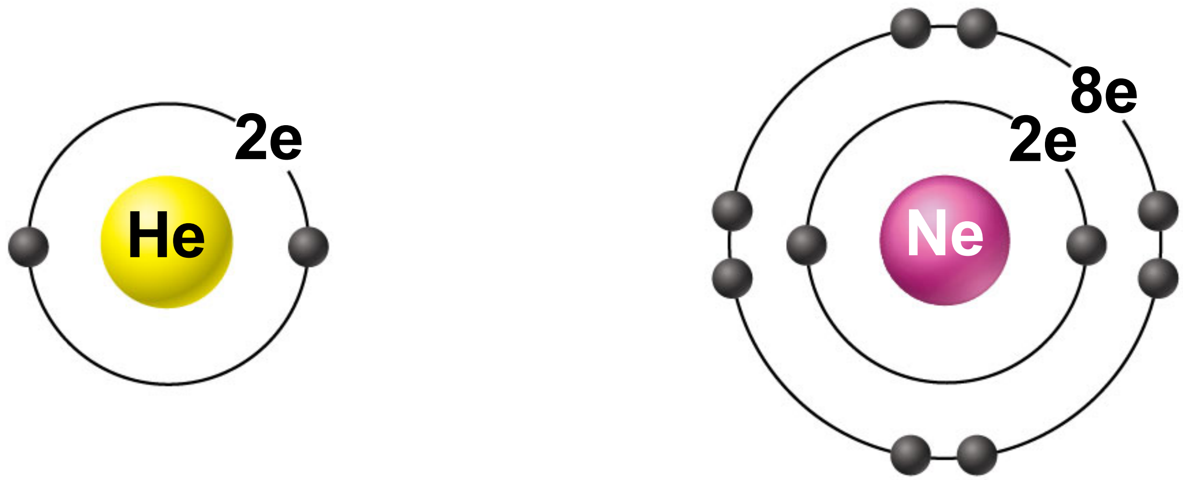
Chlorine (poisonous gas)

→

Sodium chloride (table salt)

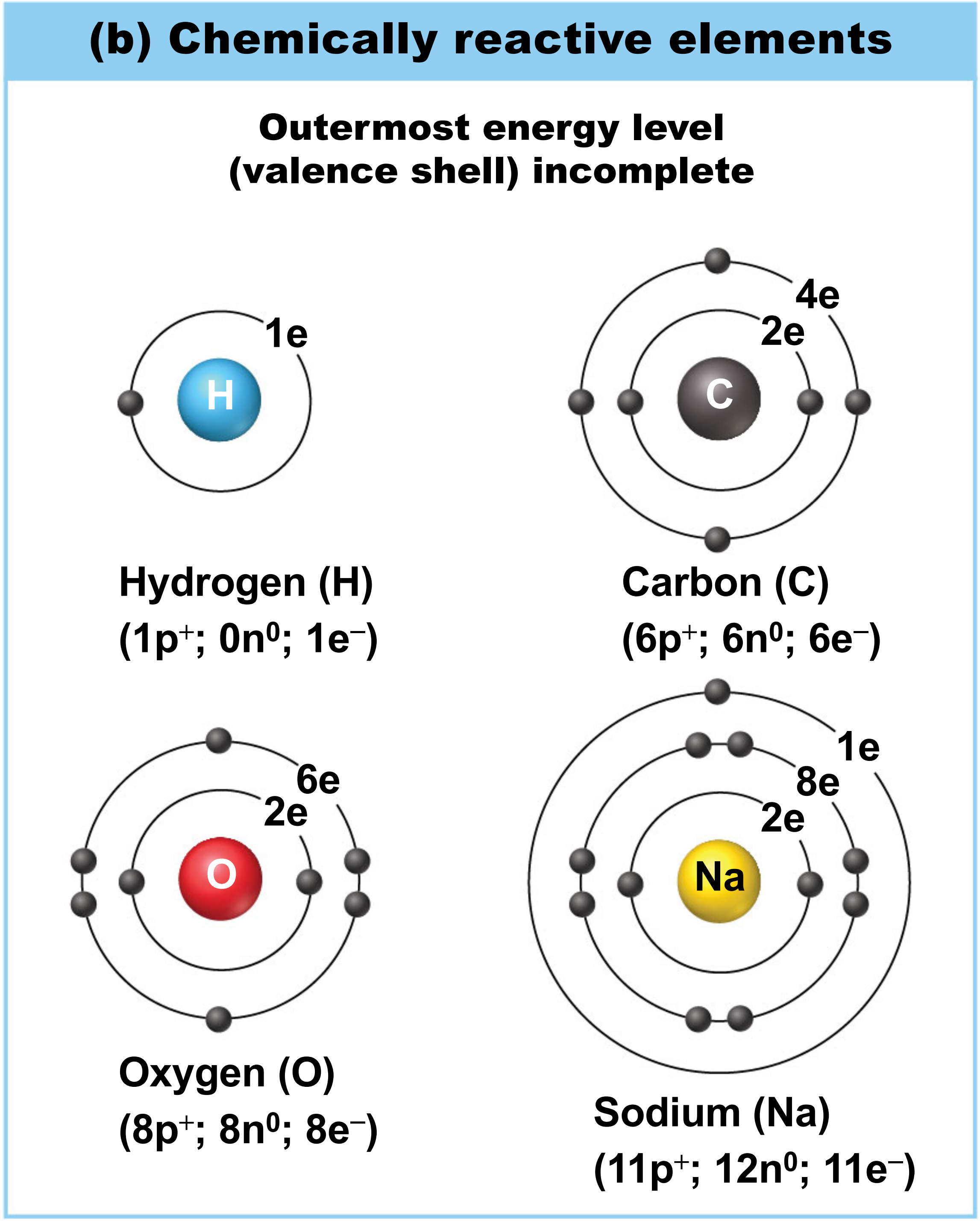
(a) Chemically inert elements

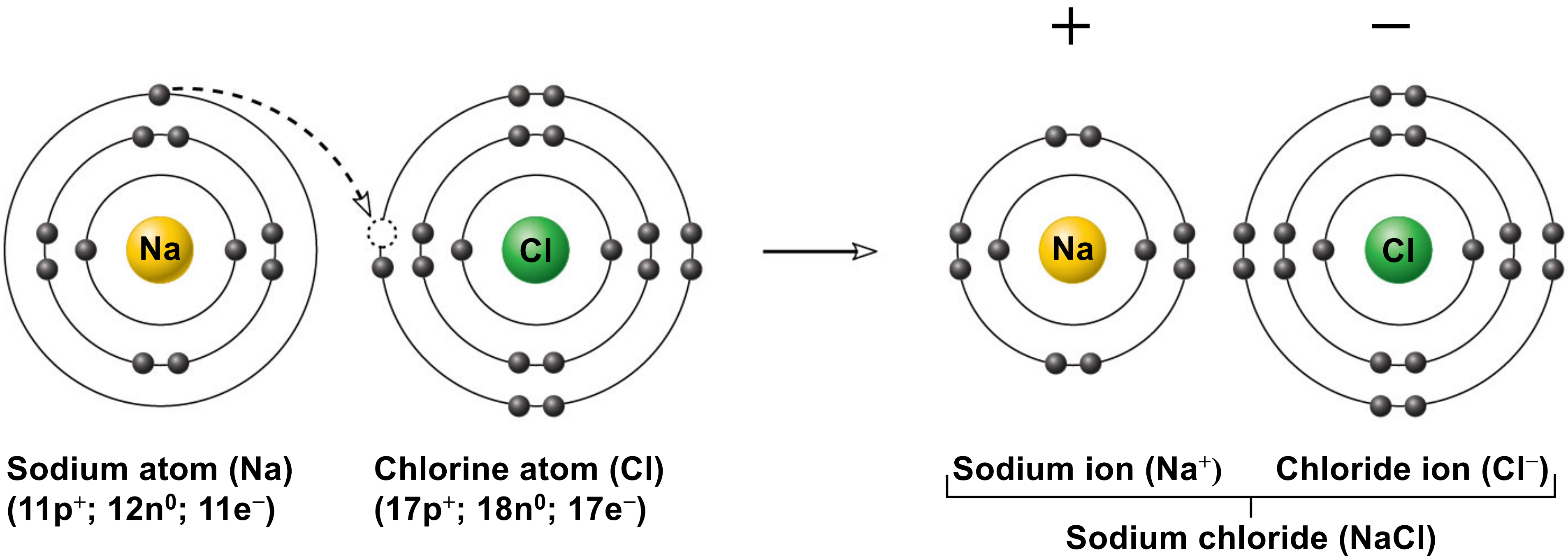
Outermost energy level (valence shell) complete

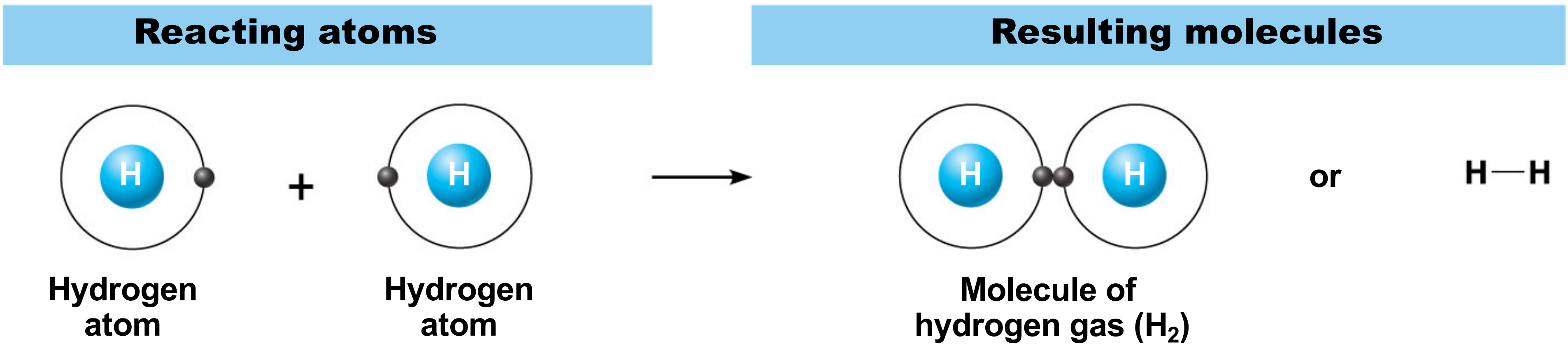


Helium (He)
($2p^+$; $2n^0$; $2e^-$)

