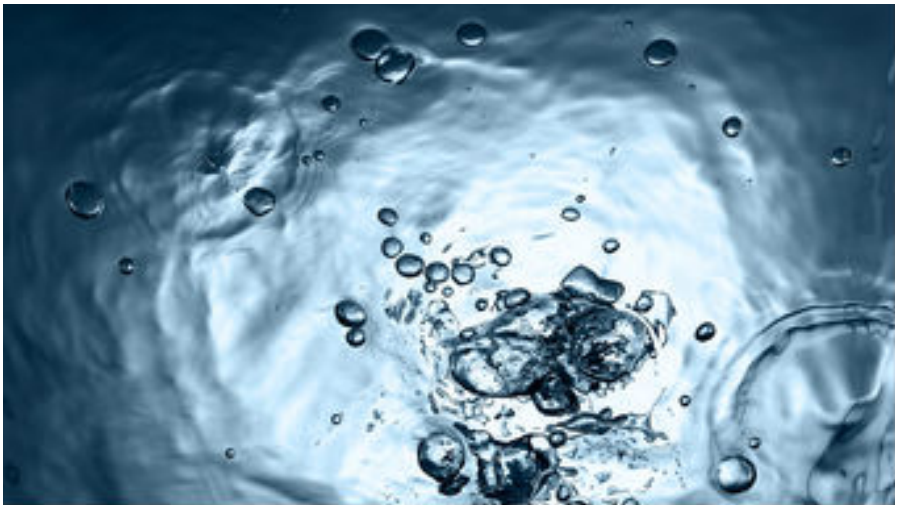
Lesson # 4:
Water: Its Properties, and Its Roles in Earth's Surface Processes



http://bigthink.com/

Lesson Summary

- **Grade level:** 6th -8th and 9th-12th

- **Preparation time:** See each activity for preparation time

- **Lesson time:** ~1 hour for Activity 1; 30 minutes each for 2 optional activities; and 30 minutes for optional misconceptions activity

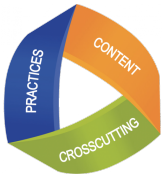
- **Learning outcomes:** The goals of this lesson are to introduce students to the first component that contributes to sustaining life on Earth, water, and to familiarize students with the water cycle.

What students do

The goals of this lesson are to give students an overview of the components contributing to sustaining life on Earth, with a focus on water. It will introduce students to the basics of water and its properties, as well as what makes it crucial to life on Earth.

At the end of this lesson, students will be able to:

- ✓ **Draw** the chemical structure of water and **list** its chemical and physical properties
- ✓ **Explain** behavior of water based on its chemical and physical structures
- ✓ **Explain** why water is crucial for life on Earth
- ✓ **Illustrate** and **explain** the water cycle via a concept sketch
- ✓ **Recognize** many properties about water and how it is used by our society



The following Next Generation Science Standards will be addressed in this lesson:

Science and Engineering Practices:

Obtaining, evaluating, and communicating information

Grades 6-8:

MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

Grades 9-12:

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

Resources needed:

- **Accompanying PowerPoint Presentation and activity Documents:**

"Ne lesson mini water cycle activity for middle school.pdf"

(System requirement: PDF reader)

- **Computer lab for classroom with access to the Internet** for group or individual online activities accessed at:

1. http://www.epa.gov/ogwdw/kids/flash/flash_watercycle.html
2. http://www.epa.gov/safewater/kids/flash/flash_qagame.html*
3. http://www.epa.gov/ogwdw/kids/flash/flash_wordscramble.html
4. http://www.epa.gov/safewater/kids/flash/flash_matching.html

- **Computer with access to the Internet and projection capability** to show video accessed at:

1. http://bigthink.com/think-tank/astrobiology-the-search-for-life-begins-with-water -Astrobiology: The Search for Life Begins with Water

TeacherTube.com Fun Videos about Water:

2. http://teachertube.com/viewVideo.php?video_id=230786&title=The_Water_Cycle_Rap* - The Water Cycle Rap
3. http://www.youtube.com/watch?feature=player_embedded&v=HVT3Y3_gHGg* - Water - Liquid Awesome
4. http://teachertube.com/viewVideo.php?video_id=222450&title=The_Phase_Changes_of_Water_Song* - The Phase Changes of Water Song
5. http://teachertube.com/viewVideo.php?video_id=69855*- Water Cycle Music Video

*Optional.

