A Whole New World: The Search for Water

An original lesson by Heather Miller and Nick Ahlers

Focus on Inquiry

Students will run a variety of tests on different liquids in which they will collect and graph data, collaborate and discuss their findings, compare their findings to known characteristics of water, make a claim, provide evidence and justification to support their claim, and create an advisory report of their findings.

Lesson Content Overview

Students will run various tests and compare their collected data to the known characteristics of water. Students will gain an understanding that water is unlike other liquids in the way that it moderates temperature, in its cohesive strength, in its ability to expand upon freezing, in its pH neutrality, and in its designation as the "universal solvent."

Duration	Setting	Grouping	PTI Inquiry Subskills
3-4 days	Classroom	2-4 students	2.5, 2.6, 3.1, 3.5, 4.2, 4.4, 5.2, 5.3, 5.7, 5.8, 6.1, 6.2, 7.1, 7.2 , 7.3, 7.5

Lesson Components	Estimated Time		Inquiry Subskills Used	Technology Used	Level of Student Engagement	Brief Description
Engage	5-10 min	Day 1		computer, projector	3	Students will watch the intro video that tasks them with the job of analyzing the liquid samples. Alternative to watching the video would be the teacher reading the passage to students to rally their support.
Explore	75 min	Day 1 & Day 2	2.5, 2.6, 3.1, 3.5, 4.2, 4.4, 5.8	hot plate, stopwatch	3	Students will test the liquid samples at 5 different stations: temperature moderation, cohesion, density, pH, and solubility.
Explain	20 min	Day 3	5.2, 5.3, 7.1, 7.2	none	2	Students will use their data, graphs, and reading passage information to formulate a claim about which planet's liquid is the most like water. Students will provide evidence and justification for their claim.
Expand/Elaborate	20 min	Day 3	5.7, 6.1, 6.2, 7.1	none	3	Students will collaborate with others by completing a gallery walk in which one of the group members stays behind to defend the group's claim. Groups will then get back together to finalize their claim, evidence, and justification.
Evaluate	20 min	Day 4	7.1, 7.2, 7.3, 7.5	none, computer optional	2	Students will write a letter to the United Nations making and supporting their claim to advise the UN on which planet to pursue. Student will take the Properties of Water Assessment.

Level of Student Engagement

1	Low	Listen to lecture, observe the teacher, individual reading, teacher demonstration, teacher-centered instruction
2	Moderate	Raise questions, lecture with discussion, record data, make predictions, technology interaction with assistance
3	High	Hands-on activity or inquiry; critique others, draw conclusions, make connections, problem-solve, student-centered

Next Generation Science Standards – Inquiry

NGSS Practice 3: Planning and Carrying Out Investigations
NGSS Practice 4: Analyzing and Interpreting Data
NGSS Practice 5: Using Mathematics

NGSS Practice 6: Constructing Explanations
NGSS Practice 7: Engaging in Arguments from Evidence
NGSS Practice 8: Obtaining, Evaluating and Communicating Information

Next Generation Science Standards – Earth Science

HS-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

ESS2.C: The Roles of Water in Earth's Surface Processes
The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

Florida Science Standards – Nature of Science

SC.912.N.1.1: Define a problem based on a specific body of knowledge, for example: biology, chemistry, physics, and earth/space science, and conduct systematic observations, examine text and other sources of information to see what is already known, use tools to gather, analyze, and interpret data, pose explanations or descriptions of events, use appropriate evidence and reasoning to justify these explanations to others, communicate results of scientific investigations, and evaluate the merits of the explanations produced by others.

Florida Science Standards – Life Science

SC.912.L.18.12: Discuss the special properties of water that contribute to Earth's suitability as an environment for life: cohesive behavior, ability to moderate temperature, expansion upon freezing, and versatility as a solvent.

Materials and Advance Preparation

Materials List

Class set:

- 1000 mL (1 L) of Hydrochloric Acid (1 M)
- 1000 mL (1 L) of Hydrogen Peroxide (3%)
- 1000 mL (1 L) of Isopropyl Alcohol (70%)
- 1000 mL (1 L) of water
- 2 hot plates
- 4 thermometers
- 8 – 100 mL glass beakers
- 2 – 1000 mL glass beakers or graduated cylinders
- 8 soufflé cups (3 oz)
- 1 penny
- 4 eye droppers
- Paper towel
- 4 – 25 mL graduated cylinders
- 2 – 2 mL scoop or measuring spoon
- 2 stir rods
- Spoon
- Ice cubes
- 1-2 vials of pH paper (full scale indicator)
- Timers (stopwatch or cell phone)

Student materials:

- Pen or pencil
- Student Blackline Master Handouts (Blackline Master 1, A-F)
- Goggles

Blackline Masters

1. **Blackline Master 1 (A-F):** A Whole New World: The Search for Water Student Handout
2. **Blackline Master 2 (A-E):** Lab Procedures
3. **Blackline Master 3 (A-B):** ADI Worksheet & Guide
4. **Blackline Master 4:** Writing Rubric
5. **Blackline Master 5:** Properties of Water Assessment
6. **Blackline Master 6:** Answer Keys

Advance Preparation

1. Prepare the video for the engage activity.
2. Make copies of the student blackline masters (1 per student/group depending on teacher's preference)
3. Make copies of Lab Station Directions
4. Set up all lab stations (see specific directions).

