

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

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AIP | **History Programs**
Center for History of Physics + Niels Bohr Library & Archives



Motivation?

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At Work Clipart Lab Job Famous Astrophysicist

The image displays a Google search results page for the query 'physicist'. The page is organized into a grid of image thumbnails. At the top, there is a navigation bar with tabs for 'Web', 'Images', 'News', 'Videos', 'Books', and 'More'. The 'Images' tab is selected. Below the navigation bar, there are several categories of images: 'At Work', 'Clipart', 'Lab', 'Job', 'Famous', and 'Astrophysicist'. The main content area is a grid of image thumbnails. The first row includes portraits of Albert Einstein, a man pointing at a chalkboard with a diagram, a cartoon scientist, a man in a lab coat working with equipment, a group of people in a meeting, a portrait of Albert Einstein, and a portrait of a man in a suit. The second row includes portraits of Albert Einstein, a man pointing at a chalkboard with a diagram, a portrait of Albert Einstein, a portrait of a man in a suit, a portrait of a woman in a suit, a portrait of a man in a suit, a portrait of a man in a suit, and a portrait of a man in a suit. The third row includes portraits of a man in a suit, a man with a long white beard, a man in a suit, a man in a lab coat working with equipment, a portrait of Albert Einstein, a portrait of a man in a suit, a portrait of a man in a suit, and a portrait of a man in a suit. The fourth row includes a man pointing at a chalkboard with mathematical equations, a man pointing at a chalkboard, a man pointing at a chalkboard with mathematical equations, a man pointing at a chalkboard with mathematical equations, a man pointing at a chalkboard with mathematical equations, a portrait of a man in a suit, and a man sitting at a desk. The fifth row includes portraits of a man in a suit, Albert Einstein, a man in a suit, a close-up of Albert Einstein's face, a man in a suit, a man in a suit, and a man in a suit.

Creating educational materials:

The screenshot shows the AIP website page for 'Materials for Teachers & Students'. The page has a blue header with the AIP logo and a search bar. Below the header is a navigation menu with options like 'Programs and Resources', 'Publications', 'Career Resources', 'Member Societies', 'About AIP', and 'Donate now'. The main content area is divided into a left sidebar and a main column. The sidebar contains links for 'Scholarship at the Center', 'Education outreach', and 'Documenting the History of Physics'. The main column features a section for 'Materials for Teachers & Students' with a paragraph about guides for teachers and students, and a section for 'Teaching Guides on Women and Minorities in the Physical Sciences' with an image of people and a paragraph about lesson plans. There is also a 'History Programs News' section with three news items and a 'Public Lecture' section for Ainissa Ramirez.

<https://www.aip.org/history-programs/physics-history/materials-teachers-students>

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Home > History Programs > Materials for Teachers & Students

Center for History of Physics

Materials for Teachers & Students

In accordance with its mission, the Center for History of Physics produces guides for teachers and students about a variety of topics relating to the physical sciences. The guides are intended to support the needs of both casual and serious researchers.

Teaching Guides on Women and Minorities in the Physical Sciences

These guides are intended to increase knowledge of and generate discussion about the historical and contemporary experiences of women and minorities in physics, astronomy, and related disciplines. They are comprised of ready-to-use lesson plans, as well as other resources to assist educators and students as they design their own lessons and embark on independent research projects.

[See teaching guides >>](#)

History Programs News

Voices of the past reimagined
Upgrade to oral history webpages makes resource more useful

APS physics Transcendence: A new play read at the 2015 APS April Meeting explores the Einstein Nobel Prize controversy

Expanding NBL&A resources to include meteorology
500 texts to be added; more resources linked through ICOS

MORE HISTORY PROGRAM NEWS

Public Lecture

Ainissa Ramirez, science communicator
July 28; 4-5 pm, Hoff Theater, Univ. of Maryland

[MORE INFORMATION ▶](#)

In the Spotlight

From the Physics Today Archives (Pluto) – July 2015

Found in the archives: Joanna

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CONTACT CENTER FOR HISTORY OF PHYSICS

One Physics Ellipse
College Park, MD 20740

<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 and 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:

Year	Nobel Prize	It was awarded to	Should it have been awarded to
1944	Chemistry	Otto Hahn	Lise Meitner?
1950	Physics	Tsung Dao Lee & Chen Ning Yang	Chien-Shiung Wu?
1957	Physics	Cecil Powell	Marietta Blau?
1974	Physics	Martin Ryle & Antony Hewish	Jocelyn Bell Burnell?

