ACTIVITY 7

Addressing Cognitive Bias in Science

READING

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ACTIVITY SUMMARY

This activity uses historical and modern examples of disease discovery and treatment to demonstrate how scientific practices rely on slow thinking and an actively open mindset. Students read two case studies: one about the pellagra epidemic in the 1900s and the other about the recent development of the COVID-19 mRNA vaccine. Both case studies show the use of the skills learned in the activity in real-world scientific contexts. Students analyze both case studies to learn how individual and community practices help scientists reduce bias, establish reliable conclusions, and advance science.

ACTIVITY TYPE
READING

NUMBER OF
40–50 MINUTE
CLASS PERIODS
1–2

KEY CONCEPTS & PROCESS SKILLS

1. Slow thinking relies on careful reasoning and is useful for complex or higher-stakes situations. Slow thinking takes time and effort but is less prone to cognitive error when evaluating information and reaching conclusions.
2. Common scientific practices are designed to support slow thinking, which makes scientific conclusions more reliable.
3. An actively open mindset helps reduce errors from cognitive biases and cognitive shortcuts by deliberately seeking out new ideas and information that could change one's mind.

CONCEPTUAL TOOLS

VOCABULARY DEVELOPMENT

clinical trial
a carefully controlled experiment to test a medicine's safety and effectiveness

peer review
a process in which a scientist's research is critically evaluated and judged by other independent experts

TEACHER BACKGROUND INFORMATION

Protein Synthesis

Protein synthesis is the process by which cells build the proteins they need to function, grow, and repair themselves. In eukaryotic cells, it begins in the nucleus, which contains all the genetic instructions to make every protein in the body in the form of DNA. The first step in the process is transcription in which the master instructions in a gene's DNA are copied into a mobile molecule called messenger RNA (mRNA). A simple analogy is to imagine DNA as a permanent reference book in a library and mRNA as a photocopy that can be taken home. The mRNA then travels out to a ribosome in the cytoplasm for the second step, called translation. During translation, the ribosome reads the mRNA's code in sets of three bases called codons. Specialized molecules called transfer RNA (tRNA) deliver specific amino acids to the ribosome based on the mRNA's instructions. These amino acids are linked together into a long chain called a polypeptide, which then folds into a functional protein.

The mRNA vaccine technology uses the body's own natural processes for making proteins. Proteins are one of the three macronutrients in food that provide energy. Proteins are used primarily for building tissues, such as muscle and bone. They also make up hormones and important components of chemical reactions that help different parts of the body communicate and function.

MATERIALS & ADVANCE PREPARATION

FOR THE TEACHER

- VISUAL AID 7.1 "Read, Think, and Take Note Guidelines"

FOR EACH GROUP OF FOUR STUDENTS

- STUDENT SHEET 7.1 "DART: Examples of Scientific Practices" (OPTIONAL)
- STUDENT SHEET 1.3 "Unit Concepts and Skills" (OPTIONAL)

FOR EACH STUDENT

- 3–5 STICKY NOTES

Consider if you would like to show a video for the first part of the reading in addition to the written content. If so, here are two credible options.

- SEPUP at The Lawrence Hall of Science
  Pellagra Video
- Extra History channel (YouTube)
  Pellagra: A Medical Mystery

TEACHING NOTES

Suggestions for **discussion questions** are highlighted in gold.

Strategies for the **equitable inclusion of diverse students** are highlighted in light blue.

GETTING STARTED (10-20 MIN)

1 **Review unit concepts related to scientific investigation by using a word sort.**

- Depending on your student population, you may want to conduct a word sort before starting the activity to make sure students have an understanding of the major themes they will need to complete this activity. This quick formative assessment presents one or more sets of words. In each list, one word is not related to the others, and another word encompasses the remaining words. The following two word sorts can be used to support a review of basic causation ideas. For more information on a word sort, see Appendix 1: Literacy Strategies.

- Have students copy the lists of words that follow. Instruct them to look for a relationship among the words within each list. Then, ask them to cross out the word or phrase that does not belong in each list and highlight the word or phrase that includes the others on the list. Have students write a sentence to show how the highlighted word or phrase is related to all the other words or phrases in the list. Note that there may be more than one correct answer to a single word sort.

LIST 1

scientific investigation
fast thinking
slow thinking
evidence
actively open mindset

LIST 2

scientific investigation
confirmation bias
availability shortcut
alternative explanation
new evidence

Sample Student Response

LIST 1

scientific investigation
~~fast thinking~~
slow thinking
evidence
actively open mindset

In scientific investigations, the researchers should use slow thinking to gather and analyze the evidence with an actively open mindset.

