The Nobel Prize in Physics: Four Historical Case Studies

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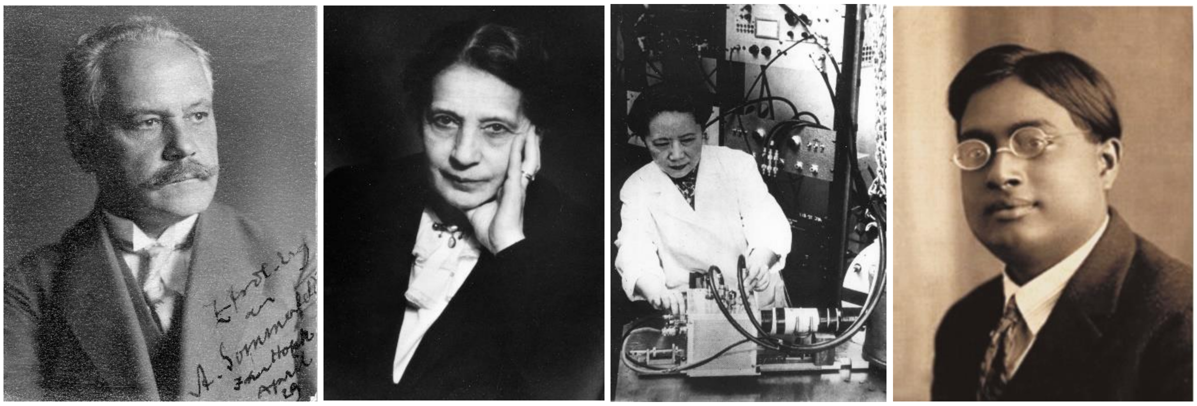

From left: Arnold Sommerfeld, Lise Meitner, Chien-Shiung Wu, Satyendra Nath Bose.
Images courtesy of the AIP Emilio Segré Visual Archives.

Grade Level(s): 11-12, College **Subject(s): History, Physics**

In-Class Time: 50 - 60 minutes **Prep Time: 15 – 20 minutes**

Materials

- Photocopies of case studies (found in the Supplemental Materials)
- Student internet access

Objective

Students will investigate four historical case studies of physicists who some physicists and historians have argued should have won a Nobel Prize in physics: Arnold Sommerfeld, Lise Meitner, Chien-Shiung Wu, and Satyendra Nath Bose. With each **Case Study**, students examine the historical context surrounding the prize that year (if applicable) as well as potential biases inherent in the structure of the Nobel Prize committee and its selection process. Students will summarize arguments for why these four physicists should have been awarded a Nobel Prize, as well as potential explanations for why they were not awarded the honor.

Introduction

Introduction to the Nobel Prize

In 1895, Alfred Nobel—a Swedish chemist and engineer who invented dynamite—signed into his will that a large portion of his vast fortune should be used to create a series of annual prizes awarded to those who “confer the greatest benefit on mankind” in physics, chemistry, physiology or medicine, literature, and peace.[1] (The Nobel Prize in economics was added later to the collection of disciplines in 1968). Thus, the Nobel Foundation was founded as a private organization in 1900 and the first Nobel Prizes were awarded in 1901.

Nominations for a Nobel Prize start with the Nobel Committee, which sends nomination forms to approximately 3,000 individuals in September of the year before each prize is awarded. Those who usually receive the nomination forms are former Nobel laureates and prominent academics working in each relevant area. The Nobel Committee then nominates about 300 potential awardees from the list of nominations they receive. The nomination records are sealed for 50 years following the award of each prize. The awardees are selected by a majority-vote process, and a Nobel Prize—which cannot be awarded posthumously—can only be shared among up to a maximum of three people. Nobel laureates receive a medal, diploma, and between $800,000 – $1 million, a sum which is divided between the awardees if there is more than one for that particular year.

The Nobel Prize in Physics

Awarded annually by the Royal Swedish Academy of Sciences in Stockholm, Sweden, the Nobel Prize in physics is given to “the person who shall have made the most important discovery or invention within the field of physics.”[2] It was the first mentioned in Alfred Nobel’s will because, at the end of the nineteenth century, physics was considered as the “foremost of the sciences.”[3] The physics prize has been awarded 113 times between 1901 and 2019 to 213 Nobel laureates. Of the laureates, only three have been women: Marie Curie (1903), Marie Goeppert-Mayer (1963), and Donna Strickland (2018). *Physics Today* presented an interesting study about the 386 people who were nominated for the prize between 1901-66 that students will explore in this lesson.