- **Materials for water cycle demonstration (Activity 1):**

  - 1 plastic tub
  - 1 plastic cup
  - 1 small rock or marble
  - 1 watering can
  - 1 measuring cup (optional)
  - 1 roll of cling wrap plastic (or similar)

- 1 roll of wide tape to seal the still
- 2 – 4 Liters of soil or sand (depending on size of still)
- 1 – 2 cups of water (depending on size of still)

- **Materials for trivia game activity:**

  - Cards printed and cut out, included in this lesson packet
  - Buzzers (optional)

Copyright/permission statement:

Science of the Topic

1. Read the following:

In the F_p lesson we learned how astrobiologists search for habitable planets when they talk about finding planets capable of sustaining life. Now, in the N_e lesson, we focus on environments on those planets that make them "habitable," at least in our current understanding of this idea based on the one example we have: the life on our own planet. In this lesson, we focus on the major characteristic common to all life on earth: it needs water to survive! Yes, every single organism needs this basic solvent to use for its chemical reactions - from bacteria to elephants to the fungi that live in rocks. So, let's learn what makes this special solvent so necessary for all living things.

The human body is made up of between 50% and 70% water, and the brain itself contains over 80% water. We use water every day in cooking, drinking, washing, and more. However, how much do we actually know about water, except for the fact that its chemical formula is H_2O and it boils at 100°C at sea level?

Teacher's Tip: To enhance students' knowledge of water, teacher is to first share with students the "Properties of water.ppt." The teacher is free to look over slides and take out whichever ones he or she does not wish to show due to time or curriculum constraints. Teacher should make sure to take some time to go over the materials before presenting to the class. Also in the same class period, the teacher can go over the water cycle animation using the link provided later in this lesson (http://www.epa.gov/ogwdw/kids/flash/flash_watercycle.html).

2. After this, teachers may wish to show the following TeacherTube.com optional videos about different properties of water and the water cycle:

1. http://teachertube.com/viewVideo.php?video_id=230786&title=The_Water_Cycle_Rap* - The Water Cycle Rap
2. http://www.youtube.com/watch?feature=player_embedded&v=HVT3Y3_gHGg* - Water - Liquid Awesome
3. http://teachertube.com/viewVideo.php?video_id=222450&title=The_Phase_Changes_of_Water_Song* - The Phase Changes of Water Song
4. http://teachertube.com/viewVideo.php?video_id=69855*- Water Cycle Music Video

Vocabulary List

Students can be given the following terms to define as a take-home or class discussion assignment at any part of this lesson which the teacher feels is appropriate, or just to have while doing the lesson for reference. Online sources for these definitions are provided. Students or teachers may wish to explore these sites further. If assigning these words for students to define, a print out sheet follows.

1. **Water** – an odorless, colorless, and tasteless liquid (at room temperature) with a chemical compound consisting of two hydrogen atoms and one oxygen. The name water typically refers to the liquid state of the compound. The solid phase is known as ice and gas phase is called steam.

   (http://chemistry.about.com/od/chemistryglossary/g/water-definition.htm)

2. **pH** – a scale used to measure how acidic or basic a substance is. The pH scale ranges from 0 to 14. A pH of 7 is neutral; a pH less than 7 is acidic; and a pH greater than 7 is basic. Pure water has a neutral pH. But when chemicals are mixed with water, the mixture can become either acidic or basic. pHs of some common household materials can be found in Fig.1.

