In Support of Basic Science

Setting the Stage

Whenever federal budgets are tightened, program funding may be reduced, including money that goes to funding scientific research projects. When the general public hears about odd research projects funded through their tax dollars, they may become alarmed. For example, $500,000 was given to researchers to determine which stimuli cause rats, monkeys, and humans to bite and clench their jaws. A closer look at this study reveals that it investigated reflex control in jaw muscles. At first glance, the results of this basic research study may not have seemed to have practical applications; however, the results could be applied to many fields of science or medicine such as neurology and dentistry. It is important for students to understand the process of scientific research, both basic and applied research, as vehicles for advancing our knowledge of science. It is also important for them as citizens to understand science from a funding viewpoint. This activity will challenge their thinking about the nature of science. It can be implemented at any time during the school year when deemed appropriate, such as the onset of a scientific investigation.

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Activity Overview

- *Part 1 – (10 minutes) Class discussion and heat map*
  Students participate in a discussion about the process of science and take an initial stance on funding of basic science research.
- *Part 2 – (20 minutes) Examples from history*
  Students learn that basic and applied science research are interconnected.
- *Part 3 – (15 minutes) The spending debate*
  Students gather evidence for and against funding basic research with tax dollars.
- *Part 4 – (15 minutes) Heat map and wrap up*
  Students participate in the same heat map survey from Part 1 and discuss how their understanding may have changed.

Instructional Overview	
Grade Level	Middle School
Instructional Time	60 minutes *(total time needed)*
NGSS Standards Alignment	MS Understandings about the Nature of Science (Appendix H): As related to Science and Engineering Practices: ● Scientific Investigations Use a Variety of Methods ● Scientific Knowledge is Based on Empirical Evidence ● Scientific Knowledge is Open to Revision in Light of New Evidence ● Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena As related to Crosscutting Concepts: ● Science is a Way of Knowing ● Science is a Human Endeavor ● Science Addresses Questions About the Natural and Material World.
Driving Question	● What is the process by which scientists create their investigations of basic science?
Learning Goals	● Students develop an awareness of the process of science from developing a research question, to applying for funding, to sharing results, to applying research to solve problems. ● Students develop and apply communication skills when confronted with controversy and debating.
Materials	❑ Marker board or document camera to make class lists ❑ Internet access
Material Preparation	❑ Review the science research projects chosen as examples for this activity. ❑ Locate statistics/percentages for government spending
Vocabulary	Basic Science: Study of mechanisms behind phenomena which could later be used in practical applications such as in medicine, engineering, or other applied sciences. Applied Science: Applying science to practical human problems. Private or public entities participate in applied science. Many times a profit could be made from applying science to solve problems. NSF: The National Science Foundation, one of several government science agencies that funds basic and applied research in the U.S. Proposal: Created by scientist(s) outlining a project they would like to undertake if funding were available. Typically there is a “request for proposals” (RFP) related to a specific research area that a scientist(s) would answer by submitting a proposal.

	Grant: Money that scientists apply for in a competitive peer-reviewed process to pay for research.

Part 1
Class Discussion and Heat Map (10 minutes)

Class Discussion:

Ask the students to share with a partner what they know about the process of science and how scientists at universities or corporations go about their roles as scientists. After a few minutes, ask a few students to share their ideas.

> If they have a family member who is a scientist, they may have some familiarity with the process, but they may not know that scientists at nonprofits or universities are required to submit proposals and compete for available money from the federal government or a philanthropic organization.

Next, ask students if they know the difference between basic science, often performed by those working at universities, and applied science, often performed at a company.

> They likely will not know the difference, or they may recognize that science investigations at a company in most cases assists the company in generating a profit. Provide examples of basic science research such as those that ask questions related to molecular biology or geophysics.

Ask them if they would fund basic science if they were in a position to do so?

