Water in the Solar System (55 min)

Overview

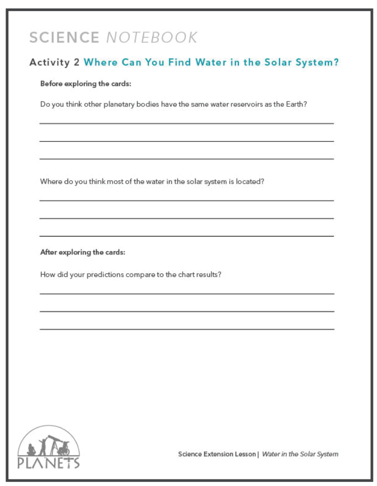
In this activity, youth will get information about different planetary bodies to discover where water can be found in our solar system. Examples from Earth and other planets will be used. The objective of the exercise is for youth to visualize where, and in what types of reservoirs, water is present in our solar system. Then youth will compare and contrast the amount and accessibility of water among the sites.

Youth will learn:

- Water is abundant in our solar system
- Water is found in different reservoirs (surface, subsurface, and atmosphere)
- More water is located in the outer part of the solar system than closer to the Sun

In this activity:

Planetary Cards



SCIENCE NOTEBOOK

Activity 2 Where Can You Find Water in the Solar System?

Before exploring the cards:

Do you think other planetary bodies have the same water reservoirs as the Earth?

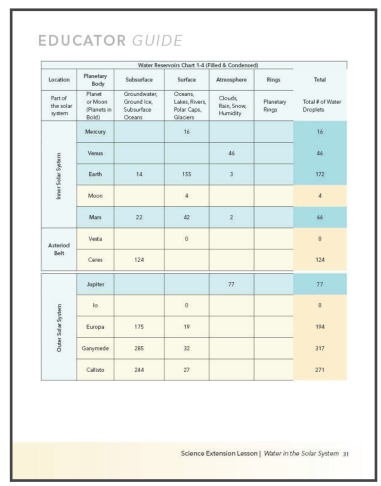
Where do you think most of the water in the solar system is located?

After exploring the cards:

How did your predictions compare to the chart results?

Science Extension Lesson | *Water in the Solar System*

Science Notebook



EDUCATOR GUIDE

Water Reservoirs Chart 1-4 (Filled & Condensed)

Location	Planetary Body	Subsurface	Surface	Atmosphere	Rings	Total
Part of the solar system	Planet or Moon (Planets in Bold)	Groundwater, Ground Ice, Subsurface Oceans	Oceans, Lakes, Rivers, Polar Caps, Glaciers	Clouds, Rain, Snow, Humidity	Planetary Rings	Total # of Water Droplets
Inner Solar System	**Mercury**		16			16
	Venus			46		46
	Earth	14	155	3		172
	Moon		4			4
	Mars	22	42	2		66
Asteriod Belt	Vesta		0			0
	Ceres	124				124
Outer Solar System	**Jupiter**			77		77
	Io		0			0
	Europa	175	19			194
	Ganymede	285	32			317
	Callisto	244	27			271

Science Extension Lesson | *Water in the Solar System* 31

Solar System Charts

Introduction (5 min)

1. Tell youth that in this activity they will get to look at NASA images from other planetary bodies to investigate where water is found in the solar system. These bodies include asteroids, dwarf planets, planets, and moons.

2. Ask youth: "What are the different reservoirs of water that we learned about in Exercise 1?" *Surface, subsurface, atmosphere.* "Do you think other planetary bodies have those same reservoirs?" Tell youth to record their prediction in their science notebook. *In this activity we will find out!*

