TEACHING A DIVERSE HISTORY OF PHYSICS: WOMEN AND AFRICAN AMERICANS IN THE PHYSICAL SCIENCES

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Brean Prefontaine, Drexel University

Mentor: Dr. Greg Good
Motivation?
Creating educational materials:

https://www.aip.org/history-programs/physics-history/materials-teachers-students
Lesson plans and more…

• Currently on the AIP Center for History of Physics website there are:
  • 20 lesson plans pertaining to women in the history of physics and related fields
  • 19 lesson plans pertaining to African Americans in the history of physics and related fields

• Most lesson plans are accompanied with additional materials (such as case studies, crossword puzzles, worksheets, video links, and suggestions for other activities)
Current Lesson Plans:

**Fair or Unfair: Should these Women have received the Nobel Prize, Too?**

**Objective**
Students will learn about the lack of recognition that plagued the careers of women scientists, while at the same time developing reasoning and debating skills.

**Introduction**
The Nobel Prize, established in 1895 from an endowment in the will of dynamite-discoverer Alfred Nobel, is perhaps the most prestigious prize in science. Great celebration, as well as great scandal, surrounds the yearly prize announcements. It has been argued that Lise Meitner, Chien-Shiung Wu, Marietta Blau, and Jocelyn Bell Burnell have been unfairly denied the Nobel Prize that had been awarded to their male colleagues. But were their contributions significant enough to merit equal recognition? You decide!

**Instructions**
Information is provided about four cases where the Nobel Prize for Physics or Chemistry was given to a man but not his female collaborator. Students should divide into small groups and using the information provided as well as their own research, prepare a case arguing for or against the fairness of the awards. Each group will debate their case either with the other team or in front of the rest of the class. The question should then be put to a vote, with three possible outcomes:

1. The Nobel Committee made the right decision and the Prize was correctly awarded
2. The Nobel Committee did not award the Prize correctly but the female scientist should have been the recipient of the award
3. The scientists involved both qualified and contributed equally and the award should have been shared

It should become clear that none of these cases are simple and none have an obvious answer. In almost every case, legitimate arguments could be made for each of the three outcomes. The cases under consideration include:

<table>
<thead>
<tr>
<th>Year</th>
<th>Nobel Prize</th>
<th>It was awarded to</th>
<th>Should it have been awarded to</th>
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<tr>
<td>1944</td>
<td>Chemistry</td>
<td>Otto Hahn</td>
<td>Meitner?</td>
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<td>1950</td>
<td>Physics</td>
<td>Tuong Dao Lee &amp; Chen Ning Yang</td>
<td>Wu?</td>
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<td>1957</td>
<td>Physics</td>
<td>Cecil Powell</td>
<td>Blau?</td>
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<tr>
<td>1974</td>
<td>Physics</td>
<td>Martin Ryle &amp; Antony Hewish</td>
<td>Jocelyn Bell Burnell?</td>
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**In Class Time**
45-90 minutes

**Prep Time**
30 minutes

**Materials**
- Photocopies of case studies
Utilizing Resources:
The 5E model:
Lesson Plan: Fair or Unfair
Should these women have won Nobel Prizes?

Clockwise from top left: Lise Meitner, Marietta Blau, Chien-Shiung Wu, Jocelyn Bell Burnell. Images courtesy of the AIP Emilio Segre Visual Archives.

Introduction
The Nobel Prize, established in 1895 from an endowment in the will of dynamite discoverer Alfred Nobel, is perhaps the most prestigious prize in science. Great celebration and occasionally scandal surrounds the yearly prize announcements. It has been argued that Lise Meitner, Chien-Shiung Wu, Marietta Blau, and Jocelyn Bell Burnell were unfairly denied the Nobel Prize that was awarded to their male colleagues. Were their contributions significant enough to merit equal recognition? You decide!

Instructions/Activities
Engagement: 8-10 minutes
A few days or a day before the lesson, assign students to a group and assign one physicist to each group. The students should read through the provided case study and conduct outside research on the assigned physicist. The list of additional resources in this lesson contained various materials on each physicist. These materials vary in reading level, length, and depth of scientific content but contain significant information about these physicists. Be sure to also ask students to conduct research on the Nobel Prize as well especially the statistics pertaining to women. This research can be done individually or as a group.

What is the teacher doing?
Ask students to come prepared to class on the day of the lesson with information about their physicist and the Nobel Prize.

What are students doing?
Students should work on researching materials as a homework assignment. The list of sources contained in the additional resources section of the lesson plan should be used a starting point and should be made available to all students.

On the day of the lesson, ask students to share information about the Nobel Prize. This is a time for students to recall what they learned about the Nobel Prize. The following questions can be used as guidance:

- When was the Nobel Prize established and by whom?
- What was the purpose of establishing the Nobel Prize? Does it still hold that same significance today?
- How many prizes have been awarded?
- How many of those were awarded to females?
- How many females have received a Nobel Prize in physics?