Brief Introductions to the Four Historical Case Studies

Arnold Sommerfeld: Arnold Sommerfeld (1868-1951) was a German theoretical physicist who made significant contributions to atomic and quantum physics. He succeeded Ludwig Boltzmann at the Institute of Theoretical Physics at the University of Munich—it was here that he gained international recognition for his contributions to the structure of the atom by suggesting changes to Bohr’s famous orbital model. Despite being nominated for the Nobel Prize in physics 84 times, more than anyone else in its history, he was never awarded the honor. However, he is the physicist with the highest number of doctoral students who eventually won Nobel Prizes: including Werner Heisenberg, Wolfgang Pauli, Peter Debye, and Hans Bethe, to name a few.[4]

Lise Meitner: Lise Meitner was a 20th century Austrian physicist who was critical to the discovery of *nuclear fission*. She became the second woman to earn a doctorate in physics from the University of Vienna in 1905. While researching radioactive decay processes alongside Otto Hahn in Berlin, the Second World War broke out and, because of her Jewish heritage, she was forced to emigrate to Sweden. The experiments they had performed together—and Meitner correctly interpreted—led to the discovery of nuclear fission, but Otto Hahn was solely awarded the Nobel Prize in chemistry in 1944.

Chien-Shiung Wu: Chien-Shiung Wu was a leading 20th-century Chinese-American nuclear physicist. After working on the Manhattan Project during the Second World War, she focused on designing

[1] “Alfred Nobel’s will.”
[2] Excerpt from the will of Alfred Nobel. See “The Nobel Prize in Physics.”
[3] From “The Nobel Prize in Physics.”
[4] Beléndez, “Sommerfeld: the Eternal Nobel Candidate.”

experiments to measure *beta decay*, a form of radioactivity in which a proton turns into a neutron (and vice versa) by emitting a *beta particle*—an electron. While observing the emission of cobalt-60, she observed that the particles had a *preferred direction* of emission, which violated the *principle of parity*. This principle states that for any particle interaction, one cannot distinguish right from left or clockwise from counterclockwise. Her discovery confirmed a theory by Tsung-Dao Lee and Chen Ning Yang, who were later awarded the Nobel Prize in physics in 1957. Wu was not included.

Satyendra Nath Bose: Satyendra Nath Bose was a 20th century theoretical physicist who made significant contributions to the statistical foundations of quantum mechanics. In 1924, Bose authored the "fourth and last of the revolutionary papers of the old quantum theory," in which he derived Planck's law in a revolutionary way.[5] With little success publishing his paper, he sent it directly to Einstein and asked him to translate it for *Zeitschrift für Physik,* a prestigious physics journal. Einstein was impressed by Bose's work, and they continued to collaborate. Their partnership resulted in several significant physical theories, including *Bose-Einstein statistics* and the *Bose-Einstein condensate*. Several Nobel prizes were awarded for work related to the *boson*, force-carrying particles named after Bose himself, and Bose had collaborated with several physicists who would later become laureates. Despite this, and the fact that Bose was nominated 4 times for the prize, he was never awarded the honor.

Instructions/Activities

Engage: 5-10 minutes

Begin class with a short introduction to the Nobel Prize. Ask the students about their prior knowledge of the award: What disciplines can be awarded a Nobel Prize? Do they know any Nobel laureates? How does the nomination and selection process work? Use information from the "Introduction to the Nobel Prize" and "The Nobel Prize in Physics" sections above. Another option is to show this short speech by Donna Strickland about experimental physics from a Nobel Prize banquet. You can also show this interactive world map of Nobel laureates from *Physics Today*.	
What is the teacher doing? The teacher is asking students about their prior knowledge of the Nobel Prizes.	**What are the students doing?** Students are answering the teacher's questions, offering their knowledge of the Nobel Prizes.

Explore: 20 minutes

Divide the class into four groups, each will be assigned one of the following case studies. Students will research their given **Case Study**, take notes on details of the historical context, and summarize potential reasons for why their physicist did not receive a Nobel Prize. Students should also read "Box 2: Nobel Controversies."	
What is the teacher doing? Divide the class into four groups and assign each group one of the Nobel Case Studies. Each group should receive printed copies of the **Case Study** and have internet access to access "Physics Nobel nominees, 1901-66."	**What are the students doing?** Students are gathering into assigned groups and researching their assigned Nobel **Case Study** and answering the **Discussion Questions**. Students should also use data from the *Physics Today* article, "Physics Nobel nominees, 1901–66."

[5] Wali, "The man behind Bose statistics," 46.

Explain: 10 minutes

Each group presents their **Case Study** and findings to the rest of the class.	
What is the teacher doing? Listen to the group presentations and ask any additional clarifying or follow-up questions. Be sure that students cite arguments for why their physicist was not awarded the Nobel Prize, but also reasons why the laureate was deserving of such recognition.	**What are the students doing?** As a group, students share their findings from their **Case Study**, describing relevant historical details and citing different potential reasons for why the Nobel Prize was not awarded to their physicist, but also reasons for why the winner deserved the prize.