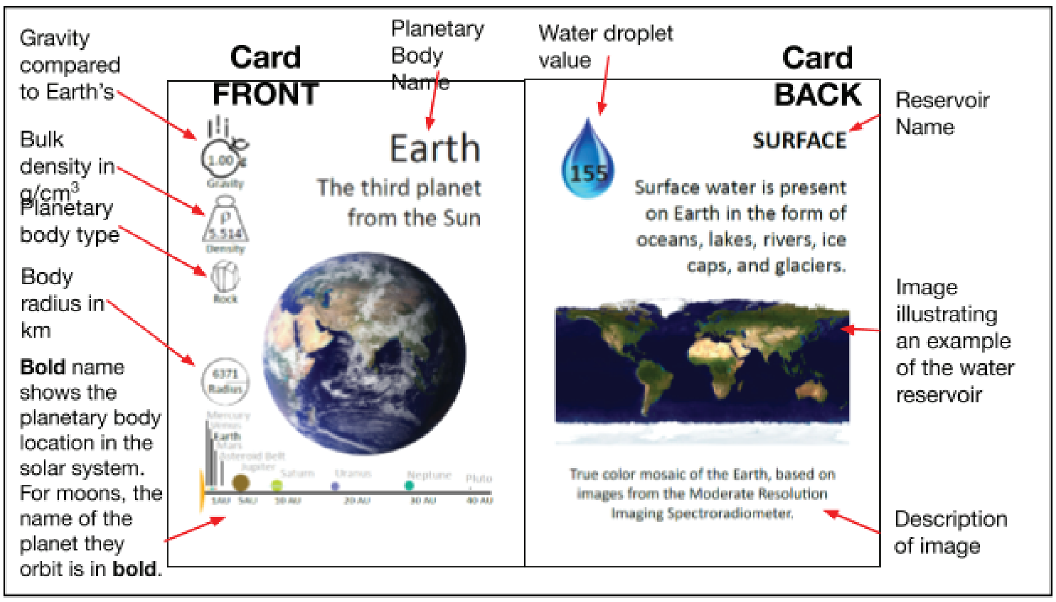
Getting to know the Planetary cards (15 min)

1. Split youth into groups of 2-4. Give each group a set of Planetary information Cards.

2. Familiarize youth with the card fronts. Tell youth to pick up one of the cards and explain each icon:
   - The number in the falling apple icon is the surface gravity of the body compared to Earth (g). The gravity of a body depends on its mass. Have youth find cards for Earth and Mars and look at the gravity numbers. For Earth the gravity value is 1.0 g. For Mars the gravity value is 0.38 g (because Mars has less mass). This means that if you weighed 100 pounds on Earth, you would weigh 38 pounds on Mars.
   - The number in the weight icon labeled with a "ρ" is density. The density of an object is a measure of how much material, or mass, is packed into its volume (how big it is) and is measured in units of grams per cubic centimeter. The density of rock ranges from 2.5 to 3.5 grams per cubic centimeter. The density of water is 1.0 gram per cubic centime ter. The density of ice is around 0.92 grams per cubic centimeter, a bit less than water (which is why ice floats on liquid water). The density of planetary bodies helps us deter mine what it's made of.
   - The icons for rock, ice, and gas indicate what the body is mostly made of. The inner planets are rocky. The outer planets are mostly gas or a mixture of ice and gas. The moons of outer planets and asteroids are either rocky or mixtures of rock and ice. Ask youth: "Why is the Earth considered a rocky planet?"

Although there is ice on the surface and gas in the atmosphere, most of the Earth is made up of rock.

- The average radius of the planetary body provides a means to compare the sizes of different planetary bodies, or to calculate the total volume of the planetary body.
- Across the bottom of the front of the card, the planets are shown in order of increasing distance from the Sun. We can measure this distance in Astronomical Units, noted as AU. One AU is defined as the average distance from the center of the Earth to the center of the Sun. Have youth look at cards for Earth and for Pluto. Pluto's average distance is almost 40 times the average distance from the Earth to the Sun!



3. Familiarize youth with the card backs. Tell youth to flip their card over and explain each icon:

- On the back side they will see a label indicating the type of water reservoir on that planetary body and a picture showing an example.
- At the top of each card, there is a water droplet and number representing the amount of water that exists in that particular reservoir. The water droplet number is directly related to the volume of water in the reservoir and allows us to compare the amount of water on different planetary bodies across the solar system.
- The image on the back of the card shows an example of the water reservoir, including a description of the image, or a model of what scientists think the reservoir looks like.