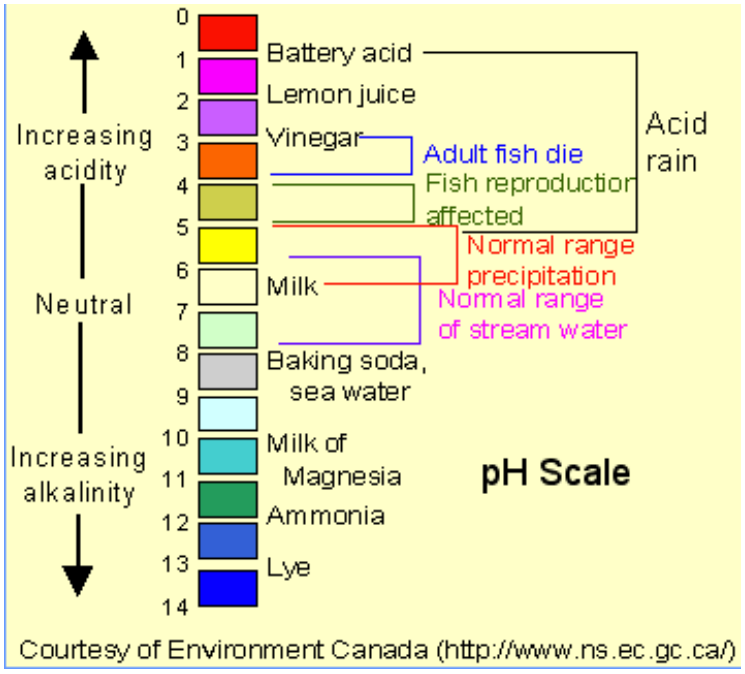


Figure 1. pH of some common materials

(http://www.elmhurst.edu/~chm/vchembook/184ph.html)

3. **Water cycle**, also known as **hydrologic cycle**, is a continuous cycle in which water evaporates, travels into the air and becomes part of a cloud, falls down to earth as precipitation, and then evaporates again. This is a never-ending cycle that regulates Earth's temperature as well as the temperature of the human body.

   (From: http://www.drinktap.org/kidsdnn/Portals/5/story_of_water/html/hydrocycle.htm and http://water.epa.gov/learn/kids/drinkingwater/waterfactsoflife.cfm)

4. **Evaporation** – the change of a substance from a liquid to a gas

5. **Condensation** – the change of a substance from a gas to a liquid

6. **Precipitation** – water that falls to Earth from the sky as rain, snow, sleet, or hail —as a direct result of condensation

7. **Groundwater** – water beneath the earth's surface between saturated soil and rock that supplies wells and springs

   Source for items 4, 5, 6 and 7: http://web.ccsd.k12.wy.us/techcurr/Science/04/0202watrcycl.html

Vocabulary list

Name: _____
Due: _____

1. Water
2. pH
3. Water cycle or hydrologic cycle
4. Evaporation
5. Condensation
6. Precipitation
7. Groundwater

Activity 1: The water cycle using a mini solar still

Time: 2 sessions of 30 minutes each; Total: 1 hour activity (plus, allow 3-4 hours for solar still to complete its water cycle (or this can be done over two class periods)

Level: 6^{th}-8^{th} grade

Standards with which it aligns:

Science and Engineering Practices:

Obtaining, evaluating, and communicating information
And
#ESS2.C: Core Idea ESS2: Earth's Systems: The Roles of Water in Earth's Surface Processes

See page 3 of the N_e lesson mini water cycle activity for middle school.pdf for more science concepts and positive attitudes learned in this activity.

About this activity: Students observe the water cycle in action inside a mini solar still. The still consists of a plastic tub filled with a layer of moist soil or sand, and sealed with cling wrap. Water evaporates from the soil, condenses on the cling wrap and trickles to a point directly above a cup. In a few hours on a hot day, the still will collect enough water to partially fill the cup.