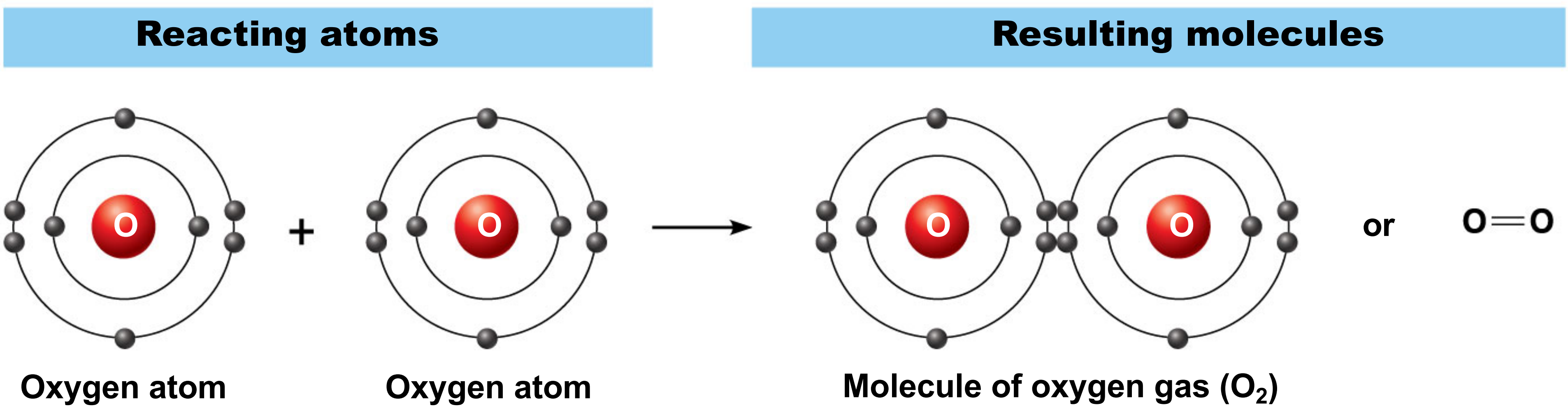
Neon (Ne)
($10p^+$; $10n^0$; $10e^-$)


(b) Chemically reactive elements
Outermost energy level
(valence shell) incomplete
1e
H
Hydrogen (H)
(1p$^+$; 0n^0; 1e$^-$)
4e
2e
C
Carbon (C)
(6p$^+$; 6n^0; 6e$^-$)
6e
2e
O
Oxygen (O)
(8p$^+$; 8n^0; 8e$^-$)
1e
8e
2e
Na
Sodium (Na)
(11p$^+$; 12n^0; 11e$^-$)

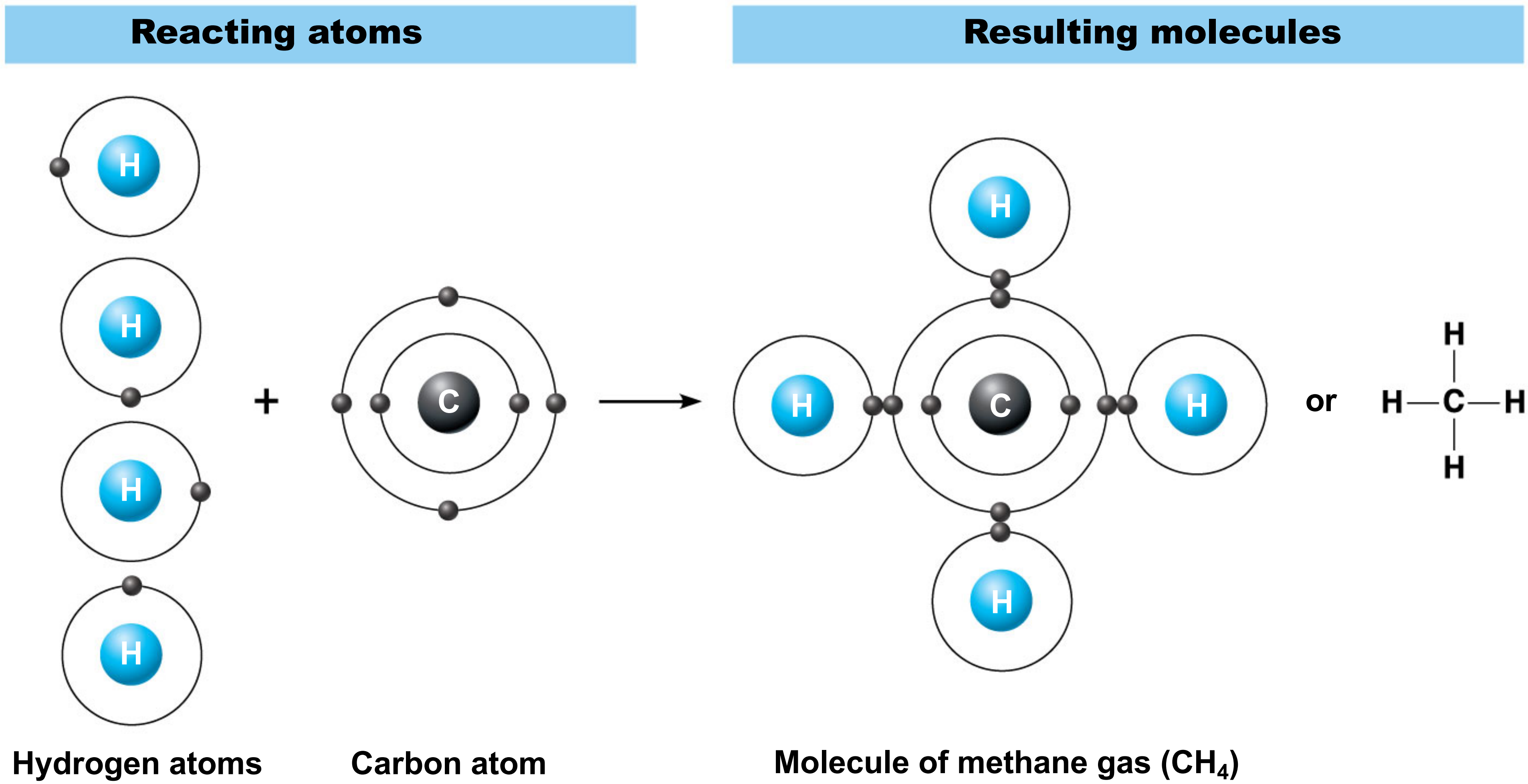

+
−
Na
Cl
Na
Cl
Sodium atom (Na)
(11p$^+$; 12n^0; 11e$^-$)
Chlorine atom (Cl)
(17p$^+$; 18n^0; 17e$^-$)
Sodium ion (Na^+)
Chloride ion (Cl^-)
Sodium chloride (NaCl)



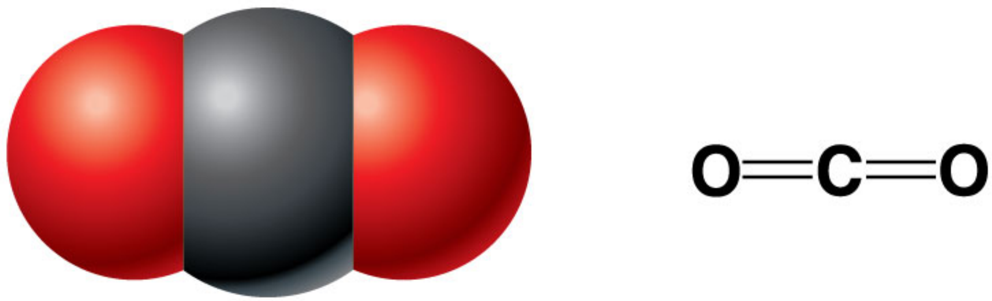
(a) Formation of a single covalent bond



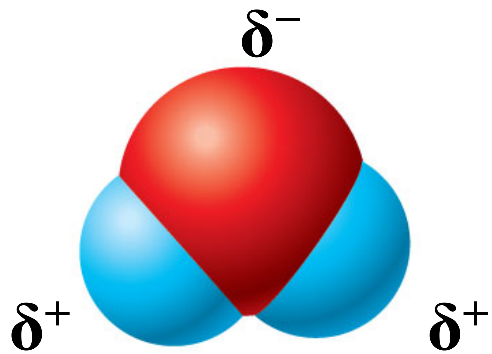
(b) Formation of a double covalent bond



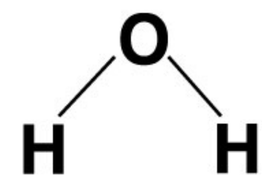
(c) Formation of four single covalent bonds