In Class Time

45-90 minutes

Prep Time

30 minutes

Materials

- Photocopies of case studies

Case Study: Jocelyn Bell Burnell

1974 Nobel Prize in Physics awarded to collaborators Martin Ryle and Antony Hewish

- Burnell arrived in Cambridge in 1965 and Antony Hewish was preparing to construct a radio telescope with the aim of looking for "twinkling" radio sources.
- She spent her first two years helping to build the telescope, making the cables herself among other duties, and began her true research in 1967 when the telescope was switched on.
- When analyzing the data from the telescope, she came across a small part which did not agree with what she would have expected. She was able to prove that it was coming from stars further away than our own sun.
- She soon realized that the pulses she was seeing on the charts were very evenly spaced and she began to find it in the same area of the sky at varying times.
- These pulses were unlike anything seen from a star before.
- She found another source pulsating even faster, but just as regularly and on the same frequency.
- Hewish published an article detailing the work on pulsars with S.J. Bell listed as the second author of five. The media became obsessed with her story and she received much press coverage for her involvement.
- The 1974 Nobel prize in physics was awarded jointly to Hewish and Sir Martin Ryle, another astronomer for their work in radio astrophysics, with Hewish receiving it for

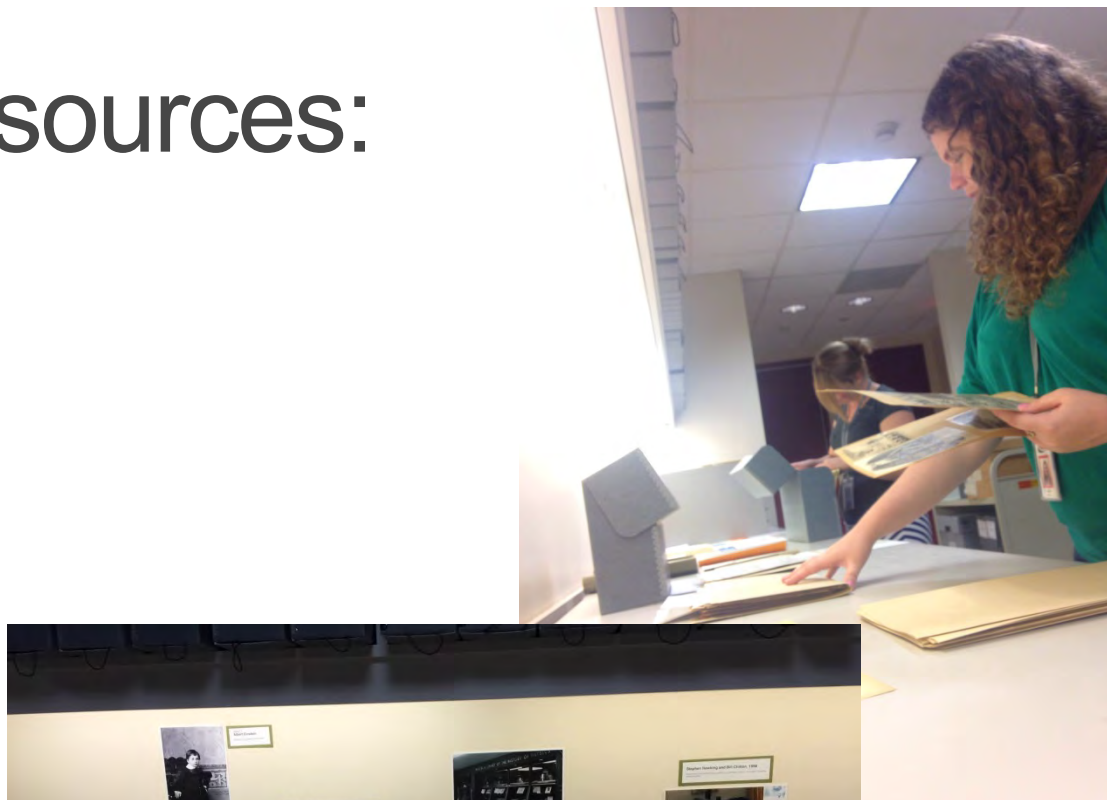
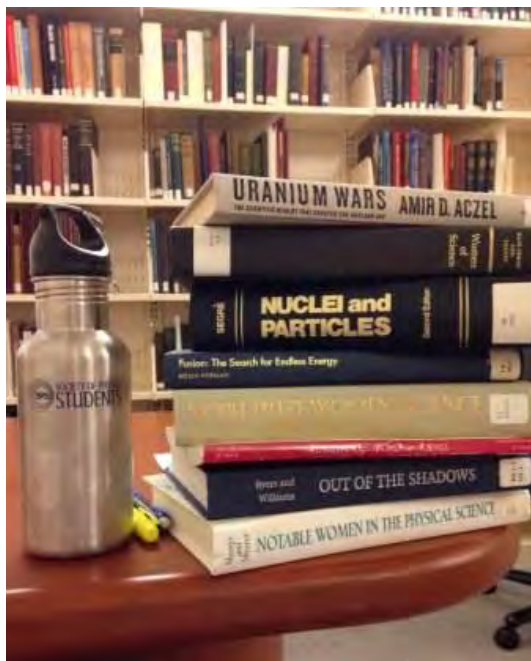
"his decisive role in the discovery of pulsars"

