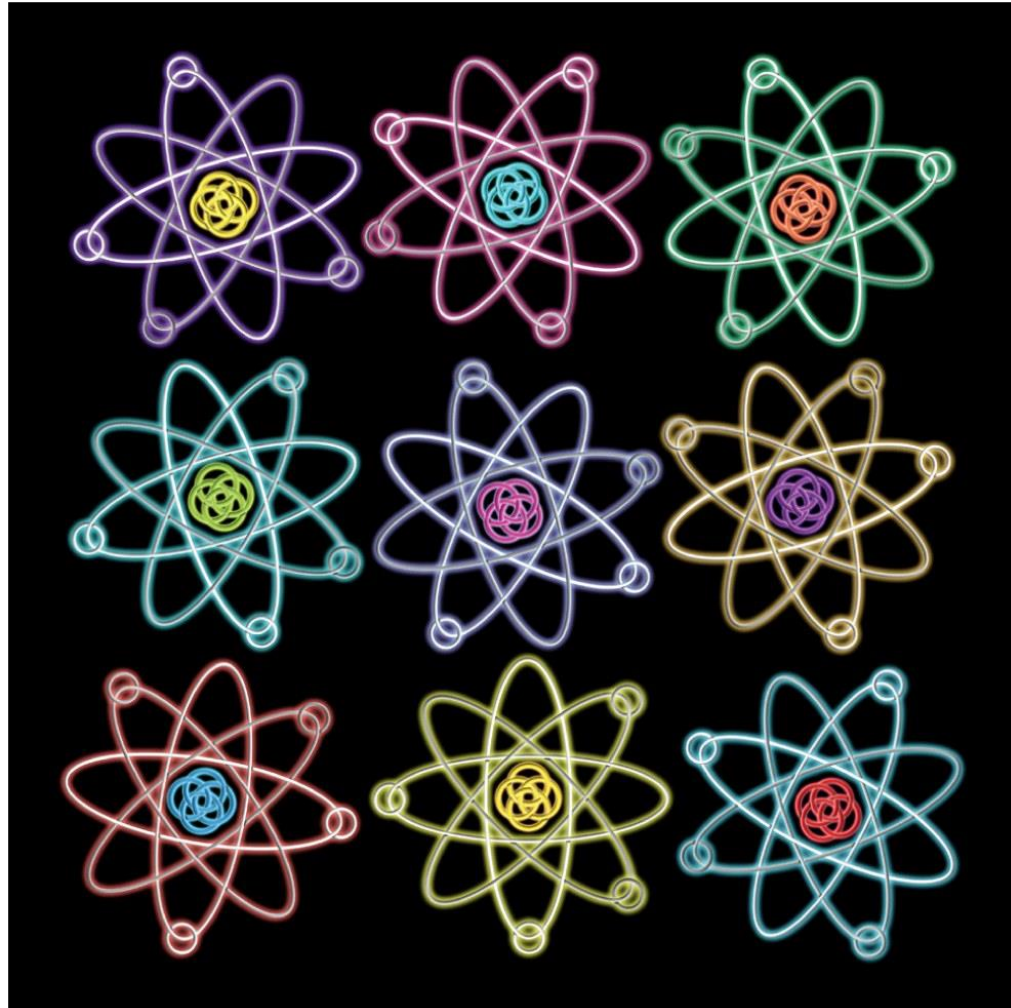


Chapter 2: Chemistry



Raw materials and fuel for our bodies

2.1–2.3
Atoms form
molecules through
bonding.



2.1 Everything is made of atoms.

- An **element** is a substance that cannot be broken down chemically into any other substances.
- An **atom** is a bit of matter that cannot be subdivided any further without losing its essential properties.



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Atomic Structure: The nucleus, protons, and neutrons

