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Cover produced by Laughing Crow Curriculum LLC
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FUNDING SOURCE

This curriculum was made possible by "Collaborations to Understand Research and Ethics" (CURE), supported by the National Center for Research Resources and the Division of Program Coordination, Planning, and Strategic Initiatives of the National Institutes of Health through Grant #R25OD011138. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the NIH, or NWABR's consultants or advisory board members.

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The Social Nature of Scientific Research

CURRICULUM OVERVIEW

Is science self-correcting over time? Do the processes involved in biomedical research—collaboration, communication, skepticism, peer review—lead to a valuable and objective way of learning about the world?

This curriculum introduces students to ways in which scientific research is conducted, how social forces influence scientific priorities, and how basic scientific research may, or may not, support medical applications for human health. Throughout the unit, students are asked to consider their roles and responsibilities as scientifically literate citizens.

RESEARCH ETHICS SERIES ENDURING UNDERSTANDINGS

- The biomedical research process is complex and dynamic, requiring information and tools of reasoning.
- The biomedical research process is driven by potential benefits to people and animals.
- The biomedical research process has evolved as scientists and other members of society have reflected on acceptable practices. It continues to do so as our knowledge expands.
- The biomedical research process requires active participation by scientists, consumers, clinicians, citizens, and research participants.

The Social Nature of Scientific Research curriculum is part of NWABR's Research Ethics Series, which also includes *The Science and Ethics of Animal Research* and *The Science and Ethics of Humans in Research* (see page 8).

INSTRUCTIONAL COMPONENTS

Elements: The curriculum consists of a formative assessment, five sequential lessons, a summative assessment, and supplementary classroom tools supporting student media review and analysis.

The media review and analysis support tools can be used throughout the unit or school year to help students become more comfortable with formulating and criticizing arguments.

Time:

Element	Approximate Time Required
Formative Assessment	1 class period of 55 minutes
Lesson One	5 class periods of 55 minutes each
Lesson Two	1 class period of 55 minutes
Lesson Three	1-2 class periods of 55 minutes each
Lessons Four and *Five*	1 class period each
Summative Assessment	1 class period to begin; additional time depends on how much in-class time is given for completing the assignment.
Supplementary media review and analysis support tools (in *Appendix*)	As needed; can be used independently throughout the school year.

Targeted Audiences: Grades 7–12

Systems Thinking

Science is a human enterprise conducted in a social context; science and its technological applications clearly have interconnected ethical implications. This curriculum seeks to integrate elements of the research endeavor and impact student learning in the following ways:

- Students learn to look at the interconnections between parts in a system rather than looking at qualities of separate objects.
- Students see a "web" of interconnection between a set of events, rather than thinking linearly about the events.
- Students understand that a whole system may have different properties than the parts of the system.

Fostering a Safe Classroom Environment

It is especially important to foster a safe classroom atmosphere when students must consider and discuss possibly controversial issues. The ethical issues addressed throughout this curriculum may involve conflicting moral choices. Please review or create classroom discussion ground rules ("norms") before beginning the unit (see *Appendix*, *Creating Discussion Ground Rules*).

THE SOCIAL NATURE OF SCIENTIFIC RESEARCH

Essential Questions

1. How is scientific research different from other ways of discovery and learning about the world?
2. How does the ethical conduct of scientific research lead to a process that promotes accountability, integrity, and intellectual honesty?
3. How are scientific research, society, and culture shaped and influenced by each other?
4. How does scientific research develop and change in response to new evidence, knowledge, and the application of new tools?
5. What is my role and responsibility as a scientifically literate citizen?

LESSON OVERVIEW

The ***5 E Learning Cycle Model***, as publicized through its use in the BSCS (Biological Sciences Curriculum Study) science program, incorporates five phases of learning: engagement, exploration, explanation, elaboration, and evaluation. The lessons in this curriculum follow the 5 E Model to guide students through this powerful cycle of learning. In the lesson plan descriptions provided below, notes indicate which stage of the 5 E Learning Cycle Model aligns with each lesson plan.

Formative Assessment: Identifying Misconceptions

"Engage"

The Formative Assessment is an "engage" activity in which students consider whether they agree or disagree with statements about the social nature of scientific research. Students first talk in pairs, then "vote with their feet" by standing along a continuum that best represents their position on the statement. This serves to take students' prior knowledge into account for the remainder of the unit, and uncovers potential misconceptions about the social nature of scientific research.

Graphic Organizer

"Explain"

The *Unit Graphic Organizer* helps students consolidate concepts and show relationships between subsystems of scientific research they will learn about in this unit. This organizer will be revisited at the end of each lesson.