Fill in any blank spots in your students’ knowledge. Students can ask questions about the Nobel Prize to make sure that they understand what it is and why people receive it.

Grade Level(s): 9+
Subject(s): History, Physics
In-Class Time: 45-90 minutes
Prep Time: 30 minutes

Materials
- Photocopies of case studies
- Internet access
- Other research resources

Objective
Students will learn about the lack of recognition that plagued the careers of female scientists while demurring research, reasoning, and debate skills. This lesson is intended for high school as college level.
Grade Level(s): 9+  
Subject(s): History, Physics

In-Class Time: 45-90 minutes  
Prep Time: 30 minutes

Materials
- Photocopies of case studies
- Internet access
- Other research resources

Objective
Students will learn about the lack of recognition that plagued the careers of female scientists while developing research, reasoning, and debate skills. This lesson is intended for a high school or college level audience. The lesson can also be found in a format that is acceptable for middle school students.
Case Study: S. Jocelyn Bell Burnell
1974 Nobel Prize in Physics awarded to Martin Ryle and Antony Hewish

As a 24-year-old graduate student, Susan Jocelyn Bell Burnell observed the first known pulsar, a type of star that gives out rapid and regularly spaced radio signals. She began her graduate studies in 1965 at Cambridge under Antony Hewish, an astronomer working on designing a radio telescope to detect “twinkling,” quick-changing radio sources known as quasars outside of our galaxy. Bell and other students helped build the telescope over a span of two years, though Bell alone ran the device and analyzed the data. In October of 1967, Bell noticed regularly recurring signals that looked different than quasar signals or interference from other places. At first, her professor thought that the signals were man made, and the pair even entertained the idea of an alien source. Bell solidly determined that the unusual signals were not terrestrial and found a few different sources of the same type of signals in different locations in the sky. The discovery was published in 1968 with Hewish as the first author and Bell as the second author of five.¹

The 1974 Nobel Prize in Physics went jointly to Hewish and his own mentor, Sir Martin Ryle, a long serving head of the Cambridge radio astronomy group. The pair was recognized for their work in the advancement of radio astrophysics, with Hewish recognized specifically for “his decisive role in the discovery of pulsars.”² Bell and Hewish jointly received the 1973 Michelson medal from the Franklin Institute in Pennsylvania for the discovery of pulsars. The media became obsessed with Bell’s story, and she received great press coverage for her involvement in pulsar discovery. Her role has been argued to be the most important in the discovery as she initially noticed the tiny and easily missed signals and proved that they were from stars further away from our own Sun. On the other hand, Hewish’s ideas sparked the construction of the telescope used to make the discovery. Bell Burnell never revealed bitterness that she did not receive the Prize, personally believing that advisors that set up their own lab assume risks that deserve reward.

African American physicists lesson plan:
Excerpt One: On His Family and Growing Up

Carruthers:
My father was George Archer Carruthers, and he was a general engineer by trade. He went to the University of Illinois, like I did. In fact, that’s probably part of the reason why I got into the University of Illinois. I don’t remember a whole lot about what kind of work my father did, but the earliest that I can remember was that in 1947 we moved from Cincinnati to a farm near Columbus, Ohio, which is about fifteen miles from downtown Cincinnati. At that time it was called a farm, not a boondock, you might say. So from the time I was seven till I was twelve, my childhood was spent in the country, so to speak, in rural surroundings.

DeVorkin:
Who did your father work for?

Carruthers:
He worked for the Wright-Patterson Air Force Base in Dayton, Ohio, so he had a steady job.

DeVorkin:
That’s quite a distance. Why did you stay in the Cincinnati area if he worked there?

Carruthers:
Actually, I think that he changed jobs after we moved to the country. He was no longer connected with Cincinnati. I don’t remember exactly when he changed jobs. It might have been sometime around three years after that.

DeVorkin:
Tell me a little bit about your mother, her name and what she was like, what she did.

Carruthers:
My mother’s maiden name was Sophia Singley. Both of my father and mother were born in Cincinnati, I guess just before I was born. I don’t remember much about her background. She studied in science or engineering, but I don’t remember exactly what it was.

DeVorkin:
Let me go a little farther back in your family. Your father had an advanced degree in what?

Carruthers:
He had a PhD in electrical engineering.

Primary Source:
Letter to Thomas Jefferson from Benjamin Banneker, 1791

Baltimore County, (Maryland) near Ellicott’s Mills, August 19, 1791. To Thomas Jefferson, Esquire, Secretary of State.

SIR,

I AM fully sensible of the greatness of that freedom, which I take with you on the present occasion; a liberty which seemed to me scarcely allowable, when I reflected on that distinguished and dignified station in which you stand, and the almost general prejudice and prepossession, which is so prevalent in the world against those of my complexion.

I suppose it is a truth too well attested to you, to need a proof here, that we are a race of beings, who have long labored under the abuse and censure of the world; that we have long been considered rather as brutish than human, and scarcely capable of mental endowments.