Elaborate: 15 minutes

In their groups, students will read "Boosting Inclusivity in the Nobels" and prepare answers to the following questions:

(1) What is one potential reason that not as many women have been awarded Nobel Prizes?

- "Today's prizes are often based on work carried out decades ago, when barriers in academia to women and other under-represented groups were even more formidable than they are today."

(2) What are four suggested actions that could increase diversity of Nobel laureates?

- Release the data.
- Diversify the sources that nominations are accepted from.
- Allow Nobel archives to be opened to historians.
- Allow posthumous recognition.

What is the teacher doing?	**What are the students doing?**
Teacher passes out copies of "Boosting Inclusivity in the Nobels" and answers questions as they arise.	Students are reading "Boosting Inclusivity in the Nobels" and discussing the questions provided above.

Evaluate: Class Discussion (5 minutes) or Take-Home Assignment

Class Discussion: If time permits, lead a discussion with students about their main takeaways from the in-class activities. You can use the following example questions:

- What are some limitations of the Nobel Prize committee selection process?
- In your opinion, why is the Nobel Prize such a prestigious award?

Take-Home Assignment: Read the article "The Absurdity of the Nobel Prizes in Science" from *The Atlantic* and write a response to the author's opinions. What arguments does he make against the prestige of the Nobel Prize? Do you agree or disagree with him? Why or why not?

Required/Recommended Reading and Resources

Nobel Prize Resources:

- Anonymous. (2019). Boosting Inclusivity in the Nobels. *Nature*, 574, 295.
- Nye, M. J. (2019). Shifting Trends in Modern Physics, Nobel Recognition, and the Histories that We Write. *Physics in Perspective*, 21, 3–22.
- Smart, A. G., Grant, A., & Stasiewicz, G. (2017). Physics Nobel nominees, 1901-66. *Physics Today*.

- Smart, A. G., Grant, A., & Stasiewicz, G. (2017). The international aspirations of the Nobel Prize. *Physics Today*.
- Yong, E. (2017). The Absurdity of the Nobel Prizes in Science. *The Atlantic*.

Arnold Sommerfeld:
- Smart, A. G. (2016). How to almost win the physics Nobel. *Physics Today*.
- Beléndez, A. (2017, July 24). Sommerfeld: The Eternal Nobel Candidate. *Open Mind BBVA*.

Lise Meitner:
- Crawford, E., Sime, R. L., & Walker, M. (1997). A Nobel Tale of Postwar Injustice. Physics Today, 50(9), 26–32.
- Sime, R. L. (1998). Lise Meitner and the Discovery of Nuclear Fission. *Scientific American*, 278(1), 80–85.

Chien-Shiung Wu:
- "Chien-Shiung Wu." (2016). *Physics Today*.
- Tsjeng, Z. (2018, March 15). Forgotten women in science: Chien-Shiung Wu. Cosmos: The Science of Everything.

Satyendra Nath Bose:
- Wali, K. (2006). The man behind Bose statistics. *Physics Today*, 59(10), 46–52.

Further Reading and Additional Resources

- Website for the Nobel Prize in Physics: http://www.nobelprize.org/nobel_prizes/physics/laureates/
- Anonymous. "How to change the Nobel Prize rules." *Nature* 287 (1980): 667–668.

Extensions

"Women Who Changed Science." Teaching guide from NobelPrize.org.

Related AIP Teacher's Guides on Women and Minorities in the Physical Sciences:
- Lise Meitner: Her Life in Modern Physics
- Chien-Shiung Wu, Nuclear Physicist
- Outcasts and Opportunities: The Effects of World War II on Female Physicists

Common Core Standards

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

Writing	
CCSS.ELA-LITERACY.W.11-12.1	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
CCSS.ELA-LITERACY.W.11-12.2	Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.

CCSS.ELA-LITERACY.W.11-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
CCSS.ELA-LITERACY.W.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
CCSS.ELA-LITERACY.W.11-12.9	Draw evidence from literary or informational texts to support analysis, reflection, and research.
Speaking & Listening	
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.11-12.2	Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.
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.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.11-12.6	Evaluate authors' differing points of view on the same historical event or issue by assessing the authors' claims, reasoning, and evidence.
CCSS.ELA-LITERACY.RH.11-12.8	Evaluate an author's premises, claims, and evidence by corroborating or challenging them with other information.
CCSS.ELA-LITERACY.RH.11-12.9	Integrate information from diverse sources, both primary and secondary, into a coherent understanding of an idea or event, noting discrepancies among sources.