Lesson One: Gummy Bear Lab Meeting

"Explore & Explain"

In this lesson, students participate in a scenario-based lab activity designed to help them define qualities that result in reliable and meaningful scientific research. By having students conduct an investigation that gives highly variable results within and between lab teams, students learn the importance of making ***strong arguments*** in science as they use evidence and reasoning to support their claims. They also **communicate**, **collaborate**, and **skeptically evaluate** each other's claims. Other aspects of scientific practice that the lesson illustrates include the importance of repeated trials, replicable methods, and integrity and honesty in data collection. After a class discussion of the checks and balances in place to ensure good science, teams repeat the lab activity with a protocol that they decide upon collaboratively. Lastly, students prepare to "submit their results for publication" and learn about the ***peer review*** process.

Lesson Two: *"Stupidity" in Science—A text-based discussion*

"Elaborate"
Students participate in a text-based discussion of the article "The importance of stupidity in scientific research" by Martin Schwartz. Using evidence found in the text, students consider how success is defined in scientific research and discuss how scientific pursuits may require persistence despite setbacks and a tolerance for ***not knowing*** much of the time. Students then relate their experiences of ***not knowing*** during the gummy bear lab from the previous lesson to the social nature of scientific research. This type of text-based discussion is a ***Socratic Seminar***.

Lesson Three: Science through the Centuries

"Explore & Explain"
In this lesson, students participate in an historical activity demonstrating how current research builds on prior understanding, and how scientific priorities are influenced by the social and health concerns of the time. This is a "jigsaw" activity, in which students are first divided into four different time period groups (1700s, 1800s, 1900s, and 2000s) to discuss social concerns and medical technology of the time. Each time period is seen through the eyes of four individual characters: a ***citizen***, a ***medical practitioner***, a ***person with Type I Diabetes***, and a ***scientist***. The students then regroup by character roles to compare themes over time. Lastly, students are introduced to ***translational research*** and see that, in many cases, basic research and the resulting application to human health are many decades apart.

Lesson Four: The Process of Scientific Research

"Explain"
Students arrange sets of cards to show their understanding of the process of biomedical research. Students see how basic research may lead to studies involving both animals and humans and may culminate in the availability of new treatments and medications. They then apply their understanding of the overall progression of biomedical research to early chromosomal studies and the story of Gleevec, a drug approved by the Food and Drug Administration (FDA) in 2001 to treat chronic myelogenous leukemia. Lastly, students consider the ethical guidelines that scientists follow in every stage of research. This lesson includes instructions on how to arrange the cards using a ***foldable***.

Lesson Five: Who Should Decide?

"Elaborate & Evaluate"
In this lesson, students participate in a Structured Academic Controversy around the question, "Should citizens determine funding for scientific research?" The general public can often see the importance of human research and clinical trials, but they may not be able to see the value of ***basic research***, especially when the budgets are tight. The National Science Foundation (NSF) distributes funds for basic research, and because the outcomes of the research are not always directly applicable to a health treatment or cure, questions can be raised about a study's usefulness. Students explore both sides of this issue before examining their own personal views.

Summative Assessment: Case Study

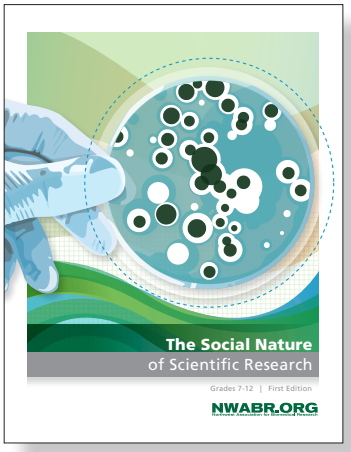
"Evaluate"
Students apply the concepts they have learned during the unit to a case study or other chosen material from the class. From their completed graphic organizers, students choose three concepts to evaluate and explain how the concept contributes to the process of scientific research. Students also communicate the importance of being scientifically literate in their roles as science students, members of society, users of medications, and potential voters and taxpayers.

Appendix and Supplementary Tools

The two supplementary student handouts in this section can be used independently or together any time during the school year. The *Media Review and Analysis* handout can be used to support students in analyzing media for purpose, perspective, assumptions, claims, and impact. This handout can be used in any subject and for most types of media. An optional section on ***scientific process*** can be used for students analyzing scientific articles. Students are further supported in thoughtful analysis by using a handout entitled *My Evolution of Thought*, which helps students identify their attitude toward a subject before and after analysis. These tools help students explore the importance of being scientifically literate about the social nature of scientific research in a world influenced by mass media.

