Science is a Way of Knowing

Lesson Set 1 of 5

NATURE OF SCIENCE

NCSE National Center for Science Education

Teacher Prep

Age Levels: 6th - 12th grade
Note: MS modifications referenced in Student Directions

Time Commitment: 4-6 days
(if all activities completed)

Key Vocabulary/Concepts: characteristics of life, viruses, scientific process, scientific inquiry, misconceptions in science, FLICC, CONPTT, vaccines, smallpox, Edward Jenner

Materials:

- Internet access
- 3"x5" Notecards (in-person) or Google Jamboard (remote)
- Mystery cube cut-outs (in-person) or mystery cube image files (remote)
- Copies of the simple and complex versions of the Science Flowchart, placed in a plastic sleeve (keep the complex version covered with a colored sheet of paper until needed)

Apps and Software:

- Google Jamboard
- Wakelet access
- Kahoot access
- YouTube access
- EdPuzzle access

Introduction

This lesson introduces students to a basic understanding of the scientific process in action.

Additionally, by the end of this lesson, the student will understand that, while an experiment may come to a conclusive end, the process of science is ongoing, continually evolving as new evidence emerges, and will recognize that science cannot answer questions that do not pertain to natural processes.

Teacher Goals

1) Introduce the entire unit by emphasizing that science is non-linear and constantly changing (and this is okay!)
2) Provide students with clear examples of the scientific process in action
3) Provide the students with a series of tools to help them determine the validity of online resources and social media content at grade-appropriate levels

Student Learning Goals

1) Identify what is/isn't recognized as science by the scientific community
2) Compare and contrast the differences between *observations* and *inferences*
3) Evaluate and explain the scientific process
4) Evaluate the validity of online resources and social media content
5) Investigate the statement: *Science and religion are compatible*

Nature of Science Lesson Plan Series

https://ncse.ngo/supporting-teachers/classroom-resources

NATURE OF SCIENCE

Background

Teacher Knowledge

Nature of Science

For more in-depth discussions with students, the term "scientific method" is an outdated way of referring to the scientific process (see Understanding Science: How Science Works). Despite what is found in most textbooks, strive to change your vocabulary from this more linear motif to the more encompassing terminology—*the scientific process*. Also, consider not teaching this concept from a textbook chapter, but instead with open-ended discussions and readings that build a better framework for understanding how science actually works.

Read about FLICC, the tactics used by science denial. Also, it is strongly recommended that teachers read through William F. McComas's publication on the nature of science, *The Nature of Science in Science Education: Rationales and Strategies*. He summarizes this text in his article "The Principal Elements of the Nature of Science: Dispelling the Myths," which can be found in the Lesson One supplemental materials.

Scientific Concepts:

Since each lesson's theme centers on the basic concepts of epidemiology, refresh your understanding of this topic. Look at the extension activities/supplemental materials for more in-depth explanations on the history of vaccines, Edward Jenner, and smallpox as the first viral case study.

Discussion Points

- What constitutes science?
- How are the parts of the scientific process interconnected?
- How do you evaluate online resources for scientific reliability?
- What are examples of misconceptions/disinformation that have become prevalent during scientific research about COVID-19?

Core Misconceptions

✘	**MISCONCEPTION:** ***Science is complete, absolute, and unchanging.***
✔	**FACT: Science is an ongoing process, and there is much more yet to learn about the world.**
✔	**FACT: Even the most sound and well-accepted parts of science can change in light of further theory and evidence.**
✔	**FACT: Even the most sound and well-accepted parts of science, while revisable in principle, are unlikely to be overturned—especially when supported by multiple lines of evidence.**
✔	**FACT: Science is about building knowledge, but science is also about *applying* knowledge, often through engineering and technology. Applications of science can thus lead to changes in our scientific knowledge.**

✘	**MISCONCEPTION:** ***Science can answer all questions.***
✔	**FACT: Science can only answer questions about the natural world.**
✔	**FACT: Science is the project of explaining phenomena in the natural world. It is not capable of addressing questions—such as those involving individual morals, social values, and religious ideals—that transcend that realm.** ***NOTE: Science should be used to inform our understanding of morality, but only in conjunction with philosophy, sociology, and political science.***
✔	**FACT: Science is not necessarily at odds with religion; they are primarily aimed at making sense of different realms of the human experience.**

Prerequisite Student Knowledge

Before beginning Lesson One, provide students an opportunity to discuss their current understanding of the COVID-19 pandemic. Additionally, students will need a basic understanding of the **characteristics of life** and **viral structure** (using COVID-19 as your model).