- Burnell never revealed bitterness that she did not become the fifth person to receive a Nobel Prize for her doctoral research and she received many other awards and recognitions throughout her career.

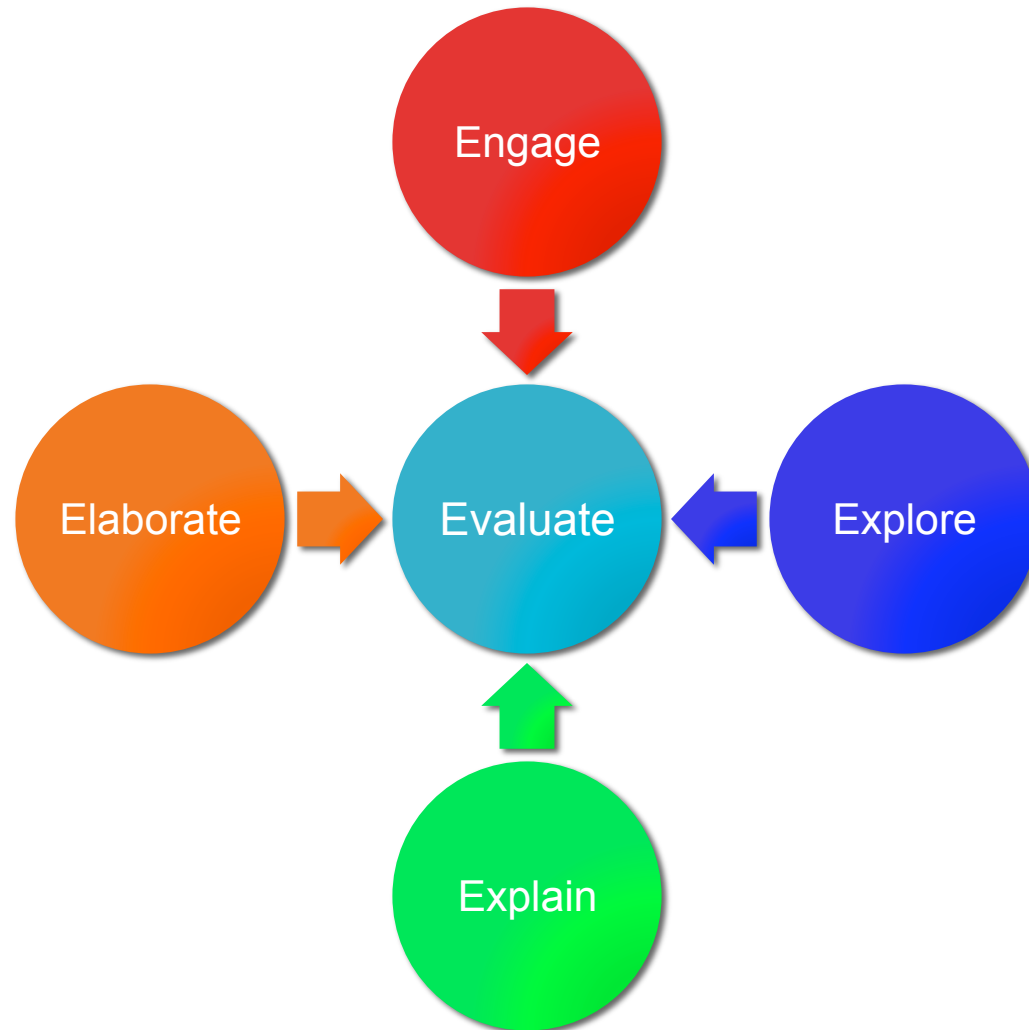


The Open University, courtesy AIP Emilio Segre Visual Archives

Utilizing Resources:



The 5E model:



Revised Lesson Plans:



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 Segré Visual Archives.

Grade Level(s): 9+	Subject(s): History, Physics
In-Class Time: 45-90 minutes	Prep Time: 30 minutes
Materials	
<ul style="list-style-type: none"> • 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.



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 as 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?

Students will share out information that they learned about the Nobel Prize. Specific information should be included in response to questions.

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 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 mentor 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.



¹ A. Hewish, S.J. Bell, J.D.H. Pilkington, P.F. Scott, and B.A. Collins, "Observation of a rapidly pulsating radio source," *Nature* 217, no. 5130 (1968): 709-713. The Open University, accessed 10/1/2014. Emilio Segre Visual Archives

² "The Nobel Prize in Physics 1974," http://www.nobelprize.org/nobel_prizes/physics/laureates/1974/

African American physicists lesson plan:



African Americans in Astronomy and Astrophysics



Principal Investigator Dr. George Carruthers (right) and Project Engineer William Conway with the Apollo 16 ultraviolet camera/spectrograph instrument. Naval Research Laboratory (NRL), courtesy AIP. Emilio Searé Visual Archives, Ronald E. Mickens Collection.

Grade Level(s): 9-12 Subject(s): History, Physics, Astronomy