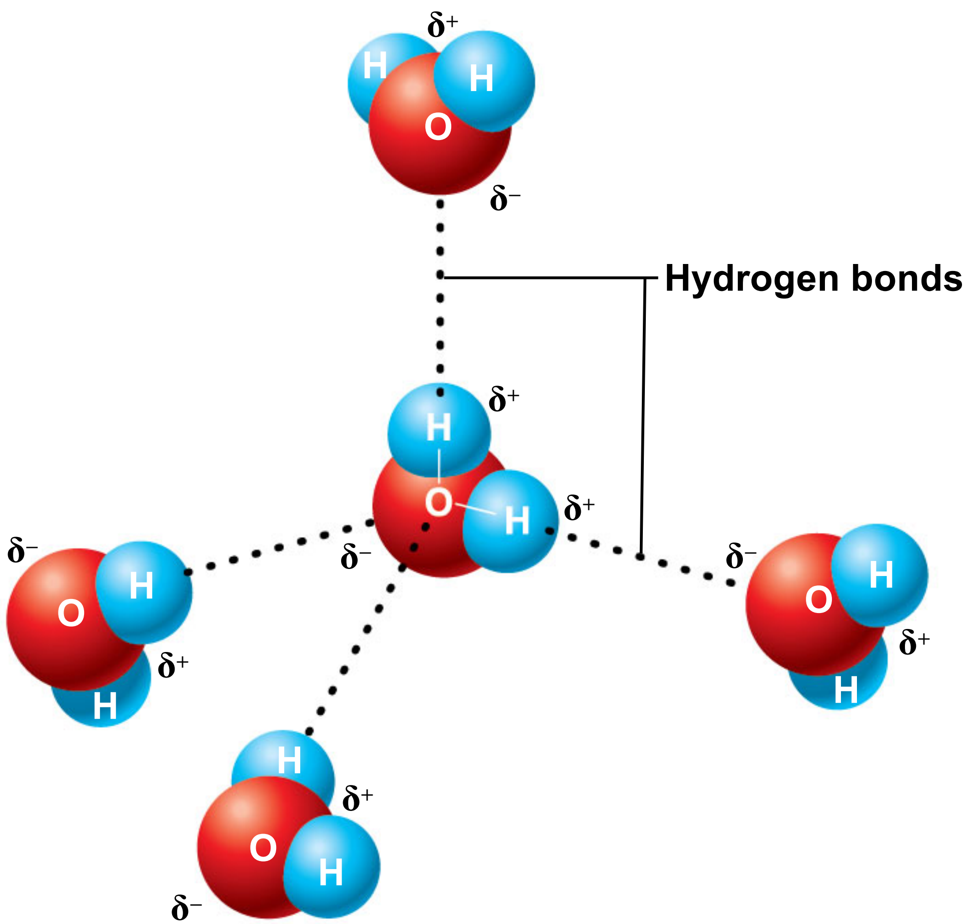


(a) Carbon dioxide (CO_2)



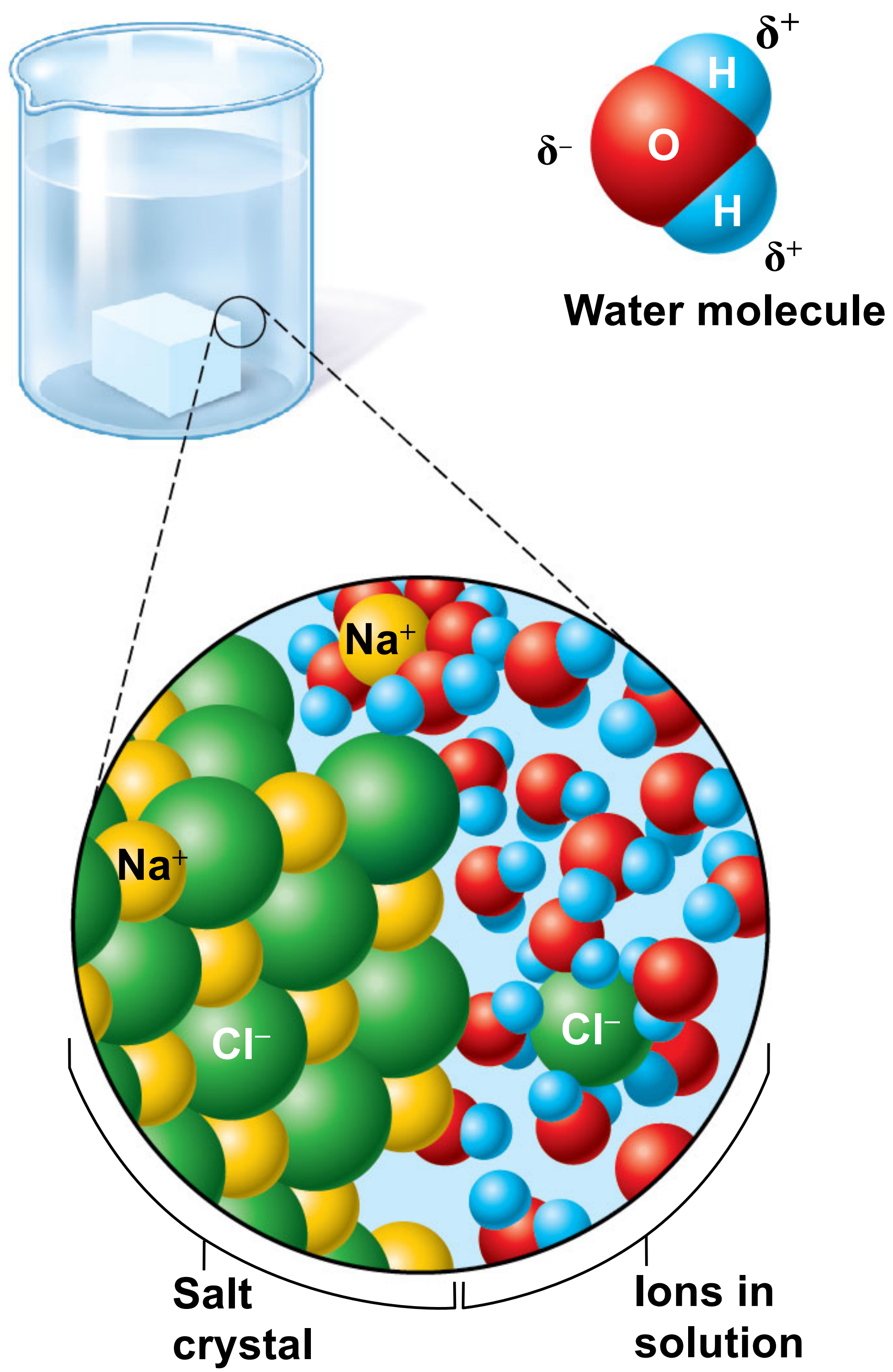
(b) Water (H_2O)



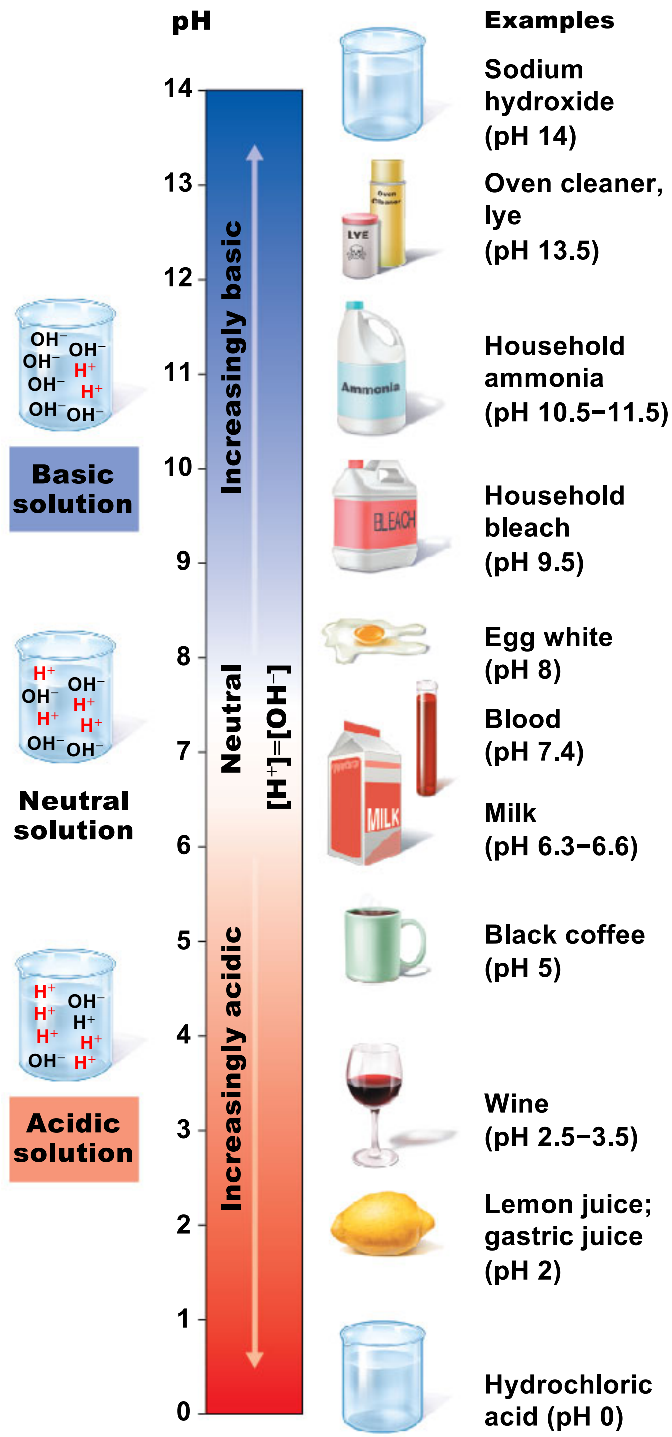


(a)

(b)



δ+
H
δ−
O
H
δ+
Water molecule
Na+
Na+
Cl−
Cl−
Salt crystal
Ions in solution


pH
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Increasingly basic
Neutral
[H+]=[OH−]
Increasingly acidic
Basic solution
Neutral solution
Acidic solution
OH−
H+
Examples
Sodium hydroxide (pH 14)
Oven cleaner, lye (pH 13.5)
Household ammonia (pH 10.5−11.5)
Household bleach (pH 9.5)
Egg white (pH 8)
Blood (pH 7.4)
Milk (pH 6.3−6.6)
Black coffee (pH 5)
Wine (pH 2.5−3.5)
Lemon juice; gastric juice (pH 2)
Hydrochloric acid (pH 0)
LYE
Ammonia
BLEACH
MILK

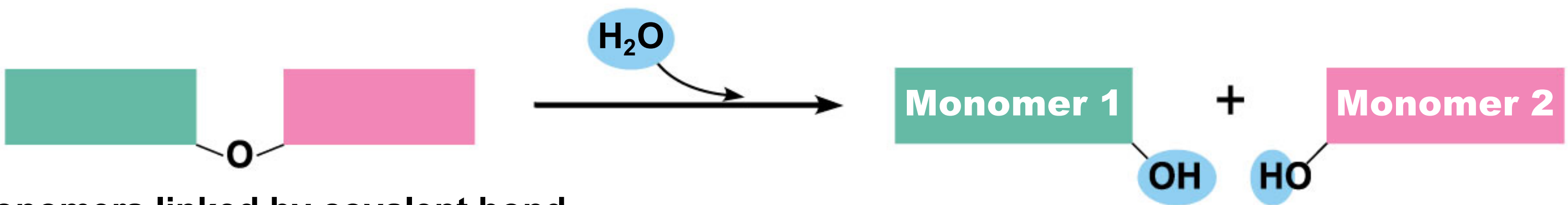
(a) Dehydration synthesis

Monomers are joined by removal of OH from one monomer and removal of H from the other at the site of bond formation.

