Lesson Plan
Maria Mitchell: Pioneering American Astronomer

Maria Mitchell with her students (and telescope in the background) Courtesy AIP Emilio Segre Visual Archives

Grade Level(s): 9-12	**Subject(s): Astronomy, History**
In-Class Time: 45-75 minutes	**Prep Time: 10-15 minutes**

Materials

- Copies of the Maria Mitchell *Renaissance Women* chapter (included in Supplemental Materials)
- Internet access and/or ability to project a webpage.

Objective

Students will learn about Maria Mitchell and her work in observational astronomy. This lesson is intended to teach students about the early history of astronomy in America and the position of women in science during the 1800s. This lesson will also demonstrate the relevance of this history to current scientific work.

Introduction

Maria (pronounced ma-RYE-ah) Mitchell is the first female astronomer in America to be recognized for her independent professional achievements. She was the first person to discover a comet using a telescope, and was widely hailed during her lifetime as a diligent scientist.

In 1818, Maria Mitchell was born on Nantucket Island in Massachusetts, the third of thirteen children. Her parents were Quakers. They believed that women had the same intellectual capability as men, and encouraged Maria in academic pursuits. Maria's father was an amateur astronomer, and his observations and charts were important to the sailors of the island's whaling community. Maria often assisted her father with his observations, learning how to observe a great deal with very simple instruments.

In 1847, Maria was observing the stars and saw a fuzzy dot near the North Star. After continued observation and considering her knowledge of the stars, she determined it was a comet. She showed it to her father, who agreed, and they wrote a letter to the Harvard Observatory to determine if it had been seen by anyone else. This was not just curiosity, because the King of Denmark would award a gold metal to anyone who observed a comet that could only be seen with a telescope. Although Maria's comet was later discovered independently by famous astronomers in Europe, it was determined that Maria was the first to see what would be named "Comet Mitchell 1847VI."

This discovery led to quick fame for Maria Mitchell, and she was elected the first female member of the American Academy of Arts and Sciences (1848) and the Association for the Advancement of Science (1850). This notoriety allowed Mitchell to get a paid position (very rare for women in science at this time) at the U.S. Nautical Almanac, calculating accurate positions of the planet Venus. Her newfound fame also convinced people across America to donate funds for a new, more powerful telescope for Maria. In 1858, she received a highly advanced telescope from "the Women of America." The telescope is now on display in the Smithsonian Museum of American History.

In 1865, Mitchell became the first faculty member of the newly established Vassar College. This was only the second American women's college, and the first to allow female professors. Despite having never attended college herself, Mitchell became one of the most celebrated teachers at the school. She taught many young women astronomy and insisted on advanced mathematical education for her classes. At Vassar, she was also made director of the Observatory, and continued to record many observations. Although Mitchell was extremely grateful to be offered the position, it was not without its challenges. She had to constantly argue against the belief that women were ill-suited for scientific and mathematical work. She was also paid only one-third of the salary the male professors at Vassar received.

Maria Mitchell was professor at Vassar for 23 years. In her later years, she also became more active in advocacy groups, helping to found the moderate feminist organization the Association for the Advancement of Women in 1873, and serving as the chair of its science committee until her death. She died at home in Lynn, Massachusetts in 1889 at the age of 70. To preserve her legacy, the Maria Mitchell Association was formed in 1902 and continues to operate observatories and museums in her hometown of Nantucket to preserve science on the island.

Instructions

Engage: 10-15 minutes

The lesson will begin by asking students to think about how women scientists have been treated throughout history. Introduce Maria Mitchell, and then project or let them read a short blog post showing her induction letter into the American Academy of Arts and Sciences.	
What is the teacher doing? Before the start of class, read Maria Mitchell's American Academy of Arts and Sciences induction letter and the accompanying blog post at http://yestdaysisland.com/what-is-this/. Start by asking students if they know who the first American to discover a comet is. It may surprise them to hear that it was actually a woman. Then ask how they think people in the general public and scientific community reacted to this discovery. Next, have students look at Maria Mitchell's American Academy of Arts and Sciences induction letter (either by printing copies and handing it out or by projecting the letter in class). Ask them what they think of the letter, prompt them to note the crossed out "sir" and "fellow" and discuss the implications (which are the topic of the blog post).	**What are the students doing?** The students should read Mitchell's acceptance letter and the accompanying blog post. They should note the crossed out "sir" and "fellow" and become aware of the implications of those edits. They should also consider how they would feel if they received a letter like the one sent to Mitchell by the AAAS.