In-Class Time: (see below) Prep Time: 10-15 min for each part

- Part One: The Life of Benjamin Banneker (45-60 min)
- Part Two: Dr. George Carruthers, Space Scientist (45-60 min)
- Part Three: African American Astronomers and Astrophysicists (Work done at home, in-class presentations)

Materials

- Part One: The Life of Benjamin Banneker
 - Access to internet in order to provide groups of 3-4 copies of Benjamin Banneker's 1793 almanac, found at the Temple University Libraries page: <http://digital.library.temple.edu/cdm/ref/collection/p16002coll5/id/237>.
 - Copies of the Banneker's Almanac Worksheet (see supplemental material)



Name: _____ Date: _____

Benjamin Banneker's Almanac of 1793

Use Benjamin Banneker's almanac published in 1793 to answer the following questions.



How many eclipses were there in 1793? When were they?

What was the weather like on Valentine's Day?

On what day, hour, and minute was the full moon in March 1793? What was the weather like that day?

What is the cure (called a "receipt") for "eruptions in the face"? What do you think are "eruptions in the face?"

When were the supreme courts held in Philadelphia?

Excerpt One: On His Family and Growing Up

Carruthers:

My father was George Archer Carruthers, and he was a general engineer by the University of Illinois, like I did. In fact, that's probably part of the reason why I went to the University of Illinois. I don't remember a whole lot about what kind of work he did, the earliest that I can remember was that in 1947 we moved from Cincinnati to a town in Ohio, which is about fifteen miles from downtown Cincinnati. At that time it was a backwoods, you might say. So from the time I was about seven till I was twelve, I grew up 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 pretty good bit.

