Unit: ***Space***

Lesson 9: ***The Sun and Seasons***

Summary: In this lesson, students use balloons as a model of the Earth and a light bulb in the middle of a dark room as a model of the sun. They simulate the Earth's rotation on its axis to create a "day" by turning the balloon, simulate Earth's orbit around the sun to create a "year" by walking around the room, and visualize why we experience changing seasons.

School Year: 2014/2015

Developed for: Lord Strathcona Elementary School, Vancouver School District

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Grade level: Presented to grade 6/7; appropriate for grades 3 – 7 with age appropriate modifications

Duration of lesson: 1 hour and 20 minutes

Objectives

1. Understand how the orbit of the Earth around the sun gives us the seasons.
2. Experiment with magnetism and heat to understand some properties of the sun.

Background Information

Given the many misconceptions out there about why we have seasons, it makes it ever important to model the seasons in a way that students can grasp and remember. The first activity in this lesson attempts to do that.

The sun is unimaginably large and hot, hence unfamiliar physical phenomena occur within it, for example enormous moving magnetic fields and convection currents, whose effects are felt on Earth. Small-scale explorations of these same phenomena in the classroom introduce students to these phenomena and help them relate to the many images and movies of the sun's surface.

Vocabulary

<u>season</u> A season is a time during the year with a certain number of hours of daylight and often with characteristic weather. Seasons result from the Earth's tilt and its orbit around the sun

<u>plasma</u> A fourth state of matter, formed by giving a gas more energy, where atoms are separated into ions and electrons.

convection — A method of heat transfer, where groups of energetic molecules move together, carrying heat energy with them.

Materials for Seasons Model Activity #1

- room that can be made dark
- balloon, one per student, medium green or blue
- globe, or map, showing equator and land masses
- light fixture with bulb, that can be placed in the centre of the room near head-height
- sharpie per student/small group

Materials for Plasma Activity #2

- plasma ball
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Materials for Heat Convection Activity #3

- Large tub with clear sides, 30-40cm wide and 20-30cm deep
- Food dye
- Four sturdy cans, or supports, a touch taller than the styrofoam cup
- Cold water, to fill the tub
- Pipette
- A kettle to produce boiling water
- A styrofoam cup

Materials for Magnetic Field Patterns Activity #4 (enough for each individual or pair of students)

- various magnets (round, bar, fridge magnets), at least one per student
- iron filings sealed into clear salad containers, three or four for the group

Materials for Sounds of the Sun Activity #5

- empty shoe boxes
- various materials to add to the boxes for the ball to bang against e.g. metal cups, soft cloth, rice grains
- small metal balls
- tape to seal the boxes and to secure items inside

In the Classroom

Introductory Discussion

1. Introduce the sun with a movie of the rotating sun (Ref. 1).
2. Continue with sun facts:
    - The sun rotates every 26 days.
    - It is very hot: 15 million°C in the centre, 5,500°C on the surface.
    - It is huge: 1.4million km wide. One million Earths would fit in it.
3. The sun is a ball of gas, split into charged particles (called plasma) by intense heat and pressure. In its core, hydrogen nuclei fuse together to make helium nuclei, producing huge amounts of energy - so much that we can feel it from 150 million km away.
4. The sun is 4.6 billion years old and has enough hydrogen to last for another 5 billion years. Every second, the sun's core converts 4 million tons of matter into pure energy.
    - Tell students that the lesson starts with an activity that models why we have seasons.
    - Then they will rotate through four stations to explore some properties of the sun
5. **Processes of science** that the students will focus on: accurate drawing of observations, interpreting graphs, inferring, concluding.

Science Activities

PART ONE

(1) Activity: Seasons Model

Purpose of Activity: Model the seasons on Earth as we orbit the Sun.

Methods and Instructions:

Set-up prior to experiment: Set the light bulb and fixture in the centre of the room, using a table, so the light bulb is at head height. Blow up a balloon for each student, only half inflating it, so that it is as round as possible.

Students will work individually.