Lesson Information

Learning Objectives

1. The student will be able to accurately collect data, graph data, collaborate and discuss their findings, compare their findings to known characteristics of water, make a claim, provide evidence and justification to support their claim, and create an advisory report of their findings
2. The student will be able to accurately explain their understanding that water is unlike other liquids in the way that it moderates temperature, in its cohesive strength, in its ability to expand upon freezing, in its pH neutrality, and in its designation as the "universal solvent."

Prior Knowledge Needed by the Students

- Basic measurement and experimentation skills. Students should have some basic knowledge of atoms, molecules, and bonding.

Background Information

Covering more than 75% of Earth's surface, water is by far the most abundant natural resource on Earth. It is also its most important resource: life of any kind would not exist without it. Water possesses a series of unique properties that make it especially suitable for the gargantuan task of sustaining life on planet Earth.

Water molecules are made of two hydrogen and one oxygen atom held together by covalent bonds. When water molecules bond together, strong hydrogen bonds connect one molecule to the next. It can change states of matter freely, depending on the temperature of its environment. When water freezes into a solid, it forms a geometric pattern that spaces the molecules further apart than in a liquid state which takes up more space (i.e. expansion). Because of this expansion, solid water becomes less dense than liquid water and will FLOAT on its surface. If ice did not float on the surface of water, our lakes, rivers and oceans would freeze from the bottom up. This would trap and kill the organisms that live in these environments. Instead, the top layer of frozen water acts as an insulator keeping the water underneath slightly warmer than freezing.

Water can dissolve more substances than any other liquid. Because of its dissolving superpower, water is often referred to as the "universal solvent." Water's ability to dissolve so many substances is critical to every living thing on Earth. Wherever water goes, whether it's through our bodies or through the ground, it takes along valuable chemicals, minerals, and nutrients necessary for life. The uneven sharing of electrons on one side of the water molecule creates a positive charge on one end, which makes it very easily attracted to other molecules. Sometimes water can become so attracted to other substances that it breaks down the forces holding the substance together and is able to dissolve it.

Cohesion is a property of water that refers to how strongly water molecules are attracted to each other. Water is more cohesive than any other non-metallic liquid and is sticky and clumps together into drops. In a water molecule, the two hydrogen atoms align themselves along one side of the molecule and the oxygen atom aligns itself along the other side. This makes the oxygen side have a slight negative charge and the side with the hydrogen atoms have a slight positive charge. When the positive side of one water molecule comes near the negative side of another water molecule, they attract each other (opposites attract) and form a bond. This property of water molecules (*bipolar = two poles*) gives water its

cohesive nature and its ability to stick together. This cohesive force allows for water to move upward against gravity in huge plants like the giant Sequoia Trees. Without cohesion, water would not reach the upper branches and leaves of trees.

A substance's pH refers the amount of hydrogen ions that are in a solution. pH stands for "potential hydrogen." pH is measured on a scale of 0-14. A substance with a pH below 7 are generally considered to be acidic (the lower the pH, the stronger the acid). A substance with a pH greater than 7 is considered to be basic (the higher the pH, the stronger the base). A pH at or around 7 is considered to be neutral and are neither an acid nor a base. Water has a pH of approximately 7, making it neutral. The pH of a liquid like water determines the solubility of nutrients and metals. When the pH of water is too low (acidic), metals are more likely to dissolve and create a toxic environment. The pH of water also determines whether aquatic life can use it and live in it. When the pH is too high or too low, it will kill aquatic organisms and would be unsuitable for drinking.

Temperature moderation refers to water's ability to maintain a fairly consistent temperature. Water molecules are attracted to one another by hydrogen bonds and this limits the movement of the molecules. This strong attraction between water molecules means that a large amount of energy is required to increase or decrease the temperature of water. Large bodies of water are slow to change temperature (such as lakes and oceans) which is good for the organisms living in them. Also, due to their high water content, the bodies of organisms are also slow to change temperature and this makes maintaining a stable body temperature easier. *~While temperature moderation refers to the difficulty or ease of raising or lowering the temperature, temperature variation refers to the difference between the highest and lowest temperature of a liquid during a given time frame.*

Perlman, Howard. (2015) *USGS: Water Properties and Measurements.* Retrieved from http://water.usgs.gov/edu/waterproperties.html.

Lesson Procedure

Engage

1. Students will watch a video clip from "the future" that shows the dire condition that the Earth is in and will establish the premise that we are on the search for a new planet with water. Video clip can be accessed at: https://drive.google.com/open?id=0B3ft7TkiNrXxVXBTbEZsUHliU3c.
    - *There are no pop-ups or ads to worry about when playing this video. Make sure that you extend the frame to "full screen" when playing this video.*
2. Alternatively, students can read the intro to the lesson instead of watching the video or in addition to watching the video.
3. Students will be introduced to their "Tasks" for discovering which new planet will be most habitable for human life.

Explore

1. Students will conduct 5 different labs to test the properties of 4 different liquids: density, temperature moderation, cohesion, solubility, and pH.
2. Students will collect data on all four liquids so that they can make a recommendation to the "United Nations" on which liquid is most similar to water.
3. Students should be given 15-20 minutes to complete each of the different labs.
4. Students will first collect their data on their lab sheet and then transfer the pertinent information to their Master Data Sheet.
5. Students will graph the results from the Temperature Moderation Lab and the Cohesion Lab.
6. While students are working on their labs, the teacher should be moving from station to station to ensure that students are using proper lab procedures and answering questions as needed.
7. With large classes, it is recommended that at least 2 of each station are set-up by the teacher so that all student groups can be exploring the different properties of the liquids at the same time (a total of 10+ lab stations) and can move on to a new lab station when they complete their current lab.
8. Please see the set-up and procedures for each individual lab for additional information on the labs.