Student Directions

Anchoring Phenomenon

Anchor 1: Conquering a Deadly Virus

- As a kickstarter/bellwork activity, have students pick up a 3" x 5" notecard and write down a complete sentence to answer this question: *What is Science Anyway?*
- Have students watch the Ted-ED Video: How We Conquered The Deadly Smallpox Virus (4:34)
  NOTE: Be sure to have students watch this either at the beginning of class or as homework the day before you start this lesson set
- The video provides an introduction to epidemiology and immunology and is used to set up all five nature of science lesson sets. It also will provide an introduction to Edward Jenner, the scientist who is the focus of Lesson Set One
- Be sure to have students watch this at either the beginning of class or as homework the day before you start Lesson One

Anchor 2: Science Surprises

- Before providing students any information on the scientific process, scientific inquiry, and how science works, hand out the worksheet titled "Introduction to the Scientific Process: Science Surprises Probe" or make a copy of the Science Surprises Google Form provided to evaluate students
- Have students fill out this worksheet and turn it in (along with their notecard) as a pre-assessment tool; be sure to read their responses before leading the classroom discussion in Part C on "Science Is Statements" and "CONPTT" (see Activities and Handouts)
- This formative assessment probe was designed using the same format used by Page Keeley in her *Uncovering Student Ideas in Science Series*

Activities and Handouts

Part A: Mystery Cube

- Follow the directions provided in the teacher handout, "Introduction to the Scientific Process: Mystery Cube Activity"
- There are many variations of this activity to choose from on the internet, so feel free to substitute your favorite warm-up activity in place of the one provided
- **Teacher Tip:** If you are using an online meeting format during remote learning, be sure to practice setting up breakout rooms before attempting this activity
- **Teacher Tip:** If using electronic versions of the cube, be sure to give each student in a group a different electronic cube image (.jpg)

Activities and Handouts (continued)

Part A: Mystery Cube (continued)

- This activity was adapted from an NIH Curriculum Supplement Series titled "Doing Science: The Process of Scientific Inquiry" ©2005 by BSCS

Part B: Understanding Science

- Before starting this activity, show students the YouTube Video clip "The Pinball Machine of Science" (4:56)
- Students will need to have read the article about Edward Jenner titled "Edward Jenner and the history of smallpox and vaccination" by Stefan Riedel, MD, Ph.D. (either assign as homework or read together in class)
- Follow the directions provided in the teacher handout, "Introduction to the Scientific Process: *Understanding Science* Flowchart"
- If you would rather use a different scientist than Edward Jenner, simply replace the homework reading with the desired case study (*Understanding Science* originally used Walter Alvarez's work on the K-Pg (K-T) boundary as their lesson's focus)
- This activity was adapted from the University of California Museum of Paleontology, and the Regents of the University of California's Understanding Science Lessons provided in the 9-12 teacher's lounge © 2020

Part C: What Science Is

- **Teacher Tip:** If in-class or synchronous remote learning, this lesson would be an interactive discussion; if asynchronous remote learning pre-record this lesson
- Middle School Option: *Science Is* Statements
  - Before starting this middle school explanatory lesson, show students the YouTube Video clip titled "Science in Action: How Science Works" (5:53)
  - Using the provided "Science Is" PDF, in presentation mode, to illustrate the most important aspects of science to students
- High School Option: The Characteristics of Science "CONPTT" Powerpoint
  - Before starting this high school explanatory lesson, show students the YouTube Video clip titled "Science in Action: How Science Works" (5:53)
  - Using the provided PDF (in presentation mode) and table handout, introduce students to the acronym CONPTT (**C**onsistent, **O**bservation, **N**atural, **P**redictable, **T**entative, and **T**estable)
- **Teacher Tip:** A study guide was generated by Steven M. Dickhaus that can be used to prepare for this discussion (this is also the basis of the CONPTT Presentation)

Activities and Handouts (continued)