1. Give each student a balloon to represent Earth.
2. Ask students to hold the balloon with the tied neck at the bottom, then to draw on the equator with a sharpie. Then draw on a rough outline of North America, using a globe or map as a guide. Add a dot for Vancouver. Keen students can add other places that they know/are from.
3. Ask the students to stand in a circle around the light fixture, large enough so they have good elbow room between them.
4. Darken the room.
5. Ask students to point the North Pole of their "Earth" balloons towards a high feature in the room e.g. a corner. The designated feature of the room is the "Pole Star" or "North Star". With

the North Pole towards the Pole Star, each Earth should be tilted, ideally at an angle close to the real tilt of the Earth (24 degrees from the vertical).

6. Ask students to position their Earth in front of their bodies so that the "sun" is shining on the Earth, while maintaining the tilt towards the Pole Star.
7. Ask students which is East and West on their Earth. If they look at the continent of North America, it should help them. Ask students to rotate the Earth in the correct direction: the sun rises in the East, so the light of the bulb should hit the east coast of North America first. They will be rotating their Earths counterclockwise (when viewed from the top). For the real Earth, each rotation takes one day. As the sun hits our continent it is daytime here, and as we continue to rotate it becomes night time.
8. Tell students that the will now model what happens during the year, as the Earth orbits the Sun once. Ask students to walk in a circle around the "sun", always tilting their North Pole towards the Pole Star, while continually rotating their Earth counterclockwise. Once they have walked completely around the sun and ended up back where they started, a year has passed.
9. Now walk through another year while asking students to keep an eye on how much sun Vancouver on their Earth receives through the year. Ask where in the circle does Vancouver get the most time in the sun. (The northern hemisphere will be tilted towards the sun at this position in the circle.) This is the position of midsummer - the summer solstice. Mark this place in the circle with "June" (on the floor, or on the wall behind the circle). Ask where in the circle does Vancouver get the least sun exposure. (The northern hemisphere will be tipped away from the sun at this position in the circle.) This is midwinter, or the winter solstice. Mark this position with "December". It should be exactly across the circle from June.
10. (Optional: Add that the vernal (spring) and autumnal equinoxes fall between, in March and September. Students can locate where their birthday month falls in the circle.)
11. Now ask students to orbit the sun once more holding their tilted rotating Earths and watch what happens to the North and South Poles. (Each of them get sun all day for part of the year. The sun never sets in Northern Canada in the summer as it is so close to the North Pole.)
12. Optional: Discuss seasons in the northern and southern hemispheres, especially if a child in the class is from the southern hemisphere. In the northern hemisphere, mid summer is in June, whereas in the southern hemisphere, midsummer is in December.
13. To review:
    - In our summer, the northern hemisphere is tilted toward the sun, so has more hours of sunlight through the day (as shown by the above activity). More hours of sun exposure makes it warmer. (See Ref. 2.)
    - In addition, the hemisphere that is tilted toward the sun also receives more direct rays of sunlight (or rays that are closer to perpendicular or a 90° angle), which means more intense radiation, so more heat.
    - The combination of more direct rays of sunlight and more hours of daylight causes the hemisphere that is tilted toward the sun to receive more solar radiation and to have warmer temperatures.
14. Please note: A common misconception is that our seasons are caused by the distance from the sun. This is not the case. Our seasons are caused by the hours of sunlight, and the angle of the sun's rays, as described above.

PART TWO

For the following four activities, divide the class into four groups of students, which will rotate through the activities. The sun phenomena noted at the end of each activity should be reviewed in a wrap-up discussion once all students have rotated through all stations.

(2) Activity: Plasma Ball

Purpose of Activity: To visualize the fourth state of matter, plasma.

Methods and Instructions:
Set-up prior to experiment: none
Students will work in a group that is a quarter the size of the class.

1. Review states of matter that the students know: usually solid, liquid and gas.
2. Review the spacing of the atoms/molecules in each state of matter (close in solids, further apart and free to move in liquids, even further apart and even more energetic in gases) and that in each state the particles are progressively more energetic.
3. Tell students that when gas is energized even more, the atoms split apart and the electrons become free from the nuclei. This is a fourth state of matter, called plasma.
4. In the plasma ball, plasma is produced when electrons moving at high speed (from the central electrode to the glass of the ball) bump into gas atoms and break them apart. The location of the plasma is visualized by the coloured streamers of light.
5. Discussion of sun phenomenon: In the sun, the extremely high temperatures and pressure split the atoms to make plasma. Most of the sun is made up of plasma.