> Be sure they provide arguments for their ascertains. Mention that the money used by scientists at universities or nonprofits is acquired by writing proposals to funding groups like the National Science Foundation or philanthropic organizations that put out competitive “requests for proposals” (RFP). The decision who is awarded the money for research is decided by peer review panels who assess the proposals to identify the most viable of all the ones that were submitted. Scientists who are awarded the funding have an obligation to follow through on their proposals and submit progress reports along the way.

All of the above may not be known by students. To support their understanding of this, ask them what qualities in a proposal would they be looking for if they were on a review panel.

List these ideas on a marker board or chart paper so it may be referred to later.

Heat Map:

A “heat map” routine supports students' views on complex topics and in this case it is about funding science research with tax dollars.

Designate one side of the room as *strongly agree*, the other side as *strongly disagree,* and the middle as a gradient between these two opinions. Ask students to move to where their opinion falls in response to the question: *Should the government fund basic science research like on that studies jaw clenching in various species?*

Call on several students from across the gradient to hear why they are standing where they are. Mention that they will participate in the same heat map exercise at the end of the activity.

Part 2
Examples from History (20 minutes)

After the heat map exercise, provide students with at least one example of how basic science is foundational to applied science. Take examples from history of what people at the time thought was pointless or very pure science research that ended up being incredibly useful to science, healthcare, and technology today. Although examples that relate specifically to what the students have been learning in class are great to include, here are a few possibilities:

Examples:

- Elizabeth H. Blackburn: Pond scum and telomeres
- Osamu Shimomura: Glowing jellyfish and GFP
- Thomas Hunt-Morgan: Fruit fly breeding and chromosomes
- Joao Pedro de Magalhaes: Naked mole rat and cancer resistance
- Covid-19 research and the resultant vaccines

The goal of sharing these examples is to support the fact that basic and applied research are tightly interconnected--many advances in applied science happen because of what we learn in basic science. Science progress needs basic science.

Ask pairs of students to research an application in science and the basic science that supports its origins. Allow them up to 15 minutes to gather this information and ask them to report their findings.

Part 3
The Spending Debate (20 minutes)
Should the government fund basic science research?

Have the students create a chart in their notebooks with two columns: *Reasons For* and *Reasons Against*. Have them come up with two reasons why the government should fund basic science and two reasons why the government should not fund basic science.

Next, they move around the classroom and fill out three more reasons in each column by talking to other students. They are only allowed to fill out one reason per student that they talk to until they reach five reasons in each column.

Bring the class back together and generate a class list of *Reasons For* and *Reasons Against*. Fill in anything important they missed by prompting them to think of different reasons Important note: in each case when a "claim" is asserted in their reasons, require that students provide an example/evidence to support their claim.

Here is a list of possible reasons:

Should the government fund basic science research?

Reasons For	Reasons Against
• Keeps U.S. ahead in global economy • U.S. should keep pace with other countries in scientific discoveries • The pure need to learn and understand our world • Basic research needs to be funded understanding that there is no immediate profit • Moves science forward • "Useful" research is built upon basic research • Small part of government budget • Grants process is reviewed and competitive • Keeps science discoveries public property	• Economic downturn • Government debt • Waste of money • Pointless • Could be funding more important research • Politics

Review this list in light of Parts 1 and 2 of this activity. Locate and provide statistics showing the percentages of government spending on different projects such as military, social programs, education, and science research. Give the students time to ask questions. Mention that they will connect these ideas while revisiting the heat map.

Part 4
Heat Map and Wrap-up (15 minutes)

Heat-Map:

Again divide the room into a spectrum from *strongly agree* to *strongly disagree* and have the students move to a place in response to the question *Should the government fund basic research?*

Have the students who changed position from the first heat-map raise their hands.

Wrap-up:

Have a classroom discussion about how student's opinions have changed or stayed the same and what they have learned. Discuss how the issue is complex and why people might be so divided in the US today. Begin within table groups and then go around the room and have the table groups share what they talked about.

Finally, ask them about how this activity applies to how they are learning science in school.