This activity is in the pdf document, "N_e lesson mini water cycle activity for middle school.pdf." See page 2 of the document for more information.

Learning Outcomes:

The following taxonomy for learning is adapted from Anderson and Krathwohl's (2001) taxonomy, which has two domains: Knowledge and Cognitive Process. According to these outcomes, after this activity, students will:

1. **Remember** the concepts of a basic water cycle by
    1. **Recognizing** that the water cycle in the mini solar still is an example of the natural water cycle

6. Create scientific ideas about the water cycle by
6.1 Generating hypotheses as to what will happen if the surrounding conditions are varied (location with respect to temperature)

Directions:

Obtain the following materials and equipment:

- 1 plastic tub
- 1 plastic cup
- 1 small rock or marble
- 1 watering can
- 1 measuring cup (optional)
- 1 roll of cling wrap plastic
- 1 roll of wide tape to seal the still
- 4 liters of soil or sand (depending on size of still)
- 1 – 2 cups of water (depending on size of still)

Students should be put into groups however the teacher chooses.

Introductions:

Follow instructions in "**Procedure**" section of the activity document, "Ne lesson mini water cycle activity for middle school.pdf."

For the two introductory steps, teachers can have students working in groups to discuss the questions if time permits. If not, a shorter class discussion is appropriate.

Teacher's Tip: Ensure the cup is directly under the pebble or marble – on sunny days exceeding 25oC, the still should collect more than half a cup of water in approximately 3 to 4 hours.

Assessment

There is an exercise in the "conclusion" section of the activity (see pg. 4) which provides suggested discussions and assignments for this activity where students may either discuss in groups and then present a group consensus to the class, raise hands and answer individually, or write down their observations and turn them in for credit. Several assessment options are given below. A rubric is provided as stand-alone versions the next page, separated if teachers want to pass either one out to students.

Assessment option 1: If this is assigned as a take-home project or an in-class demonstration, teachers may assign a write-up of what students observe and have students submit a report on the water cycle describing the events taking place in the mini solar still that lead to water condensing back into the cup. Also in the report, teachers should have students compare the water cycle in the mini solar still with the natural water cycle. Creativity and making diagrams should be strongly encouraged.

Assessment option 2: If this is an in-class demonstration without a write-up assignment, teachers may have a class discussion in groups or individually where students are split into focus groups which discuss the contrasts between the water cycle that took place in the mini solar still with a natural water cycle that students observe on a daily basis. Each group can discuss among itself and then pick one representative to share their observations with the class. If grading this discussion, assessment can be assigned based on efforts and clarity of discussion. The rubric on the next page can be used for an individual student or a group.

Assessment option 3: Alternatively, the class can be split into two groups. One group (or more than one if teachers wish to have more than two groups) can discuss the cycle observed in the demo cup while another group discusses the contrasts between that group's observations and those that occur in the natural water cycle outside. If grading this discussion, assessment can be assigned based on efforts and clarity of discussion rather than completion. The rubric on the next page can be used for an individual student or a group.

Assessment option 3: If this is done as a group activity, group members can grade each other based on discussion rubric 2 and submit to the teacher the grade they felt that each other member deserved based on their inter-group participation.

Criteria For Grading Water Cycle Activity

Grade	Recognized that the water cycle in the mini solar still is an example of the natural water cycle	Created scientific ideas about the water cycle by
Expert	• Successfully recognized that the water cycle in the mini solar still is an example of the natural water cycle • Accurately described or sketched cycle	• Successfully generated hypotheses as to what will happen if the surrounding conditions are varied
Proficient	• Mostly recognized that the water cycle in the mini solar still is an example of the natural water cycle • Mostly accurately described or sketched cycle	• Mostly generated hypotheses as to what will happen if the surrounding conditions are varied
Intermediate	• Somewhat recognized that the water cycle in the mini solar still is an example of the natural water cycle • Somewhat accurately described or sketched cycle	• Somewhat generated hypotheses as to what will happen if the surrounding conditions are varied
Novice	• Did not recognize that the water cycle in the mini solar still is an example of the natural water cycle • Did not accurately describe or sketched cycle	• Did not generate hypotheses as to what will happen if the surrounding conditions are varied

Optional activity: Interactive Water Cycle

Time: 30 minutes or less in computer lab or as a take-home assignment

Level: 6th -12th

About this activity: In this activity, students will use an online interactive tool to observe and learn about the water cycle.