(3) Activity: Heat convection

Purpose of Activity: To visualize heat convection.

Methods and Instructions:

(This demonstration was adapted from ref. 3.)

Set-up prior to experiment: stand a desk or table in an open area of the classroom. Arrange the four cans on the desk so that they can support the tub at each corner. Fill the large tub with cold water and stand it on the four cans so that it is stable. Wait for the water to become completely still before proceeding. Boil the kettle of water, so that it is quick to boil again.

Students will work in a group that is a quarter the size of the class.

1. Ask the students to stand around the tub, so that they can see through the sides of the tub.
2. Suck up a little food dye into the pipette, then very slowly and carefully lower the pipette into the water and deposit a pool of food dye on the base of the tub. Slowly remove the pipette from the tub, so as to disturb the water as little as possible.
3. Reboil the kettle, then immediately fill the styrofoam cup with boiled water. Slide the cup under the tub, and leave it directly below the pool of food dye.
4. After a minute, streams of food dye should start to flow upwards from the food dye (see photos below and ref. 3). Students should draw what they see on their worksheet (following this lesson).
5. You may need to carefully wipe condensation from the outside of the tub to keep the view clear.

5. Explanation: The hot water in the styrofoam cup heats up the water and food dye directly above it, making this region flow upwards in the water (because it is less dense than the surrounding cooler water). It takes heat energy with them, and is moving by "convection". The visualized convection currents are beautiful as they trace out the curving patterns of heated water.
6. Discussion of sun phenomenon: This activity demonstrates the convection currents that carry hot gas from the centre to the surface of the sun. Ref. 4 is a video of granulations on the sun's surface, caused by convection currents in the sun. They can also be seen in Ref. 1.

(4) <u>Activity</u>: Magnetic Field Patterns

<u>Purpose of Activity</u>: To view and experiment with the shapes of magnetic field lines.

<u>Methods and Instructions:</u>
Set-up prior to experiment: none
Students will work in pairs, or ideally, individually if there are enough materials.

1. Move a magnet under the iron filings to see the patterns they make. Find the lines that the iron filings assemble into.
2. Use lines to draw the shape of the magnetic field on a worksheet (following this lesson).
3. Discussion: The patterns show how the force of the magnet spreads out around it. Different magnets have different force field shapes.
4. Discussion of sun phenomenon:
   - Magnetic fields in the sun are made by the moving charged particles of the plasma particles which make up the sun.
   - The sun's plasma forms moving magnetic fields within the sun, which also loop outwards from it. The image in Ref. 5 shows the field lines.
   - The movie in Ref. 6 shows loops of gas being pulled out and along the magnetic field lines of the sun. To see these gas loops to scale, see the image in Ref. 7.
6. The sun's magnetic field lines sometimes twist so much that they "snap", sprawling prominences (hot loops of plasma) into space. The plasma that escapes streams away from the sun as solar winds, filling the heliosphere (which extends beyond the solar system).
7. Sunspots (darker regions on the surface of the sun) are caused by strong magnetic fields blocking heat from the centre of the sun. Larger sunspots are larger than Earth.

(5) Activity: Sounds of the Sun

Purpose of Activity: An analogy for how scientists can deduce what the sun is made of by listening to the sounds coming from inside it.

Methods and Instructions:
This activity is adapted from Ref. 8.

Set-up prior to experiment: Leave one shoe box empty, and tape different times into the others. For example, metal cups in one, a ball of cloth in another, and rice in another. Add a metal ball to each box.

Seal the boxes. Make sure all holes are blocked, especially for a box containing rice grains. Students will work in pairs.

1. Ask students to tip the boxes, and deduce what is inside from the sounds they hear.
2. Discussion of sun phenomenon: Scientists listen to the sounds coming from the inside of the sun, to learn about its interior structure. The sun's sound waves bounce from one side of the sun to the other in about two hours, and are influenced by conditions inside the sun. The sun's sound waves are very low frequencies, too low for us to hear. To be able to listen to the sounds of the sun, the scientists speed up the waves 42,000 times. Listen to Ref. 9 for an audio track of just a few of the 10 million sounds inside the sun.

References

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