Environmental Stewardship

Lesson 3: Water, Water, Everywhere: The Chemistry and Importance of Water

Grade Level 9-12
Time Required 50 minutes

Background

Water, climate, and life itself are deeply interconnected. Water exists naturally in 3 phases on the Earth and covers almost ¾ of Earth's surface. Despite its extensive presence on Earth, only a small percentage (0.024%) is available as liquid freshwater. The accessibility and conservation of freshwater continues to be one of the most critical challenges facing us. Water scarcity is currently affecting more than 30 countries and by the year 2050, 75% of the world's population will be facing water stress. The preservation of the world's freshwater, and mitigation of water pollution is an urgent issue.

Objectives

The purpose of this lesson is to help students understand the basic chemistry of water and how this chemistry relates to the unique abilities of water.

Engineering Connections: Environmental Engineering, Chemical Engineering, Civil Engineering

Water is a precious and limited natural resource, and management of this resource is a challenge that is being addressed in multiple fields of engineering. Engineering solutions to water management challenges must be sustainable, while being affordable and minimizing environmental impacts. The fields of Water Engineering (a branch of Civil) and Environmental Engineering have experienced recent growth in jobs due to the need for developing solutions to water challenges.

I Can:

- **Define and correctly use related functional vocabulary: solubility, solvent, solute, concentration, polarity, hydrogen bonding, cohesion, adhesion, contamination, pH, acid, base**
- **Explain how the polarity of water results in the function of water as a solvent and in many of its biological functions.**
- **Describe density differences in phases of water**
- **Relate water's ability as a solvent to the dissolving of substances in the environment.**

HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics
Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*

HS-ESS3-4 Earth and Human Activity
Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*

HS-ETS1-1 Engineering Design
Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Keywords
solubility, solvent, solute, concentration, polarity, hydrogen bonding, cohesion, adhesion, contamination, pH, acid, base

Pre-Assessment: (Formative) Complete the PLIX assessment on Water and Hydrogen Bonding on CK12: https://www.ck12.org/assessment/tools/geometry-tool/plix.html?eId=SCI.CHE.702&questionId=55b7e4f6da2cfe192229d02c&artifactID=2164225&plix_redirect=1

Activities: Students will take notes using Cornell notes or preferred teacher format. Suggested videos are linked below powerpoint, but other attention grabbers such as water demonstrations showing adhesion, cohesion, polarity can be done prior to notes.

Teacher Presentation:

Powerpoint: Water, Water, Everywhere: The structure, properties and importance of water

Supportive resources:

Videos:

Water –Liquid Awesome – Crash Course video https://youtu.be/HVT3Y3_gHGg

Why Does Ice Float in Water? Ted Ed https://youtu.be/UukRgqzk-KE

Student Follow Up Reading: https://www.ck12.org/chemistry/structure-of-water/lesson/Structure-of-Water-CHEM/?referrer=concept_details

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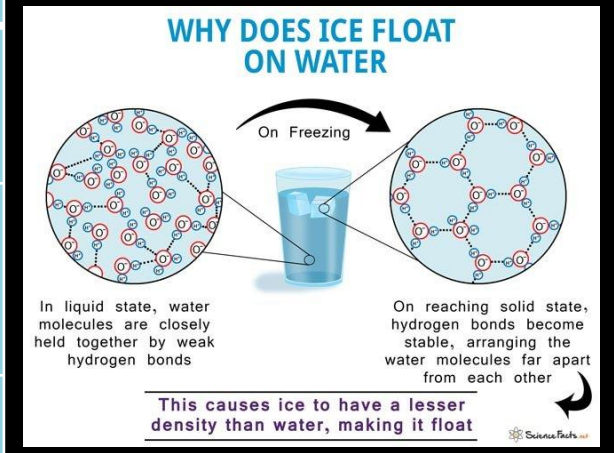
WATER, WATER, EVERYWHERE

STRUCTURE , PROPERTIES, AND IMPORTANCE OF WATER

WHAT MAKES WATER SO SPECIAL?