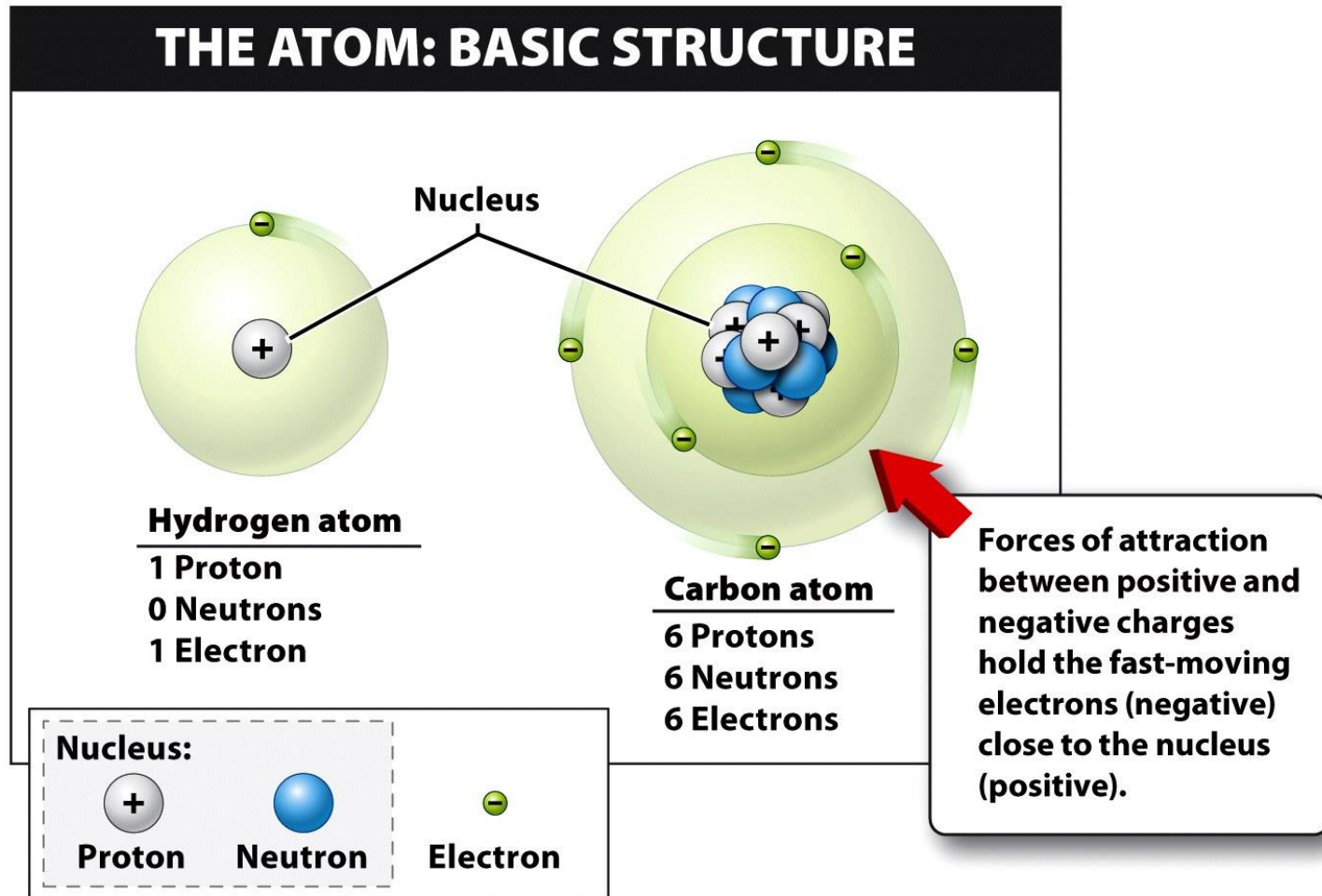


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Atomic Structure: Electrons

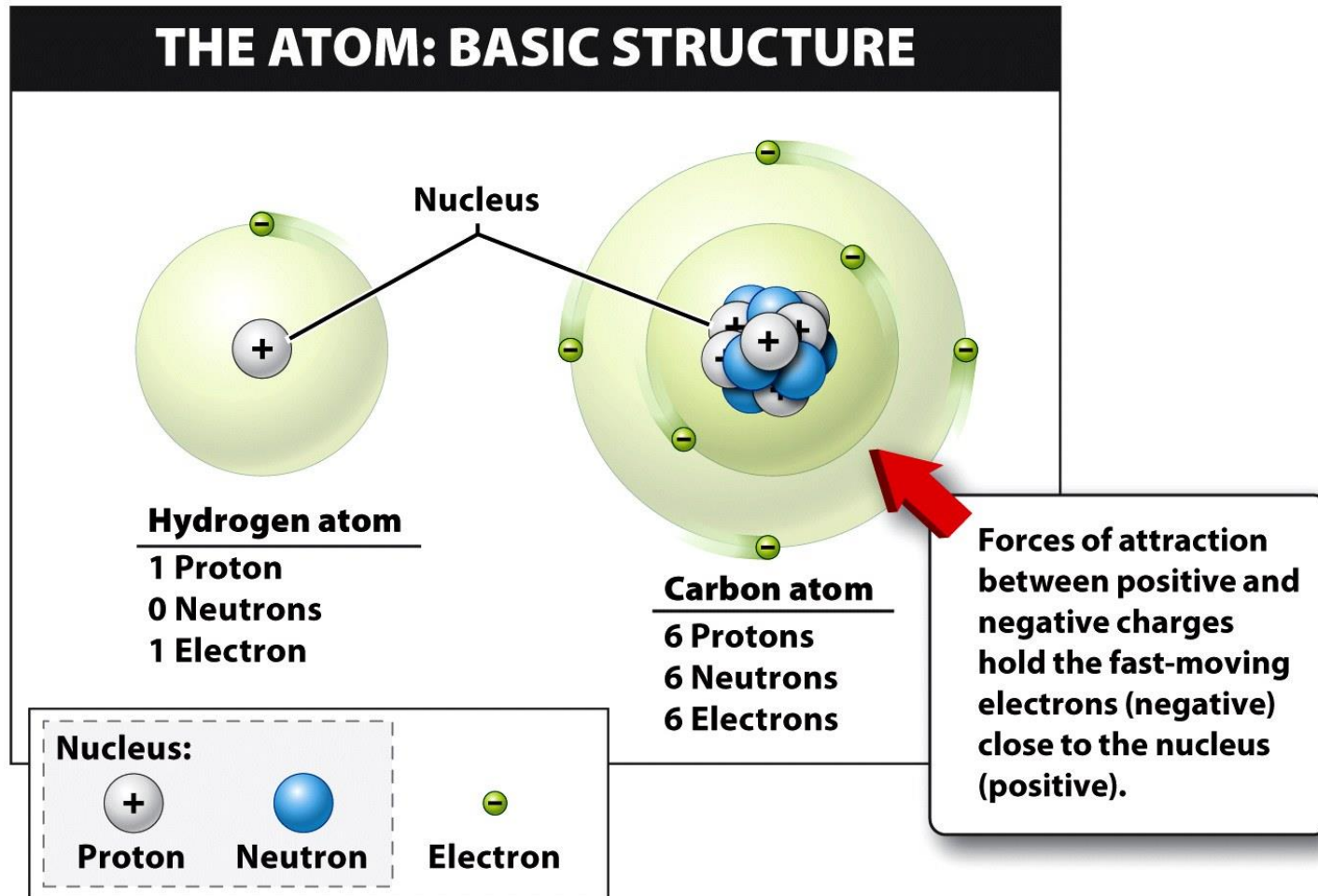


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Atomic Numbers

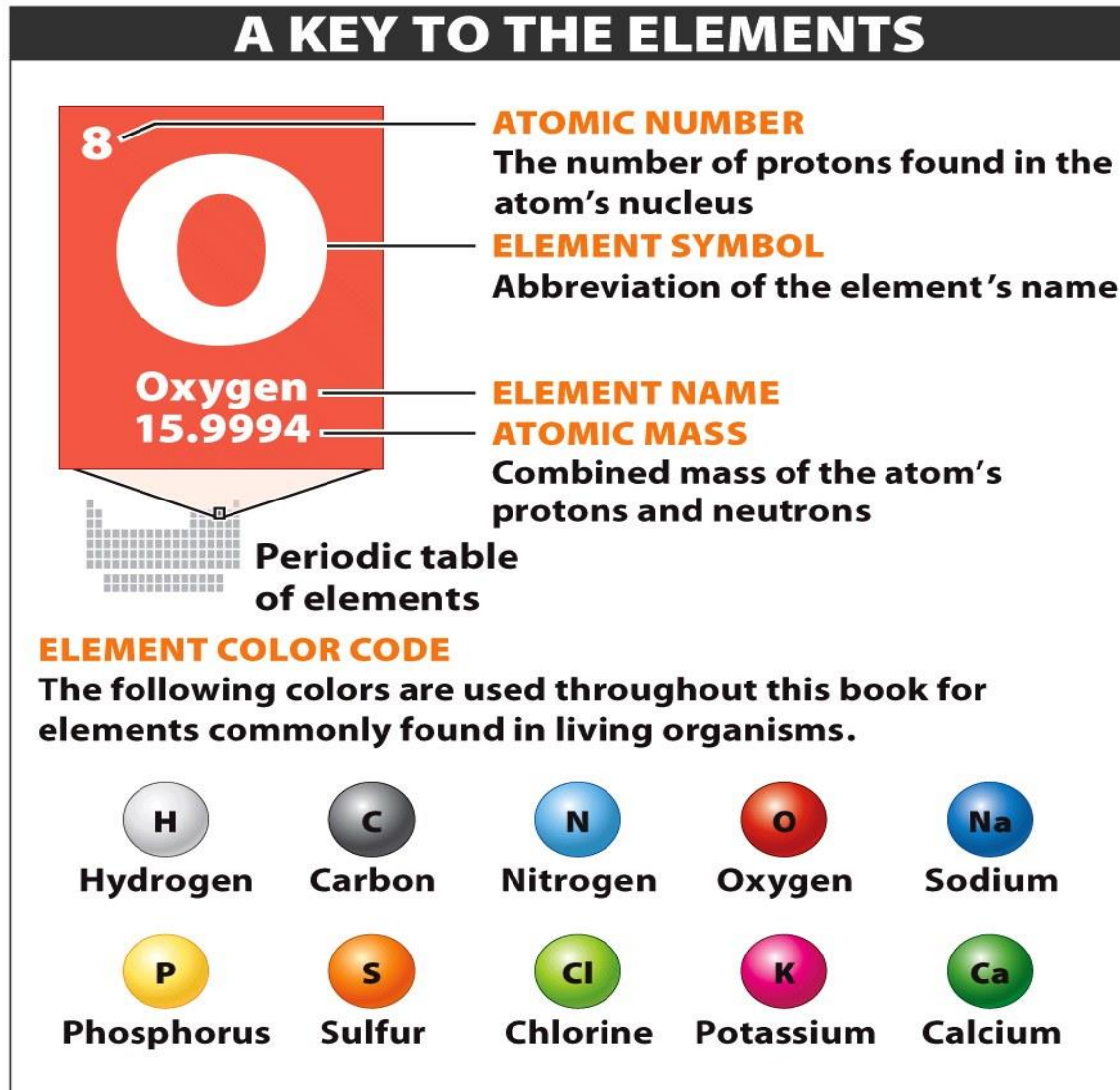


Figure 2-3

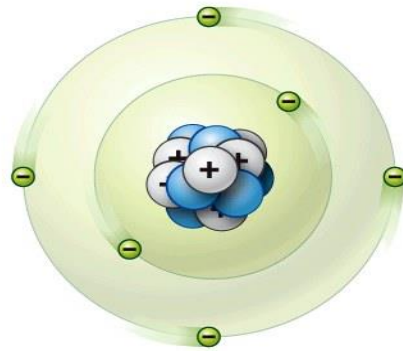
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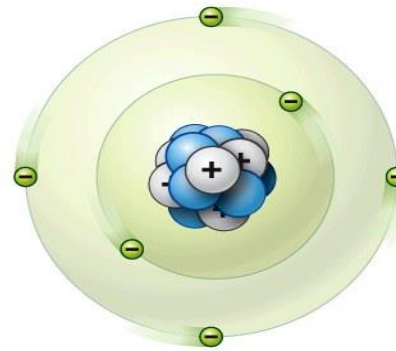
Isotopes

ISOTOPES

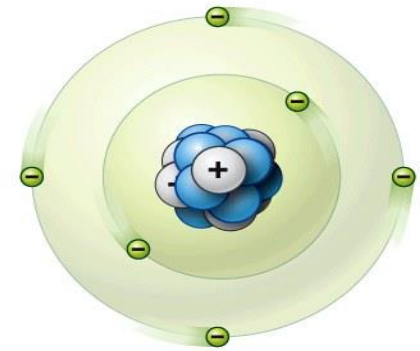
Atoms with the same atomic number (i.e., the same number of protons) but different atomic mass are isotopes.