LIST 2

scientific investigation
confirmation bias
~~availability shortcut~~
alternative explanation
new evidence

In a scientific investigation, the researchers should avoid confirmation bias by gathering new evidence to examine alternative explanations.

- Let students know that in this activity, they will read about how the scientific process uses slow thinking by investigating two disease outbreaks—one from 100 years ago and one that is more recent. In both cases, the outbreaks led to pandemics, and the principles of an actively open mindset from scientists helped find a cure in each case. Remind students to be on the lookout for these aspects of scientific practice in the case studies they will read.

PROCEDURE SUPPORT (20-30 MIN)

2 Review the Read, Think, and Take Note Guidelines to support students' reading comprehension.

- Review the Read, Think, and Take Note Guidelines to support students in completing the reading. The Read, Think, and Take Note strategy provides an opportunity for students to record their thoughts, reactions, and questions on sticky notes as they read. The notes serve to make concrete the thoughts arising in their minds and then serve as prompts to generate conversation or write explanations. You can use Visual Aid 7.1, "Read, Think, and Take Note Guidelines," to review this literacy strategy. If your students are unfamiliar with the strategy, it can be helpful to demonstrate with a short passage of simple text, such as the Introduction to the activity. For more information about the Read, Think, and Take Note strategy, see Appendix 1: Literacy Strategies.

- In particular, ask students to place a sticky note in locations where they see cognitive biases and cognitive shortcuts. This will help them prepare to answer Build Understanding item 1.

3 Support student's synthesis of information as they complete the reading.

- To help synthesize the information in the reading, you may have students work in pairs to complete optional Student Sheet 7.1, "DART: Examples of Scientific Practices." For more information on a Directed Activity Related to Text (DART), see Appendix 1: Literacy Strategies. Students can complete this student sheet as an individual, in pairs, or as a class. A sample student response to Student Sheet 7.1 can be found at the end of this activity.

- Decide how you would like students to complete the reading. The reading is divided into two case studies. Depending on the time you have available and the reading abilities of your students, consider supporting students with one or more of the following options:

  - Have students take turns reading with a partner. Students can alternate reading one paragraph at a time.

  - Have pairs divide the case studies: have one student read the first case study and the other student read the second case study. Partners can then summarize the main points of their case study for each other and share the thoughts and questions they recorded on their sticky notes.

  - Chunk the case studies into smaller sections by stopping the class at intervals to review the main points and notes they recorded in each section. This can give you an opportunity to clarify students' questions and discuss the main ideas as they read.

  - Provide copies of the reading so students can record their thoughts and questions directly onto the pages.

- Review the terms introduced in this activity and answer students' questions. Support students, particularly emerging multilingual learners, in sensemaking and language acquisition by adding words from this activity to the word wall. Record the terms *clinical trial* and *peer review* and provide examples as needed. For more information on a Word Wall, see Appendix 1: Literacy Strategies.

SYNTHESIS OF IDEAS (10-20 MIN)

4 Highlight essential ideas about scientific processes from the reading.

- Ask students to share their responses to Build Understanding items 1–3. Point out that scientific practices incorporate a very structured way to go about using slow thinking and an actively open mindset. This forces scientists to consider evidence, reasoning, reducing bias, and alternative ideas as part of their work process to understand the natural world.
- Discuss some of the improvements of the scientific process from the time of the pellagra investigation to the mRNA vaccine trials. For example, Goldberger did not use blind experiments or placebos in his experiments. The procedures for reducing bias were not required at that time. However, the process of peer review was in place, albeit less formal, because other scientists later verified his work.
- Ask, How do scientists use slow thinking and an actively open mindset in ways that are similar to and different from how slow thinking and an actively open mindset are used in everyday situations? Students should respond in a way that shows they can see the similarities that both require a reduction of bias and consideration of evidence before making a judgement. Differences include how much more evidence and analysis is involved in a scientific experiment compared to a social media post.
- To conclude the activity, evaluate whether your students are able to answer the Guiding Question, *How does slow thinking improve scientific conclusions?* Use this as a chance to revisit and summarize the key concepts and process skills of the activity that relate to scientific processes such as experimental design and peer review.

5 Summarize the key concepts and process skills of the unit.

- You may wish to revisit optional Student Sheet 1.3, "Unit Concepts and Skills," to help students formally organize the ideas introduced in the unit so far. Students can place the headings of the main ideas—confirmation bias and an actively open mindset—into the organizer and add examples from their classroom experiences in Activities 5–7. See the end of Activity 1 in the Teacher's Edition for a sample student response.

