Science Unit: ***Space***

Lesson 13: ***Spectroscopes and Light***

Summary	Students build spectroscopes using cereal boxes, yogurt lids, old CDs, and tape. They use their scopes to view the component colours of light from light bulbs and from the sun.
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 4 – 7 with age appropriate modifications
Duration of lesson:	1 hour and 20 minutes
Safety Notes:	Students should never look directly at the Sun with their spectroscope and must be capable of following the safety instructions detailed below.

Objectives

1. Discover the spectra of various light sources, including various light bulbs and the sun, by making a spectroscope.
2. Understand how astronomers use telescopes to view star spectra and figure out the composition and movement of stars.

Background Information

Astronomers observe starlight with telescopes, as a window into the lives of stars. The spectra of stars give information on what stars are made of, the life cycles of stars, and their movements. Students can make a simple spectroscope and use it to compare the spectra of different light sources, including various light bulbs as well as the sun. With luck, they may even be able to observe Fraunhofer lines in the Sun's spectrum, which are extensively studied by scientists, along with the Fraunhofer lines of other stars, to understand the lives of stars.

Vocabulary

spectrum	A pattern of rainbow colours formed as a source of light is split into its component colours of light. Different light sources (inlcuding stars) have their own spectra. Spectra also include light wavelengths beyond the visible colours (e.g. UV and IR).
spectroscope	An instrument to display spectra, and show the intensity of each wavelength of light.

Materials (for each spectroscope)

- cereal box
- duct tape, about 1m per spectroscope
- light bulbs with flxtures: incandescent, fluorescent, LED
- pencil and ruler
- protractor
- the sun!
- cutting blade
- scissors
- yogurt lid cut into a square, with a 1mm slit cut into it
- DVD, recordable works way better, especially for viewing the sun's spectrum

In the Classroom

Introductory Discussion

1. Ask students if they have looked up at the stars. Explain that each of them is a sun like ours, but much further away. The light from our sun takes eight minutes to reach Earth. Light from the next nearest star (Alpha Centauri) takes more than four years to reach us - it is four “light years” away (a light year is a measure of distance). The light reaching us from some stars has been travelling for billions of years. So seeing the light from stars shows how they used to look.
2. Telescopes collect the light from far away stars, which can then be analysed with a spectroscope. A spectroscope splits the light into its colours, to form a spectrum. The pattern and intensity of each colour in the spectrum can tell us what the star is made of, and how stars change as they age.
3. Tell students that they will make their own spectroscope to view the spectra of some light bulbs and the sun.

Processes of science that the students will focus on: mechanical manipulation, close observation, accurately describing observations, classifying and comparing data, inferring, concluding.

Important Safety Guidelines:

If students do view the sun’s spectrum with their spectroscope, they should never look directly at the sun, but only through their spectroscope.

If the sun is very bright, they should take the extra precaution of pointing their spectroscope a little to the side of the sun, rather than directly at it.

If, at any time, they get bright light coming into their eyes through the spectroscope, they should stop pointing their spectroscope in that direction.

Science Activity

Activity Title: Spectroscope

Purpose of Activity: To view the spectra of various light sources, including the sun.

Methods and Instructions:
Students can work individually, or in pairs or small groups to reduce prep time.

Set-up prior to experiment:

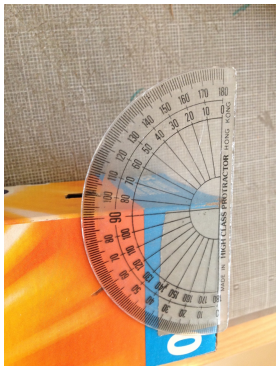
a. Flatten the cereal boxes. Use the pencil and ruler to draw panels, so that the cereal box can be folded into a square tube, making use of the folds already present in the box (side panels of cereal box may become one or two sides of the spectroscope).
b. Score folding lines, on the outside of the fold (printed side of the box) all the way across the box. (The brown inside of the box will end up on the inside of the tube, as it is darker and will reflect less light.) Cut all the way through the cardboard when you reach the end tabs.
c. Cut end tabs at one end of the cereal box to 3cm; leave long tabs the other end.
d. At the end with longer tabs, cut off one of the middle tabs, and on same panel, cut a hole (4-5.5cm from end and 1cm wide). This viewing hole is on “the top” of the spectroscope.
e. Cut pieces of flat yogurt tub lid about 5cmx5cm for each student. Cut a slit in it, 2.5cm long and 1mm wide.
f. Cut DVDs in half with sharp scissors (less likely that the layers will separate than trying to snap it).

Students continue assembly of their spectroscope in class:

1. Fold the prepared cereal box into a square tube and tape the long side with duct tape.

2. Tape the yogurt tub slit onto the end of the spectroscope with the short tabs, making sure that with the viewing hole on the top, the slit is horizontal, and the tube is squared. (You will likely need to cut a couple of the tabs shorter, so they don't cover up the slit.)
3. Add more tape cross-wise to make sure the slit is secure and light proofed. (See image).

4. At the other end of the tube (near the viewing hole), tape the tabs shut, leaving an opening on the top edge.
5. From this opening, measure a 60° angle from the vertical, on both sides, and mark a line at this angle in pencil (image at near right). Cut slits 4cm long along this line. Insert the half DVD. (Image right.)
6. Check each spectroscope, to see that a spectrum is visible before taping the DVD in place (point the slit directly at a light source, then look through the hole at the reflection of the light off the DVD).



Using the spectroscopes:

1. Set up two or three light bulbs around the classroom.
2. Explain to students how to use their spectroscope: point the slit directly at a light source, then look through the hole at the reflection of the light off the DVD. They should see a rainbow of colours, in different patterns, depending on the light source.
3. Explain that the spectroscope separates the colours of light into a spectrum. Each light bulb will have its own spectrum as the light it emits is made up of different colours. Ask students to view the various light sources and record on their worksheet what they find. (Worksheet follows this lesson.)
4. Students should find that viewing an incandescent or LED bulb with their spectroscope will show a continuous spectrum - the colours are all smeared together. Every wavelength of light is emitted by these kinds of bulbs. In contrast, a fluorescent bulb will show distinct lines of colour - a broken spectrum. The colour of the lines present depend on the gases inside the fluorescent bulb (often mercury and argon), which emit certain wavelengths of light when they are excited.
5. Take the students outside to view the sun's spectrum with their spectroscope - they should not point it directly at a bright sun but a little to the side. They will see that the sun makes a continuous spectrum, so emits all wavelengths of light.
6. If they are lucky, they will see Fraunhofer lines in the sun's spectrum - dark lines crossing the spectrum that are the result of gases in the sun (and also the earth's atmosphere) absorbing certain wavelengths of light. (See Ref. 1.) Scientists look at the position of these dark lines to deduce what molecules our sun, and other stars, are made of.

References

1. <http://www.britannica.com/EBchecked/topic/217627/Fraunhofer-lines> Sun spectrum with Fraunhofer lines. Encyclopedia Britannica. Accessed May 16, 2015.