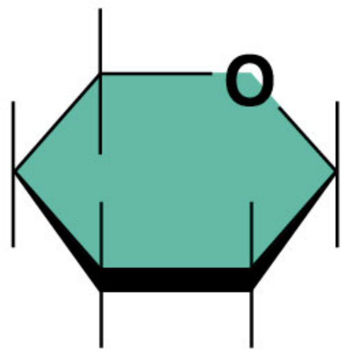
Monomers linked by covalent bond

(b) Hydrolysis

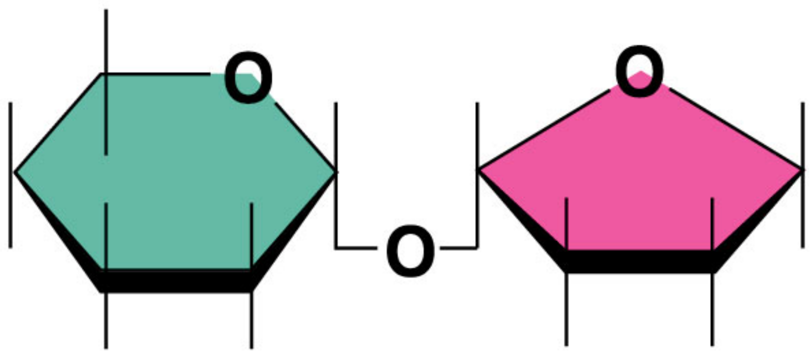
Monomers are released by the addition of a water molecule, adding OH to one monomer and H to the other.



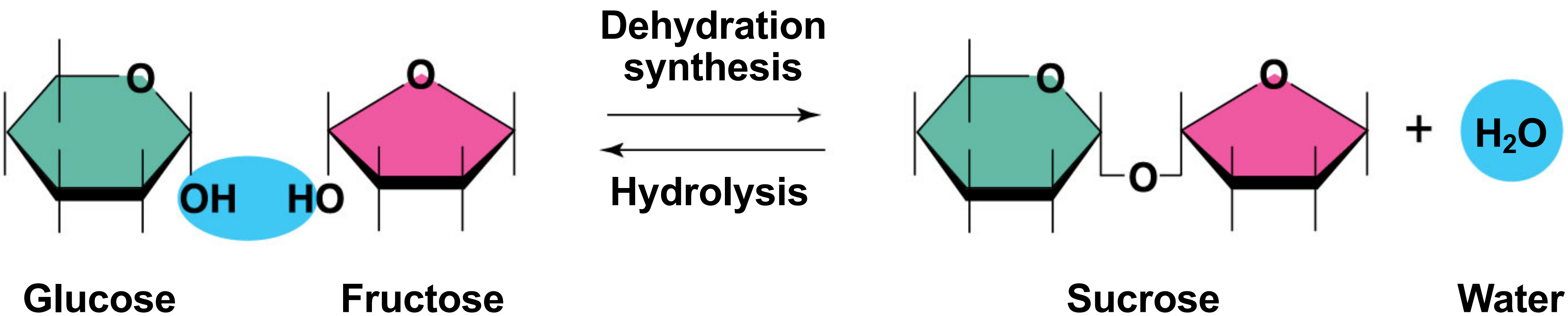
Monomers linked by covalent bond



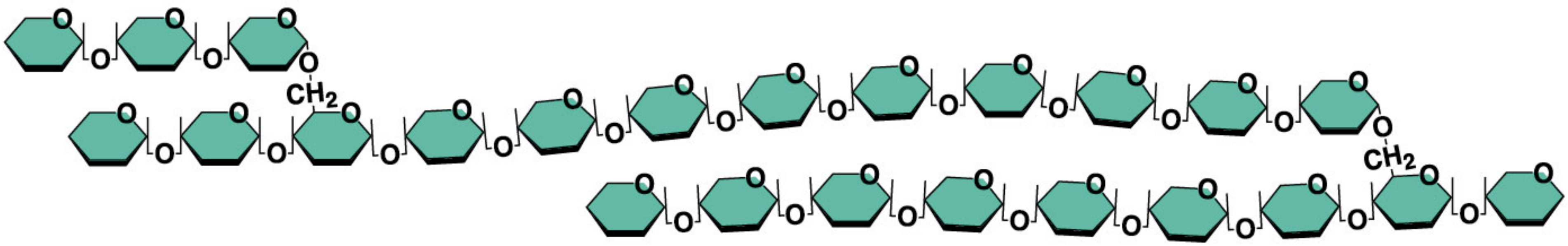
(a) Simple sugar (monosaccharide)



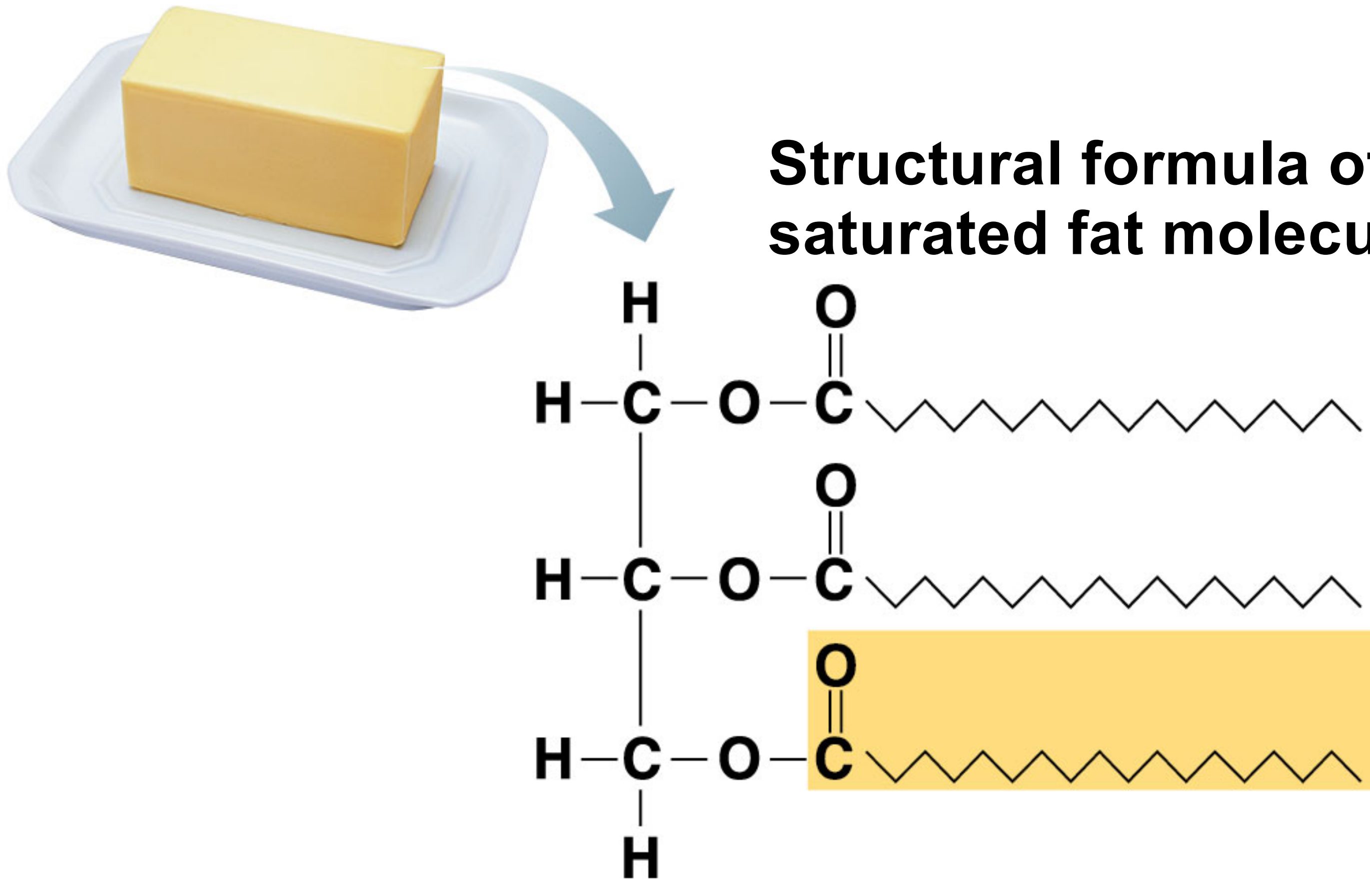
(b) Double sugar (disaccharide)