Sir, I hope I may safely admit, in consequence of that report which hath reached me, that you are a man far less inflexible in sentiments of this nature, than many others; that you are measurably friendly, and well-disposed towards us; and that you are willing and ready to lend your aid and assistance to our relief, from those many distresses, and numerous calamities, in which we are reduced. Now Sir, if this is founded in truth, I apprehend you will embrace every opportunity, to eradicate that train of absurd and false ideas and opinions, which so generally prevails with respect to us, and that your sentiments are concurrent with mine, which are, that one universal Father hath given being to us all; and that he hath not only made us all of one flesh, but that he hath also, without partiality, afforded us all the same sensations and endowed us all with the same faculties; and that however variable we may be in society or religion, however diversified in situation or color, we are all of the same family, and stand in the same relation to him.

Sir, if these are sentiments of which you are fully persuaded, I hope you cannot but
Standards and the lessons:

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<tr>
<th>Common Core Standards</th>
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<td>For more information on Common Core Standards, visit <a href="http://www.corestandards.org/">http://www.corestandards.org/</a></td>
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<th>History/Social Studies</th>
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<tr>
<td><strong>CCSS ELA-LITERACY RH 9-10.1</strong> Cite specific textual evidence to support analysis of primary and secondary sources, attending to such features as the date and origin of the information.</td>
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<tr>
<td><strong>CCSS ELA-LITERACY RH 9-10.2</strong> 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.</td>
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<tr>
<td><strong>CCSS ELA-LITERACY RH 9-10.4</strong> Determine the meaning of words and phrases as they are used in a text, including vocabulary describing political, social, or economic aspects of history/social science.</td>
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<td><strong>CCSS ELA-LITERACY RH 9-10.5</strong> Analyze how a text uses structure to emphasize key points or advance an explanation or analysis.</td>
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<td><strong>CCSS ELA-LITERACY RH 9-10.8</strong> Assess the extent to which the reasoning and evidence in a text support the author's claims.</td>
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<tr>
<td><strong>CCSS ELA-LITERACY RH 11-12.1</strong> 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.</td>
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<tr>
<td><strong>CCSS ELA-LITERACY RH 11-12.2</strong> 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.</td>
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<tr>
<td><strong>CCSS ELA-LITERACY RH 11-12.5</strong> Analyze in detail how a complex primary source is structured, including how key sentences, paragraphs, and larger portions of the text contribute to the whole.</td>
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<tr>
<td><strong>CCSS ELA-LITERACY RH 11-12.4</strong> Determine the meaning of words and phrases as they are used in a text, including analyzing how an author uses and refines the meaning of a key term over the course of a text (e.g., how Madison defines <em>faction</em> in <em>Federalist</em> No. 10).</td>
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<tr>
<td><strong>CCSS ELA-LITERACY RH 11-12.5</strong> Analyze in detail how a complex primary source is structured, including how key sentences, paragraphs, and larger portions of the text contribute to the whole.</td>
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<tr>
<td><strong>CCSS ELA-LITERACY RH 11-12.7</strong> Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as orally).</td>
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Additional Materials:

- This summer we also developed three games that can be played in the classroom:
  - Phystory
  - The Scientists of Catan
  - Heads Up

- All of these games will be available online in PDF format so that teachers can download and make their own set.
The Scientists of Catan

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Heads Up

**Ada Lovelace**  
*(1815-1852)*

**Granville T. Woods**  
*(1856-1910)*

**Marie Curie**  
*(1867-1934)*

**Lewis Howard Latimer**  
*(1848-1928)*

**Elijah McCoy**  
*(1844-1929)*

**Stephen Hawking**  
*(1942-*)

**Richard Feynman**  
*(1918-1988)*

**Emmy Noether**  
*(1882-1935)*

**Carl Friedrich Gauss**  
*(1777-1855)*
Phystory

1609
Kepler's first two laws of planetary motion are published.

1621
Willebrord Snellius states his law of refraction.

1687
*Principia Mathematica* is first published by Isaac Newton.

1753
Benjamin Banneker finishes work on what would be the first clock made in the United States.

1791
*Pennsylvania, Delaware, Maryland, and Virginia Almanak and Ephemeris* is published.

1732
Laura Bassi becomes the first official female physics professor.

1835
Mary Somerville and Caroline Herschel become the first female inductees into the Royal Astronomical Society.

1837
The Institute for Colored Youth, which would later become Cheyney University of Pennsylvania, is founded as the first HBCU in the United States.

Maria Mitchell becomes the first female member of the American Association for the
Incorporating Teacher Feedback
Principles and Standards for School Mathematics
Pre K - 12
National Council of Teachers of Mathematics

Rocket Activities

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<th>Pop Can &quot;Hero Engine&quot;</th>
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<td>Pop! Rockets Launcher</td>
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<td>High-Power Paper Rocket Launcher</td>
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Future Topics:

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