CARBON-12



CARBON-13



CARBON-14

⊕ Protons	6	6	6
● Neutrons	6	7	8
⊖ Electrons	6	6	6
Atomic mass	12	13	14

Figure 2-4

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Radioactive Atoms

- A few atomic nuclei are not stable and break down spontaneously.
- These atoms are **radioactive**.
- They release, at a constant rate, a tiny, high-speed particle carrying a lot of energy.

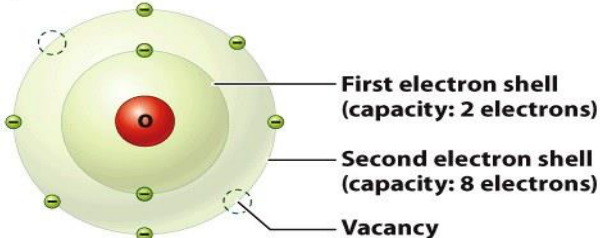
2.2 An atom's electrons determine how (and whether) the atom will bond with other atoms.

Electron shells

Electron Shells



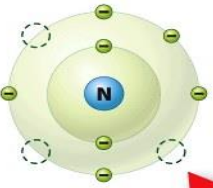

ELECTRON SHELLS AND ATOM STABILITY

ELECTRON SHELLS
Electrons move around the nucleus in designated areas called electron shells. An atom can have as many as seven electron shells in total.



Oxygen atom

ATOM STABILITY
Atoms become stable when their outermost shell is filled to capacity. Stable atoms tend not to react or combine with other atoms.

UNSTABLE ATOMS	STABLE ATOMS
 <p>Hydrogen atom</p>	 <p>Helium atom</p>
 <p>Nitrogen atom</p>	 <p>Neon atom</p>

Only when atoms have electron vacancies in their outermost shell are they likely to interact with other atoms.

Figure 2-6

The Versatility of Carbon

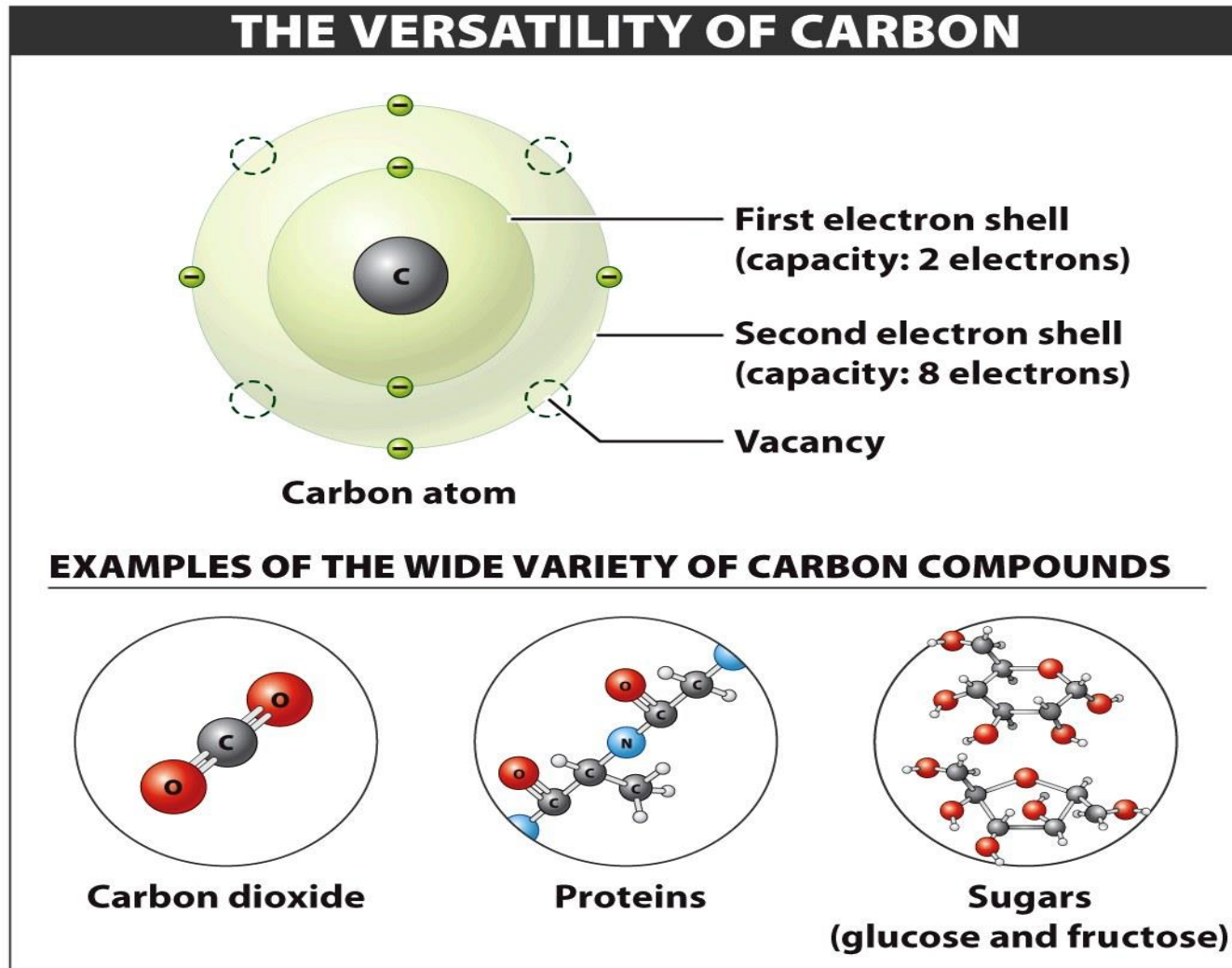
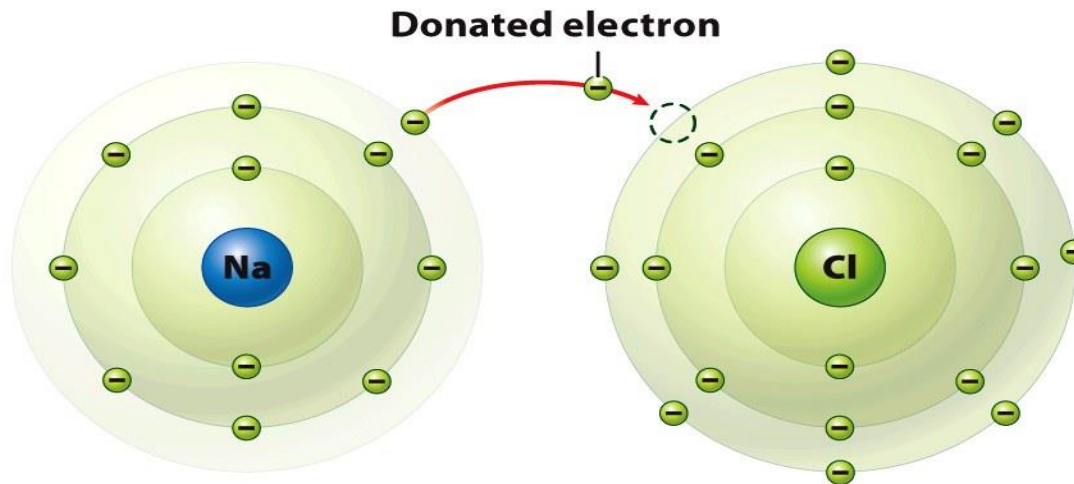


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Ions

IONS ARE CHARGED ATOMS

An atom that loses one or more electrons becomes positively charged, while an atom that acquires electrons becomes negatively charged. This transfer of electrons is driven by the fact that atoms with full outer electron shells are more stable.



SODIUM ION

⊕ 11 Protons
11 Neutrons
⊖ 10 Electrons

CHLORIDE ION

⊕ 17 Protons
17 Neutrons
⊖ 18 Electrons

**NET
CHARGE**

+ Positive

- Negative

Figure 2-8

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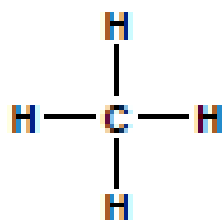
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2.3 Atoms can bond together to form molecules or compounds.