9. **NOTE: Please make sure that students are wearing appropriate lab safety wear such as goggles, lab aprons, and safety gloves as appropriate. Also, please make sure that you discuss the safety protocols associated with all of the chemicals and lab equipment before students begin working.**

Explain

1. To demonstrate their understanding of their experiences, students will analyze the data that they have collected, compare it to the information that they have about water, and make a claim about which liquid is the most like water.
2. Students will complete the Argument Driven Inquiry (ADI) form with their claim (which liquid they think is the most like water), their evidence (what evidence have they collected that supports their claim), and their justification (how does the evidence that they've provided demonstrate that this liquid is or is not like water).
3. Some questions you might ask students while they work include:
    1. *What do you know about water that will help you distinguish which liquid is the most like water? Student responses may vary but could include I know that water has a pH of 7, I know frozen water floats on liquid water, I know that water is very cohesive, I know that it takes a lot of energy to heat up or cool down water, I know that most anything will dissolve in water.*
    2. *What is it about that liquid (the one that the students chose) that makes you think that it's the most like water? Student responses may vary but could include I know that this liquid is the most like water because it has a pH close to 7, it floats on liquid water, it is very cohesive, it took a lot of energy to heat up or cool down, or that it dissolved most of the solutes..*
    3. *What is it about these other liquids that has convinced you that they are not like water? Student responses may vary but could include that they did not do what is described in the response to #2.*
    4. *What can you tell me about your data? Students' responses will vary but they may discuss difficulties that they had at one or any of the stations or that they are or are not confident in their data.*
    5. *What can you tell me about your graphs? Students' responses will vary but could include that in their temperature moderation lab, they saw one liquid that heated up very quickly and cooled down very quickly, whereas the others heated and cooled more slowly. In their cohesion graph, they should be able to explain that their bars represent the different amounts of drops that stayed on the penny and the higher the bar, the more cohesive the liquid is.*
    6. *How do you think life on Earth would be different if water had the same properties as one of these other liquids? Students' responses will vary but could include that ice would sink to the bottom of lakes, rivers, and the ocean, that our planet would heat up quickly in the day due to the "water" heating up quickly and would then have drastic cooling trends in the evening, that organisms would not be able to dissolve the gases and molecules they need for their bodily processes because the "water" that made up their body was not a good solvent, or that trees would grow shorter because "water" wasn't as cohesive and couldn't climb to those high heights.*
    7. *What difficulties did you have during the labs? Students' responses will vary.*
    8. *How accurate do you think your data is? What makes you think that? Students' responses will vary.*
    9. *What could you have done differently during your investigation to get better results? Students' responses will vary but could include improved measurement and observational techniques.*
    10. *What other tests could you conduct on these liquids to add to your evidence? Students' responses will vary.*
    11. *How would these additional investigations help you decide which liquid is the most like water? Students' responses will vary.*
    12. *How confident are you that your claim is accurate? Students' responses will vary.*

Expand

1. Students will complete a collaboration activity where one of the group members will be chosen (randomly) to leave the group and join another group to share out information from their home group and gather information from the group they are visiting.
2. Sharing with the new group should not take any more than 5 minutes.
3. The stray student will then return back to their home group to share the information learned from the group they were visiting.
4. The teams will complete this activity 3 more times with the 3 other different group members.
5. Upon completion of the collaboration activity, teams will discuss what they learned from the other groups and make any revisions to their ADI form that they feel are necessary.
6. Using their ADI form, groups will compose a letter to the United Nations informing them of their findings, citing their evidence and justification, and promoting one of the planets as the potential new home for mankind.
7. Students will use the writing rubric to guide the writing of their letter.

Evaluate

FORMAL EVALUTION

1. Letter to United Nations
2. Properties of Water Assessment: Blackline Master 5.

INFORMAL or OPTIONAL EVALUTIONS

1. Student questioning (see Explain Section)
2. Student/group observation
3. ADI Form
4. Data Tables and/or Lab Findings

WRAP UP.

Students will watch a video clip from the United Nations thanking them for their feedback and letting them know (conclusively) which liquid was the most like water, highlighting the properties of water, and explaining why water is critical to life on Earth. The video can be found here: https://drive.google.com/open?id=0B3ft7TkiNrXxWndfNmZJQlNpek0

- *There are no pop-ups or ads to worry about when playing this video. Make sure that you extend the frame to "full screen" when playing this video.*

Supplementary Resources

Teachers

Perlman, Howard. (2015) *USGS: Water Properties and Measurements.* Retrieved from http://water.usgs.gov/edu/waterproperties.html.

Students

Freeman, S. (2006) *Biological Science,* Second Edition, Pearson Prentice Hall, Inc. http://www.sumanasinc.com/webcontent/animations/content/propertiesofwater/water.html

Science Kids. (2015). *Science Kids: Water Facts.* http://www.sciencekids.co.nz/sciencefacts/water.html

Utah State Government Division of Water Resources. (2015). *Water Education.* http://www.watereducation.utah.gov/waterscience/Properties/default.asp

CITATION OF SOURCES.

Perlman, Howard. (2015) *USGS: Water Properties and Measurements.* Retrieved from http://water.usgs.gov/edu/waterproperties.html.

Weintraub. (2010). Rubistar: Persuasive Essay; Argument Paper on Controversial Science. Retrieved from http://rubistar.4teachers.org/index.php?screen=ShowRubric&rubric_id=1993475&

Cimino, M. (2015). ADI Worksheet and Guide; Based on the work of Dr. Victor Sampson. Revised for the purposes of this lesson.