Explore: 15-25 minutes

The students should read the *Renaissance Women* chapter about Maria Mitchell (included in the Supplemental Materials). If desired, a handout of the Discussion Questions is available in the Supplemental Materials for students to complete while they read.	
What is the teacher doing? The teacher should hand out copies of the *Renaissance Women* chapter. If desired, hand out copies of the Discussion Questions as well. Answer any questions students have about the reading or Maria Mitchell's life.	**What are the students doing?** The students are reading the chapter and writing down any questions they have about what they read. If they are assigned the Discussion Questions handout, they should also complete that.

Explain: 10-15 minutes

Once the students have completed the readings, have a short class-wide discussion to go over the Discussion Questions and consider women's participation in science in America. After discussing Maria Mitchell and her career, you may want to bring up other firsts from this time period, such as Elizabeth Blackwell, the first woman doctor, or Arabella Mansfield, the first female lawyer.

What is the teacher doing?	What are the students doing?
The teacher should answer any questions the students have about Maria Mitchell and her career. They should then ask questions about women's place in society throughout history more generally.	The students are asking any of the questions they had and going through the answers to the discussion questions. They should also consider the changing attitudes towards women in scientific professions from the 1800s to today.

Elaborate: 15-35 minutes

There are two different opportunities for elaboration in this lesson plan. The first focuses on Maria Mitchell's scientific legacy today; the second looks at Maria Mitchell's involvement with women' scientific advancement during her later years.

Legacy: The students will now learn about the Nantucket Maria Mitchell Association, which preserves Maria Mitchell's history and scientific exploration in Maria Mitchell's hometown of Nantucket Island.

Women in Science: Alternatively, the class could focus on Maria Mitchell's involvement with women's education and scientific involvement. Have student read the Sally Kohlstedt article (available in Supplemental Materials). This focuses specifically on the later years of her life, after she had discovered the comet, but it details her involvement with organizations trying to advance women's opportunities and involvement with science.

What is the teacher doing?	What are the students doing?
Legacy: The teacher will give a short introduction to the Maria Mitchell Association. First, explain that the Association was founded in 1902 (over a decade after Mitchell's death) by her family and admirers as a way to keep the legacy of Maria Mitchell alive. It expanded in the twentieth century to include two observatories and several museums. Direct students to the website and have them explore it. Afterwards, have a short class discussion about what they discovered and why current scientists would look to Maria Mitchell for inspiration. Women in Science: Hand out copies of the Kohlstedt article for students to read. Answer any questions students have during the reading. After they have finished, lead a class discussion about the position of women in science during the late 1800s.	Legacy: Listening to the teacher's explanation of the Maria Mitchell Association. Then they will have the chance to explore its website to see how history and science are being presented and preserved today. Afterward, they will participate in a short class discussion about the Association and the legacy of Maria Mitchell. Women in Science: Reading the article about Maria Mitchell and the Advancement of Women in Science. They should take notes and ask for clarification on any uncertainties in the text. During the class discussion, they should participate and answer any of the teacher's questions.

Evaluate:

If desired, the teacher can collect the students' answers to the Discussion Questions for evaluation. A book report about a biography of Maria Mitchell is also a possible source of evaluation. A number of biographies are listed under the Extensions section.