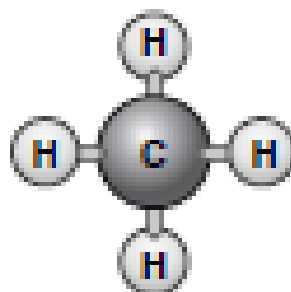
Molecules

Products of bonding!

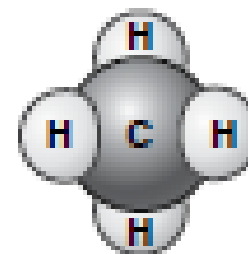
DIFFERENT WAYS OF REPRESENTING MOLECULAR STRUCTURE



"Lewis" model



"Ball-and-stick" model



"Space-filling" model

Covalent Bonds

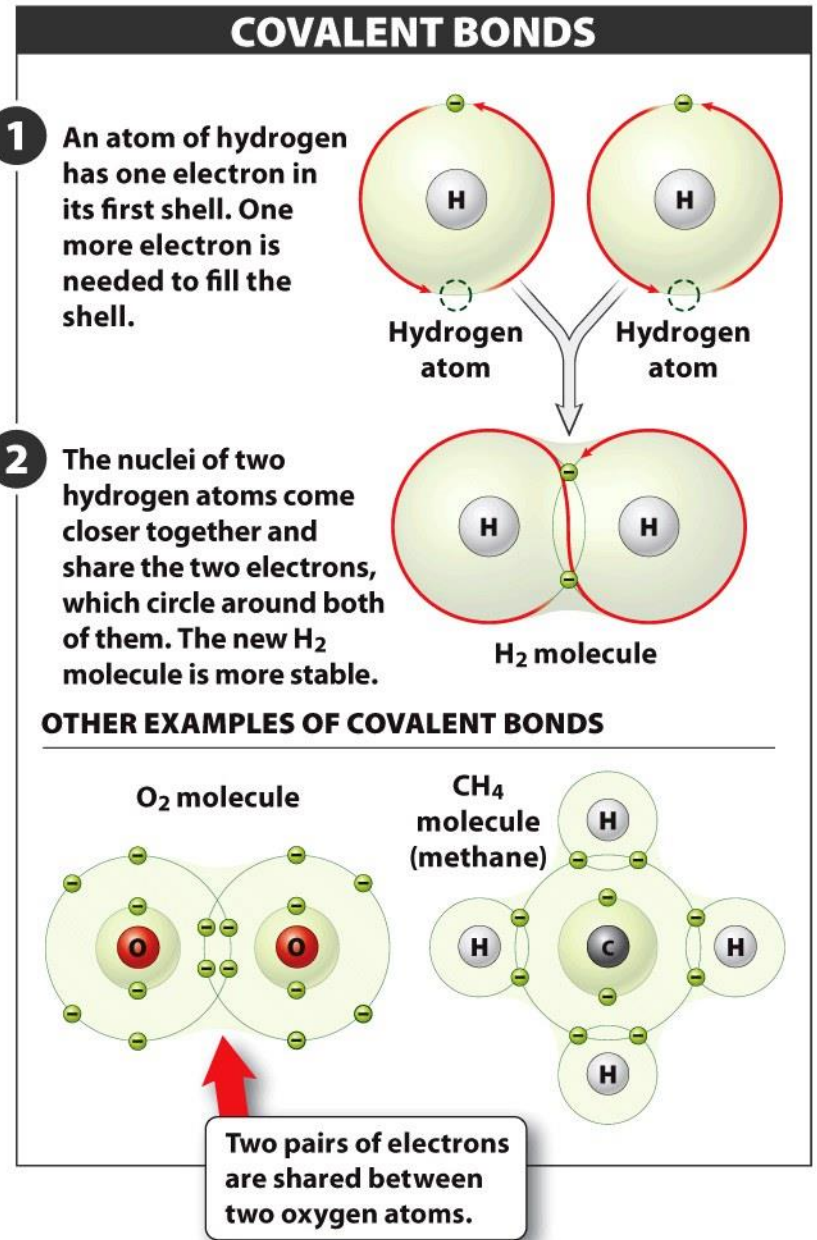


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Ions and Ionic Bonds

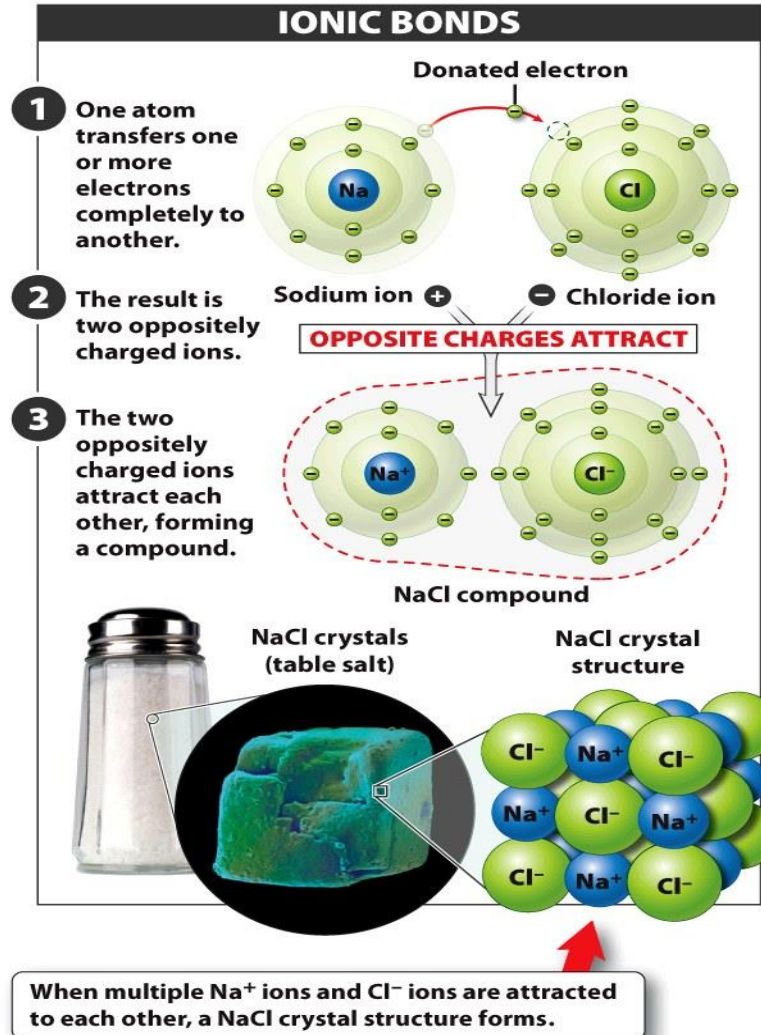


Figure 2-10

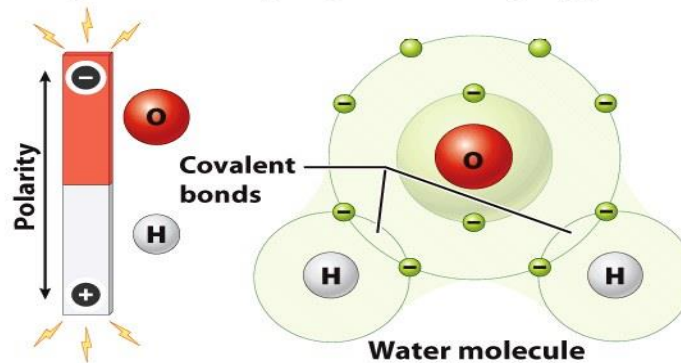
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Hydrogen Bonds

HYDROGEN BONDS

- 1** In a water molecule, oxygen's eight positively charged protons attract electrons more readily than does the single proton in the hydrogen atoms. As a result, the electrons are pulled toward the oxygen side of the molecule, making it slightly negative in charge, while the hydrogen side is slightly positive.



- 2** Hydrogen bonds are formed between the slightly positively charged hydrogen atoms of one molecule and the slightly negatively charged oxygen atom of another.