The following Next Generation Science Standards will be addressed in this lesson:

Science and Engineering Practices:

Obtaining, evaluating, and communicating information

Grades 6-8:

MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

Grades 9-12:

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

Learning outcomes

Upon the completion of this activity, students will:

6. **Create** a summary of a basic water cycle by

   6.3 Producing a labeled, annotated, detailed concept sketch summarizing the water cycle

Directions:

Follow the link http://www.epa.gov/ogwdw/kids/flash/flash_watercycle.html. The page is very self-explanatory and easy to use. Teachers should visit the site before assigning this activity to students. Ask students to draw a concept sketch summarizing the basic water

cycle in their words with clearly labeled diagrams, arrows, and maps after playing with this interactive feature. Encourage students to get creative.

Teacher's Tip: It is preferred that students work individually on this. However, if there are not enough computers for each student to have their own, teachers may divide students into small groups to view the website but concept sketches should be produced by each student individually.

Teacher's Tip: In the event that provided link is broken, teachers may perform a goggle search on the term "interactive water cycle – EPA" and click on "Thirstin's Water Cycle."

Assessment

See rubric below for grading this assignment.

Rubric for Concept Sketches of Water Cycle

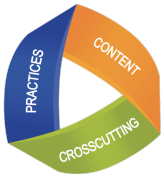
Learning Objective:	Expert	Proficient	Intermediate	Novice
Producing a labeled, annotated, detailed concept sketch summarizing the water cycle	• Student made clearly labeled drawings based on observations from website • Summary sketches encompassed whole water cycle • Sketch was neat and clear to understand • Sketch was accurate	• Student made mostly clearly labeled drawings based on observations from website • Summary sketches encompassed most of water cycle • Sketch was mostly neat and clear to understand • Sketch was mostly accurate	• Student made labeled drawings based on observations but parts were unclear • Summary sketches did not encompass whole water cycle • Sketch was not fully neat and clear to understand • Sketch had limited accuracy	• Student did not clearly label drawings based on observations from website • Summary sketches did not encompass whole water cycle • Sketch was not neat and clear to understand • Sketch was not accurate

Activity 2: Trivia game: You Think You Know About Water in Your Everyday Life?

Time: ~30 minutes; will vary depending on how many trivia questions teachers ask or whether this is a computer lab activity

Level: 9th-12th

Description: Let's find out if students know how important water is in everyday life! In this activity, the students are divided into small teams to participate in a trivia game. The number of students per team will depend on class size and how teacher wants to divide students up. The teacher may award a prize to the winning student/team if desired.



The following Next Generation Science Standards will be addressed in this lesson:

Science and Engineering Practices:

Obtaining, evaluating, and communicating information

Grades 9-12:

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

Learning outcomes

The following taxonomy for learning is adapted from Anderson and Krathwohl's (2001) taxonomy, which has two domains: Knowledge and Cognitive Process. According to these outcomes, after this activity, students will:

2. **Remember** how water affects the population, our relationship with water on our planet, and how we use it by:
    1. **Recognizing** many properties about water and how it is used by our society.

Preparation

Teachers will need to print out and cut the trivia cards that follow this page. Buzzers are recommended but optional. Teachers should print and cut out the cards attached with this activity prior to this lesson.

Directions

The teacher should divide the class into teams. Then, ask trivia questions on the cards that follow to groups in the form of a Jeopardy game with teams using buzzers. When a group knows the answer after some group consultation time (recommended: 30 seconds), they can hit their buzzer to be called upon. Teachers can also create a different way of organizing this trivia game.