4. Next, have youth look at the cards for Mercury, Europa, and Earth. Explain: All the water on Mercury is stored on its surface, so it only has one card for its surface reservoir. The number in the water droplet is (16) indicating there is not much water on Mercury's surface. Compare that with Europa, which has two cards representing the water on its surface (19) and in its subsurface (175).
5. Explain to youth that some moons and planets will have multiple cards, representing multiple water reservoirs. The droplet numbers are cumulative, so to get the total amount of water on a body, add up all the droplet numbers from that body's cards.

6. Tell youth that now they will spend 10 minutes exploring and sorting the cards. Within their small group, ask youth to discuss different ways they might sort the cards, and agree on one way to sort them. Then invite groups to share how they sorted the cards.

Note: The water droplet numbers are mathematically related to scientific estimates of the volume of water on each planetary body. For anyone interested in how, a detailed explanation can be found in the introductory cards in the Planetary Cards deck.

7. Ask: "Did we all sort them the same way?" Then challenge small groups to sort them in another way that no one mentioned. Share again. Guide youth to make these different example categories:

- » in order of increasing distance from the sun
- » planets vs. moons
- » in order of increasing abundance of water
- » different reservoirs of water
- » planets with their associated moons
- » different types of planets
- » in order of increasing gravity, density, or radius

8. Ask: "What did we learn from sorting the cards?" *There's a lot of water in the solar system. Earth doesn't have as much water as I thought. Ganymede and some other moons of Jupiter and Saturn have a lot of water.*

Investigating Water in the Solar System (25 min)

1. Now tell youth that we're going to create a chart, so we can better see reservoirs of water in the solar system. Post the 4 printed Water Reservoir Charts in different locations around the room (see the preparation section of this guide, page 22, step 2).

2. Have each group fill out one chart: Ask youth to sort the cards in their decks by planetary body (i.e., with planets and their moons together). Then assign the different planetary bodies evenly among the groups and individual cards evenly among individuals. Alternatively, you can shuffle the deck and deal the cards to youth randomly. In this scenario, the youth will find each one of their reservoirs on the corresponding chart and fill in the water droplet values individually.

3. Allow groups a few moments to get familiar with their planetary bodies.

4. Then, have each group record the water droplet number under each category in one of four *Water in the Solar System* tables. Continue until all cards have been recorded. Many boxes will be left blank. When complete, fold or cut and tape the charts together to make one large long chart and post this where everyone can see. See the blank and completed tables below. As mentioned in Step 2, in the alternative option, youth will visit multiple tables to fill in their water droplet values for each listed reservoir. When everyone has recorded all cards, have youth split into teams to total the water droplet values for each chart.

Note: Use the original option if you want to keep the planets, moons, and reservoirs together as an orderly cohesive learning unit. Use the alternative option if you have an odd number of groups or want to better distribute actions and timing among youth.

Water Reservoirs Chart 1						
Location	**Planetary Body**	**Subsurface**	**Surface**	**Atmosphere**	**Rings**	**Total**
Part of the solar system	Planet or Moon (Planets in Bold)	Groundwater, Ground Ice, Subsurface Oceans	Oceans, Lakes, Rivers, Polar Caps, Glaciers	Clouds, Rain, Snow, Humidity	Planetary Rings	Total # of Water Droplets
Inner Solar System	**Mercury**					
	Venus					
	Earth					
	Moon					
	Mars					
Asteriod Belt	Vesta					
	Ceres					

Water Reservoirs Chart 2						
Location	**Planetary Body**	**Subsurface**	**Surface**	**Atmosphere**	**Rings**	**Total**
Part of the solar system	Planet or Moon (Planets in Bold)	Groundwater, Ground Ice, Subsurface Oceans	Oceans, Lakes, Rivers, Polar Caps, Glaciers	Clouds, Rain, Snow, Humidity	Planetary Rings	Total # of Water Droplets
Outer Solar System	**Jupiter**					
	Io					
	Europa					
	Ganymede					
	Callisto					

Water Reservoirs Chart 3						
Location	**Planetary Body**	**Subsurface**	**Surface**	**Atmosphere**	**Rings**	**Total**
Part of the solar system	Planet or Moon (Planets in Bold)	Groundwater, Ground Ice, Subsurface Oceans	Oceans, Lakes, Rivers, Polar Caps, Glaciers	Clouds, Rain, Snow, Humidity	Planetary Rings	Total # of Water Droplets
Outer Solar System	**Saturn**					
	(Rings)					
	Mimas					
	Enceladus					
	Tethys					
	Dione					
	Rhea					
	Titan					
	Iapetus					