Videos and photos used in the making of the Engage and Wrap Up videos include:

Barnett, L. (2012) Great Pacific Garbage Patch: Ocean Pollution. Retrieved from: https://www.youtube.com/watch?time_continue=177&v=1qT-rOXB6NI.

China Uncensored. (2015). 20 Signs China's Pollution Has Reached Apocalyptic Levels. Retrieved from: https://www.youtube.com/watch?v=OwOBRH56Ic0

NASA. (2014). NASA illustration of HAT P 11b exo-planet. Retrieved from: http://www.clarin.com/sociedad/Detectan-atmosfera-exoplaneta-tamano-Neptuno_0_1218478477.html

NBC Learn and the National Science Foundation. (2011). Chemistry Now: The Chemistry of Water. Retrieved from http://www.nsf.gov/news/special_reports/chemistrynow/chem_water.jspb

SpaceRip. (2013). Super-Earths: New Planets Found. Retrieved from: https://www.youtube.com/watch?time_continue=2&v=UyKHwFAJ9o4

Technology tools used in the making of the Engage and Wrap Up videos include Voki: http://voki.com/, Screen Cast-O-Matic: http://screencast-o-matic.com, Windows Movie Maker, and Windows Sound Recorder. All Voki's were created and recorded by Heather Miller.

__✓__ Yes, I cited all materials and resources used in this lesson. *Heather Miller & Nick Ahlers*

Lesson authors' signatures

Blackline Master 1A

A Whole New World: The Search for Water

The year is 2065; fifty years from today. Pollution and climate change have begun to have a drastic effect on planet Earth. The planet is dying and will soon no longer be suitable for human life. An international group of scientists have been organized by the United Nations. Their task was to explore the feasibility of living on one of four newly discovered planets in other solar systems. The scientists have already sent missions to each planet and have returned with samples of the most abundant liquids found in each location. They have hired you and your team to run tests on each liquid to determine which one is most like water and could possibly sustain human life. If water is present on the planet, the planet could provide a new home for mankind.

Tasks:

- ☐ You and your team will run tests (experiments) on each liquid sample.
- ☐ Collect data from your experiments on the liquid samples and record it in your Master Data Sheet.
- ☐ Once you have collected and graphed all of your data, discuss what the data means with your group.
- ☐ Compare your findings to the information contained in the reading passage about water.
- ☐ Make a claim as to which liquid is most like water and would support life.
- ☐ Provide evidence and justification from your reading, data, and graphs to support your claim.
- ☐ Collaborate with other groups to discuss and defend your claims.
- ☐ Finalize your claim and generate a report to send to the United Nations advising them on which planet to pursue as mankind's new home.

Blackline Master 1B

Water Wisdom

Covering more than 75% of Earth's surface, water is by far the most abundant natural resource on Earth. It is also its most important- life of any kind would not exist without it. Water possesses a series of unique properties that make it especially suitable for the gargantuan task of sustaining life on planet Earth.

Water molecules are made of two hydrogen and one oxygen atom that are bonded together by a series of strong hydrogen bonds. It can change states of matter freely, depending on the temperature of its environment. When water freezes into a solid, it forms a geometric pattern that makes it expand and take up more space. Because of this expansion, solid water becomes less dense than liquid water and will FLOAT on its surface. If ice did not float on the surface of water, our lakes, rivers and oceans would freeze from the bottom up. This would trap and kill the organisms that live in these environments. Instead, the top layer of frozen water acts as an insulator keeping the water underneath slightly warmer than freezing.

Water can dissolve more substances than any other liquid. Because of its dissolving superpower, water is often referred to as the "universal solvent." Water's ability to dissolve so many substances is critical to every living thing on Earth. Wherever water goes, whether it's through our bodies or through the ground, it takes along valuable chemicals, minerals, and nutrients necessary for life. The hydrogen bond that exists on one side of the water molecule has a positive charge, which makes it very easily attracted to other molecules. Sometimes water can become so attracted to other substances that it breaks down the forces holding the substance together and is able to dissolve it.

Cohesion is a property of water that refers to how strongly water molecules are attracted to each other. Water is more cohesive than any other non-metallic liquid and is sticky and clumps together into drops. In a water molecule, the two hydrogen atoms align themselves along one side of the molecule and the oxygen atom aligns itself along the other side. This makes the oxygen side have a slight negative charge and the side with the hydrogen atoms have a slight positive charge. When the positive side of one water molecule comes near the negative side of another water molecule, they attract each other (opposites attract) and form a bond. This property of water molecules (*bipolar = two poles*) gives water its cohesive nature and its ability to stick together. This cohesive force allows for water to move upward against gravity in huge plants like the giant Sequoia Trees. Without cohesion, water would not reach the upper branches and leaves of trees.

A substance's pH refers the amount of hydrogen ions that are in a solution. pH stands for "potential of hydrogen" or "power of hydrogen." pH is measured on a scale of 0-14. Organisms with a pH below 7 are generally considered to be acidic (the lower the pH, the stronger the acid). Organisms with a pH greater than 7 are generally considered to be bases (the higher the pH, the stronger the base). Organisms with a pH at or around 7 are generally considered to be neutral and are neither an acid nor a base. Water has a pH of approximately 7, making it neutral. The pH of a liquid like water determines the solubility of nutrients and metals. When the pH of water is too low (acidic), metals are more likely to dissolve and create a toxic environment. The pH of water also determines whether aquatic life can use it and live in it. When the pH is too high or too low, it will kill aquatic organisms and would be unsuitable for drinking.