WATER CHEMISTRY

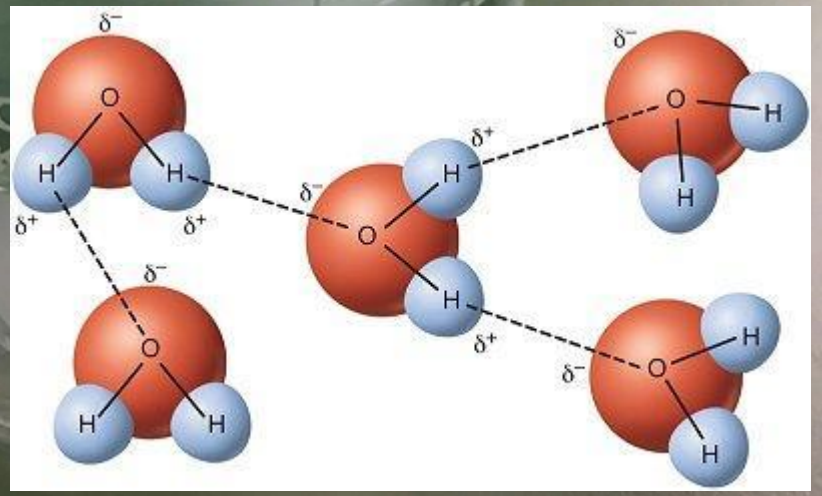
Formula:	**H_2O**
Boiling point	**100° Celsius**
Density	**Solid ~ 0.92 g/cm³** **Liquid ~ 1.00 g/ml** **Gas ~ 5.98×10^{-4} g /cm³**
Acid/Base	**Can act as both an acid and a base**



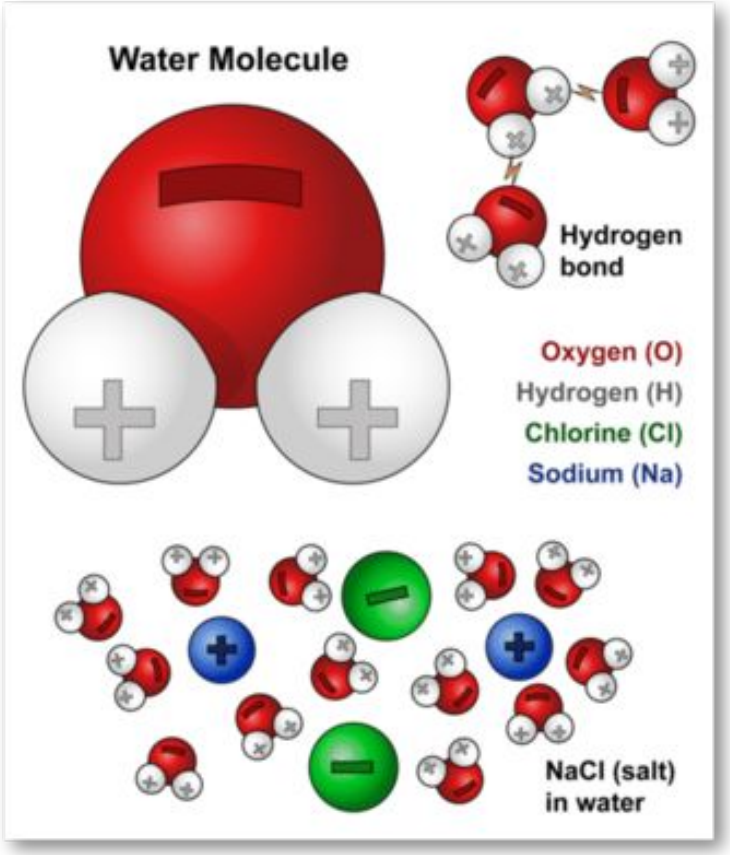
https://www.researchgate.net/post/Density_of_water_higher_than_density_of_ice

HYDROGEN BONDING

Surface tension is the result of cohesion between water molecules. Cohesion is the ‘stickiness’ between water molecules because of the polarity of the molecules. The oxygen in a water molecule has more ‘pull’ on the electrons. This pull is known as electronegativity, and it causes the oxygen side to have slight negative charge and the hydrogen side has a slight positive side. These charges result in attraction known as HYDROGEN BONDING.