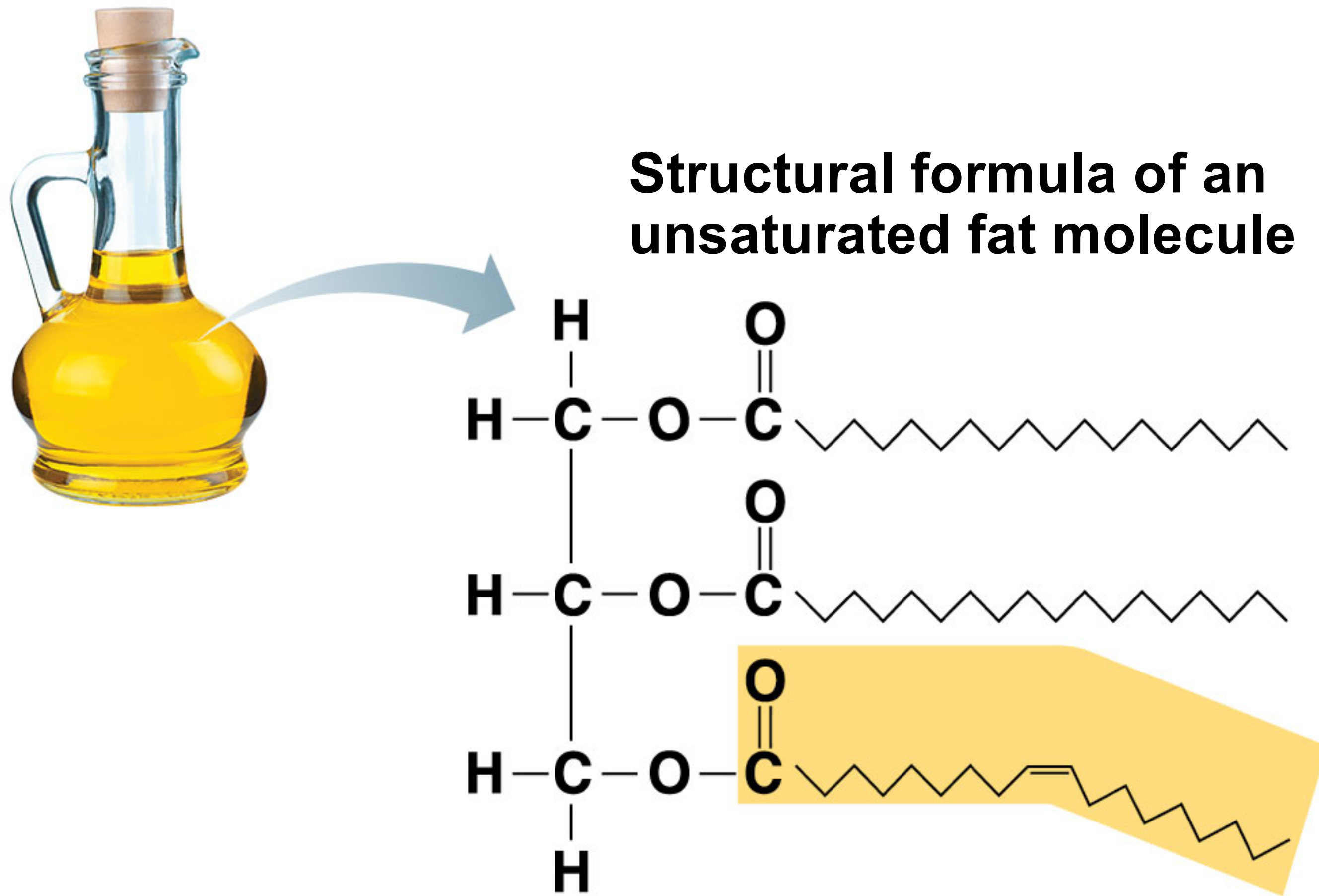
(c) Dehydration synthesis and hydrolysis of a molecule of sucrose



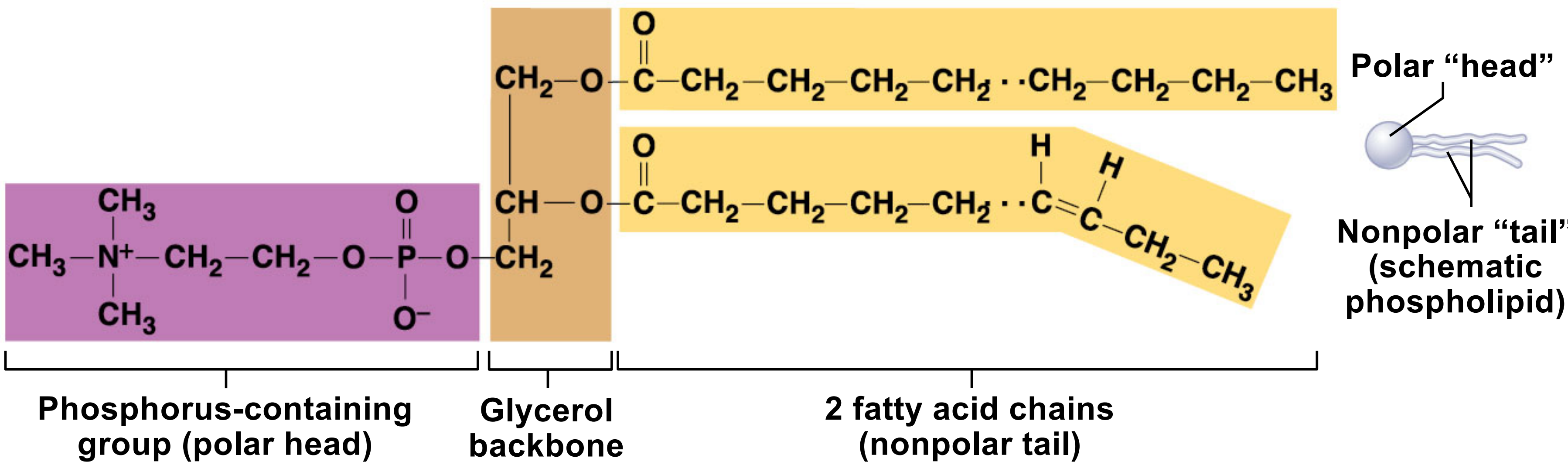
(d) Starch (polysaccharide)



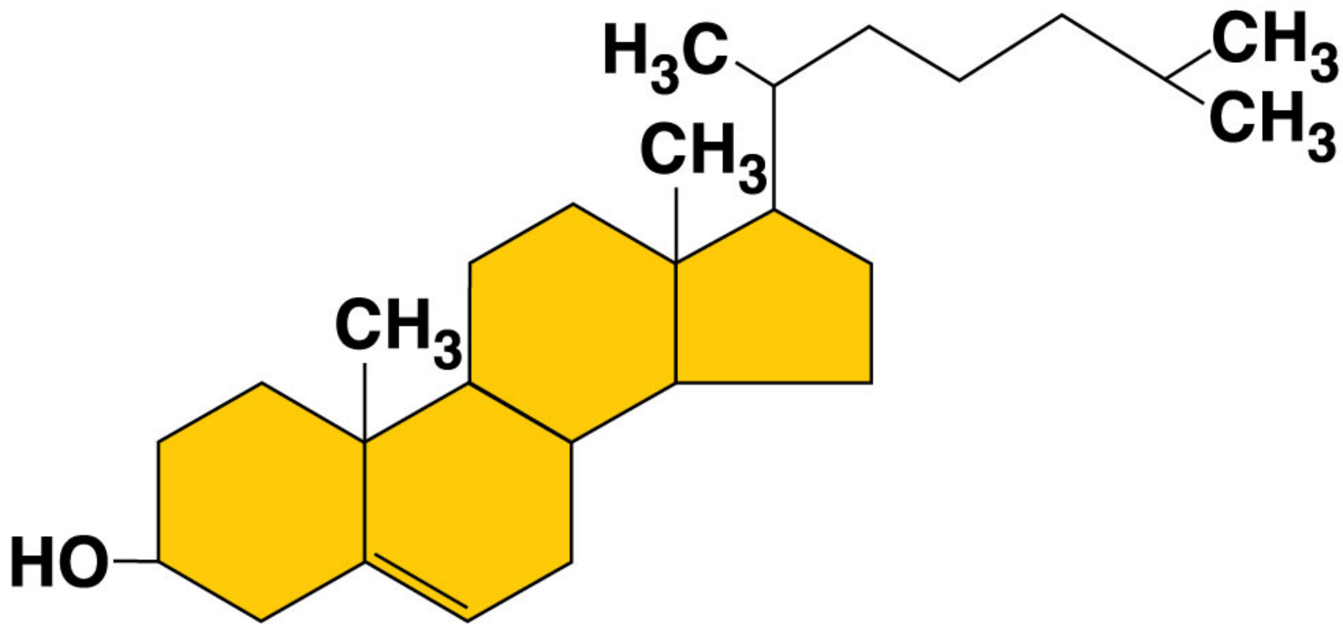
(a) Saturated fat. At room temperature, the molecules of a saturated fat such as this butter are packed closely together, forming a solid.



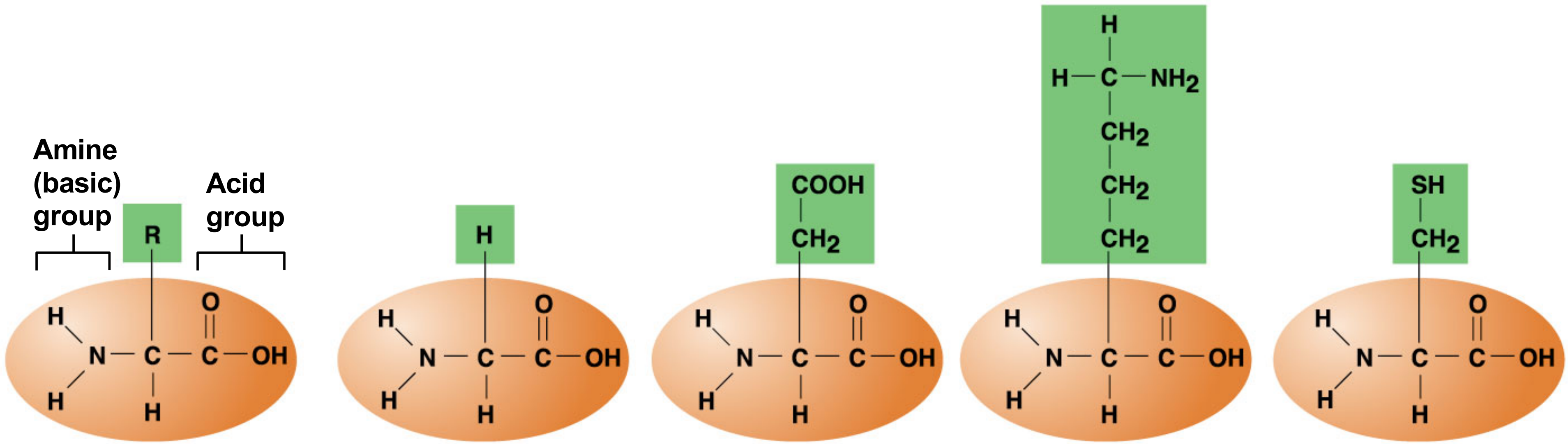
(b) Unsaturated fat. At room temperature, the molecules of an unsaturated fat such as this olive oil cannot pack together closely enough to solidify because of the kinks in some of their fatty acid chains.