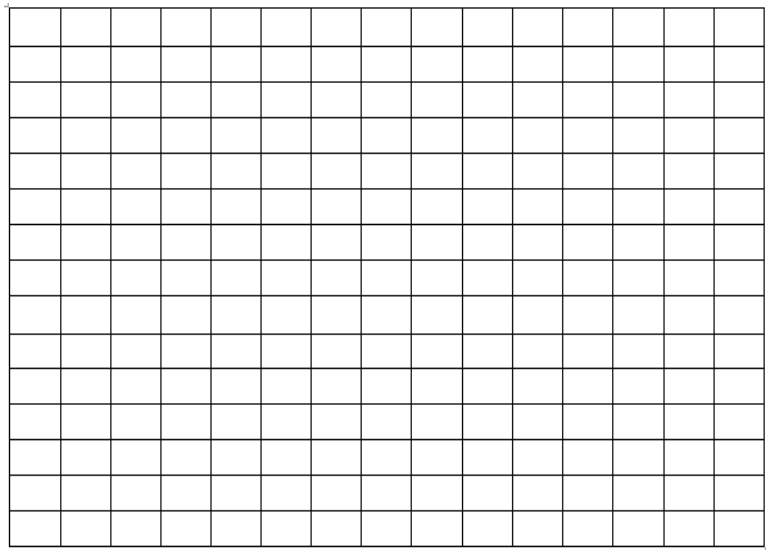
Temperature moderation refers to water's ability to maintain a fairly consistent temperature. Water molecules are attracted to one another by hydrogen bonds and this limits the movement of the molecules. This strong attraction between water molecules means that a large amount of energy is required to increase or decrease the temperature of water. Large bodies of water are slow to change temperature (such as lakes and oceans) which is good for the organisms living in them. Also, due to their high water content, the bodies of organisms are also slow to change temperature and this makes maintaining a stable body temperature easier. *~While temperature moderation refers to the difficulty or ease of raising or lowering the temperature, temperature variation refers to the difference between the highest and lowest temperature of a liquid during a given time frame.*

Blackline Master 1C

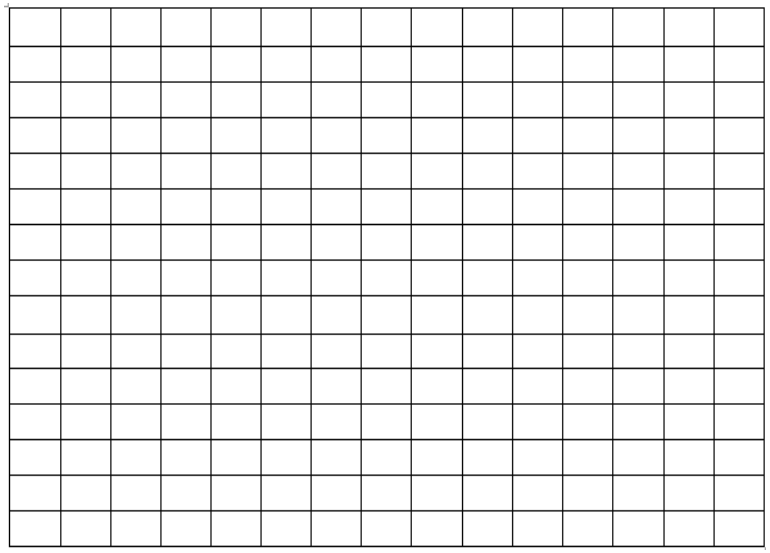
Master Data Sheet

	Color	Boiling Point	Freezing Point	Density	Density Factor	Temperature Moderation Factor	Cohesion Factor	Solubility Factor	pH	Other Observations
Liquid A		82.6°C	−89.0°C	0.786 g/cm^3						
Liquid B		150.2°C	−0.43°C	1.443 g/cm^3						
Liquid C		98.4°C	3.70°C	1.005 g/cm^3						
Liquid D		103.0°C	-18.0°C	1.048 g/cm^3						

Temperature Moderation Graph



Cohesion Graph



Blackline Master 1D

Temperature Moderation/Variation Data

Time (minutes)	Temperature Readings			
	Liquid A	Liquid B	Liquid C	Liquid D
0:00 (starting temperature)				
1:00 (heat)				
2:00 (heat)				
3:00 (heat)				
4:00 (heat)				
5:00 (heat)				
6:00 (cool)				
7:00 (cool)				
8:00 (cool)				
9:00 (cool)				
10:00 (cool)				
Temperature Moderation Factor				

Calculating Temperature Moderation Factor

1. Subtract your STARTING temperature from your HIGHEST recorded temperature (likely at 5:00 minute mark). This is range #1.
2. Subtract your ENDING temperature from your HIGHEST recorded temperature (likely at 5:00 minute mark). This is range #2.
3. Find the average (mean) of the two ranges by adding the two ranges together and dividing by two.
4. The average (mean) that you calculated is your temperature moderation factor.
5. Complete these calculations for each of the four liquids.
6. Enter these values into the master data table in the column labeled “Temperature Moderation Factor.”