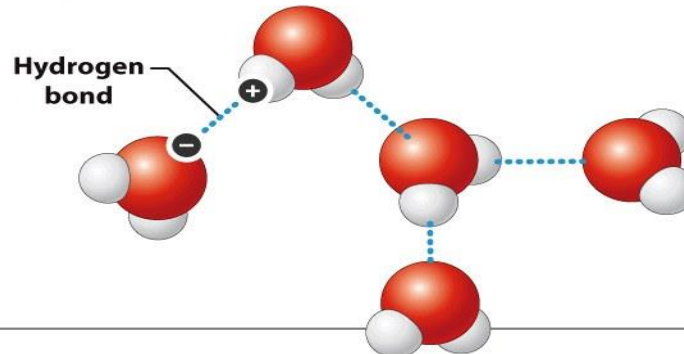


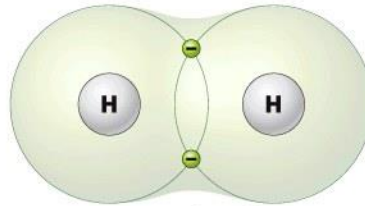
Figure 2-11
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SUMMARY: THREE TYPES OF BONDS

COVALENT BOND

A strong bond formed when atoms share electrons in order to become more stable, forming a molecule.

BOND STRENGTH: **STRONG**

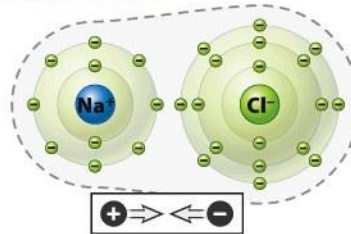


H₂ molecule

IONIC BOND

An attraction between two oppositely charged ions, forming a compound.

BOND STRENGTH: **STRONG**

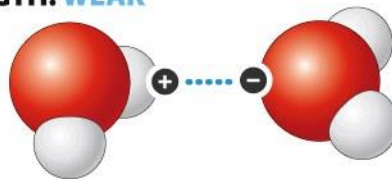


NaCl compound

HYDROGEN BOND

An attraction between the slightly positively charged hydrogen atom of one molecule and the slightly negatively charged atom of another.

BOND STRENGTH: **WEAK**



H₂O molecule

H₂O molecule

Figure 2-12

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2.4–2.6
Water has
features that
enable it to
support all life.