(b) Typical structure of a phospholipid molecule (phosphatidylcholine). Two fatty acid chains and a phosphorous-containing group are attached to a glycerol backbone.



(c) Cholesterol. Simplified structure of cholesterol, a steroid, formed by four interlocking carbon rings.



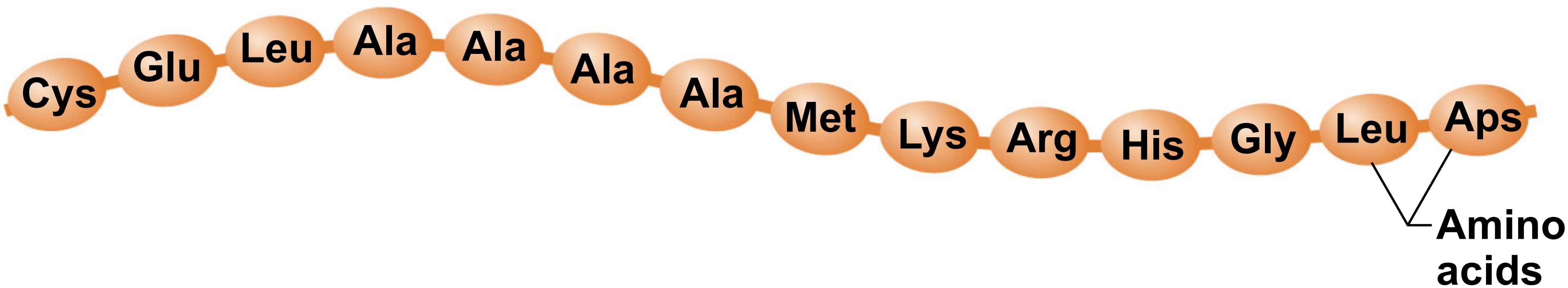
(a) Generalized structure of all amino acids.

(b) Glycine is the simplest amino acid.

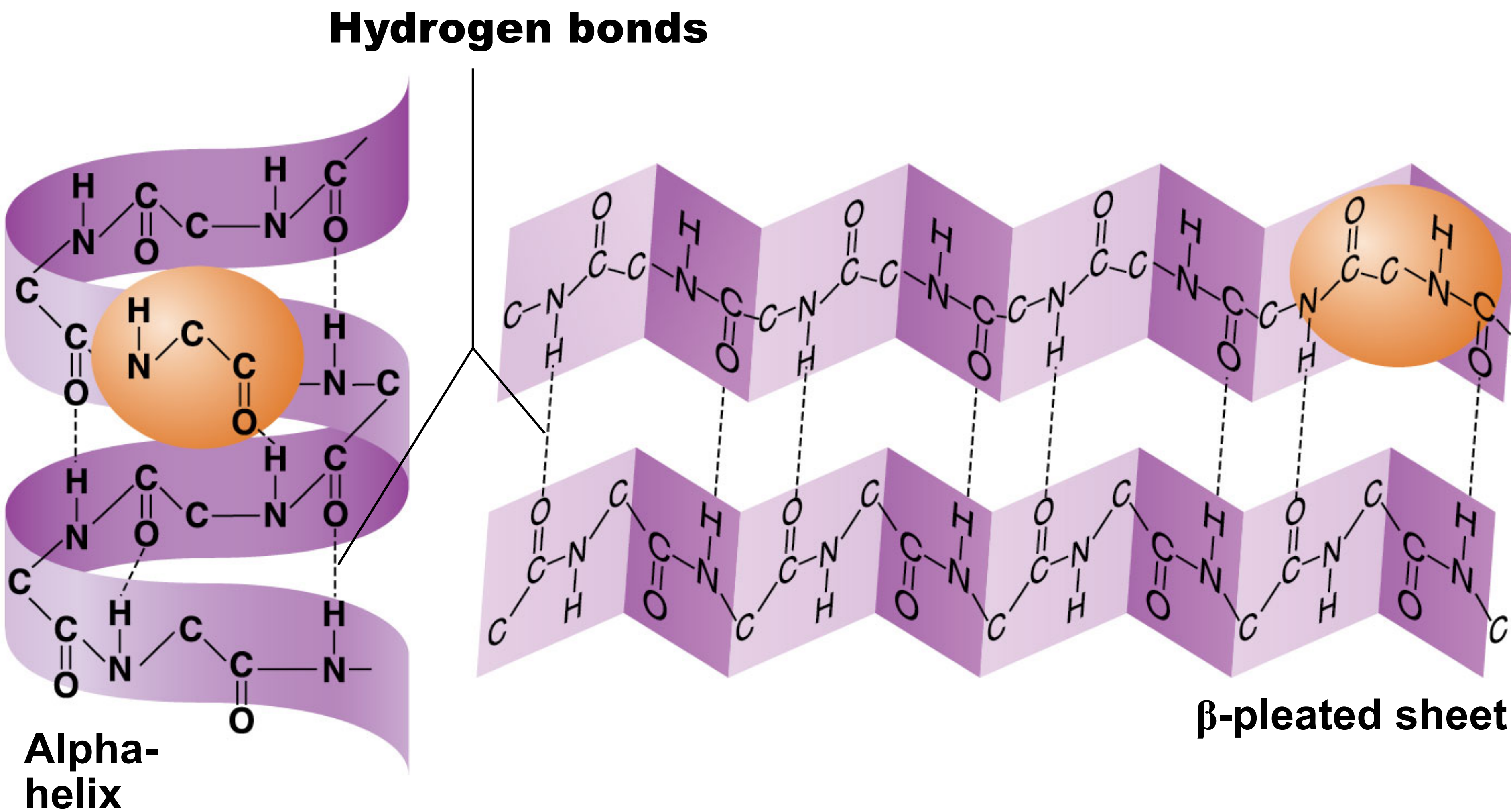
(c) Aspartic acid (an acidic amino acid) has an acid group (—COOH) in the R group.

(d) Lysine (a basic amino acid) has an amine group ($—NH_2$) in the R group.

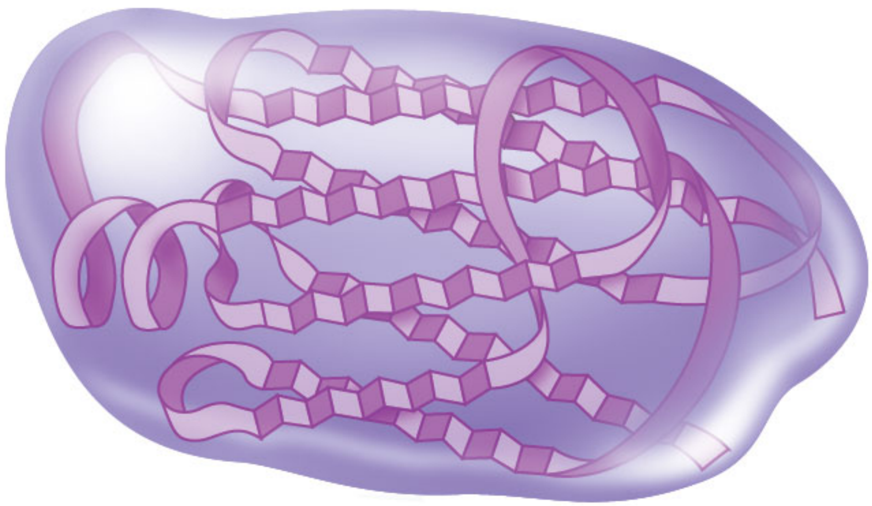
(e) Cysteine (a basic amino acid) has a sulfhydryl (—SH) group in the R group.



(a) Primary structure. A protein's primary structure is the unique sequence of amino acids in the polypeptide chain.

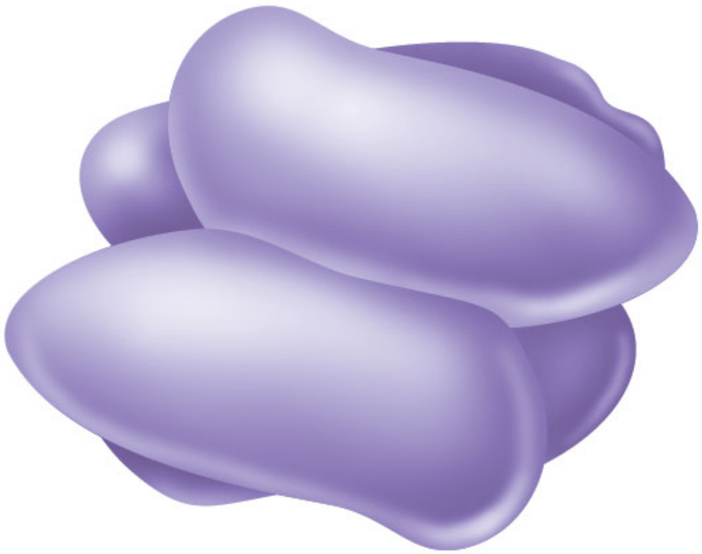


(b) Secondary structure. Two types of secondary structure are the alpha-helix and beta-pleated sheet. Secondary structure is reinforced by hydrogen bonds, represented by dashed lines in this figure.



