## **Ch 2 The Chemical Context of Life**

# **Concept 2.3: The formation and function of molecules depend on chemical bonding between atoms**

## Atoms with incomplete valence shells can share or transfer valence electrons with certain other atoms

## This usually results in atoms staying close together, held by attractions called **chemical bonds**

# **Covalent Bonds**

## A **covalent bond** is the sharing of a pair of valence electrons by two atoms

## In a covalent bond, the shared electrons count as part of each atom’s valence shell

## Two or more atoms held together by valence bonds constitute a **molecule**

# **Figure 2.7**

# **Figure 2.8**

# **Figure 2.9**

# **Figure 2.10**

# **Ionic Bonds**

## **Atoms sometimes strip electrons from their bonding partners**

## A **cation** is a positively charged ion

## An **anion** is a negatively charged ion

## An **ionic bond** is an attraction between an anion and a cation

# **Figure 2.11**

# ***Hydrogen Bonds***

## A **hydrogen bond** forms when a hydrogen atom covalently bonded to one electronegative atom is also attracted to another electronegative atom

# **Weak Chemical Bonds**

## Most of the strongest bonds in organisms are covalent bonds that form a cell’s molecules

## Weak chemical bonds, such as ionic bonds and hydrogen bonds, are also important

## Many large biological molecules are held in their functional form by weak bonds

# ***Van der Waals Interactions***

## If electrons are distributed asymmetrically in molecules or atoms, they can result in “hot spots” of positive or negative charge

## **Van der Waals interactions** are attractions between molecules that are close together because of these “Hot Spot” charges

## Van der Waals interactions are individually weak

## But together, such interactions can be strong, as between molecules of a gecko’s toe hairs and a wall surface

# **Concept 2.5: Hydrogen bonding gives water properties that help make life possible on Earth**

* All organisms are made mostly of water and live in an environment dominated by water**4 Emergent**

**Properties of Water Contribute to Earth’s Suitability for life:**

### Cohesive behavior

### Ability to moderate temperature

### Expansion upon freezing

### Versatility as a solvent

### ***Cohesive Behavior***

### Due to multiple hydrogen bonds of water molecules

#### H-bonds cause H2O molecules to stay close together = **Cohesion,**

####  H-bonds also cause H2O molecules to clinging to another substance = **Adhesion,**

#### tends to be difficult to break the surface = **Surface Tension**

# ***Ability to moderate temperature***

## The **specific heat** of water is

## The specific heat of a substance is the amount of heat that must be absorbed or lost for 1 g of that substance to change its temperature by 1 degree C

##  1 cal/g/°C

## Water resists changing its temperature because of its high specific heat. Why?

### Water’s high specific heat can be traced to hydrogen bonding

### Heat is released when hydrogen bonds form

#### Liquid state to SOLID (Ice) : bonds formed

### Heat is absorbed when hydrogen bonds break

#### Liquid to GAS (water vapor/steam): bonds break

#### Evaporative cooling: cools remaining surface water

* The high specific heat of water keeps temperature fluctuations within limits that permit life
* Evaporative cooling of water helps stabilize temperatures in organisms and bodies of water

# **Figure 2.19**

* Water absorbs heat from warmer air and releases stored heat to cooler air and it can do this absorbing/releasing of large amount of heat with only a slight change in its own temperature
* This allows oceans to moderate coastal climates,

***Expansion upon freezing***

# Water reaches its greatest density at 4deg C, then get less dense as it freezes

# Ice floats in liquid water because hydrogen bonds in ice are more “ordered,”

#  (the bonds held at arm’s length apart so there are less of them packed together) making ice less dense

# If ice sank, all bodies of water would eventually freeze solid, making life impossible on Earth

# Instead ice floats and insulates the water below allowing for life under the water surface to survive

# **Figure 2.20**

# ***Water: The Solvent of Life***

## A **solution** = homogeneous mixture of substances

## A **solvent =** dissolving agent of a solution

## The **solute =** substance that is dissolved

## An **aqueous solution =** water is the solvent

## **Figure 2.21**

* Water is a versatile solvent due to its polarity, which allows it to form hydrogen bonds easily
* When an ionic compound is dissolved in water, each ion is surrounded by a sphere of water molecules called a hydration shell
* Neg O regions attract to Pos Na cations, & Pos H regions attract to Neg Cl anions
* **Figure 2.22 A water-soluble protein**
* Water can also dissolve compounds made of nonionic polar molecules
* Even large polar molecules such as proteins can dissolve in water if they have ionic and polar regions

# ***Hydrophilic and Hydrophobic Substances***

## A **hydrophilic** substance is one that has an affinity for water

## A **hydrophobic** substance is one that does not have an affinity for water

## A **colloid** is a stable suspension of fine particles in a liquid