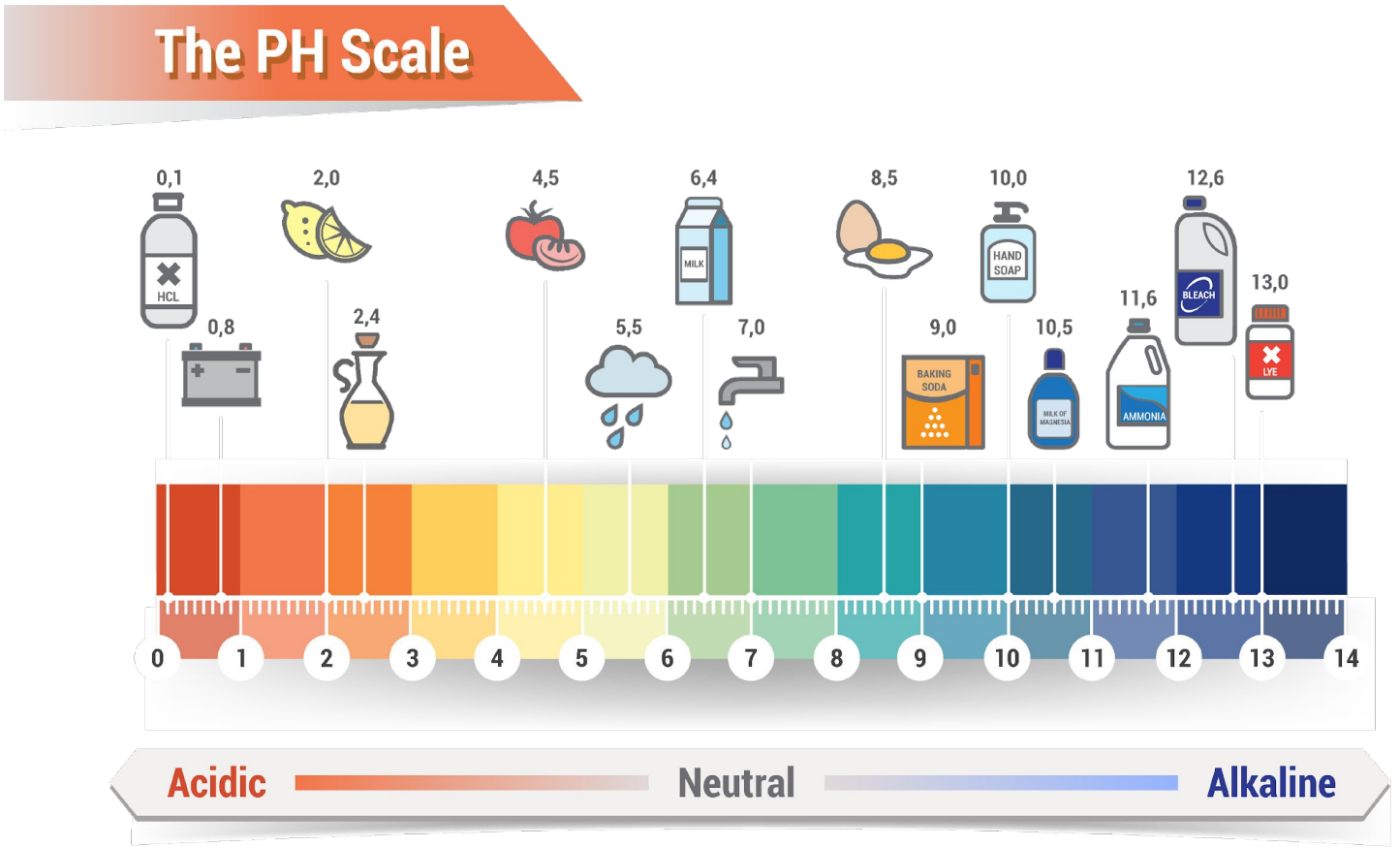
WATER: THE "UNIVERSAL SOLVENT"



https://www.usgs.gov/special-topic/water-science-school/science/water-universal-solvent?qt-science_center_objects=0#qt-science_center_objects

Water can dissolve many things, leading to its nickname as the universal solvent. The polar nature of the water molecule allows it to be an effective solvent because it can be attracted to many kinds of substances. Opposite charges attract so the ends of molecules that have different charges are attracted and can be pulled apart, leading to dissolving. Dissolving of charged particles is important in the formation of ionic solutions.