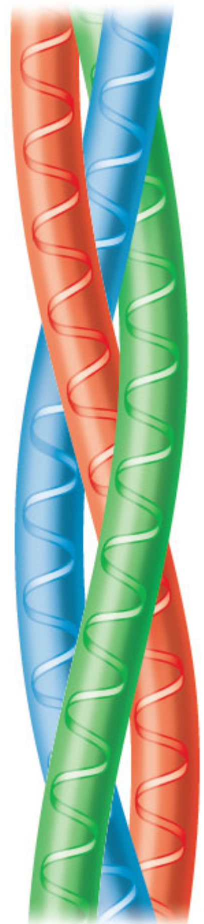
Protein (if > 50 amino acids) or polypeptide (if < 50 amino acids)

(c) Tertiary structure. The overall three-dimensional shape of the polypeptide or protein is called tertiary structure. It is reinforced by chemical bonds between the R-groups of amino acids in different regions of the protein chain.

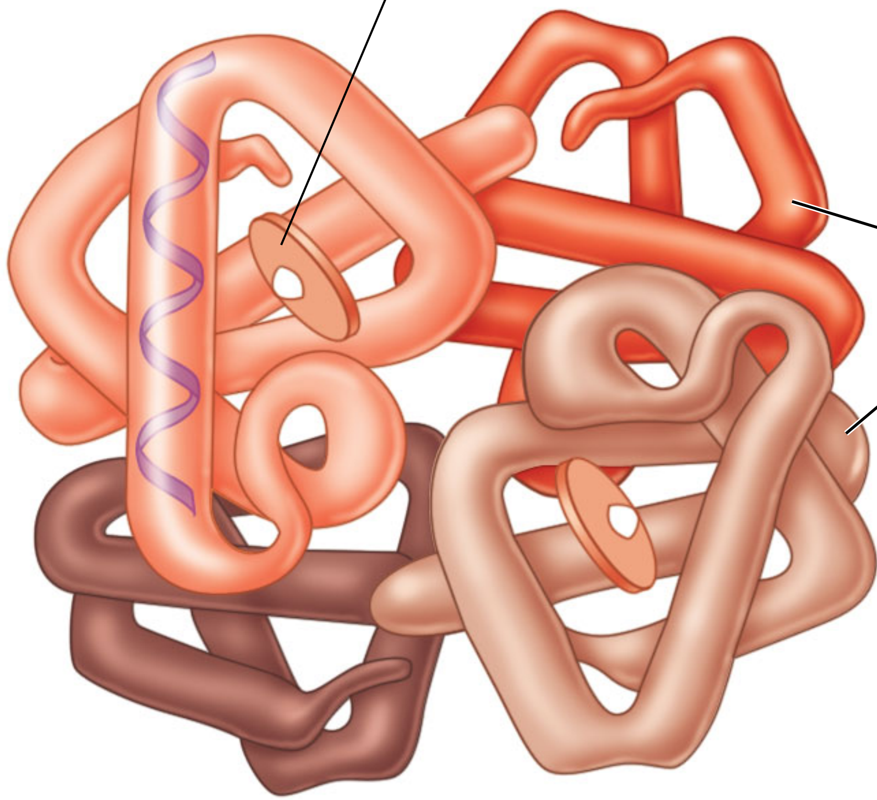


Complex protein with four polypeptide subunits, each with tertiary structure

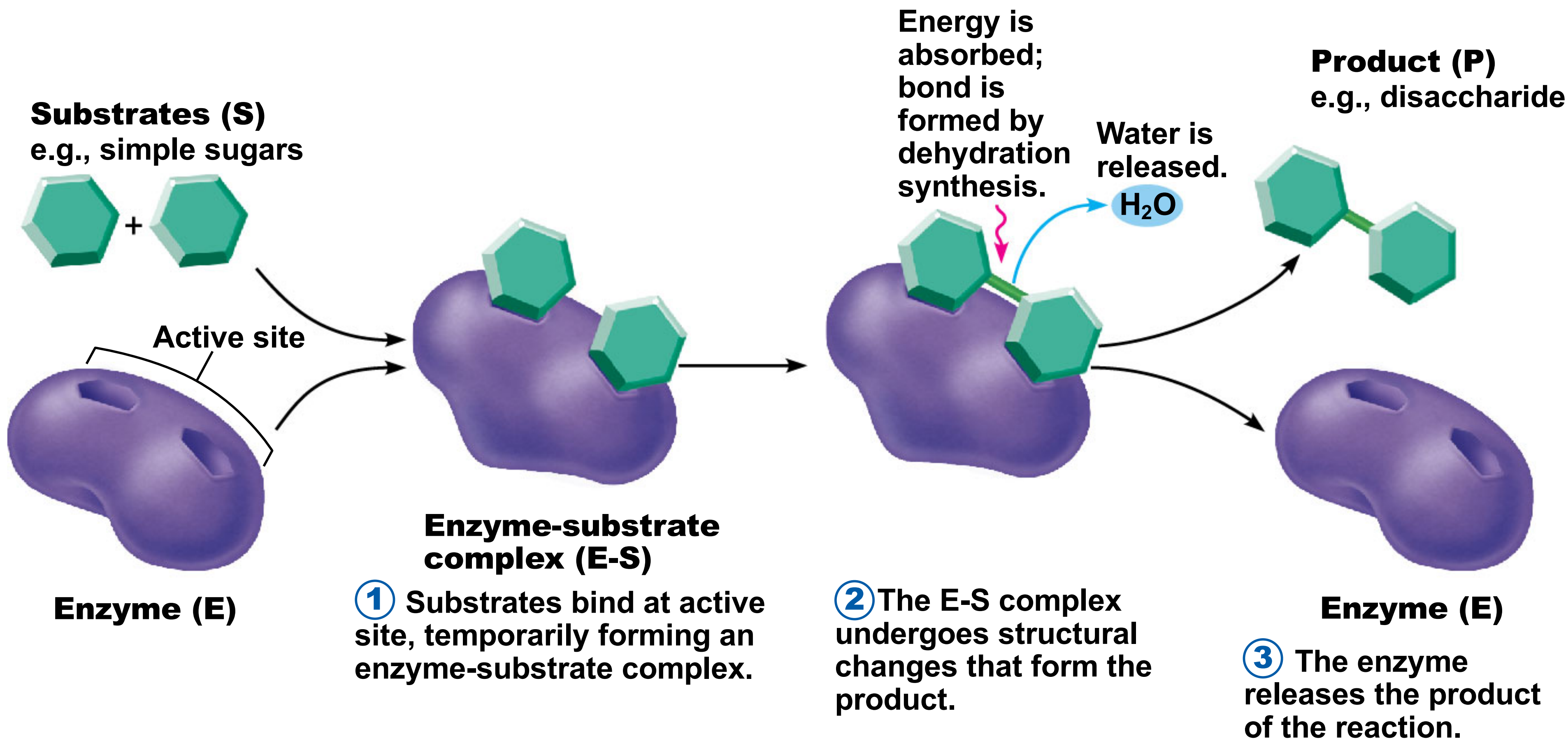
(d) Quaternary structure. Some proteins consist of two or more polypeptide chains. For example, four polypeptides construct the protein hemoglobin, a blood protein.

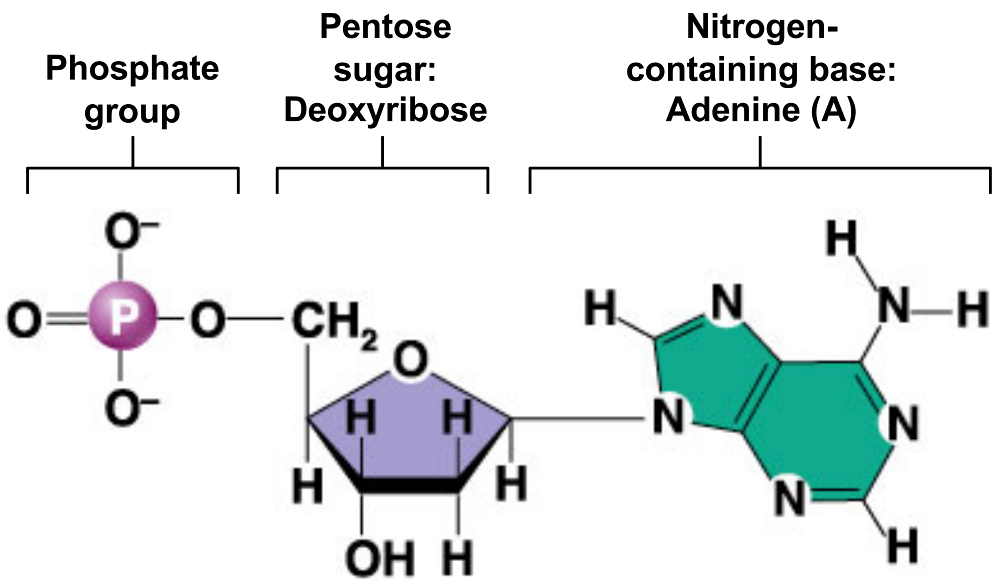


(a) Triple helix of collagen
(a fibrous or structural protein).