Liquid A

[ ] Highest Temperature — [ ] Starting Temperature = [ ] Range #1

[ ] Highest Temperature — [ ] Final Temperature = [ ] Range #2

[ ] Range #1 + [ ] Range #2 /2 = [ ] Temperature Moderation Factor

Liquid B

[ ] Highest Temperature — [ ] Starting Temperature = [ ] Range #1

[ ] Highest Temperature — [ ] Final Temperature = [ ] Range #2

[ ] Range #1 + [ ] Range #2 /2 = [ ] Temperature Moderation Factor

Liquid C

[ ] Highest Temperature — [ ] Starting Temperature = [ ] Range #1

[ ] Highest Temperature — [ ] Final Temperature = [ ] Range #2

[ ] Range #1 + [ ] Range #2 /2 = [ ] Temperature Moderation Factor

Liquid D

[ ] Highest Temperature — [ ] Starting Temperature = [ ] Range #1

[ ] Highest Temperature — [ ] Final Temperature = [ ] Range #2

[ ] Range #1 + [ ] Range #2 /2 = [ ] Temperature Moderation Factor

Blackline Master 1E

Cohesion Data

	Number of Drops			
	Trial 1	**Trial 2**	**Trial 3**	**Average (Cohesion Factor)**
Liquid A				
Liquid B				
Liquid C				
Liquid D				

Calculating Cohesion Factor

1. Find the average (mean) of the number of drops for each liquid by adding the number of drops for the three trials together and dividing by three.
2. The average (mean) that you calculated is your cohesion factor.
3. Complete these calculations for each of the four liquids.
4. Enter these values into the master data table in the column labeled “Cohesion Factor.”

Liquid A

[ ] + [ ] + [ ] = [ ] /3 = [ ]

Trial 1 Trial 2 Trial 3 Total Average (Cohesion Factor)

Liquid B

[ ] + [ ] + [ ] = [ ] /3 = [ ]

Trial 1 Trial 2 Trial 3 Total Average (Cohesion Factor)

Liquid C

[ ] + [ ] + [ ] = [ ] /3 = [ ]

Trial 1 Trial 2 Trial 3 Total Average (Cohesion Factor)

Liquid D

[ ] + [ ] + [ ] = [ ] /3 = [ ]

Trial 1 Trial 2 Trial 3 Total Average (Cohesion Factor)

Blackline Master 1F

Solubility Data

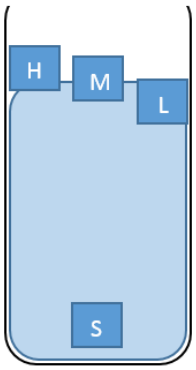
Solvents	Solutes		
	Powdered Substance	Granular Substance	Number of Solutes Dissolved (Solubility Factor)
Liquid A			
Liquid B			
Liquid C			
Liquid D			

Calculating Solubility Factor

1. Count how many of the solutes dissolved in the liquid. Your options are 0, 1, or 2.
2. Complete these calculations for each of the four liquids.
3. Enter these values into the master data table in the column labeled "Solubility Factor."

Density Data

	Float or Sink	Height of Float (Density Factor)
Liquid A		
Liquid B		
Liquid C		
Liquid D		



High Float: Most or all of the cube is above the top of the liquid.
Moderate Float: The cube is approximately half above and half below the top of the liquid.
Low Float: Most or all of the cube is below the top of the liquid.

Sink: The cube is at or near the bottom of the container.

pH Data

	pH	Acid, Base, or Neutral
Liquid A		
Liquid B		
Liquid C		
Liquid D		

Blackline Master 2A

Temperature Moderation Lab Procedure

1. Pour 50mL of each liquid in to four separate beakers *(or verify that there is 50 mL of liquid in each beaker)*.
2. Place a thermometer into each liquid.
3. After waiting for 30 seconds, record the *starting temperature* of each liquid in your data table.
4. Place all four beakers onto a hot plate(s).
5. Heat all four beakers using **MEDIUM** heat.
6. Record the temperature of each liquid every minute for 5 minutes while they heat up. **DO NOT REMOVE THE THERMOMETERS FROM THE BEAKERS WHEN READING THE TEMPERATURE.**
7. After 5 minutes, remove the liquids from the hot plate(s) and place them on an insulated surface.
8. Record the temperature of each liquid every minute for 5 minutes while they cool down. **DO NOT REMOVE THE THERMOMETERS FROM THE BEAKERS WHEN READING THE TEMPERATURE.**
9. Calculate the Temperature Moderation Factor of each liquid using the direction on your data sheet.
10. Record the Temperature Moderation Factors on the Master Data Sheet.

Blackline Master 2B

Solubility Lab Procedure

1. Pour 25mL of ONE of the liquids into each of the two beakers.
2. Add 2 mL of each solute to each of the beakers.
3. Stir the solution for 60 seconds with the stir rod.
4. Record the results **(dissolved, did not dissolve)** in your data table.
   - ***Dissolved means that it is completely mixed and you cannot see individual particles.***
5. Rinse out the beakers.
6. Repeat steps 1-5 with the other three solvents.
7. Calculate the Solubility Factor of each liquid using the directions on your data sheet.
8. Record your Solubility Factors on the Master Data Sheet.

Blackline Master 2C

Cohesion Lab Procedure

1. Place a penny on the paper towel.
2. Extract one of the liquids from the cup with an eyedropper.
3. From a close distance, carefully drop the liquid on the penny **ONE DROP AT A TIME** while counting how many drops you have placed.
4. Continue dropping the liquid onto the penny until the liquid overflows onto the paper towel.
5. Record the number of drops in your data table.
6. Repeat steps 1-5 two more time for accuracy.
7. Repeat steps 1-6 with the other three liquids.
9. Calculate the Cohesion Factor for each liquid using the directions on your data sheet.
10. Record your Cohesion Factors on the Master Data Sheet.