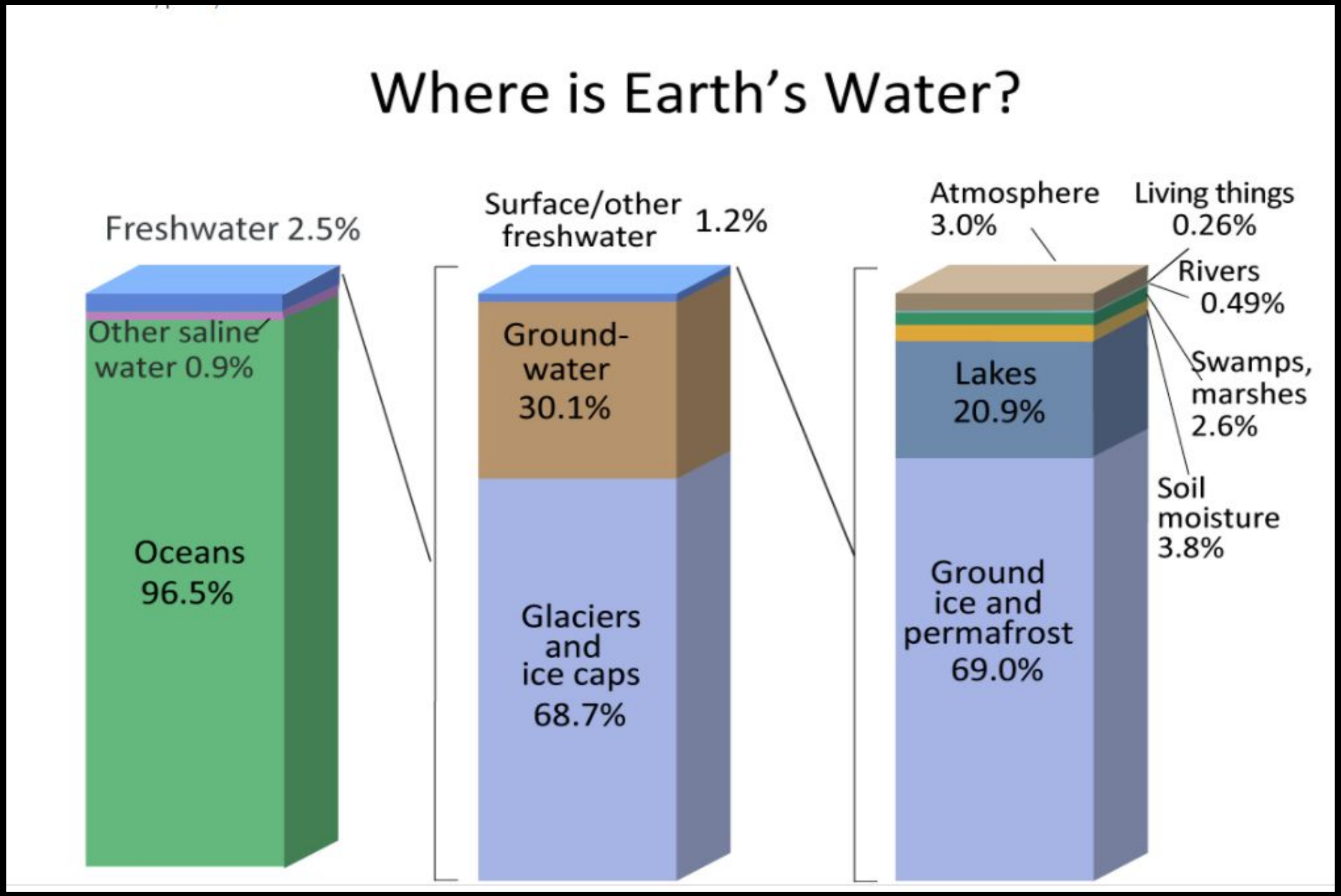
PURE WATER (DEIONIZED) HAS A PH VALUE OF 7.0. NEUTRAL.



IS WATER REALLY EVERYWHERE?

- Earth is often called the “water planet” because almost 75% of its surface is covered by water.
- Despite this large distribution, only 3% is freshwater, and 0.024% is accessible freshwater

Where is Earth's Water?



https://www.usgs.gov/special-topic/water-science-school/science/where-earths-water?qt-science_center_objects=0#qt-science_center_objects

THE WATER CRISIS

- 2.3 billion people live in water-stressed countries, of which 733 million live in high and critically water-stressed countries. (UN-Water 2021)
- Today, 1.42 billion people – including 450 million children – live in areas of high or extremely high water vulnerability. (UNICEF, 2021)
- About 4 billion people, representing nearly two-thirds of the global population, experience severe water scarcity during at least one month of the year (Mekonnen and Hoekstra, 2016)
- 700 million people worldwide could be displaced by intense water scarcity by 2030. (Global Water Institute, 2013)
- Nearly half the global population are already living in potential water scarce areas at least one month per year and this could increase to some 4.8–5.7 billion in 2050. About 73% of the affected people live in Asia (69% by 2050). (Burek et al., 2016)

REFERENCES

- https://www.usbr.gov/mp/arwec/water-facts-ww-water-sup.html
- https://www.usgs.gov/special-topic/water-science-school/science/water-properties-photo-gallery?qt-science_center_objects=0#qt-science_center_objects
- https://www.unwater.org/water-facts/scarcity/