DeVorkin:

That's quite a distance. Why did you stay in the Cincinnati area if he worked in Dayton?

Carruthers:

Actually, I think that he changed jobs after we moved to the country. He was in Cincinnati. I don't remember exactly when he changed jobs. It might have been 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 my father and mother were originally from Cincinnati, I guess just before I was born. I don't know her background was in terms of the occupational specialty that she studied in school, 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 from the University of Illinois.

Primary Source:

Letter to Thomas Jefferson from Benjamin Banneker, 1791

Text from Benjamin Banneker's 1793

almanac, <http://digital.library.temple.edu/cdm/ref/collection/p16002coll5/id/237>.

Baltimore County, (Maryland) near Ellicott's Mills, August 19, 1791. To Thomas Jefferson, Esq., 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, to 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 general 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:



Common Core Standards

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



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.9-10.4	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.
CCSS.ELA-LITERACY.RH.9-10.5	Analyze how a text uses structure to emphasize key points or advance an explanation or analysis.
CCSS.ELA-LITERACY.RH.9-10.8	Assess the extent to which the reasoning and evidence in a text support the author's claims.
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.11-12.5	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.
CCSS.ELA-LITERACY.RH.11-12.4	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 <i>faction</i> in <i>Federalist</i> No. 10).
CCSS.ELA-LITERACY.RH.11-12.5	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.
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

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

The Scientists of Catan

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1



Heads Up



ADA LOVELACE
(1815-1852)



MARIE CURIE
(1867-1934)



EMMY NOETHER
(1882-1935)



GRANVILLE T. WOODS
(1856-1910)



LEWIS HOWARD LATIMER
(1848-1928)



ELIJAH MCCOY
(1844-1929)



STEPHEN HAWKING
(1942-)



RICHARD FEYNMAN
(1918-1988)



CARL FRIEDRICH GAUSS
(1777-1855)

Phystory

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

1753

Benjamin Banneker's *Pennsylvania, Delaware, Maryland, and Virginia Almanak and Ephemeris* is published.

1791

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

1837

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

1609

Willebrord Snellius states his law of refraction.

1621

Principia Mathematica is first published by Issac Newton.

1687

Laura Bassi becomes the first official female physics professor.

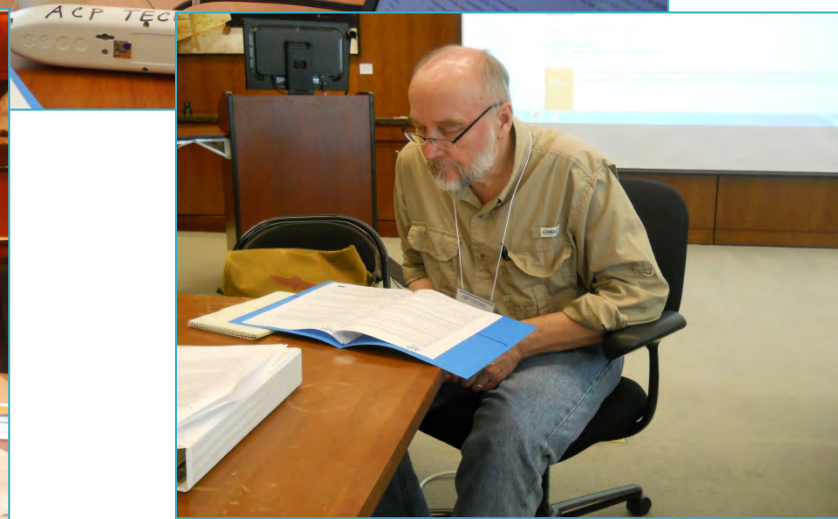
1732

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

1835

Maria Mitchell becomes the first female member of the American Association for the