Blackline Master 2D

Density Lab Procedure

1. Pour 500ml of each of the liquids into four different beakers (this may already be done for you).
2. Gently place an ice cube into ONE of the beakers and observe whether the ice cube floats or sinks in the liquid.
3. Record your observations on your data sheet.
4. Observe and record the floating location of the ice cube. Use the floating diagram on your data sheet to help you.
5. With the spoon, gently scoop the ice cube out of the liquid and into the disposal/sink.
6. Repeat steps 2-4 with the other three liquids.
7. Record your Density Factors on the Master Data Sheet.

Blackline Master 2E

pH Lab Procedure

1. Using ONE pH test paper, dip the end of the paper into your sample of Liquid A.
2. The paper will turn color.
3. Compare the color on your test paper to the color chart provided to determine the pH.
4. Write the pH on your data table and your Master Data Sheet.
5. Throw away the pH test strip as it cannot be used again.
6. Repeat steps 1-5 for all four different liquids.

	Acid	Neutral	Base
pH range	1 to 6.9	7	7.1 to 14

Blackline Master 3A

ADI Worksheet

Guiding Question: Which liquid is most like water and would support human life?

Claim: *(make a statement about which liquid is most like water)*

Evidence	Justification
*(**put** your data, graphs, text, etc that helps to support your claim here)*	*(**explain how** your data, graphs, text, etc helps to support your claim here)*

Blackline Master 3B

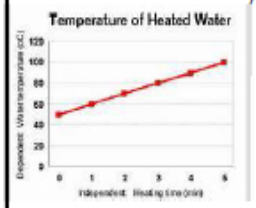
ADI Guide

Guiding Question: This is the question you are answering by doing the lab. This may be provided by your teacher.

Student Names:

Claim: This is your answer to the guiding question. This is done at the END of the lab, after you have all of your evidence collected. Start your claim using the phrase, *"Our evidence supports…"*

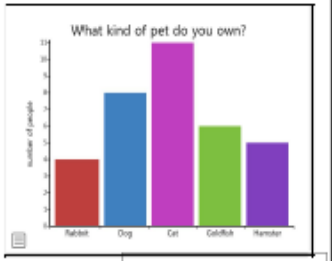
Evidence: is collected throughout the lab and placed here.
Evidence can be any of the following:



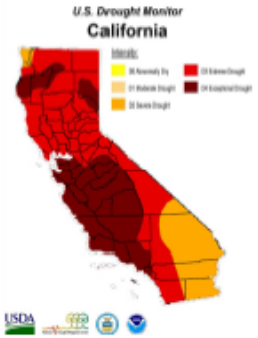
Data can be represented *quantitatively* as a line graph *(left)* or bar graph *(right)*

Evidence can be shown *quantitatively* in a data table (right)

Does Water pH Affect Tadpoles?	
pH of Water	Number of Tadpoles
8.0	45
7.5	69
7.0	78
6.5	88
6.0	43
5.5	23



Evidence can be provided by drawing a picture *(left) or highlighting a map! (right)*



Evidence can be collected from books, the Internet, or your textbook and organized as a bulleted list.

Use Math! Max, Min, Mean, Slope

Justification:

Written in PARAGRAPH form!

- Uses the evidence to support the claim and answer the guiding question.
- Uses **all key vocabulary** in the paragraph. *Words are not defined*, but are used in the student explanation.

Steps to a well written Justification:

1. State what your initial hypothesis was.
2. State if your hypothesis was supported, and how you know.
3. Restate your claim.
4. Using the evidence on the *left* side of this poster, explain how you came to your claim. **Use your evidence and research in your response!**
5. Explain any possible experimental errors/outliers and give Reasons for further research.

Blackline Master 4

Writing Rubric

CATEGORY	4 - Above Standards	3 - Meets Standards	2 - Approaching Standards	1 - Below Standards	Score
Focus or Thesis Statement	The thesis statement names the claim, an overview of the evidence, and gives a call to action.	The thesis statement names the claim and an overview of the evidence.	The thesis statement outlines some or all of the evidence OR names the claim.	The thesis statement does not name the claim AND does not outline any of the evidence.	
Evidence and Examples	All of the evidence and examples are specific, relevant and explanations are given that show how each piece of evidence supports the claim.	Most of the evidence and examples are specific, relevant and explanations are given that show how each piece of evidence supports the claim.	At least one of the pieces of evidence and examples is relevant and has an explanation that shows how that piece of evidence supports the claim.	Evidence and examples are NOT relevant AND/OR are not explained.	
Accuracy	All supportive facts and statistics are reported accurately.	Almost all supportive facts and statistics are reported accurately.	Most supportive facts and statistics are reported accurately.	Most supportive facts and statistics were inaccurately reported.	
Sequencing	Arguments and support are provided in a logical order that makes it easy and interesting to follow the author's train of thought.	Arguments and support are provided in a fairly logical order that makes it reasonably easy to follow the author's train of thought.	A few of the support details or arguments are not in an expected or logical order, distracting the reader and making the essay seem a little confusing.	Many of the support details or arguments are not in an expected or logical order, distracting the reader and making the essay seem very confusing.	
Transitions	A variety of thoughtful transitions are used. They clearly show how ideas are connected.	Transitions show how ideas are connected, but there is little variety.	Some transitions work well, but some connections between ideas are fuzzy.	The transitions between ideas are unclear OR nonexistent.	
Audience	Demonstrates a clear understanding of the potential reader and uses appropriate vocabulary and arguments. Anticipates reader's questions and provides thorough answers appropriate for that audience.	Demonstrates a general understanding of the potential reader and uses vocabulary and arguments appropriate for that audience.	Demonstrates some understanding of the potential reader and uses arguments appropriate for that audience.	It is not clear who the author is writing for.	
Closing paragraph	The conclusion is strong and leaves the reader solidly understanding the writer's position. Effective restatement of the position statement begins the closing paragraph.	The conclusion is recognizable. The author's position is restated within the first two sentences of the closing paragraph.	The author's position is restated within the closing paragraph, but not near the beginning.	There is no conclusion - the paper just ends.	
Sentence Structure	All sentences are well-constructed with varied structure.	Most sentences are well-constructed and there is some varied sentence structure in the essay.	Most sentences are well constructed, but there is no variation is structure.	Most sentences are not well-constructed or varied.	
Grammar & Spelling	Author makes no errors in grammar or spelling that distract the reader from the content.	Author makes 1-2 errors in grammar or spelling that distract the reader from the content.	Author makes 3-4 errors in grammar or spelling that distract the reader from the content.	Author makes more than 4 errors in grammar or spelling that distract the reader from the content.	

