**Multiwavelength Astronomy: The History of Optical Astronomy, by Caroline Herschel and Lyman Spitzer**

http://ecuip.lib.uchicago.edu/multiwavelength-astronomy/optical/history/index.html

**Subject(s):** Astronomy/Space Science

**Grade(s) Level:** 9-12

**Duration:** One Class Period

**Objectives:** As a result of reading The History of Optical Astronomy, students will be able to

- Discriminate between reflecting and refracting telescope designs and describe the differences between them;
- Explain how a telescope focuses light;
- Articulate the limitations of ground-based telescopes and propose solutions to these limitations;
- Identify important astronomical discoveries made and personages working in the optical regime;
- Discuss examples of problem-solving and creativity in astronomy.

**Materials:** Internet connection and browser for displaying the lesson.

**Pre-requisites**: Students should be familiar with the Electromagnetic Spectrum. Before using the lesson, students should familiarize themselves with all vocabulary terms.

**Procedures:** Students will read the lesson and answer assessment questions (listed under evaluation).

**Introduction:** In reading this lesson, you will meet important individuals in the History of Optical Astronomy. They are:

> **Caroline Lucretia Herschel** was a German-born British astronomer and the sister of astronomer Sir William Herschel. She is the discoverer of several comets, in particular, the periodic comet 35P/Herschel-Rigollet, which bears her name.
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> **Lyman Strong Spitzer, Jr.** was an American theoretical physicist, astronomer and mountaineer. He carried out research into star formation, plasma physics, and in 1946, conceived the idea of telescopes operating in outer space. Spitzer is the namesake of NASA's Spitzer Space Telescope.

**William Herschel** was an astronomer and composer. Born in Germany, Herschel followed his father into the Military Band of Hanover before emigrating to Britain at age 19. He became famous for his discovery of the planet Uranus along with two of its major moons (Titania and Oberon) and also discovered two moons of Saturn. In addition, he was the first person to discover the existence of infrared radiation.

**Adaptations:** Have students read portions (or all) of the lesson in small groups and answer questions together. The small groups report back to the class as a whole with their responses.

**Additional Discussion Question(s):**

- **W**hich historical figure in the lesson do you most identify with? Explain why.
- What kind of problems did these astronomers encounter and how did they overcome them?

**Evaluation:**

1. What type of telescope delivered the results Galileo described in his book "Starry Messenger" (*Sidereus nuncius)*? What did he observe about the moon? The Milky Way? Jupiter?
2. How does a telescope focus light? What are the key differences in how this is accomplished in a reflecting vs. refracting design?
3. Explain chromatic aberration. Why is this problem for astronomers?
4. Why do stars and galaxies look slightly fuzzy when viewed from a telescope on Earth?
5. How did the RAND project lead to the Hubble space telescope? What are some of the key events in the history leading to the deployment of Hubble?
6. What controversy did Hubble encounter soon after launch and how was it resolved?

**Extensions:** Students research the historical eras in which the Herschels and Spitzer worked, paying attention to the socio-political context of these eras. Students analyze the differences and similarities and compare their results with the current socio-political context for astronomical research.

**Suggested Readings:** The lessons on the science, tools, and impact of Optical Astronomy from the Multiwavelength Astronomy website.

**Links:** These websites are recommended for providing background and supplemental information:

Tour of the Electromagnetic Spectrum http://missionscience.nasa.gov/ems/
Telescopes from the Ground Up http://amazing-space.stsci.edu/resources/explorations/groundup/
Telescopes from the Ground Up: Science Basics http://amazing-space.stsci.edu/resources/explorations/groundup/lesson/basics/index.php
The Hubble Site http://hubblesite.org/

**Vocabulary:** The following terms are used and defined in the lesson. Teachers may want to review these in advance of using the lesson with students.

atom
Bachall, John
Cambridge University
comet
constellation
Copernicus
Crocker, Jim
double star
dust grain
electron
florin
galaxy
Galilei, Galileo
Georgium sidus
Goddard Space Flight Center
Hadley, John
Harvard University
Herschel, William
Hubble Space Telescope
nebula
molecule
Newton, Isaac
optics
Orbiting Astronomical Observatories
Orbiting Solar Observatories
parabolic
Parsons, William
pound
Princeton University
prism
Project Stratoscope
Royal Society of London
Schwarzschild, Martin
solar eclipse
SONAR
Space Science Board
Space Shuttle
spectrograph
spectrometer
Sputnik
Yale University

**Standards:** This lesson addresses Next Generation Science Standards HS-PS4-4, HS-PS4-5; HS-ESS1-2; HS-ETS1-2, HS-ETS1-3; and Common Core standards CCSS.ELA-Literacy.RST.9-10.1, 9-10.2, and 9-10.4.