2.4 Hydrogen bonds make water cohesive.

WATER: HIGH SURFACE TENSION

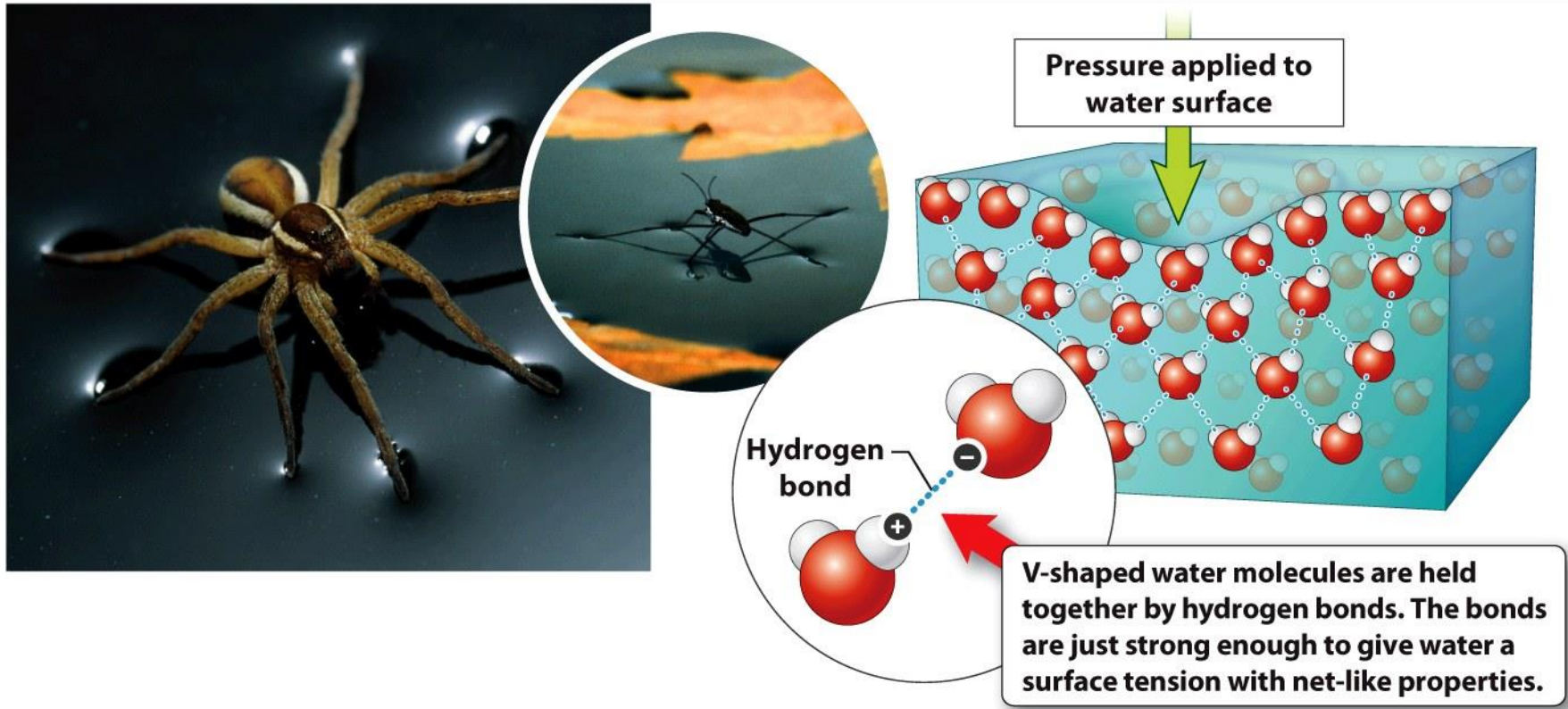


Figure 2-13

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WATER: HIGH SURFACE TENSION

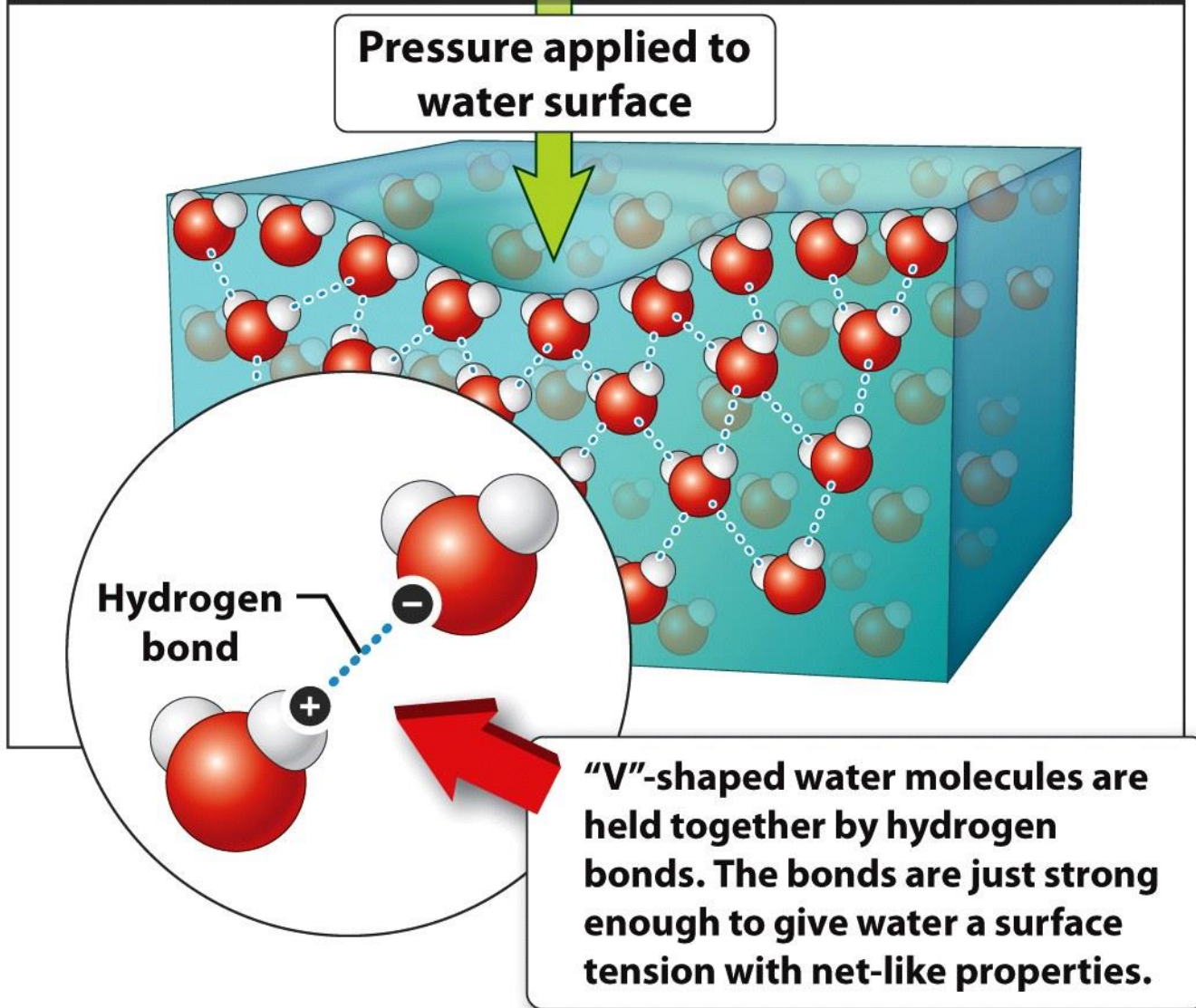


Figure 2-13 part 2

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Take-home message 2.4

- Water molecules easily form hydrogen bonds, giving water great cohesiveness.

2.5 Water has unusual properties that make it critical to life.

- Cohesion
- Large heat capacity
- Low density as a solid
- Good solvent

Cohesion

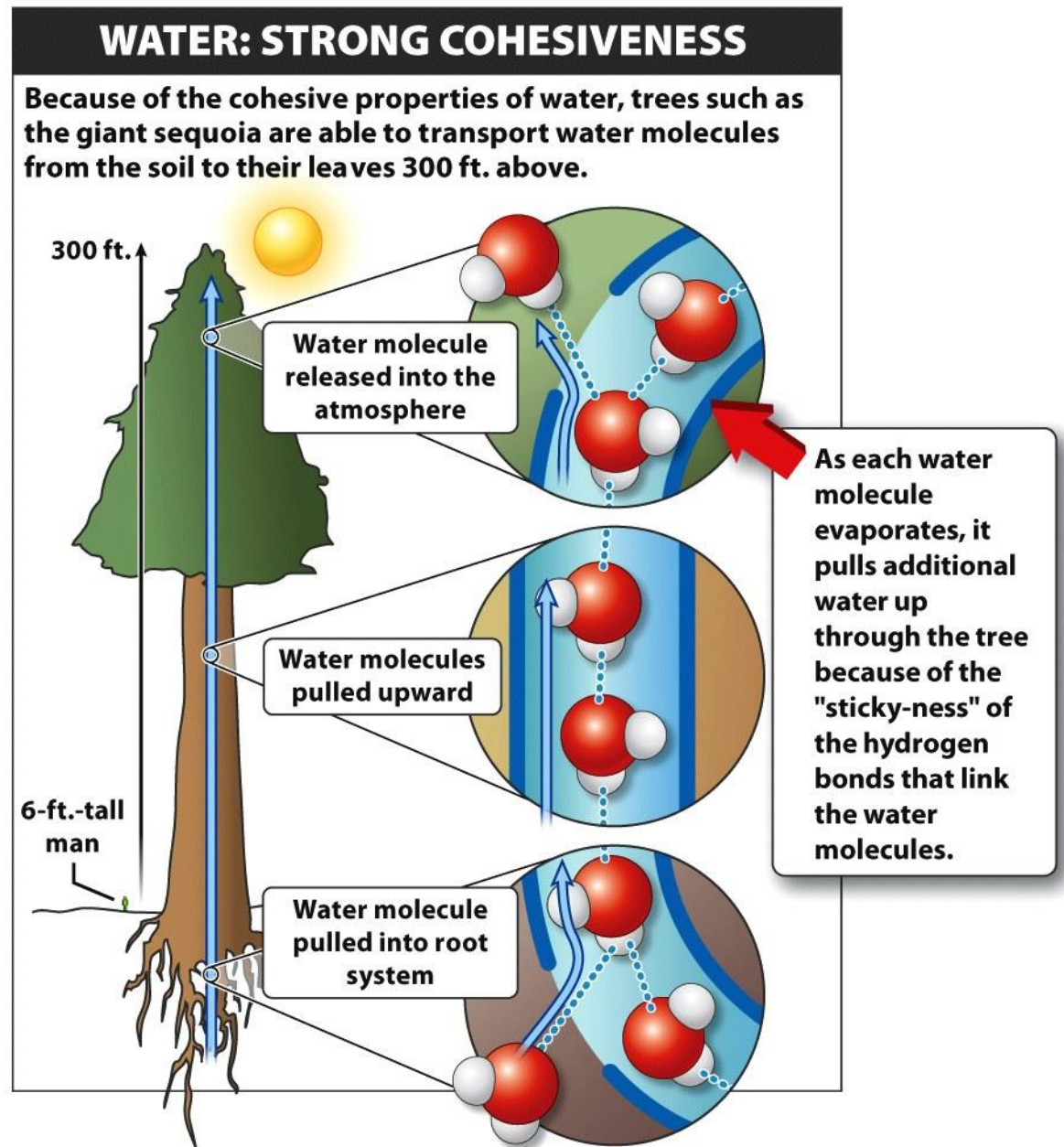


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Heat Capacity

WATER: HIGH HEAT CAPACITY

1 Heat (energy) from the sun disrupts some of the hydrogen bonds between water molecules.

2 New hydrogen bonds are formed almost as quickly as they are disrupted.

3 Because heat energy from the sun is used up breaking and re-forming hydrogen bonds, the water temperature doesn't increase by much.

4 Molecules that make up sand, on the other hand, don't have so many hydrogen bonds, so the heat of the sun just increases the temperature.

..... Disrupted bond
..... Newly formed bond

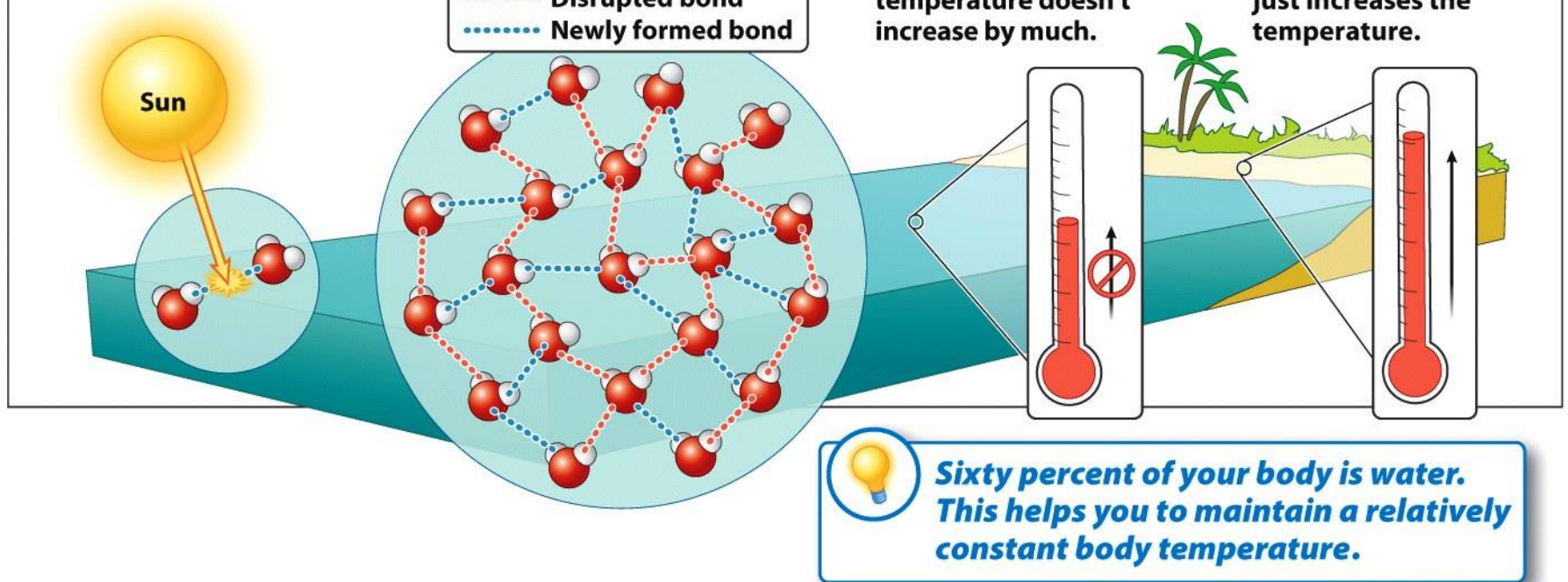


Figure 2-15
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Why do coastal areas have milder, less variable climates than inland areas?

