Science Unit: *Space*

Lesson 11: *Solar System: The Planets*

Summary:	Students make scale models of the sun and planets from modeling clay and place them across a field to visualize the vast distances between them (size and distance measurements included below). They also use sand, water and rocks to simulate geological processes that occur on the surfaces of distant planets and relate them to the abstract patterns visible from Earth.
School Year:	2014/2015
Developed for:	Lord Strathcona Elementary School, Vancouver School District
Developed by:	Ingrid Sulston (scientist); Reid McInnes and Phyllis Daly (teachers)
Grade level:	Presented to grade 6/7; appropriate for grades 1 – 7 with age appropriate modifications
Duration of lesson:	1 hour and 20 minutes
Notes:	In a Scientist in Residence lesson developed for younger students, two separate activities were used to first model the planets to scale, then to model the relative spacing of the planets. See: "Our Star the Sun and its Friends the Planets" in Lesson 6 of the Space Unit: www.scientistinresidence.ca/pdf/space-science/Space/SRP_Space_Lesson%206%20F.pdf

Objectives

1. Grasp the vast distances between the planets by constructing a scale model of the Solar System across the school grounds.
2. Understand how scientists interpret the geologic features of planets through exploration of sand and water phenomena.

Background Information

The Solar System is unimaginably large, and the planets within it are unimaginably far apart. A scale model which is true to relative planet size as well as their distance apart can begin to impress upon students (and teachers) the distances we are dealing with across the Solar System.

The abstract patterns seen on the surfaces of planets, even from far off, allows scientists to start an understanding of what they are made of and how they got to be that way. Geological features formed by aeolian processes (wind) and fluvial processes (movement of liquid, including water) give evidence for, respectively, an atmosphere, and for past or present liquids flowing over the surface. Students experiment themselves to understand how basic patterns formed by wind or a liquid can give information on the climate and geology of a planet.

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Vocabulary

solar system	A star and all the objects that orbit around it. Our Solar System consists of the sun, eight planets and their natural satellites (such as our moon), the dwarf planets, the asteroids and comets.
planet	A body that orbits a star, is large enough for its own gravity to make it round, and has also "cleared its neighbourhood" of smaller objects around its orbit.
aeolian process	Features created by wind. A planet must have an atmosphere to have aeolian processes.
fluvial process	Features created by a flowing liquid.

Materials for Scale Model of Solar System

- printed image of the sun, 10cm in diameter
- modelling clay in these colours: grey, red, blue, white, brown, green; or colours that can mix to make these colours
- rulers
- metre stick

Materials for Planet Surface Features activity (for each group of 2 or 3 students)

- tray containing a little sand (about 50ml) and water
- tray containing with a little sand (about 50ml) and two rocks
- plexi cover for the tray (to prevent sand blowing out)
- stra w

In the Classroom

Introductory Discussion

1. Introduce the Solar System and how it formed. The Solar System started as a cloud of gas and dust particles. Even these tiny particles have gravity and so are attracted to each other. The centre of the cloud got dense and hot enough for nuclear reactions to start (hydrogen molecules fusing into helium), and our sun to be born.
2. The remaining gas and dust slowly coalesced into the planets. The closer planets, with the warmth of the sun evaporating any water, were made from metal and rock. The outer planets, far enough from the sun for ice and small molecules to stick around, formed the large gas giants.
3. In this lesson we will make a scale model of the planets, then look at some of their surface features to understand their geology and climate.
4. **Processes of science** that the students will focus on: close observation, classifying and comparing data, inferring, concluding, predicting.

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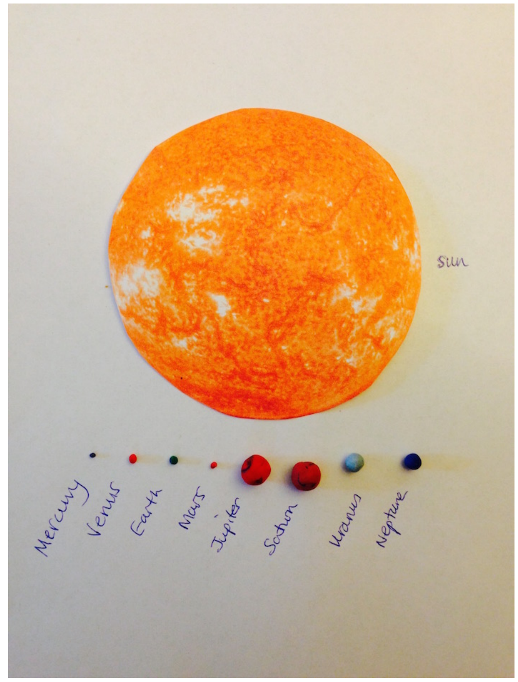
Science Activities

(1) Activity: Model Solar System



Purpose of Activity: To impress upon students the enormous distances between planets in our Solar System.