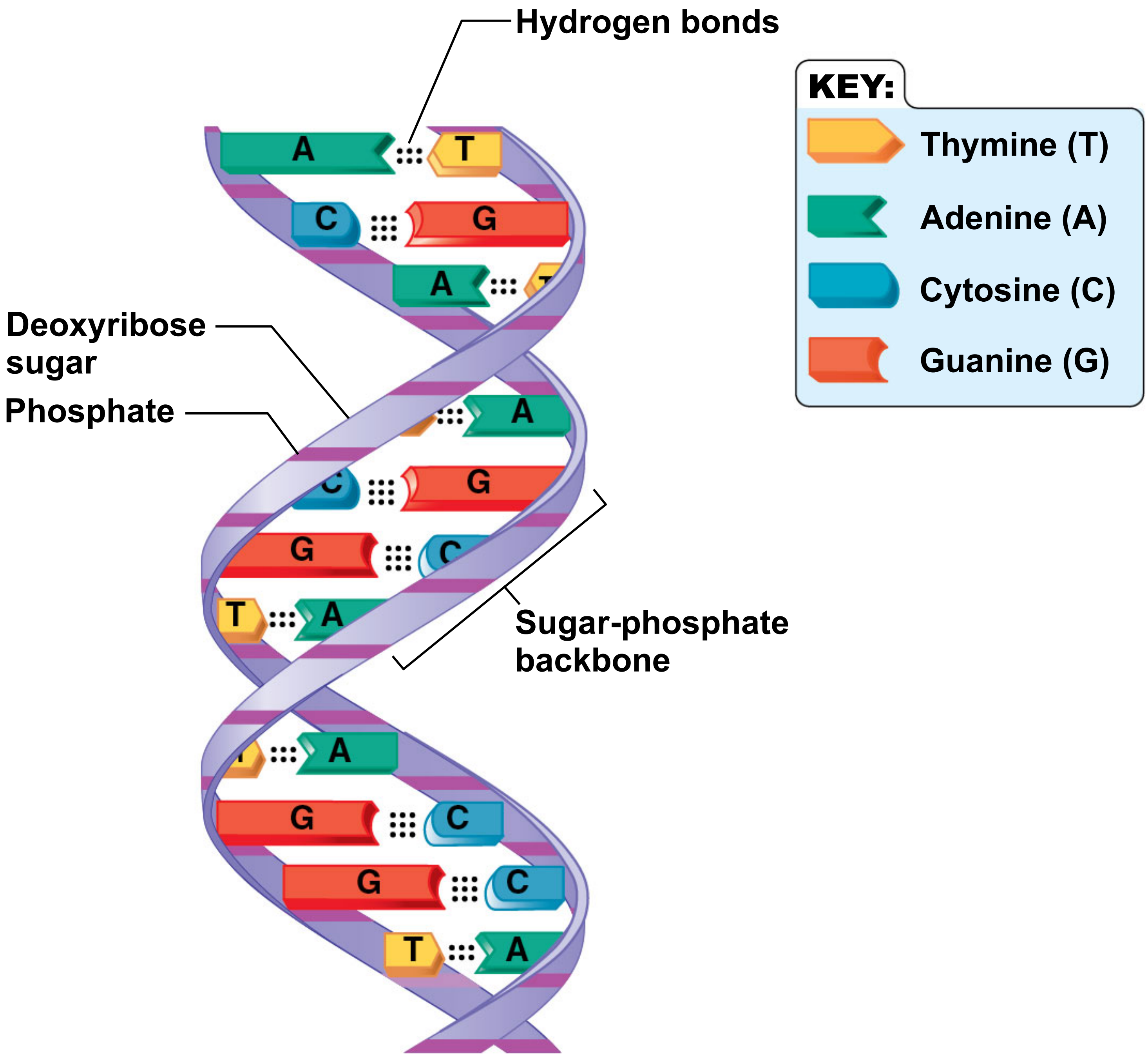
(b) Hemoglobin molecule composed of the protein globin and attached heme groups. (Globin is a globular, or functional, protein.)


Substrates (S)
e.g., simple sugars
+
Active site
Enzyme (E)
Enzyme-substrate
complex (E-S)
1 Substrates bind at active site, temporarily forming an enzyme-substrate complex.
Energy is absorbed; bond is formed by dehydration synthesis.
Water is released.
H_2O
2 The E-S complex undergoes structural changes that form the product.
Product (P)
e.g., disaccharide
Enzyme (E)
3 The enzyme releases the product of the reaction.

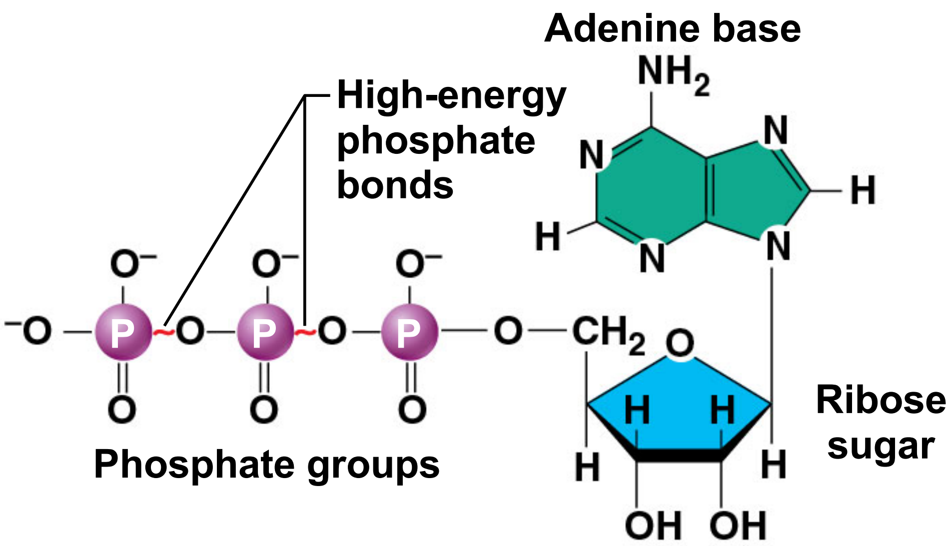


(a) Adenine nucleotide
(Chemical structure)

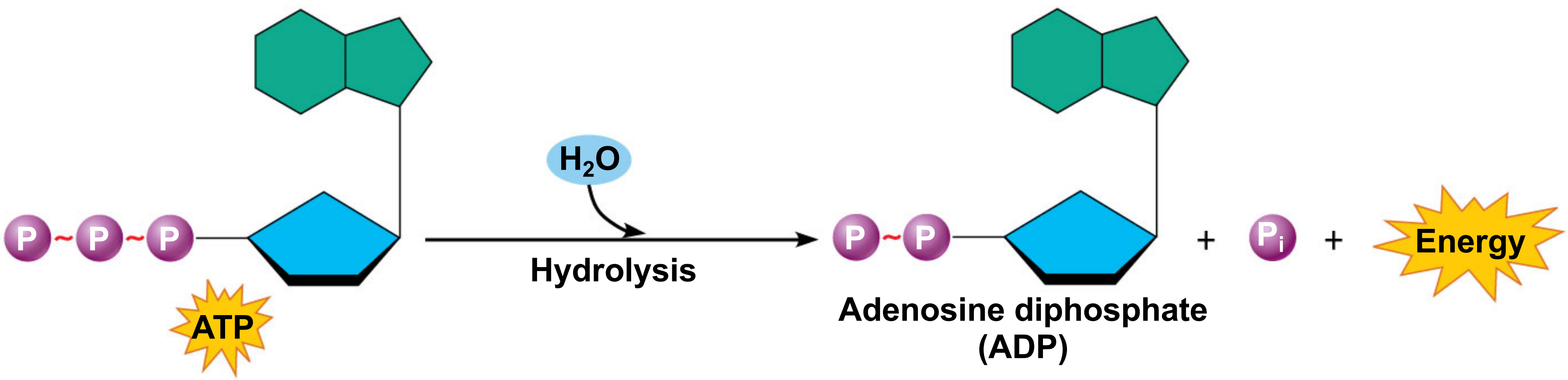
(b) Adenine nucleotide
(Diagrammatic representation)



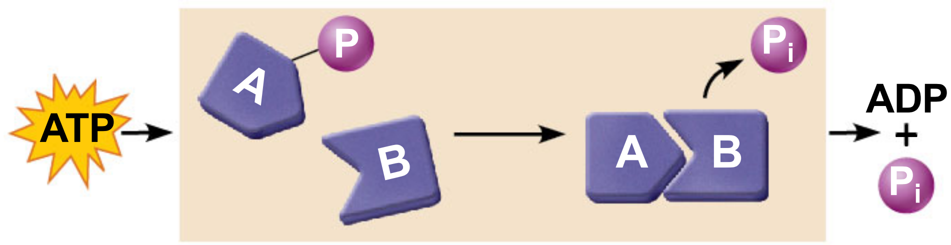
(d) Diagram of a DNA molecule



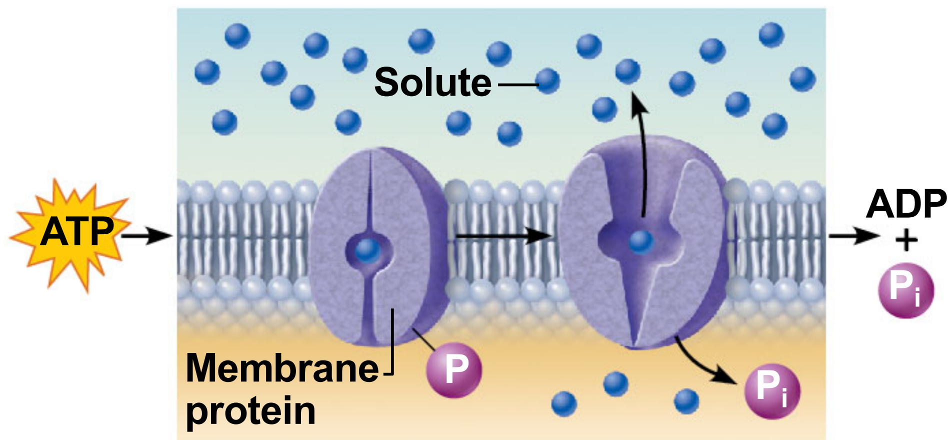
(a) Adenosine triphosphate (ATP)



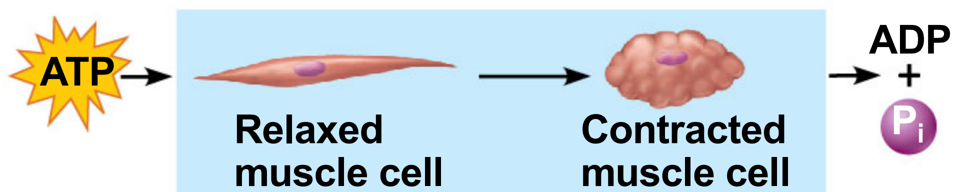
(b) Hydrolysis of ATP



(a) Chemical work. ATP provides the energy needed to drive energy-absorbing chemical reactions.



(b) Transport work. ATP drives the transport of certain solutes (amino acids, for example) across cell membranes.



(c) Mechanical work. ATP activates contractile proteins in muscle cells so that the cells can shorten and perform mechanical work.