Low Density as a Solid

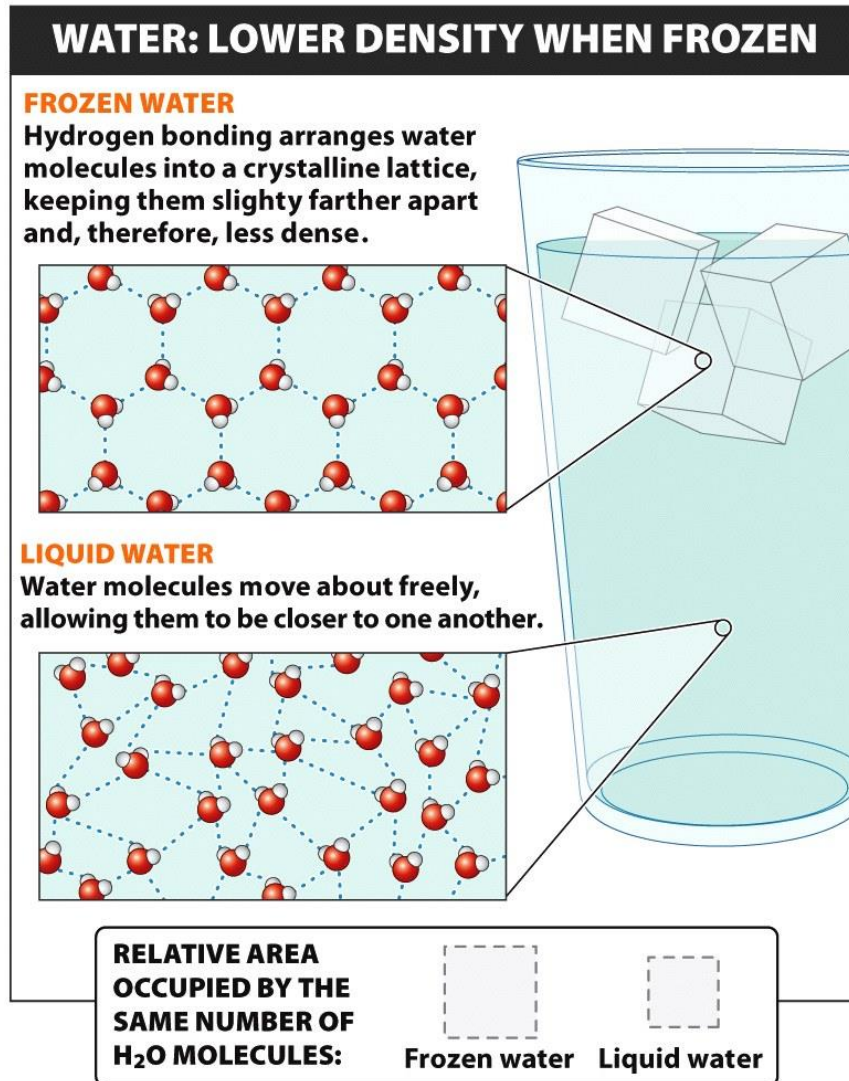


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WATER: A GOOD SOLVENT

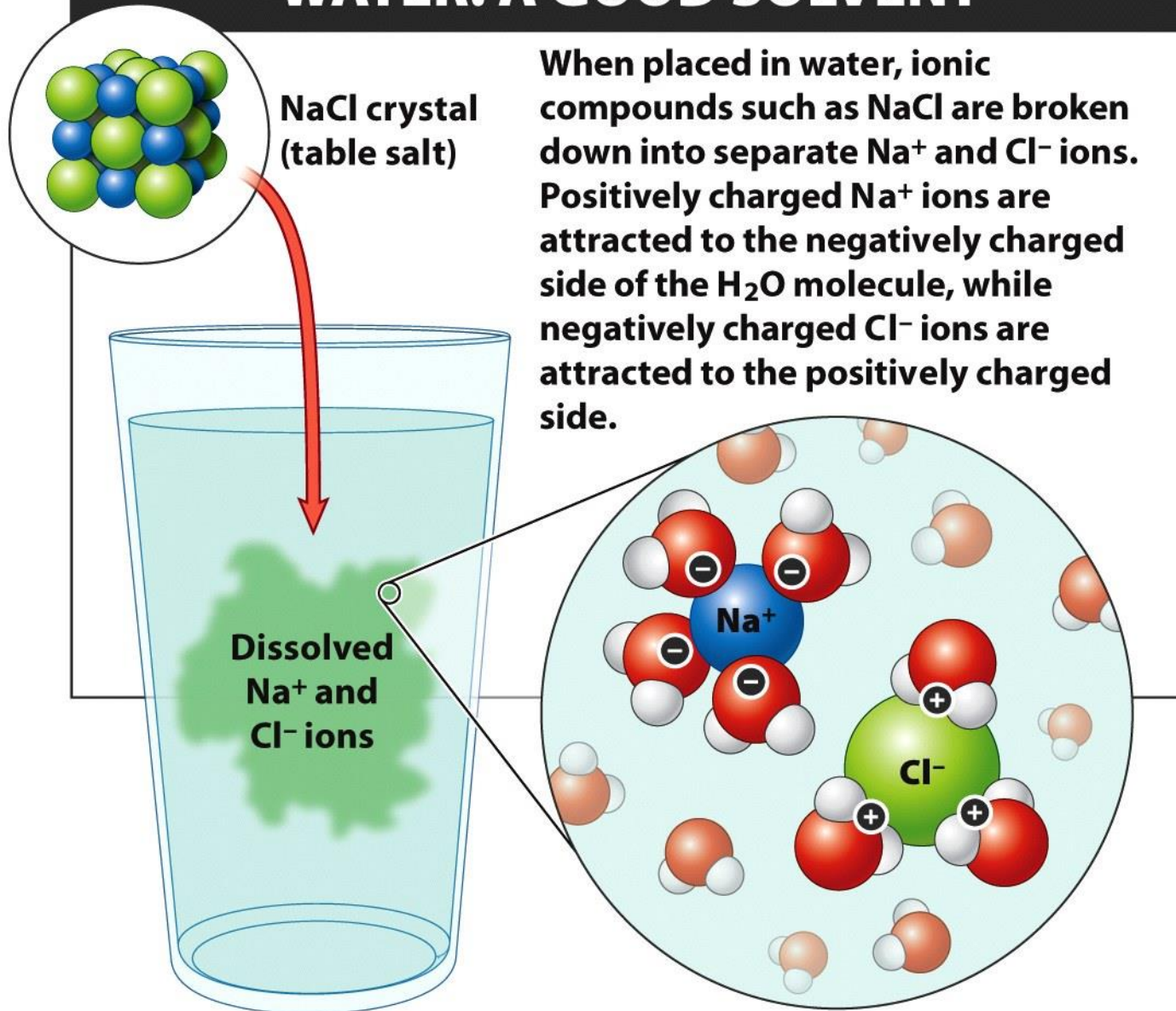


Figure 2-17

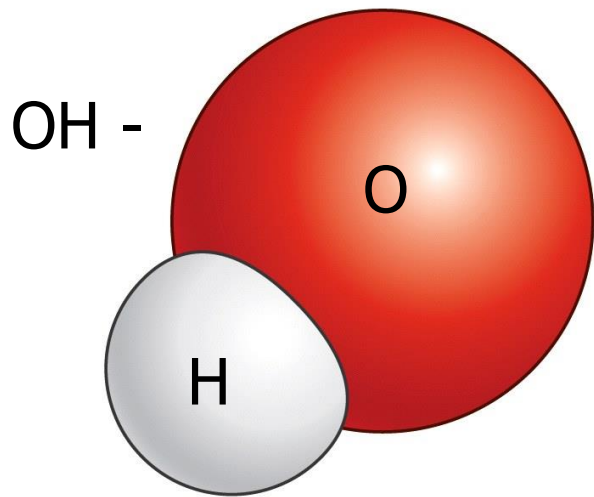
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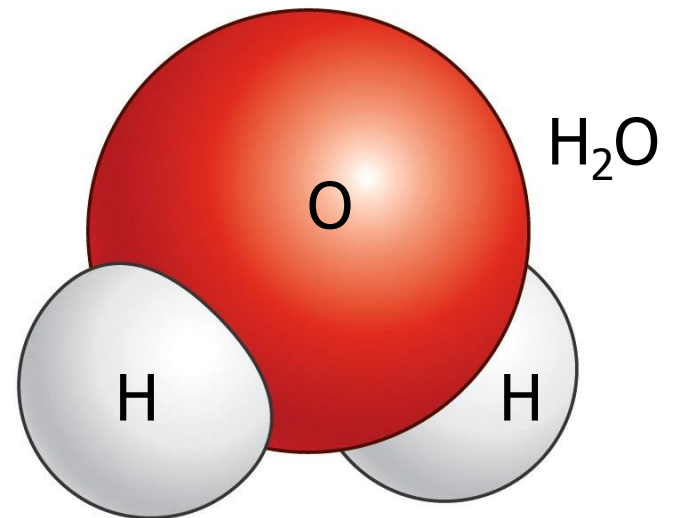
Why don't oceans freeze as easily as fresh water lakes?

2.6 Living systems are highly sensitive to acidic and basic conditions.

Hydrogen Ions and Hydroxide Ions



Ionized Hydroxide
Molecule



Non-Ionized Water
Molecule

pH Scale

□ The amount of H^+ in a solution is a measure of its acidity and is called **pH**.

□ **Acids**

□ **Bases**

THE pH SCALE



ACIDS

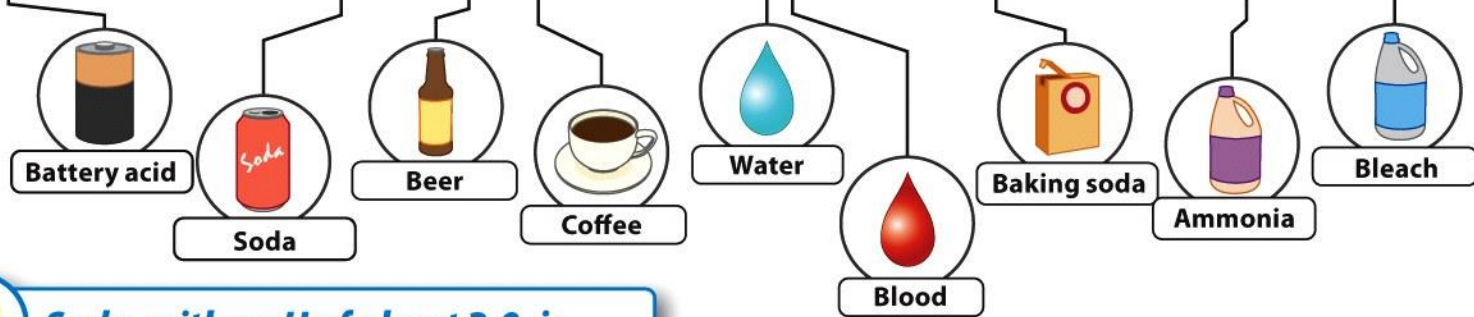
Acids are fluids that have a greater proportion of H^+ ions to OH^- ions.

- H^+ ions are very reactive.
- Strong acids are corrosive to metals.
- Acids break down food in your digestive tract.