Water Reservoirs Chart 4						
Location	Planetary Body	Subsurface	Surface	Atmosphere	Rings	Total
Part of the solar system	Planet or Moon (Planets in Bold)	Groundwater, Ground Ice, Subsurface Oceans	Oceans, Lakes, Rivers, Polar Caps, Glaciers	Clouds, Rain, Snow, Humidity	Planetary Rings	Total # of Water Droplets
Outer Solar System	**Uranus**					
	Miranda					
	Ariel					
	Umbriel					
	Titania					
	Oberon					
	Neptune					
	Triton					
Kuiper Belt	Pluto					
	Charon					

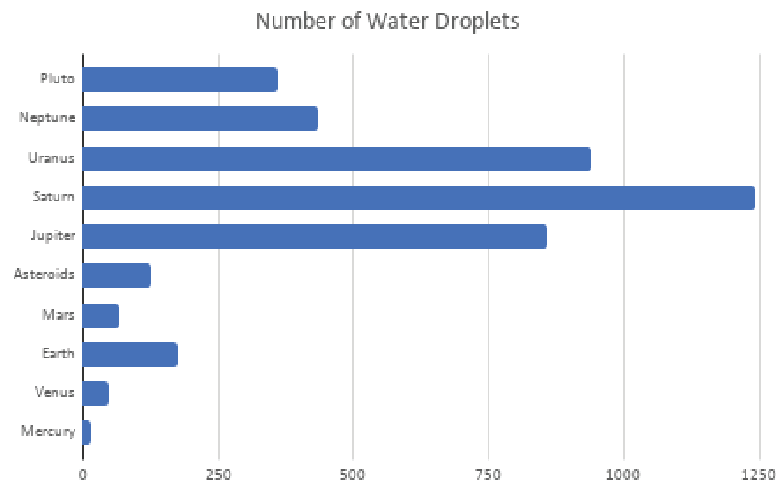
Water Reservoirs Chart 1-4 (Filled & Condensed)						
Location	**Planetary Body**	**Subsurface**	**Surface**	**Atmosphere**	**Rings**	**Total**
Part of the solar system	Planet or Moon (Planets in Bold)	Groundwater, Ground Ice, Subsurface Oceans	Oceans, Lakes, Rivers, Polar Caps, Glaciers	Clouds, Rain, Snow, Humidity	Planetary Rings	Total # of Water Droplets
Inner Solar System	**Mercury**		16			16
	Venus			46		46
	Earth	14	155	3		172
	Moon		4			4
	Mars	22	42	2		66
Asteriod Belt	Vesta		0			0
	Ceres	124				124
Outer Solar System	**Jupiter**			77		77
	Io		0			0
	Europa	175	19			194
	Ganymede	285	32			317
	Callisto	244	27			271

Outer Solar System	**Saturn**			72		72
	(Rings)				91	91
	Mimas	79	9			88
	Enceladus	81	9			90
	Tethys	134	15			149
	Dione	129	14			143
	Rhea	141	16			157
	Titan	255	28			283
	Iapetus	153	17			170
Outer Solar System	**Uranus**	200				200
	Miranda	86	10			95
	Ariel	133	15			148
	Umbriel	138	15			153
	Titania	156	17			173
	Oberon	154	17			171
	Neptune	197				197
	Triton	213	24			237
Kuiper Belt	Pluto	187	21			208
	Charon	137	15			152

5. Once the table is all put together and posted, ask youth to describe any trends that they see.

6. Next, ask youth to add up all the water that is contained within each planet group, for example all the water on Jupiter and all its moons, and all the water on Saturn and all its moons, etc. The chart below shows the answers.

Planetary Body AND Moons	Total # Water Droplets
Mercury	16
Venus	46
Earth	176
Mars	66
Asteroids	124
Jupiter	859
Saturn	1243
Uranus	940
Neptune	434
Pluto	360



7. Have youth generate a bar graph in their science notebooks similar to the one shown above based on the total number of water droplet numbers found in each planetary body group.