Part D: Examining Reliable Resources

- Middle School Option: FABLE Student Handout
  - A student named Hannah Logue invented the acronym FABLE (Find, Analyze, Bias, Look, Exert) and has a fantastic TEDxYouth Video "How to Spot Fake News" (7:14) that can be shown to provide more background to students
  - A Wakelet, Coronavirus Information/Misinformation, has been provided to allow students the opportunity to examine reliable and unreliable COVID-19 internet resources
  - Using FABLE, assign each student certain portions of the Wakelet research, filling out a FABLE for each source (minimum of two recommended)
  - Generate an interactive discussion with students via an online synchronous meeting or in-class activity, if possible. Have students share their FABLEs and conclude the reliability of the resource as a group
  - If presented asynchronously, have students place all filled in FABLEs into a group folder, then have each student peer review two FABLEs other than their own, indicating if they agree or disagree with the original FABLE's conclusions on an online discussion board or Google Jamboard
- High School Option: CRAAP/STINK/CREATE/Baloney Detector Student Handout
  - For the high school activity, there are three variations provided for investigating reliable online resources (see Lesson Set 1 Folder, Part D); the teacher should pick the strategy that works best for their classrooms
  - A Wakelet, Coronavirus Information/Misinformation, has beenn provided to allow students the opportunity to examine reliable and unreliable COVID-19 internet resources
  - Using the desired format, assign each student certain portions of the Wakelet research, filling out a document for each source (minimum of two recommended)
  - Generate an interactive discussion with students via an online synchronous meeting or in-class activity, if possible. Have students share their research and conclude the reliability of the resource as a group
  - If presented asynchronously, have students place all documents into a group folder, then have each student peer review two other students' work, indicating whether they agree or disagree with the original student's conclusions on an online discussion board or Google Jamboard

Activities and Handouts (continued)

Part E: The Characteristics of Science Denial

- FLICC/CONSPIR Student Handouts
  - Provide students with color copies of the FLICC/CONSPIR information sheets (when possible) for them to keep throughout the year for reference or have them keep digital copies in their school folders
  - NCSE will be providing multiple opportunities to use these infographics in the classroom as our resource collection continues to grow throughout the year
  - To wrap up Lesson Set One, have students watch a selection of John Cook's video series on Critical Thinking about COVID-19
  - The following misconception videos have EdPuzzles to help explain the characteristics of science denial in the context of current events (more to come!):
    - Anecdotes and Hydroxychloroquine (4:56)
      - EdPuzzle version
    - False Choice between Economy and Health (3:31)
      - EdPuzzle version
    - False Analogies about Cupcakes and Obesity (5:16)
      - EdPuzzle version
    - Pattern Detection and the 5G Conspiracy (6:29)
      - EdPuzzle version
    - Mask Wearing Rights vs. Responsibilities (4:50)
      - EdPuzzle version
  - See the accompanying student worksheet titled "Introduction to the Scientific Process: Critical Thinking About COVID Video Series" for an excellent homework assignment
- Supplemental Activity: Science & Religion (coming soon!)
  - Follow the directions provided in the teacher handout, "Introduction to the Scientific Process: Science & Religion"
  - **Teacher Tip:** This supplemental activity will fit very nicely between Part C—*What Science Is* and Part D—*Examining Reliable Resources*

Extension Options

Deeper Dive

- History of Vaccines Timeline
- The origins of inoculation journal article
- Larry Flammer's Checks Lab
- BiteSci From Labs to Newsfeeds: Why We Need to be Skeptical in the Age of COVID-19
- Michael Shermer's Baloney Detection Kit/Infographic
- *The Demon-Haunted World: Science as a Candle in the Dark* by Carl Sagan, originally published in 1995, Non-fiction

Formative Assessments

- Factitious 2020 (The Pandemic Edition) Online Game to check your ability to spot fake news
  - **Teacher Tip**: The Pandemic Edition works nicely with this epidemiology unit, but the 2017 version would also be appropriate if not following the NGSS storyline provided

Online Resources

- » Ted-ED Video: How We Conquered The Deadly Smallpox Virus (4:34)
- » Edward Jenner and the history of smallpox and vaccination article
- » Biocinematics YouTube Video: The Pinball Machine of Science (4:56)
- » California Academy of Sciences YouTube Video: Science in Action—How Science Works (5:53)
- » Understanding Science: How Science Works—The Flowchart
- » Larry Flammer's CONPTT: Science vs. Non-Science Mini-Lesson
- » TEDx Talks YouTube Video: How to Spot Fake News (7:14)
- » Richard Dawkins Foundation for Reason & Science YouTube Video: Michael Shermer—Baloney Detection Kit (14:10)
- » John Cook's Critical Thinking about COVID-19 Video Series
- » COVID-19 Resources Collection (Wakelet)

Primary Literature/Works Cited

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