Alternatively, teachers can have students in a computer lab go to: http://www.epa.gov/safewater/kids/flash/flash_qagame.html and play an online interactive version of this trivia game that is automatically scored. See Assessment section for grading instructions.

Trivia Cards for the game, "So you Think You Know About Water in Your Everyday Life?"

What percentage of water on Earth is fresh water? **a. 3%** b. 50% c. 97%	What percentage of the world's fresh water can be found at the Earth's surface in lakes, rivers, streams, ponds, and swamps? **a. 0.3%** b. 5% c. 10%
What percentage of fresh water on Earth is trapped in glaciers? a. 10.5% b. 50% **c. 68.7%**	What percentage of fresh water is in the ground? a. 15% **b. 30%** c. 45%
What percentage of the Earth's surface is covered by water? a. 57% **b. 71%** c. 90%	True or false: Water can dissolve more substances than any other liquid including sulfuric acid. Answer: True
True or false: More than 25% of bottled water comes from a municipal water supply, the same place that tap water comes from. Answer: True	True or false: A ten meter rise in the sea levels due to melting glaciers would flood 25% of the population of the United States. Answer: True
True or false: There is less water in the atmosphere than in all of the rivers on the planet combined. Answer: False, there is more water in the atmosphere than in all of the rivers on the planet combined.	True or false: Water boils quicker in Denver, Colorado than in New York City. Answer: True. Teacher's Tip: Ask students why they think this happens.

How much water is used in the United States per day? a. 100 million gallons b. 1 billion gallons **c. 400 billon gallons**	True or false: Nearly one-half of the water used in the United States is for thermoelectric power generation. Answer: True
How much water does an average American use in one year (indoor and outside)? a. 1,000 gallons b. 10,000 gallons **c. 100,000 gallons**	True or false: It takes six and a half years for the average American residence to use the amount of water required to fill an Olympic-sized swimming pool (660,000 gallons). Answer: True
True or false: It takes seven and a half year for the average American residence to use the same amount of water that flows over the Niagara Fall in one hour. Answer: False, only in one second.	True or false: Americans use more water each day by flushing the toilet than they do by showering or any other activity. Answer: True
True or false: Taking a bath requires up to 10-25 gallons of water. A five-minute shower uses 70 gallons of water. Answer: False, the opposite is true.	How much money does it cost per year for one person to drink their daily recommended 8 glasses of water from tap? **a. 50 cents** b. 100 dollars c. 500 dollars
How much money does it cost per year for one person to drink their daily recommended 8 glasses of water from water bottles? a. 100 dollars b. 700 dollars **c. 1,400 dollars**	True or false: There are approximately one million miles of water pipeline and aqueducts in the United States and Canada, enough to circle Earth 40 times. Answer: True

How heavy is a gallon of water? a. 1.5 lbs. b. 5 lbs. **c. 8.3 lbs.**	Water vaporizes at what temperature (at sea level)? a. 70°C b. 85°C **c. 100°C**
How much water is required to produce one slice of bread? a. 1 gallon b. 5 gallons **c. Over 10 gallons**	How much water does it take to make one cotton T-shirt? a. 1 gallon b. 500 gallons **c. Over 713 gallons**
How much water does it take to produce 1 gallon of milk? a. 100 gallons b. 500 gallons **c. 1000 gallons**	How much water does it take to make one hamburger? a. 1 gallon b. 416 gallons **c. 634 gallons**
True or false: Water is the only substance found on Earth naturally in three forms: solid, liquid, and gas. Answer: True	True or false: At one drip per second, a faucet can leak 3,000 gallons of water per year. Answer: True
How much water leaked from the New York water supply daily? a. 1 million gallons b. 26 million gallons **c. 36 million gallons**	What is the percentage of the human body weight that is made up of water? a. 25 – 50% **b. 55 – 78%** c. 79 – 90%

Assessment:
If done in teams as an in-class trivia game, no assessment is necessary. If teachers have access to individual computers for each student and choose to assign grades for this, the online game with automatic scoring is found at the link below. Teachers can grade this assignment by having students show them or print and turn in the final screen that lists how many questions they answered correct at the end. Or, students can save a screen shot (see Teacher's Tip below) of this page and print or email it to teachers. Or, the teacher can come around and check off that the student completed the activity and record their final score if done in a computer lab.

