UNIT 2: BIOCHEMISTRY

TOPIC A: WATER

Essential Idea(s)
- Water is the medium of life.

IB Assessment Statements and Class Objectives:

2.2.U1: Water molecules are polar and hydrogen bonds form between them.
- Describe the structure of an atom (in terms of protons, neutrons and electrons).
- Define ion, anion and cation.
- Contrast covalent, ionic and hydrogen bonds.
- Write the molecular formula for water and draw the atomic structure of the molecule.
- Describe the cause and effect of the polar nature of water.
- Describe where and how water is able to form hydrogen bonds.

2.2.NOS: Use of theories to explain natural phenomena- the theory that hydrogen bonds form between water molecules explain the properties of water.
- State why scientists cannot prove without a doubt that hydrogen bonds exist between water molecules.

2.2.U2: Hydrogen bonding and dipolarity explain the cohesive, adhesive, thermal and solvent properties of water.
- Contrast adhesion with cohesion.
- Outline 1 example each of the cohesive and adhesive properties of water being of benefit to life.
- Explain three thermal properties of water that are useful to living organisms.
- Outline 1 benefit each to life of water's high specific heat capacity, high latent heat of vaporization, and high boiling point.
- Explain why water is such a good solvent.
- List the types of molecules that water will dissolve.

2.2.A1: Comparison of the thermal properties of water with those of methane.
- Compare and contrast the physical properties of methane and water.
- Explain why water and methane have different thermal properties based on their molecular structures.

2.2.A2: Use of water as a coolant in sweat.
- Explain sweating as a mechanism to cool the body.

2.2.U3: Substances can be hydrophilic or hydrophobic.
- Identify whether polar, ionic, non-polar, and non-ionic molecules are hydrophilic or hydrophobic.
- Explain how to determine if a molecule is hydrophilic or hydrophobic using a diagram of its structure.

2.2.A3: Modes of transport of glucose, amino acids, cholesterol, fats, oxygen, and sodium in blood in relations to their solubility in water.
- State if the following molecules are hydrophobic or hydrophilic: glucose, amino acids, cholesterol, fats, oxygen, and sodium chloride.
- Outline the mechanism of transport in the blood of the following molecules: glucose, amino acids, cholesterol, fats, oxygen, and sodium chloride.
Basics of Biochemistry

Elements

- An element is... substance that cannot be broken down

Atoms

- An atom is... smallest unit of matter; unique to each element
- Atoms are usually electrically... neutral

**Neutrons:**
- nucleus; neutral

**Protons:**
- nucleus; positive

**Electrons:**
- negative; around nucleus in cloud

In the atomic nucleus, which provides... stability

Electrons interact with... other atoms to form bonds + exchange energy

**Ions**

- Ions are atoms that are... electrically charged because they gained or lost electrons

**Cations:**
- lost electrons + charge Na⁺

**Anions:**
- gain electrons - charge Cl⁻
<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Example</th>
<th>Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>IONIC</td>
<td>• atom gives up 1 or more of its electrons</td>
<td>NaCl</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• opposite charged ions attract</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COVALENT</td>
<td>• two atoms share 1 or more pairs of electrons</td>
<td>H₂</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• equal - nonpolar</td>
<td>H₂O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• unequal - polar</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• double bond - 2 pairs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• triple bond - 3 pairs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HYDROGEN</td>
<td>• polar molecules have partially charged atoms</td>
<td>H₂O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• partial opposite charges attract each other</td>
<td>NH₃</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• individually weak, collectively strong</td>
<td>H·FON</td>
<td></td>
</tr>
</tbody>
</table>
### Biologicaly Important Properties of Water

<table>
<thead>
<tr>
<th>Property</th>
<th>Significance for Life</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ICE FLOATS</strong></td>
<td>Ice floats and insulates the underlying water so many plants and animals are not frozen</td>
<td><strong>H-bonds lock into place</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Avoids tight packing of molecules</strong></td>
<td></td>
</tr>
<tr>
<td><strong>SOLVENT</strong></td>
<td>Water is the main transport medium for dissolved nutrients. In animals, blood (mostly water) goes throughout all parts of the body, carrying nutrients. In plants, water carries nutrients up plants and through leaves.</td>
<td><strong>&quot;Like dissolves like&quot;</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Dissolves polar/charged molecules</strong></td>
</tr>
<tr>
<td><strong>COHESION</strong></td>
<td>Cohesion explains how water molecules can form a chain in delivering moisture to the top of a tree or through the blood stream.</td>
<td><strong>Hydrogen bonds attach molecules to each other</strong></td>
</tr>
</tbody>
</table>

**Cohesion of water molecules along a surface produces SURFACE TENSION**

- Water behaves as if covered by an elastic membrane
- Molecules stick to each other