- Acids are generally sour in taste.

BASES

Bases are fluids that have a greater proportion of OH^- ions to H^+ ions.

- OH^- ions bind with H^+ ions, neutralizing acids.
- Strong bases are caustic to your skin.
- Bases can be found in many household cleaners.
- Bases are generally bitter in taste and soapy.




 **Soda, with a pH of about 3.0, is 10,000 times more acidic than a glass of water, with a pH of 7.0!**

Figure 2-18
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H⁺ Ions and Acids

- H⁺ very reactive
- Acids can donate H⁺ to other chemicals
- Stomach acids

Bases

- Low H^+
- High OH^-

- Antacids
- Baking soda, seltzer, milk of magnesia

Blood pH

□ Buffers

- can quickly absorb excess H^+ ions to keep a solution from becoming too acidic
- can quickly release H^+ ions to counteract any increases in OH^- concentration

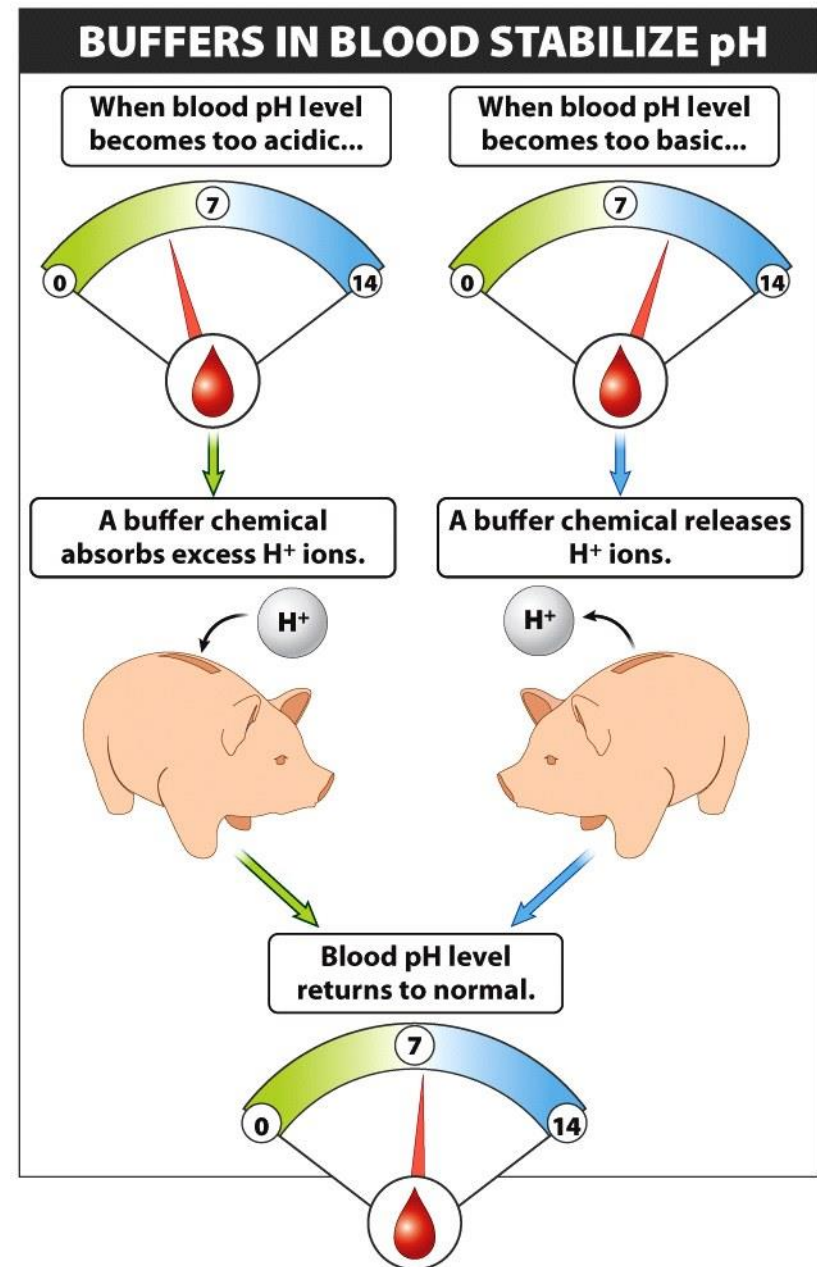


Figure 2-19

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