Blackline Master 5

Properties of Water Assessment

1. Some climates have temperatures that drop below the freezing point of water for several months. Which of the following is a unique property of water that allows life on earth to exist in aquatic environments in these types of climates?
   a. Water has adhesive properties that lower its freezing point allowing it to stay in liquid form longer.
   b. The density of water changes when it freezes so solid water is less dense than liquid water allowing it to float.
   c. Water has a high boiling point allowing it to evaporate and condense into clouds providing more liquid precipitation.
   d. The melting and freezing points of water shift based on latitude, allowing it to stay in liquid form longer in higher latitudes.

2. A drop of water placed on a smooth, dry surface will form a dome-shaped droplet instead of flowing outward in different directions. Which of these best explains this observation?
   a. The bonds between hydrogen and oxygen atoms are very strong.
   b. The electrons in the atoms attract the electrons in the other atoms.
   c. The molecules at the surface strongly cohere to the other molecules on the surface with them.
   d. Water molecules near the surface produce more buoyant force than water molecules within the liquid.

3. Areas near oceans or large lakes tend to have more moderate climates than do areas far from large bodies of water. Which of these statements best explains this observation?
   a. Water produces buoyant forces which allows it to stabilize the temperature in the area.
   b. Lakes and oceans contain dissolved solids which maintains a stable temperature in the area.
   c. Water's properties allow it to slowly change temperature which maintains the area's temperature.
   d. Hydrogen and oxygen atoms share electrons in a water molecule which stabilizes the area's temperature.

4. Which of the following properties of water is due primarily to the polarity of the water molecule?
   a. its lack of color
   b. its lack of taste
   c. its ability to dissolve substances
   d. its ability to produce buoyant forces

Use the table below to answer questions 5 & 6:

Substance	***Property 1***	***Property 2***	***Property 3***	***Property 4***	***pH***
A	*Sour*	*Fizzes when placed on aluminum*	*Is corrosive*	*Reacts with water*	*2*
B	*Bitter*	*Used for cleaning around the house*	*Has a slippery feel*	*Does not react with water*	*12*

5. Substance B is:
   a. a base
   b. a salt
   c. an acid
   d. neutral

6. Which of the following is the **MOST** valid evidence to support that substance B is **NOT** water?
   a. Water is not bitter.
   b. Water does not have a slippery feel.
   c. Water has a pH much lower than 12.
   d. Water is not used for cleaning around the house.

Blackline Master 6: ANSWER KEYS

Master Data Sheet

	Color	Boiling Point	Freezing Point	Density	Density Factor	Temperature Moderation Factor	Cohesion Factor	Solubility Factor	pH	Other Observations
Liquid A *isopropyl alcohol*	*clear*	82.6°C	−89.0°C	0.786 g/cm^3	*Sink*	*highest variation*	*lowest cohesion*	*lowest solubility*	*6-8 neutral range*	*answers will vary*
Liquid B *hydrogen peroxide*	*clear*	150.2°C	−0.43°C	1.010 g/cm^3	*Moderate to Low Float*	*moderate variation*	*high cohesion*	*high solubility*	*5-6 acidic*	*answers will vary*
Liquid C *water*	*clear*	98.4°C	3.70°C	1.005 g/cm^3	*Moderate to Low Float*	*low variation*	*high cohesion*	*high solubility*	*7 neutral*	*answers will vary*
Liquid D *hydrochloric acid*	*clear*	103.0°C	-18.0°C	1.048 g/cm^3	*Moderate to High Float*	*low-moderate variation*	*moderate cohesion*	*moderate solubility*	*1 acidic*	*answers will vary*

Temperature Moderation Graph

Cohesion Graph

Graphs will vary but should represent the students' data. Graphs should be BAR GRAPHS as they are not representing change over time. The Y-Axis should represent the temperature moderation factor or the cohesion factor. The X-Axis should represent the different liquids (A-D).

Blackline Master 6: ANSWER KEYS

ADI Worksheet

Guiding Question: Which liquid is most like water and would support human life?

Claim: *Student responses will vary. The accurate claim would be that liquid C is water.*

Evidence	Justification
Student evidence will vary but should represent their data, graphs, text, etc that helps them support their claim.	*Student justification will vary but should include their explanation of how their data, graphs, text, etc helps them to support their claim*

Blackline Master 6: ANSWER KEYS

Properties of Water Assessment

1. Some climates have temperatures that drop below the freezing point of water for several months. Which of the following is a unique property of water that allows life on earth to exist in aquatic environments in these types of climates?
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