**Adhesion helps water climb up the thin tubes of plants to the leaves**

**Adhesion and cohesion of water allows for CAPILLARY ACTION**

- Water moves up thin tubes

<table>
<thead>
<tr>
<th><strong>HIGH SPECIFIC HEAT</strong></th>
<th>Contents of cells are unlikely to freeze. Aquatic environments are thermally stable. Organisms have stable internal temperatures when the external temperature is fluctuating.</th>
<th><strong>Heats/cools slowly</strong> needs lots of energy to change temp** hard to break <strong>H-bonds</strong></th>
</tr>
</thead>
</table>
| **HIGH HEAT OF VAPORIZATION** | Organisms rely on heat of vaporization to remove body heat to remain cool. Evaporative cooling.                                                                                     | **Water surface**

**During evaporation, the more energetic particles escape from the surface leaving the less energetic ones behind.**

**H/O are clear**

**Transparency**

**Photo synthesis**
**UNIT 2: BIOCHEMISTRY**

**TOPIC A: WATER**

**Introduction:**

It has been said that “the chemistry of life is water chemistry.” Because of its chemical properties, water is the medium in which most of life’s chemical reactions occur. Life first evolved in water, and it resided there exclusively for three billion years. Most life is now concentrated in water-rich areas, and the cells of organisms are about 70 to 90 percent water. Because of its polarity, water molecules attract to each other forming hydrogen bonds. This polarity allows water to possess many important chemical and physical properties important to life. In this activity, you will rotate to each lab station performing the activity/demo that is placed there. Your task is to predict which property of water the activity/demo is trying to model. You also need to deduce what is happening on a molecular level that allows water to have this property!

*You MUST clean up after yourself at each station.*

<table>
<thead>
<tr>
<th>STATION</th>
<th>ACTIVITY</th>
<th>PROPERTIES?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Make staples float on water. Then, try a paperclip! Empty and refill beaker of water. Do not allow staples or paper clips down the drain.</td>
<td>cohesion</td>
</tr>
<tr>
<td>2</td>
<td>Count the number of drops of water you can put on top of a penny. Compare to the number of drops of oil you can put on top of a penny. Use the sponge and soap to wipe down the pennies and set on paper towel to dry.</td>
<td>cohesion/adhesion</td>
</tr>
<tr>
<td>3</td>
<td>Fill a beaker with water and sprinkle a pinch of pepper on top. Touch the tip of a toothpick into some liquid soap. Then, place the soapy tip into the water with pepper. Observe what happens. Pour the water and pepper down the drain. Return the toothpick to the beaker with the liquid soap.</td>
<td>solvent</td>
</tr>
<tr>
<td>4</td>
<td>Determine if ice sinks or floats when placed in liquid water. Pour the water and ice into the sink.</td>
<td>ice floats</td>
</tr>
<tr>
<td>5</td>
<td>Make sure the string is wet. Position one end of the string over the spout of the graduated cylinder and put the other end into the empty cup. Pull the string taught. Slowly pour the water along the string so it moves from the graduated cylinder into the cup. Clean up any spills. Empty cup.</td>
<td>adhesion</td>
</tr>
<tr>
<td>6</td>
<td>Observe a stalk of celery in a beaker of colored water. No specific clean-up is required.</td>
<td>adhesion</td>
</tr>
<tr>
<td>7</td>
<td>Add a small pinch of salt in a test tube. Fill the tube with water and cover the top with your thumb. Shake to mix the contents. What happens to the salt crystals? Pour out the salt and water. Rinse out the test tube.</td>
<td>solvent</td>
</tr>
</tbody>
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<tr>
<td>What will happen if water comes in contact with a nonpolar molecule? Mix oil and water to find out. Rinse the beaker out with soap.</td>
</tr>
<tr>
<td>Observe the temperatures of boiling water and ice. Are they changing? No specific clean-up required.</td>
</tr>
<tr>
<td>Drop 1 drop of water on the lab station and one drop of ethanol on the lab station. Rub the drops around with a finger to spread out the liquids, then compare the time it takes each to evaporate. Wipe up any extra liquid.</td>
</tr>
<tr>
<td>Read a sentence through a glass of water. No specific clean-up required.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Compound</th>
<th>Methane (CH₄)</th>
<th>Water (H₂O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonding</td>
<td>covalent</td>
<td>covalent</td>
</tr>
<tr>
<td>Polarity</td>
<td>non-polar</td>
<td>polar</td>
</tr>
<tr>
<td>Density</td>
<td>0.46 g/cm³</td>
<td>1.00 g/cm³</td>
</tr>
<tr>
<td>Heat Capacity</td>
<td>2.2 J/g°C</td>
<td>4.2 J/g°C</td>
</tr>
<tr>
<td>Heat of Vaporization</td>
<td>760 J/g</td>
<td>2200 J/g</td>
</tr>
<tr>
<td>Melting Point</td>
<td>-182°C</td>
<td>0°C</td>
</tr>
<tr>
<td>Boiling Point</td>
<td>-102°C</td>
<td>100°C</td>
</tr>
</tbody>
</table>

THE BIG IDEA: Because water is polar, it has thermal properties that sustain life on Earth.