Incorporating Teacher Feedback

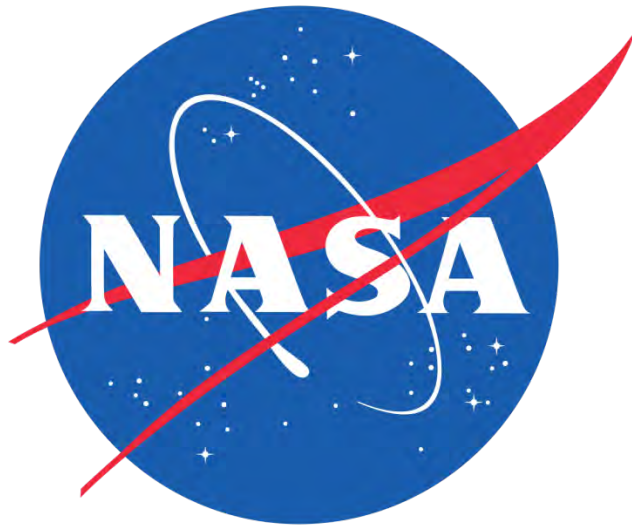


Organization:

Principles and Standards for School Mathematics

Pre K - 12

National Council of Teachers of Mathematics



Rocket Activities

	Content Standards					Process Standards				
	• Number and Operations	• Algebra	• Geometry	• Measurement	• Data Analysis and Probability	• Problem Solving	• Reasoning and Proof	• Communication	• Connections	• Representations
Pop Can "Hero Engine"	✓	✓			✓		✓	✓	✓	✓
3...2...1...PUFF!	✓		✓	✓	✓				✓	✓
Heavy Lifting	✓				✓	✓	✓	✓	✓	✓
Newton Car	✓			✓	✓	✓	✓	✓	✓	✓
Rocket Races	✓		✓	✓	✓	✓	✓	✓	✓	✓
Pop! Rockets Launcher				✓				✓		
Pop! Rockets	✓		✓	✓	✓	✓	✓	✓	✓	✓
Foam Rocket	✓	✓	✓	✓	✓		✓	✓	✓	✓
Launch Altitude Tracker	✓		✓	✓	✓	✓	✓	✓	✓	✓
High-Power Paper Rocket Launcher				✓				✓		
High-Power Paper Rockets	✓		✓	✓	✓	✓	✓	✓	✓	✓
Rocket Wind Tunnel	✓			✓	✓	✓	✓	✓	✓	✓
Advanced High-Power Paper Rockets	✓		✓	✓	✓	✓	✓	✓	✓	✓
Water Rocket Launcher				✓					✓	
Water Rocket Construction			✓	✓					✓	
Project X-51	✓		✓	✓	✓	✓	✓	✓	✓	✓

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International Conference on Physics 1934



Italian Physical Society E1



Conference On Applied Nuclear Physics E1
Conference on Applied Nuclear Physics



ICHEP E1
Seventh Annual ICHEP 1957



Solvay Conference E13
Ninth Solvay Conference on Physics



Solvay Conference E11
Seventh Solvay Conference on Physics



Solvay Conference E12
Eighth Solvay Conference on Physics



Rainwater Leo James E4
Group Photo at UKAEA Harwell



Wu Chien Shiung D5



Fowler William Alfred E4



APS E25
APS Meeting



Wu Chien Shiung F1



APS E6
APS Meeting



Phillips Melba C1
Phillips and Lesser converse



Axel Peter C6
Axel and Kuchnirs



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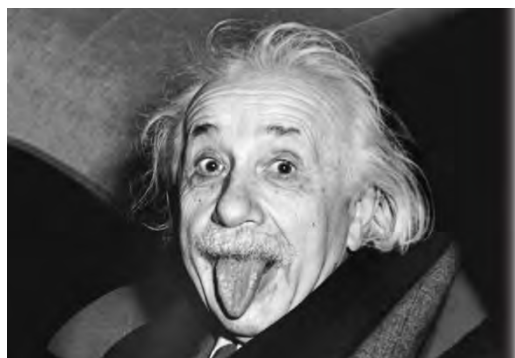
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oSTEM



Gabriela Gonzalez, courtesy of LSU



As a student,
he was no Einstein.

CONFIDENCE

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ACKNOWLEDGEMENTS

- Dr. Greg Good
- Joanna Behrman
- Joe Anderson, Melanie Mueller, Stephanie Jankowski, and all of the staff of the Niels Bohr Library and Archives
- AIP Statistical Research Center
- Society of Physics Students
- Past interns and their contributions to the project