Methods and Instructions:
Set-up prior to experiment: none

Students will work in groups, eight groups total.

1. Inform students that we will make a 1:10,000,000,000 scale model of the planets in our Solar System, then lay it out on the school grounds.
2. Together with the students, write up the planets in order, and their colours.
3. Ask students that if the sun in our model has a 10cm diameter, how large do they think the other planets would be? Once the teacher has given them a couple of the planet sizes, students, with their knowledge of relative planet sizes, may be able to guess some of the other sizes. (See Ref. 1 for calculation of sizes).
4. Add the sizes of the scaled Solar System to the table of information already gathered:

Sun/planet	Clay colour	Scaled size	Scaled distance from sun
Sun	(Printed image)	10cm	-
Mercury	dark grey	0.5mm	4m
Venus	red	1mm	8m
Earth	blue	1mm	11m
Mars	red	0.5mm	16m
Jupiter	red-brown	1cm	56m
Saturn	light red-brown	8mm	103m
Uranus	light blue	3mm	206m
Neptune	dark blue	3mm	303m

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5. Divide the students into eight groups, and ask each group to use the appropriate colour modeling clay, and their rulers, to make their scaled planet.
6. Ask students to fold their planet into a piece of scrap paper so that it does not get lost as we pace out our scale model.
7. Lay a metre stick down in the classroom and ask students to pace out a metre, so that they have a sense of how long a metre is as they count them out.
8. Stick the sun up on a wall of the room.
9. Ask the Mercury group to pace out four metres, then place their scaled planet at that location in the classroom.
10. Next, ask the Venus group to continue pacing out metres up to their designated eight metres, then place their scaled planet at that location.
11. Continue with the following planets. Earth and maybe Mars will be in the classroom, but beyond that will be out on the school grounds. Once the planet is placed on a window sill, or rock, it will look very small!
12. The outer planets may be beyond the school grounds into a park or street beyond.
13. Walking back along the route, and finding the tiny planets along the way reinforces how large the Solar System is compared to the sizes of the planets. Tell students that many of these planets also have moons orbiting them.

(2) Activity Title: Planet Surface Features

Purpose of Activity: To model patterns formed by wind and water, and relate them to real planet landscape images.

Methods and Instructions:
Set-up prior to experiment: Add the sand and rocks/sand and water to the trays.

Students will work in groups of 3 or 4.

1. Students make patterns with wind and water:
   - **Aeolian (wind) patterns** (top right photo) are made by spreading sand evenly in a tray, adding two rocks to one end of the tray, and blowing the sand along the bottom of the tray from the other end. A Plexiglas sheet covering most of the tray prevents sand from blowing out of the tray. The sand is blown from around the rocks, but remains in a streak behind the rocks.
   - **Fluvial (liquid) patterns** (bottom right photo) are made by swirling the tray of sand and water to mix them evenly, then tipping the tray so that the water runs through the sand, creating channels.
2. Students refer to their worksheet (following this lesson) to compare the patterns they make to those seen on other planets, and deduce what formed each of the pictured planetary features.

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3. Discussion for each of the worksheet images:
   - **Top left image is a Mars fluvial feature**. A drainage network of a liquid is clearly seen. There is no liquid on Mars now, only ice water. This fluvial feature is from extensive water flow in the past when Mars was warmer. Why was Mars warmer? Maybe it had an atmosphere to create a greenhouse effect. Or maybe asteroid and comet impacts which filled the atmosphere with vaporized rock and ice, resulted in several years of rainfall and flooding that formed the fluvial erosion features.
   - **Top right image on the worksheet is an aeolian feature on Mars:** wind streaks, formed by erosion of the surface rock. Erosion needs an atmosphere - a gas that can move past the surface and carry dust particles along. Mars currently has an atmosphere as we have seen tornadoes on Mars. (We also see sand dunes on Mars, further evidence of aeolian activity.)
   - **Bottom left image is an aeolian feature on Venus** - these wind streaks are formed by the carbon dioxide atmosphere of Venus blowing fine-grained particles around.
   - **Bottom right image is a fluvial feature on Titan, a moon of Saturn**. These drainage networks are formed by liquid methane! Titan has a methane cycle: it rains methane, which flows into methane rivers and lakes, from which it evaporates and rains again (just as we have a water cycle).

4. Tell students that scientists look at images similar to these from the Solar System planets, to deduce the geology and climate of a planet. Scientists also study impact craters and volcanic features in their planet research (see Ref. 2 for summary of all processes).

References

1. <http://www.exploratorium.edu/ronh/solar_system/index.html> Calculator for scale model solar system. Exploratorium. Accessed May 14, 2015.
2. <http://ares.jsc.nasa.gov/education/eeab/documents/BMM_QuickReferenceSheet.pdf> Images of planet features and how they are formed. NASA. Accessed May 14, 2015.

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