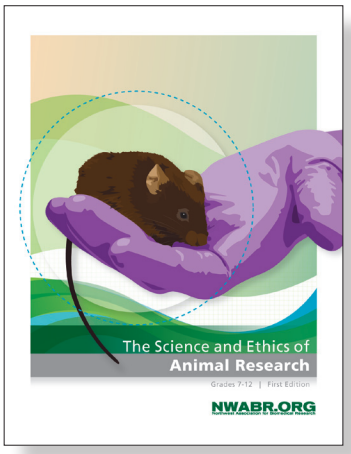
RESEARCH ETHICS SERIES

The Social Nature of Scientific Research is part of the following curricular set:



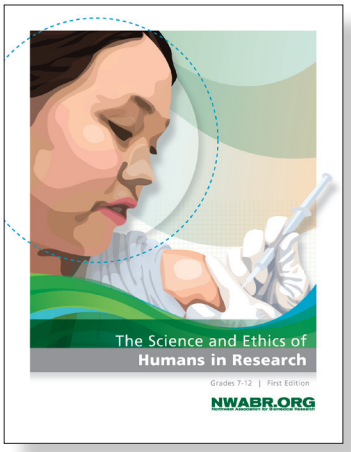
The Social Nature of Scientific Research

- How is scientific research different from other ways of discovery and learning about the world?
- How does the ethical conduct of scientific research lead to a process that promotes accountability, integrity, and intellectual honesty?
- How are scientific research and society shaped and influenced by each other?
- How does scientific research develop and change in response to new evidence, knowledge, and the application of new tools?
- What is my role and responsibility in being a scientifically literate citizen?



The Science and Ethics of Animal Research

- Why do scientists use animals in research?
- How does the history of animal research influence current views and policies?
- How do ethical considerations influence the use of animals in research?
- How can my actions reflect my position on the use of animals in research?



The Science and Ethics of Humans in Research

- How does the history of research with human participants influence attitudes, policies, and current practice?
- Why do scientists involve humans in research? How do scientists recruit, engage, and partner with study participants?
- What is the process used to make decisions regarding humans in research, and how are costs and benefits evaluated?
- How does the process of carrying out ethical trials involving humans influence the time needed to develop new cures and treatments?
- How can my actions reflect my position on research involving humans?

Each unit is designed to be used independently or as part of a larger curricular set.
All three units are available from http://nwabr.org.

CORRELATION TO NATIONAL LEARNING STANDARDS

National Standards Alignment: Science (Grades 5–12)

	Formative Assessment	**Lesson One:** Gummy Bear Lab Meeting	**Lesson Two:** "Stupidity" in Scientific Research	**Lesson Three:** Science through the Centuries	**Lesson Four:** Process of Research	**Lesson Five:** Who Should Decide?
Science as Inquiry						
Abilities necessary to do scientific inquiry.		•	•			
Understandings about scientific inquiry.	•	•	•	•	•	•
Science and Technology						
Abilities of technological design.	•			•	•	
Understandings about science and technology.	•			•	•	•
Science in Personal and Social Perspectives						
Personal and community health.				•	•	•
Science and technology in society.	•	•	•	•	•	•
Risks and benefits.	•		•	•	•	•
History and Nature of Science						
Science as human endeavor.	•	•	•	•	•	•
Nature of scientific knowledge.	•	•	•	•	•	•
Historical perspectives.	•			•	•	

Source: National Research Council. 1996. *National Science Education Standards*. Washington, D.C.: National Academies Press.

Common Core State Standards

For English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects

	Lessons 1–5
Comprehension and Collaboration, Grades 9–10	
1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.	•
a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas.	•
b. Work with peers to set rules for collegial discussions and decision-making (e.g., informal consensus, taking votes on key issues, presentation of alternate views), clear goals and deadlines, and individual roles as needed.	•
c. Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions.	•
d. Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented.	•

Source: National Governors Association Center for Best Practices, Council of Chief State School Officers. 2010. *Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects*. Washington, D.C.: National Governors Association Center for Best Practices, Council of Chief State School Officers.

Framework for K–12 Science Education

	Formative Assessment	**Lesson One:** Gummy Bear Lab Meeting	**Lesson Two:** "Stupidity" in Scientific Research	**Lesson Three:** Science through the Centuries	**Lesson Four:** Process of Research	**Lesson Five:** Who Should Decide?
Scientific Practices						
1. Asking questions.	•	•	•	•		•
2. Developing and using models.		•			•	•
3. Planning and carrying out investigations.		•				
4. Analyzing and interpreting data.	•	•		•	•	•
5. Using mathematics, information and computer technology, and computational thinking.		•				•
6. Constructing explanations.	•	•	•	•	•	•
7. Engaging in argument from evidence.		•	•	•		•
8. Obtaining, evaluating, and communicating Information.	•	•	•	•	•	•
Crosscutting Concepts						
Patterns.		•	•	•	•	
Cause and effect: mechanisms and explanation.	•	•	•	•	•	•
Systems and system models.	•	•	•	•	•	•
Core Ideas: Life Sciences						
LS 1: From molecules to organisms: structures and processes.		•		•	•	
LS 2: Ecosystems: interactions, energy, and dynamics. D: Social interactions and group behaviors.	•			•	•	•
LS 3: Heredity: inheritance and variation of traits.				•	•	

Source: Committee on Conceptual Framework for the New K–12 Science Education Standards, National Research Council. 2011. *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: National Academies Press.