Wrap Up (10 min)

1. Give youth a chance to identify patterns in the data in the space provided in the science notebook. Once most have stopped writing, lead a discussion to summarize findings. Use the following questions to guide the discussion:

» Where is water found?
Water is found in many places throughout the solar system.

» Among the planets in the inner solar system (Mercury, Venus, Earth, and Mars), which planet has the most water?
Earth.

» In our solar system, where is the majority of the water?
In the outer solar system, especially in icy moons around Jupiter and Saturn.
» What reservoirs have the most water? Do you see any patterns or differences between moons and planets? The Inner and Outer solar system?
In the outer solar system, planets only have water in the atmosphere, but moons have the most water in the subsurface
» Do you see the any patterns within single planetary systems, for example with the moons of Saturn and Uranus?
In general, the farther the moon is from its planet, the more water it has.
» Did these patterns surprise you? Did they match your predictions?
Accept all answers.
» Tell youth to think about these questions for next time:
   i. Now that we know where water is available in the solar system, do you think that it is usable for humans?
   ii. Do you think it's habitable for organisms?

Tip: Once youth have completed Activity 2, consider showing this poster to better visualize the water available in our solar system: www.planets-stem.org/water/?

2. Wrap up for the day by congratulating youth on their scientific work. Let youth know that next time, they will choose one of these watery planetary bodies to explore.

Optional PLANETS Card Games (10+ min)

If time permits, let the youth play games with the cards. Encourage them to develop their own games! Reminder: The "front side" of the card has the name of a planetary body along with its picture and physical characteristics. The "back side" of the card has information about a specific water reservoir.

Some ideas for games that can be played with the cards include:

Accretion (Easy, 2-5 players) Like the card game war or battle, the objective is to win all the cards. Alternatively, the player who collects most of the water in the solar system could be declared the winner. Shuffle all cards randomly. Deal all cards evenly among all players. In unison, each player reveals the top card of their deck, front up. Using the information on the card fronts, the player with the highest gravity value takes all the cards played and moves them to their deck. If two cards played have equal gravity values, then there is a battle. Battling players place the next card of their deck front down and then another card front up. The owner of the front up card with the higher gravity value wins the battle and adds all cards to their deck.

Build the Solar System (Moderate, 2-5 players) Shuffle all cards randomly. Deal 6 cards to each player, leaving a draw pile. The first card played must be a planet or dwarf planet. Using the solar system location information on the card fronts, the next player must build on this card by playing (1) an adjacent planet - to the right or left, (2) a moon of the planet - below, or (3) another card of the same planet - on top. A planet must be played before a moon of that planet can be played. Asteroids are played as planets (i.e., Jupiter cannot be played next to Mars). A player who can't play draws one card from the pile. If the drawn card plays they may play it, otherwise they are skipped, or are skipped if there are no more cards in the draw pile. The object is to be the first to play all their cards. To play several rounds, one may keep score with the water droplet values - whoever has the least water wins.

Crazy Earths! (Advanced, 2-4 players) Similar to the game Crazy Eights, the object of the game is to be the first player to get rid of all their cards. Shuffle all cards randomly. Deal 6 cards to each player, leaving a draw pile. The top card from the pile is then played to start the game. Players discard by matching "suits" with the top card. Unlike with regular cards, this game uses information that is on both sides of the cards. The "suits" are water reservoir (surface, subsurface, or atmosphere), composition (rock, ice, gas, gas+ice, or rock+ice), and solar system location (Mercury, Venus, Earth, Mars, Asteroid Belt, Jupiter, Saturn, Uranus, Neptune, or Pluto). One can play any Earth card at any time as a wild card. When a player plays an Earth, they declare the "suit" that the next player must play. For example, say "atmosphere" and the next player has to play an atmosphere card; or say "Saturn" and the next player must play a planet or a moon from Saturn's location in the solar system; or say "rock" and the next player must play a planetary body that is a rock type. If a player is unable to match the "suit" of the top card of the discard pile and does not have an Earth, they draw a card from the draw pile. If it plays, they can play it, otherwise their turn is skipped.