For the first game below, the final page states, "Thank you for playing the question and answer game. Your final score is, XX." The other games are similar to this.

Teachers can use this point score for grading. The sites used to derive trivia questions and score them automatically are available at:

Interactive Question and Answer Game: http://www.epa.gov/safewater/kids/flash/flash_qagame.html

Interactive Fun Facts Matching Game: http://www.epa.gov/safewater/kids/flash/flash_matching.html
(Here, note that the "details" link for hints if the wrong answer is marked may not work.)

Interactive Word Scramble Game: http://www.epa.gov/ogwdw/kids/flash/flash_wordscramble.html

Teacher's Tip: It is also possible to assign these activities as take-home assignments and turn in a printed (or electronic document version, like an image file or a document file with the page screen shot pasted) screen shot of the final score page for teachers to assess. For help on taking screenshots on various types of computers, teachers or students can refer to http://take-a-screenshot.org/. It is very useful to know how to take screen shots, a 21st century computer skill!

Optional Activity:
Misconceptions about water and the search for life in the universe

Time: 16-minute video; 10-minute group discussion (optional)

Level: 6th -12th grade

About this activity:

Teachers can read this to students:

Is water the only possible liquid solvent that life processes require? No, not necessarily!

What conditions are scientists looking for in their search for life on another planet? The presence of water is key, explains Bill Nye, The Science Guy, in this video. Want another candidate to sustain life? Liquid ammonia. But, as Nye points out, we haven't found anything on Earth or even near the Earth that can live on liquid ammonia. That is why water remains the best bet. We are creating telescopes and software that will allow us to detect water on another world.

Directions

Teachers should project this online video to the class and have a short discussion afterwards, if they have time, asking students the discussion points that follow.

http://bigthink.com/think-tank/astrobiology-the-search-for-life-begins-with-water

Suggested (optional) discussion points for the teacher to use to guide students are:

1. All life needs what to dissolve chemicals for use by organisms?

   Answer: solvents.

2. Can life live in liquid ammonia instead of water?

   Answer: We don't know because we haven't found anything that can live on ammonia instead of water. It should also be noted that some organisms can drink ammonia, but water is needed for them to survive.

3. How can we detect water on another world?

Answer: Light reflects off of water and gives a spectral signature that astronomers can detect if it is present. Also, the surface temperature of a planet can give you information about its water state.

4. Ask students about their reactions to this knowledge.

Answers will vary. Ask for evidence-based answers.

Assessment

None. However, teachers may want to assess this as a group discussion or a small focus group. If choosing to do this as a focus group, students should self-select to go into the group of their choice. Group topics will be discussion topics 1-3 listed above. Each group will discuss their conclusion and choose a representative to share their collective answer with the rest of the class after a 5-minute consultation period (time may vary at the teacher's discretion).

Congratulations!

You've completed the N_e water lesson. Stay tuned for next lesson, F_l, dealing with actual life forms that exist in some strange habitable environments, which we have just learned need to include water in some amount. In F_l, we will examine how some extreme environments with very little water can still support some interesting forms of life. We will also look at some Mars lander experiments that attempted to find life in Martian soil!

Stay tuned for additional activities added to this lesson in future iterations. These activities will deal with the idea of habitability and what it means for an environment to be "habitable" as astrobiologists understand.

Teacher's Tip: Besides the activities listed in this lesson, teachers are encouraged to see http://www.epa.gov/students/teachers.html for many more activities on water and the climate.