SAMPLE STUDENT RESPONSES

BUILD UNDERSTANDING

① **Give an example of a scientific practice from the reading that shows the following approaches, using an actively open mindset.**

a Seek out evidence for and against a claim.

Goldberger's experiments with changing the diet of those with pellagra are an example of seeking evidence for and against a claim. If improving their nutrition did not help the health of those with pellagra, that would be evidence against the nutrition hypothesis. If those with pellagra's symptoms got better with improved nutrition, that would be evidence against the germ hypothesis.

b Consider alternative explanations.

Goldberger considered alternative explanations for pellagra, such as the germ hypothesis, the toxin hypothesis, and the missing-nutrient hypothesis.

c Be open to others' ideas.

Peer review is a scientific practice that helps scientists be open to others' ideas because they have to allow other scientists to critique their work. Sometimes, this requires scientists to rethink their conclusions or conduct additional experiments to check their results.

d Evaluate the need for more evidence.

Evaluating their experimental designs can help scientists decide if they need more evidence, such as a larger-scale clinical trial.

② **Give an example from the case study about the pellagra epidemic that illustrates**

a a cognitive shortcut.

Responses will vary. One sample response is shown below.

One cognitive shortcut was the assumption that pellagra was caused by a microbe that made people sick. This was a representativeness shortcut because this idea was a result of pellagra's similarities to well-known contagious illnesses such as typhus and cholera.

a slow thinking.

Responses will vary. One sample response is shown below.

Goldberger slowed down his thinking by considering other ways people could get pellagra. He took a lot of observations and data and then developed a hypothesis that fit with all the evidence he had.

③ **Explain how the scientific practices described in the reading require scientists to apply slow thinking rather than relying on cognitive shortcuts.**

Carefully designed experiments, thorough data collection and analysis, and having scientists evaluate and critique one another's work are all elements of slow thinking. All of these reduce the chances of error and increase the accuracy of claims made by scientists.

CONNECTIONS TO EVERYDAY LIFE

④ **Imagine that when you finish a big project for school, you ask a friend to read it over before you turn it in.**

a **How is this process similar to and different from what scientists do in a peer review?**

It is similar to a peer review because you are trying to get another perspective on your work. A friend might offer information you didn't know at the time of writing.

b **How might your friend's objective feedback help you avoid a cognitive bias in your own work?**

This might help me avoid bias in my own work because the other person reading it might notice things that I did not because their existing ideas and experiences are different from mine.

⑤ **You see an article that states: *A new study showed that a newly developed vaccine for tuberculosis (TB) prevents over 50% of TB infections.* You decide to look up the study to see if you trust the results. What would you look for in the study?**

I would check and see if the vaccine was developed using a clinical trial and whether the results of the study were peer reviewed.

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STUDENT SHEET 7.1	DART: EXAMPLES OF SCIENTIFIC PRACTICES	NAME

CASE STUDY	SCIENTIFIC PRACTICE	RELATIONSHIP TO ACTIVELY OPEN MINDSET

CASE STUDY	SCIENTIFIC PRACTICE	RELATIONSHIP TO ACTIVELY OPEN MINDSET
pellagra	*Goldberger investigated hypotheses other than just the popular idea.*	*Consider alternative possibilities, reduced cognitive shortcuts.*
pellagra	*Goldberger reviewed evidence both for and against all the ideas.*	*Willingness to look at evidence that does not support their own ideas.*
mRNA vaccine	*Random assignment: The COVID–19 trial assigned people randomly.*	*This made sure that what is being tested is the only difference between groups, reducing cognitive bias.*
mRNA vaccine	*Blind assignment: COVID–19 doctors and participants did not know who received the vaccine and who did not.*	*This prevented researchers and participants from letting unconscious cognitive biases affect the data.*
mRNA vaccine	*Peer review: Other scientists examined the data and methods for the COVID–19 trial to make sure the results were valid.*	*This checks the results and forces researchers to be open to other people's ideas.*

Read, Think, and Take Note Guidelines

Stop at least three times during each section of the reading to mark on a sticky note your thoughts or questions about the reading.

As you read, use a sticky note from time to time to:

- explain a thought or reaction to something you read.
- note something in the reading that is confusing or unfamiliar.
- list a word from the reading that you do not know.
- describe a connection to something you've learned or read previously.
- make a statement about the reading.
- pose a question about the reading.
- draw a diagram or picture of an idea or connection.

After writing a thought or question on a sticky note, place it next to the word, phrase, sentence, diagram, drawing, or paragraph in the reading that prompted your note.

After reading, discuss with your partner the thoughts and questions you had while reading.