Required/Recommended Reading and Resources

- "Maria Mitchell," Van der Does, Louise, and Rita J. Simon. *Renaissance Women in Science*. Lanham, MD: University Press of America, 1999.
- Invitation to Maria Mitchell from AAAS and the Maria Mitchell Association websites.
- Kohlstedt, Sally Gregory. "Maria Mitchell and the Advancement of Women in Science." In *Uneasy Careers and Intimate Lives: Women in Science, 1787-1979*, edited by Pnina Abir Am and Dorinda Outram, 216-238. New Brunswick, NJ: Rutgers University Press, 1987.

Discussion Questions

Discussion Questions can be found as a Handout with a corresponding Answer Key in the Supplemental Materials to this lesson plan.

1. In what ways did Maria Mitchell's upbringing differ from most girls in the 1800s?
2. What kind of education did Mitchell have?
3. With what instrument did she make her discovery?
4. How did Maria know what she had discovered?
5. Why was Maria's discovery significant?
6. What sorts of honors did Mitchell receive?
7. How did people react to a woman as a professional astronomer?
8. What sorts of jobs did Maria Mitchell have in her life?
9. What causes did Mitchell support?
10. What do you think is Maria Mitchell's legacy?

Further Reading and Additional Resources

- Albers, Henry (Ed.). *Maria Mitchell: A Life in Journals and Letters*. Clinton Corners, New York: College Avenue Press, 2001.
- Wright, Helen. *Sweeper in the Sky: The Life of Maria Mitchell, First Woman Astronomer in America.* New York: The Macmillan Company, 1949.
- Bergland, Renee. *Maria Mitchell and the Sexing of Science: An Astronomer Among the American Romantics*. Boston: Beacon Press, 2008.
- Haines, Catherine. *International Women in Science: A Biographical Dictionary to 1950.* Santa Barbara, CA: ABC-CLIO Ltd, 2001.
- Ogilvie, Marilyn. *Women in Science: Antiquity through Nineteenth Century: A Biographical Dictionary with Annotated Bibliography*. Cambridge, MA: MIT Press, 1986.
- Ogilvie, Marilyn and Joy Harvey, eds. The Biographical Dictionary of Women in Science: Pioneering Lives from Ancient Times to the Mid-20th Century. New York: Routledge, 2000.

- Shearer, Benjamin and Barbara Shearer. *Notable Women in the Physical Sciences: A Biographical Dictionary*. Westport, CT: Greenwood, 1997.

Extensions

Related AIP Teacher's Guides on Women and Minorities in the Physical Sciences:

- Oral Histories of Women Astronomers (contains oral histories of several scientists who were inspired by Maria Mitchell)

NASA has several interesting videos about comets which you may want to show in class or have your students watch at home. A few samples are:

- http://www.jpl.nasa.gov/video/details.php?id=938
- http://www.jpl.nasa.gov/video/details.php?id=1398
- https://www.youtube.com/watch?v=ePTTnWGc5vE

Common Core Standards

For more information on Common Core Standards, visit http://www.corestandards.org/.

Speaking & Listening	
CCSS.ELA-LITERACY.SL.9-10.1	Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9-10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.
CCSS.ELA-LITERACY.SL.9-10.3	Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any fallacious reasoning or exaggerated or distorted evidence.
CCSS.ELA-LITERACY.SL.9-10.4	Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.
CCSS.ELA-LITERACY.SL.11-12.1	Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 11-12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.
CCSS.ELA-LITERACY.SL.11-12.3	Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used.
CCSS.ELA-LITERACY.SL.11-12.4	Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.
History/Social Studies	

CCSS.ELA-LITERACY.RH.9-10.1	Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.
CCSS.ELA-LITERACY.RH.9-10.2	Determine the central ideas or information of a primary or secondary source; provide an accurate summary of how key events or ideas develop over the course of the text.
CCSS.ELA-LITERACY.RH.9-10.3	Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.
CCSS.ELA-LITERACY.RH.11-12.1	Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole.
CCSS.ELA-LITERACY.RH.11-12.2	Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas.
CCSS.ELA-LITERACY.RH.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.

Next Generation Science Standards

For more information on the Next Generation Science Standards, visit http://www.nextgenscience.org/.
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